Appendix J

Air Quality and Greenhouse Gas Technical Report

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Air Quality and Greenhouse Gas Assessment

Appendix J: Air Quality and Greenhouse Gas

Air Quality and Greenhouse Gas Assessment

Client: Department of the Chief Minister and Cabinet, Northern Territory Government

ABN: N/A

Prepared by

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Glossary

Acronym/abbreviations	Description
µm	micrometre
µg	microgram
µg/m³	micrograms per cubic metre
ABF	Australian Border Force
ACCU	Australian Carbon Credits Union
AQIA	Air Quality Impact Assessment
AQIA study area	A 15 km by 12 km area surrounding the Project for the purpose of assessment
BHD	backhoe dredge
BoM	Bureau of Meteorology
CALMET	A diagnostic three-dimensional meteorological model, which provides input for the CALPUFF air dispersion model
CALPUFF	CALPUFF is an advanced non-steady-state air quality modelling system developed in the US
CALPOST	A post-processing package used to process the output from CALPUFF
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
$CO_2{}^{-e}$	carbon dioxide equivalent
CSD	cutter suction dredge
DAWE	Department of Agriculture, Water and Environment
DKIS	Darwin Katherine Interconnected System
DoD	Department of Defence
DPTI	Department of Planning, Transport and Infrastructure (South Australian)
EAW	East Arm Wharf
EIS	Environmental Impact Statement
EPP Air	Environmental Protection Policy (EPP) Air
ERF	Emissions Reduction Fund
g	grams
GDA	Geocentric Datum of Australia
GHG	Greenhouse gas
GWP	Global Warming Potential
ha	Hectares
HFC	hydrofluorocarbons
HP	horsepower
kL	kilolitre

Acronym/abbreviations	Description
km	kilometre
kPa	kilopascals
kW	kilowatt
kWh	kilowatt-hour
m	metre
m^2	metres squared
m^3	metres cubed
MUBRF	Multi-user Barge Ramp Facility
LAT	lowest astronomical tide
N_2O	nitrous oxide
NEPM	National Environment Protection Measure
NGA Factors	National Greenhouse Accounts Factors
NGER Act	National Greenhouse and Energy Reporting Act
NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPI	National Pollutant Inventory
NSW	New South Wales
NSW EPA	New South Wales Environmental Protection Authority
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
O_3	ozone
OLM	ozone limiting method
OPV	offshore patrol vessels
PFC	perfluorocarbons
$PM_{2.5}$	particulate matter less than 2.5 micrometres
PM_{10}	particulate matter less than 10 micrometres
SA EPA	South Australia Environmental Protection Authority
SF_6	sulfur hexafluoride
SLAMI	shiplift and associated marine industry facility
SO_2	sulfur dioxide
SPMT	Self-Propelled Modular Transportation
t	tonnes
TAPM	The Air Pollution Model; a prognostic meteorological model used to provide input into CALMET
TJ	terajoules
ToR	Terms of Reference

Acronym/abbreviations	Description
TSP	total suspended particulates
UKC	under keel clearance
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
UTM	universal transverse mercator
Vic EPA	Victorian Environmental Protection Authority
VKT	vehicle kilometres travelled
VOCs	volatile organic compounds

Executive Summary

The NTG is delivering the Darwin Ship Lift Project ('the Project') which comprises construction and operation of a ship lift facility and an adjacent maintenance facility at East Arm. AECOM has been commissioned to prepare an EIS for the Project in accordance with the Terms of Reference (ToR) for the Project and relevant guidelines.

This technical report presents the results of the Air Quality Impact Assessment (AQIA) and Greenhouse Gas (GHG) assessment for the Project which will form part of the EIS. The Technical Report has been completed with reference to the ToR which aims to maintain air quality and minimise emissions and their impact to ensure environmental values are protected. This technical report informs the air quality chapter presented within the EIS.

To determine appropriate air quality goals for the project a legislation review was undertaken. Due to the lack of applicable State Government criteria for the Northern Territory (NT), a review of air quality goals prescribed by the State Governments of Queensland, New South Wales (NSW) and Victoria was undertaken and compared to the Commonwealth Ambient Air Quality NEPM (2021) and Air Toxics NEPM (2011) standards to identify the most appropriate air quality goal.

Potential impacts to the surrounding air environment due to air emissions from construction and operational activities associated with the Project have been assessed. Pollutants of concern assessed in the AQIA were found to be combustion emissions such as particulate matter (PM_{10} and $PM_{2.5}$) nitrogen dioxide, carbon monoxide, sulfur dioxide (SO_2) and volatile organic compounds (VOCs)

Estimates of relevant GHG emissions during both construction and operation, in this case carbon dioxide (CO_2) methane (NH_4) and nitrous oxide (N_2O) have also been made. Emission sources for each scenario were identified and emission rates estimated based on published emission factors and Project specific data.

A quantitative air quality assessment using the air dispersion model CALPUFF was undertaken for the Project in accordance with the ToR and appropriate guidelines. Both construction and operational impacts were modelled for the Project to assess the potential impacts on the receiving existing environment at nearby sensitive receptors. A baseline assessment was conducted to identify existing meteorology, air quality conditions as well as the location of surrounding sensitive receptors.

Background concentrations for pollutant species of concern have been adopted for the assessment considering available monitoring data from NT EPA air quality monitoring stations. Emission sources for each scenario were identified and emission rates estimated based on published emission factors and Project specific data.

Based on the results of the dispersion modelling, there were no exceedances of the identified goals for construction or operation for any air pollutant across all averaging periods, and no significant impact were predicted for any pollutant at sensitive receptors.

GHG emission sources were identified for both the construction and operation phases, with Scope 1 and Scope 2 emissions estimated using NGER guidance and reference material. A comparison to the NT and Australian benchmark for reported emissions from 2019 data estimated a less than 1% contribution to total NGER reported emissions across the Industrial Processes and Product sector and all sectors.

Appropriate mitigation measures have been recommended for potential air quality impacts and greenhouse gas emissions attributed to both the construction and operational phases of the Project. These mitigation measures will assist in managing pollutant emissions and GHG emissions from construction and operation of the Project to prevent significant impacts occurring.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was engaged by the Northern Territory Government (NTG) to prepare an Environmental Impact Statement (EIS) for the Darwin Ship Lift Project (the Project) in accordance with the Terms of Reference (ToR) for the Project and relevant guidelines.

The NTG is delivering the Darwin Ship Lift Project ('the Project') which comprises construction and operation of a ship lift facility and an adjacent maintenance facility at East Arm. The location of the Project at East Arm is consistent with long term master planning for Darwin. The NTG has been developing land at East Arm for marine industries since 2004 and in 2014, proposed to include a ship lift as part of the development of its East Arm Marine Industry Park. The Project will enable maintenance and servicing of a broad range of industries, including the Australian Defence Force (ADF) and Australian Border Force (ABF) vessels, as well as commercial and private vessels, including those servicing the oil, gas, pearling, fishing and other marine industries.

In response to the ToR requirements, an air quality impact assessment (AQIA) has been undertaken to quantitatively assess the potential impacts from construction and operation of the Project at sensitive receptors against the relevant ambient air quality standards. This report outlines the current regulatory system relevant to air quality management, baseline air quality and meteorological conditions in the assessment study area, and the methodology used to carry out an assessment of air quality impacts associated with the Project.

In addition to the AQIA, an inventory of greenhouse gas (GHG) emissions for the construction and operational phases of the Project has also been developed. This report outlines the methodology adopted to develop the greenhouse gas emissions inventory and presents the estimated emissions for both phases.

This technical report also presents the results of the assessment and proposes mitigation measures and strategies to minimise potential air quality and greenhouse impact from the Project. This technical report supports the air quality chapter presented within the EIS for the Project.

1.1 Objective for environmental factor of air quality and greenhouse gas

The Northern Territory Environment Protection Authority (NT EPA) has developed environmental factors and corresponding objectives to improve certainty and increase transparency within the Environmental Impact Assessment (EIA) process. *Environmental factors* are those parts of the environment that may be impacted by an aspect of a proposal. There are 13 environmental factors categorised under five major themes of: Land, Water, Sea, Air and People and Communities. Each factor has a corresponding *environmental objective* which reflects the value of these parts of the environment.

The ToR identifies air quality and greenhouse gases as a key environmental factor that could be significantly impacted by the proposal. The objective associated with this factor is to:

Maintain air quality and minimise emissions and their impact so that environmental values are protected.

1.2 Terms of Reference

This technical report addresses the items of the ToR relevant to air quality and greenhouse gas. The relevant air quality and greenhouse gas ToR items are presented in Table 1.1. The section of this report which addresses each of the ToR items is also presented in Table 1.1.

Table 1.1 ToR compliance table for air quality and greenhouse gases

ID	Terms of reference requirements	Report section number
Table 1: Minimum Information required in the Proposal description		
Energy		
Provide relevant information with respect to energy during construction and operation, including but not limited to: • energy requirements and sources		Section 8.0
• consideration of renewable sources of energy and justification of selected		Section 9.2
• estimate of greenhouse gas emissions		Section 8.0
• measures to maximise energy efficiency and avoid and/or reduce greenhouse gas emissions, particularly relating to source and consumption of energy.		Section 9.2
Table 5: Minimum information required for assessment of air quality and greenhouse gases		
1.0 Environmental values		
1.1	As a minimum, describe ambient air quality of the area potentially impacted by emissions released by the Proposal.	Section 5.2
2.0 POTENTIAL IMPACTS AND RISKS		
2.1	Describe potential impacts and risks to air quality including potential impacts and risks to the environment from fugitive emissions. As a minimum: • provide an inventory of significant emissions to air likely to result from the Proposal	Section 4.2.2 Section 4.2.2.4
	• identify and provide the location of sensitive receptors on land and sea	Section 6.0
	• include reporting requirements and compliance with relevant environmental standards	Section 6.3
	• assess air emission impacts during construction and operation based on air dispersion modelling for odour and volatile organic compounds (VOCs).	Section 6.3
3.0 Mitigation and management		
3.1	Outline the measures for avoiding, minimising, managing and mitigating potential impacts and risks to air quality including: • design of painting facilities, e.g. enclosed facility with negative air capacity.	Section 9.0
4.0 Monitoring and reporting		
4.1	Describe how the Proponent will monitor and report potential impacts and risks to air quality including air quality standards and trigger values.	Section 9.3
5.0 Residual impact		
5.1	Assess residual impact or risk of the Proposal to identified values.	Section 11.0

2.0 Project Description

The NTG is developing the Project on the East Arm Peninsula within Darwin Harbour. Once constructed, the facility would be Northern Australia's largest common user ship lift. The facility is planned to be operational in 2024 and is proposed to include:

- ship lift of approximately 26 metres (m) width and 103 m length, capable of lifting vessels weighing up to 5,500 tonnes (t) including associated platform, blocking trestles and vessel transfer system
- self-propelled modular transporter (SPMT) vessel transfer system
- approximately 13 hectares (ha) of hardstand area for ship repair and maintenance
- vessel wash area with separate contained drainage and treatment system
- stormwater system to capture and treat runoff water before discharge
- enclosed blast and paint facility with separate contained drainage system
- site services and utilities
- security infrastructure
- ancillary facilities including:
  - administration building
  - ship lift control room
  - SPMT storage facility.
- access channel and dredged manoeuvring areas six wet berths
- heavy lift platforms suitable for a 100 t crane at each berth
- revetments and quay structures.

Multiple commercial marine service providers will be able to operate concurrently at the Project site, providing vessel operators with a variety of maintenance services located within a secure facility.

The Project will fill an existing market gap to facilitate further development of the region's marine services and logistics, therefore supporting jobs and economic growth of the Northern Territory.

The ship lift and transfer system has been sized to accommodate the servicing of Australian Navy offshore patrol vessels (OPVs). This would provide long-term maintenance opportunities and is mutually beneficial to Darwin and the ADF, with six of northern Australia's OPVs anticipated to be based nearby at HMAS Coonawarra.

Other vessels able to utilise the long-term maintenance opportunities provided by the facility include the pearling industry, the fishing industry, and the resources and energy sector.

The location of the Project maximises the use of existing and suitably zoned industry land and is in proximity to available and proposed industrial lots to support future growth. Environmental benefits include minimal land clearing and disturbance of mangroves and reduced dredging due to existing bathymetry. The location of the Project is shown in Figure 2.1.

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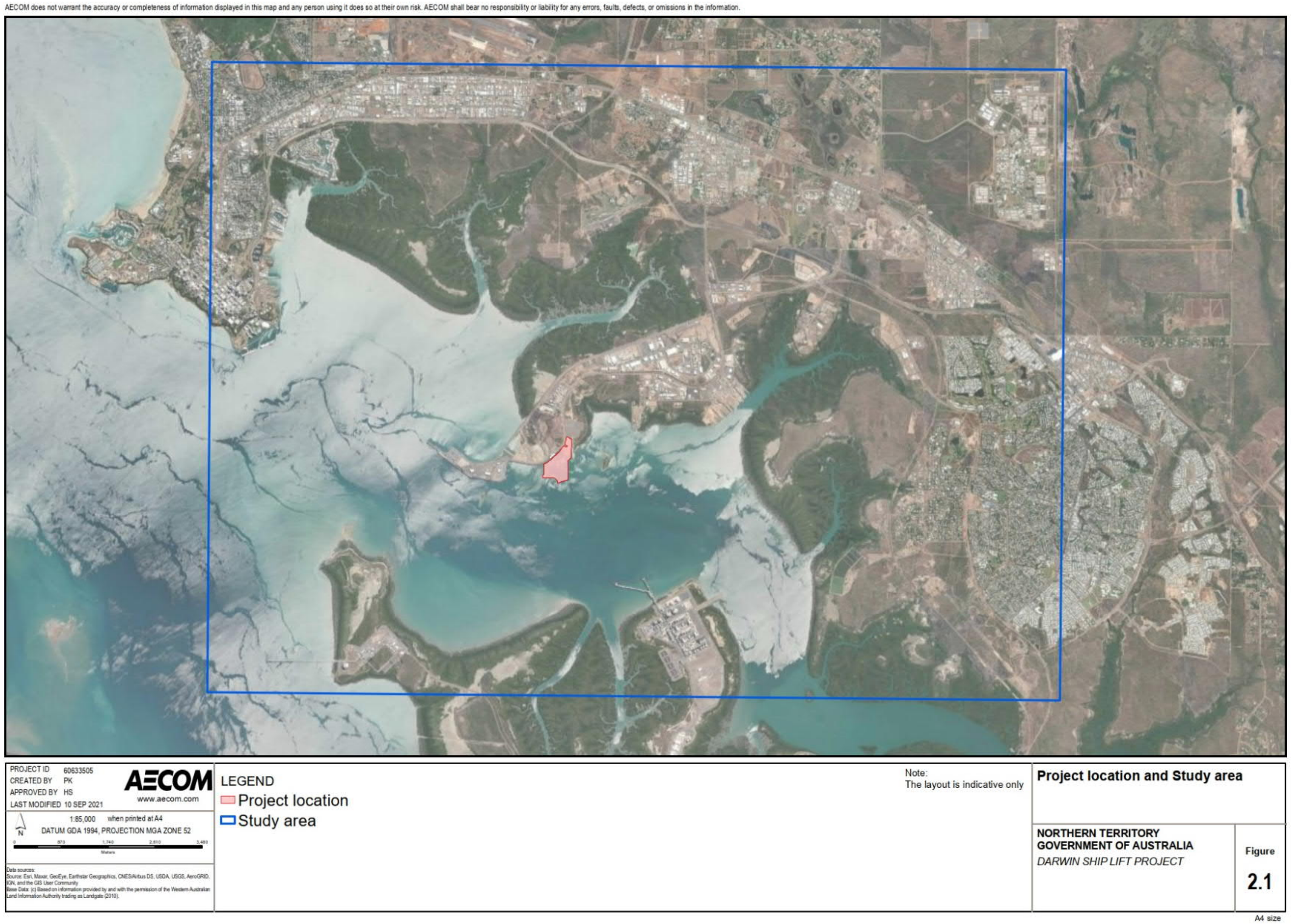

Figure 2.1 Project location and air quality study area

2.1 Construction phase

The following construction works are anticipated to be required for the Project:

- site preparation
- dredging
- transport of fill and materials
- land reclamation and revetments
- service installation, pavement sealing and paving
- piling
- infrastructure/component fabrication and installation, and
- corrosion protection.

The construction phase is expected to commence in the third quarter of 2022 and be completed in approximately 24 to 36 months following completion of approvals and detailed design by the end of 2022. The Project is planned to be operational by late 2024.

Construction activities with relevance to air quality impacts are described in detail below. Potential sources of air emissions include material handling emissions from land reclamation and importing fill, as well as combustion emissions from dredging, piling and site vehicles.

2.1.1 Site preparation

The footprint of the Project when constructed will cover 27 ha and incorporate both land and water components.

Based on current design, the area of land within the proposed Project footprint is 4.5 ha. Once constructed the land component will total approximately 15.5 ha and include 8.5 ha of reclaimed land and 2.5 ha of revetments.

Based on current design, the area of water within the proposed Project footprint is 22.5 ha. Once constructed this will measure 11.5 ha. Of this 11.5 ha, approximately 9.2 ha will require dredging for construction of the:

- ship lift and wet berths at -6.8 m (lowest astronomical tide) LAT (6 ha)
- manoeuvring basin areas at -3.3 m LAT (3.2 ha).

The existing site will be cleared of all above ground infrastructure. The landside area of the site will be levelled to allow reclamation works to commence. Existing inground services may be capped and abandoned unless expected to conflict with new services.

2.1.2 Dredging

Dredging is required to remove both consolidated (315,000m^3) and unconsolidated (185,000m^3) materials from the manoeuvring basin and wet berths area.

Two options for the dredging campaign are being examined and these include:

- Option 1 - using a cutter suction dredge (CSD), similar to that used for the neighbouring multi-user barge ramp facility (MUBRF) dredge campaign, to remove the unconsolidated material to settling ponds. A backhoe dredge (BHD) would then be used to remove consolidated stiff clays and rock to be then re-used for land reclamation; or
- Option 2 - using a BHD to remove all material, with the material re-used for land reclamation.

Under Option 1, the CSD, supported by work boats, would (pending agreement with Darwin Port) pump the unconsolidated material (via floating, submerged and/or overland pipelines) to the existing Darwin Port East Arm Wharf (EAW) settlement ponds. The dredged material would be deposited into a settlement pond in which the larger particles (sands and silts) settle out. The supernatant tailwater then flows into a second pond, in which finer particles settle out. Silt curtains may be installed to assist in this process.

Under Option 2, the BHD would deposit the dredged material onto barges, to be transferred into the reclamation area. Unconsolidated and consolidated dredged material would be mixed on site and the site progressively filled from the shoreline in a seaward direction until the extent of the proposed reclamation is reached.

2.1.3 Land reclamation and revetments

The land reclamation process will be further refined within detailed design. For the purpose of this assessment, land reclamation is assumed to be undertaken by shoreline outwards placement method. Imported fill and dredged fill material (brought to the shoreline by barge), would be placed, pushed and compacted outwards from the shoreline by earthmoving machinery. This would continue until the outward edge of the reclamation was reached and revetments are installed using geofabric, primary filter rock and pre-cast concrete armouring.

2.1.4 Construction material transport

To build the landside components of the Project and assist with land reclamation, approximately 715,000 m^3 of fill, 16,500 m^3 of revetment filter rock and 46,000 m^3 of armour materials are required. This is expected to comprise approximately:

- 400,000 m^3 of sand fill, or clean fill, transported by road from a local borrow pit site(s) within 20 km of the Project site
- 315,000 m^3 consolidated material, comprising stiff clays and rock, dredged (likely by BHD and barge) from below the ship lift system, manoeuvring basin and wet berth footprint areas which would be transported ashore
- 16,500 m^3 of filter rock sourced from a commercial quarry, and
- 46,000 m^3 of armour rock either be sourced from a commercial quarry or comprise pre-cast concrete units.

Construction of the hardstand area finished surface would require:

- 90,000 m^3 of pavement and subgrade material, and
- 1.2 ha of interlocking concrete block pavers for the SMPT vessel transfer areas.

Existing road access to EAW is via Berrimah Road, with the haul route's main highways and arterial roads designed to carry high volumes of heavy vehicle traffic. Haulage and material management areas within the Project site would be unsealed.

Details of the traffic assessment undertaken for the project are presented in Appendix L: Traffic Impact Assessment and summarised in Chapter 10: Social, Economic and Cultural Surroundings.

2.1.5 Service installation, pavement sealing and paving

On completion of the reclamation and revetment walls, underground services, permanent stormwater and waste management systems, and building foundations would be installed, and the hardstand areas paved and completed. The load ratings and final surface finish would depend on the proposed use of the area.

2.1.6 Machinery and equipment

Construction machinery and equipment requirements for the construction phase have been estimated by NTG and are presented in Table.2.1. It is noted that the exact equipment used for construction would be determined by the construction contractor.

Table.2.1 Estimated construction machinery and equipment requirements

Construction aspect	Equipment	Number required
Dredging	CSD	1
	BHD	1
	Work boats	2
	Pumps	2
	Excavator / bulldozer (pond management)	1
Land Clearing	Excavator	1
	Bulldozer	1
	Scraper	1
Revetments	Excavator	2
	Crane	2
Piling	Land-based rig	1-2
	Barge-based rig	1
	Work boats	2
	Cranes	3-4
Waterside infrastructure	Barges	2-3
	Cranes	2
	Workboats	2
Hardstand	Grader	2-3
	Roller	4
	Water truck	3
	Tipper	4
	Backhoe	2
	Skidsteer	2
	Loader	2
	Excavator	4
	Concrete truck	2
	Concrete pump	2

2.1.7 Construction schedule

Dredging is expected to be undertaken during both day and night time hours, seven days per week. The dredging would typically be continuous, but there would be periodic down time (e.g. due to relocation of the dredge, shift changes, maintenance and weather interruptions). Other activities associated with the dredging (e.g. pipeline relocations, anchor relocations, movement of attendant work boats and barges) would also need to occur intermittently during both day and night time hours.

For other construction activities working hours would be refined by the construction contractor. Works may occur on a 24-hour basis or restricted to standard daytime hours, depending on the various factors, which may include the tasks to be undertaken, available timeframes, seasonal conditions, subcontractor agreements and environmental approval conditions.

Emissions from construction activity during early morning and night time hours have higher risk potential to cause impacts to air quality at sensitive receptors due to less dispersive meteorological conditions that generally occur over these periods. This is discussed in further detail in Section 5.1.

2.2 Operation phase

The Project includes a blast and paint facility, to undertake activities including abrasive blasting for paint and corrosion removal (including anti-fouling paint) and surface preparation, then painting of the vessel hull, including the use of anti-fouling paints. Air emissions from this activity have been assessed in detail.

Shore power would be provided to ships docked at the facility and therefore auxiliary engines would not run whilst ships are at berth. On this basis, air emissions from ships at berth have not been considered in this assessment.

Ships entering and exiting the facility would be operating propulsion engines which would generate air emissions. However, these sources would be transient, as the ships move in or out of the area and air impacts would be unlikely. On this basis, these emissions were not considered in the assessment.

2.2.1 Blast and paint facility

The blast and paint facility would be a negative pressure building with air emissions exhausted via roof mounted exhaust stacks. Air filtration would be installed as part of the mechanical ventilation system to minimise emissions to air.

The blast and paint facility is expected to fit the majority of vessels. However, for longer vessels the doors to the building would remain open and temporary structures and screening would be placed around the end of the vessel (which protrudes from the building) to mitigation potential fugitive dust emissions and overspray.

2.2.2 Maintenance dredging

Maintenance dredging would likely be required in the future to maintain safe operation and manoeuvring depths within the area under the ship lift, manoeuvring basin and all wet berth pockets. The duration of maintenance dredging required and volume material moved would be lower than that required during the construction phase of the Project. Therefore, maintenance dredging has not been considered in the assessment.

2.3 Project air emissions

Review of applicable National Pollution Inventory (NPI) emission estimation manuals has been undertaken to determine the primary air pollutants of concern considered in this impact assessment. Based on the review, the pollutant species which have been considered are as follows:

- Particulate matter (TSP, PM_{10} and $PM_{2.5}$)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Carbon Monoxide (CO)
- Volatile organic compounds (VOCs);
- Odour
- Greenhouse gases (GHG).

A brief discussion regarding these pollutants and their potential effects on health and the environment is provided in the following sections.

2.3.1 Particulate matter

Particulate matter refers to the many types and sizes of particles which can be suspended in the air environment. Particulate matter is unique among atmospheric pollutants in that it is not defined on the basis of its chemical composition; as it includes a broad range of chemical species, but upon its aerodynamic size. Particle size fractions are commonly described as follows:

- particles with an aerodynamic diameter of less than or equal to 50 micrometres (µm) are classified as total suspended particulates (TSP)
- particles with an aerodynamic diameter less than or equal to 10 µm are classified as PM_{10}
- particles with an aerodynamic diameter less than or equal to 2.5 µm are classified as $PM_{2.5}$.

Particulate matter can be emitted from natural sources (bushfires, dust storms and pollens) or as a result of human activities, such as from internal combustion sources (e.g., motor vehicle emissions, power generation, incineration, etc) or from mechanical processes (e.g., excavation works, bulk material handling, crushing operations, vehicles on unpaved roads, etc).

TSP is primarily associated with nuisance impacts associated with coarse particles settling on surfaces, referred to as dust deposition. Dust deposition is a common cause of complaints, particularly due to staining of clothes (hanging on washing lines) and deposition on vehicles and windowsills. TSP, which includes the coarser size particulate matter fraction, is generated primarily from fugitive emissions sources such as vehicle travel on unsealed roads, wind erosion from exposed areas or earthen material stockpiles and handling of earthen material.

PM_{10} particles tend to remain suspended in the air for longer periods than larger particles (e.g., TSP) and can penetrate into human lungs. PM_{10} can be created in high quantities through crushing and grinding of rocks and soil. PM_{10} is also emitted from vehicle exhausts (combustion engine emissions), but in significantly lower quantities as compared with construction activities and fugitive emission sources.

Due to its smaller aerodynamic size, $PM_{2.5}$ can travel further into human lungs than the larger particulates and can be made up of heavy metals and carcinogens. Therefore, fine particulates ($PM_{2.5}$) are considered to pose a greater risk to human health than larger particle sizes (e.g., PM_{10} and TSP). However, $PM_{2.5}$ is emitted in minor quantities from mechanical sources such as construction activity and is more commonly emitted from combustion sources (i.e., road vehicles and diesel generators).

For the Project, particulate matter is a pollutant of concern for the construction phase only.

2.3.2 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). NO_x are a product of combustion processes and in urban areas motor vehicles and industrial combustion processes are the major sources of ambient NO_x.

NO_2 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 pre-existing health conditions are most susceptible to the adverse effects of NO_2 exposure.

Damage to plants can occur in environments with high concentrations of NO_x, especially in the presence of other pollutants such as O_3 and SO_2.

For the Project, NO_2 is a pollutant of concern for the construction phase only.

2.3.3 Carbon monoxide

CO is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g., oil, gas, coal and wood). It 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 carbon monoxide emissions, which are formed due to incomplete combustion of fuel.

For the Project, CO is a pollutant of concern for the construction phase only.

2.3.4 Sulfur dioxide

SO_2 is a colourless gas with a sharp, irritating odour. It is formed in combustion processes through burning fossil fuel containing sulfur, in petroleum refining and smelting mineral ores. SO_2 is an irritant gas that can cause respiratory tract infections. People with pre-existing respiratory conditions such as asthma are most sensitive to SO_2 exposure. The simultaneous presence of airborne particulate matter can compound these effects. SO_2 and its aerosols can also damage vegetation and some materials.

SO_2 in low concentrations is a common pollutant in cities and some industrial environments. Higher exposure to SO_2 is typically limited to workplace environments where it is produced as a by-product.

The regulation of low sulphur content fuel in Australia has significantly decreased the generation and concentrations of SO_2 near transport sources and concentrations are typically well below the relevant air quality goals. SO_2 emissions from significant construction plant and equipment (large combustion engines) during the construction phase have been assessed and therefore for the Project, SO_2 is a pollutant of concern for the construction phase only.

2.3.5 Volatile organic compounds

Organic compounds with a vapour pressure at 20°C exceeding 0.13 kilopascals (kPa) are referred to as volatile organic compounds. VOCs can be a major precursor in the production of photochemical smog, which causes atmospheric haze, eye irritation, and respiratory problems. VOCs are commonly emitted from vehicle exhausts. Three primary VOCs (benzene, toluene and xylenes) are components of petroleum and diesel fuel and are typically the focus for assessments of engine combustion emissions. VOCs (in particular xylenes) are also emitted from spray painting activities (such as would occur in the blast and paint facility).

For the Project, VOCs are a pollutant of concern for both the construction and operation phase.

2.3.6 Odour

Odour emissions can be either a single compound (e.g., benzene) or a mixture of compounds (a mixture of VOCs as example) that have the potential to affect environmental amenity and cause nuisance.

Odour is considered qualitatively as a pollutant of concern for both the construction and operation phases of the Project.

2.3.7 Greenhouse gases

Greenhouse gases in the atmosphere trap incoming radiation from the sun, which in turn increases temperature. This process is known as the greenhouse effect.

The six GHGs that are reported under the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act) are:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- specified hydrofluorocarbons (HFCs)
- specified perfluorocarbons (PFCs)
- sulfur hexafluoride (SF6).

For the Project the GHG species of concern are CO_2, CH_4 and N_2O.

GHG emissions are generally reported in terms of carbon dioxide equivalent (CO_2^{-e}). This is to provide a standardised unit for reporting due to different gases having varying effects on global warming impacts, known as global warming potential (GWP).

The GWP refers to the GHGs potential to trap heat in the atmosphere for a certain period (generally 100 years), relative to CO_2 (which has a GWP of one). CH_4 has a GWP of 28, which means for every tonne of CH_4 emitted, it has the same global warming effect as 28 tonnes of CO_2. As a result, GHGs such as CH_4 and N_2O have a higher potential to affect global warming.

Table 2.2 presents the GWP for the key GHGs that are anticipated to be emitted as a result of the construction and operation of the Project as advised by Department of Agriculture, Water and the Environment (DAWE) (2021).

Table 2.2 GWP of Key GHGs

Gas	Chemical formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265

A brief description of the NGER Act is provided in Section 3.2.2.1, reporting under the NGER Act requires that GHG emissions are separated into three categories referred to as emission scopes. This is the internationally accepted method of reporting on GHG emissions. The three scopes of emissions as per the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* are described in Figure 2.2.

Reporting under the NGER Act requires that organisations report Scope 1 and Scope 2 emissions, but not Scope 3 emissions, which can be reported voluntarily. This assessment has developed an emissions inventory for Scope 1 and Scope 2 emissions only. Scope 3 emissions have not been considered.

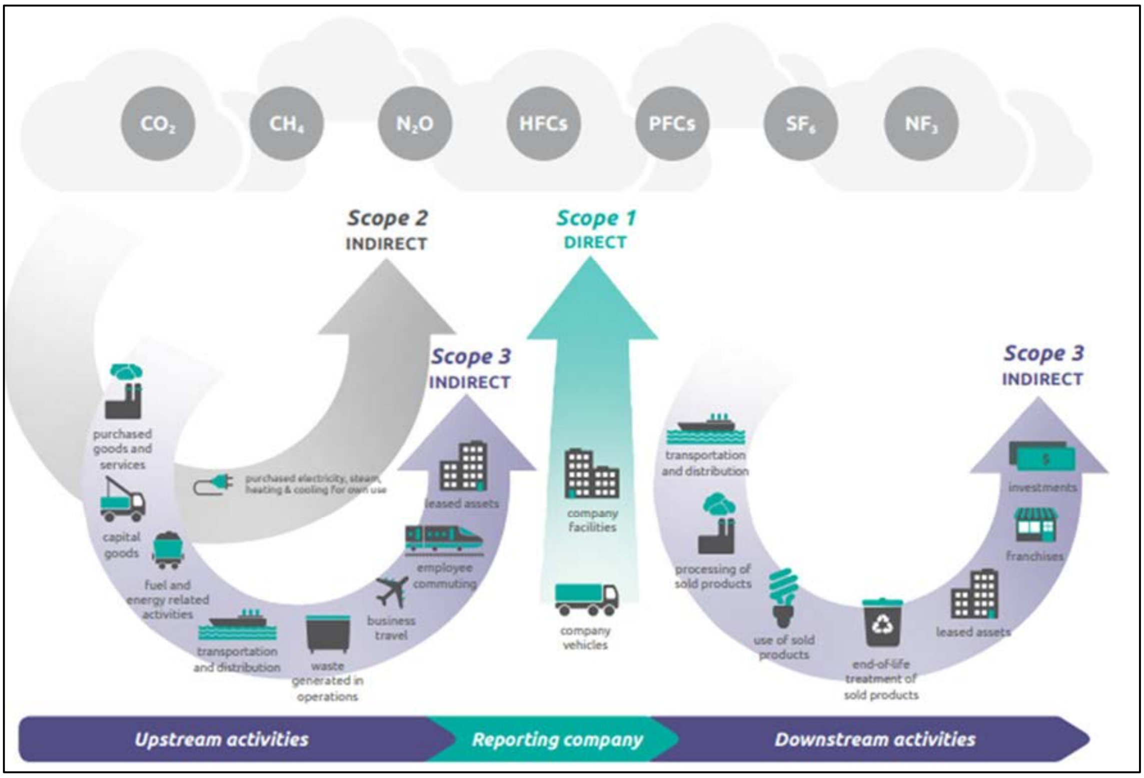

Figure 2.2 Overview of scope and emissions flow across reporting entity (GHG Protocol, 2013)

3.0 Legislation

The legislation, policies, standards and guidelines relevant to air quality and greenhouse gas in the context of the Project are described separately below.

3.1 Air quality

Air quality is an Environmental Factor as defined by the NT EPA (NT EPA, 2018). The NT EPA air quality objective is to “maintain air quality and minimise emissions and their impact so that environmental values are protected” (NT EPA, 2018).

In the NT the environment is protected by a number of legislative instruments, including the *Environment Protection Act 2019* (NT), *Environment Protection Regulations 2020* (NT), *Northern Territory Environment Protection Authority Act 2012* (NT) and the *Waste Management and Pollution Control Act 1998* (NT). However, these instruments do not contain air quality criteria or standards specifically required to be considered for air quality impact assessments.

In absence of State Government enforced air quality criteria, air quality goals for the assessment have been determined by considering air quality goals prescribed by the State governments of Queensland, New South Wales (NSW) and Victoria. Although referenced in the ToR for the Project, the air quality standards presented in the National Environment Protection (Ambient Air Quality) Measure (NEPM Ambient Air Quality) and National Environment Protection (Air Toxics) Measure (NEPM Air Toxics) are not appropriate for air quality impact assessments on an individual project level. Further discussion of the NEPM instruments is provided in Section 3.1.1.

3.1.1 National Environment Protection Council Act 1994

The *National Environment Protection Council Act 1994* (Cth) establishes and provides authority to the National Environment Protection Council (NEPC) to make National Environment Protection Measures (NEPMs) and to assess and report on their implementation and effectiveness in participating jurisdictions. National Environment Protection Measures (NEPM) are broad framework-setting statutory instruments that outline agreed national objectives for protecting or managing particular aspects of the environment. The air quality of an environment is protected by the Ambient Air Quality NEPM. Regarding concentrations of air pollutants, there are two relevant NEPMs the:

- *National Environment Protection (Ambient Air Quality) Measure 1998* (Cth)
- *National Environment Protection (Air Toxics) Measure 2004* (Cth).

The Ambient Air Quality NEPM was designed to create a nationally consistent framework for monitoring and reporting on common ambient air pollutants and provides guidance relating to air in the external environment and does not include air inside buildings or structures.

The Ambient Air Quality NEPM outlines monitoring, assessment and reporting procedures for the following pollutants:

- PM_{10}
- $PM_{2.5}$
- NO_2
- CO
- Ozone (O_3)
- SO_2.

The 2016 version of the Ambient Air Quality NEPM is referenced in the ToR for the Project. The Ambient Air Quality NEPM was amended in May 2021 (National Environmental Protection Council 2021), superseding the 2016 version. Amendments made in May 2021 included significant reductions to the standards for NO_2 and SO_2. The air quality standards associated with the Ambient Air Quality NEPM as amended on 18 May 2021 are provided in Table 3.1 in Section 3.1.2.

In addition to the Ambient Air Quality NEPM, the Air Toxics NEPM (amended 2011) provides a framework for monitoring, assessing, and reporting on ambient levels of air toxics. The purpose of this NEPM is to collect information to facilitate the development of standards for ambient air toxics.

The Air Toxics NEPM includes monitoring investigation levels for use in assessing the significance of monitored levels of air toxics with respect to human health. The monitoring investigation levels are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short term, it does not mean that adverse health effects automatically occur; rather some form of further investigation by the relevant jurisdiction of the cause of the exceedance is required. The relevant monitoring investigation levels defined in the Air Toxics NEPM are listed in Table 3.1.

The Ambient Air Quality NEPM and Air Toxics NEPM standards are intended to be applied to air quality experienced by the general population in a region. The Ambient Air Quality NEPM and Air Toxics NEPM standards are not intended to be applied to assessing air quality in areas in the region affected by localised air emissions, such as individual industrial sources or projects. The Explanatory Statement issued with amendment of the Ambient Air Quality NEPM clarifies its intent as a standard for reporting representative ambient air quality within an airshed, and not as a regulatory standard. The Ambient Air Quality NEPM does not constrain a jurisdiction’s ability to manage local or regional air quality issues.

It is noted that the NEPM air quality standards are commonly adopted as assessment criteria for the assessment of new projects for States and Territories which do not prescribe their own air quality standards, such as the NT.

Until recently (May 2021), the Ambient Air Quality NEPM standards have been comparable to the impact assessment air quality standards prescribed by other States and Territories, and this remains true for most pollutants. However, the recently amended standards for NO_2 and SO_2 are no longer consistent with the standards prescribed by other States and Territories and therefore review of appropriate assessment criteria for these pollutants is required for this Project. Further discussion is provided in Section 3.1.2.

Table 3.1 Comparison of Air Quality Goals for Human Health and Aesthetic Environment

Pollutant	Averaging Period	Air Quality Goal (µg/m^3)			
		NEPM[1]	Queensland[2]	NSW[3 b]	Victoria[4]
PM_{10}	24 hour	50	50	50	50
	Annual	25	25	25	20
$PM_{2.5}$	24 hour	25	25	25	25
	Annual	8	8	8	8
NO_2	1 hour	151	226	226	226
	Annual	28	56	56	56
SO_2	1 hour	262	523	523	523
	24 hour	52	209	209	209
	Annual	-	52	52	52
CO	8 hour	10,000	10,000	10,000	10,000
Benzene	1 hour	-	-	29[a]	580[ab]
	24 hour	-	-	-	29[b]
	Annual	9.6	6.4	-	9.6
Toluene	30 mins	-	1,100	-	-
	1 hour	-	-	339[a]	1,500[ab]

Pollutant	Averaging Period	Air Quality Goal (µg/m³)			
		NEPM[1]	Queensland[2]	NSW[3 b]	Victoria[4]
	24 hour	3,700	3,700	-	-
	Annual	376	376	-	-
Xylenes	1 hour	-	-	173[a]	22,000 [ab]
	24 hour	1,100	1,100	-	8,700[b]
	Annual	867	867	-	100

Table notes:
1. Ambient Air Quality NEPM and Air Toxics NEPM
2. Queensland Government EPP (Air) (2019)
3. NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016)
4. Victoria Government Environment Reference Standard and Guideline for Assessing and Minimising Air Pollution in Victoria
[a] 1 hour averaging period criteria are taken from the 99.9th percentile for each pollutant
[b-]Criteria are applied at and beyond the boundary of the Project and not only at sensitive receptors.
"-" indicates that no air quality goal is prescribed for this pollutant and averaging period.
Air quality goals are expressed at 25˚C and at an absolute pressure of one atmosphere (1013.25 hPa).

3.1.2 Review of air quality goals

To determine appropriate air quality goals for the Project, a review of air quality goals prescribed by the State Governments of Queensland, New South Wales (NSW) and Victoria has been undertaken in comparison to the Ambient Air Quality NEPM (2021). The review considered the following documents:

- Queensland Government Environmental Protection (Air) Policy (EPP Air) (2019)
- New South Wales (NSW) Environment Protection Authority (NSW EPA) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016), and
- Victoria Government Environment Reference Standard and the Draft[1] Guideline for Assessing and Minimising Air Pollution in Victoria.

The air quality goals from each of the referenced documents for each of the pollutant species of concern are presented in Table 3.1. The air quality goals presented in Table 3.1 are expressed at 25˚C and at an absolute pressure of one atmosphere (1013.25 hPa).

Table 3.1 shows that the air quality goals for, $PM_{2.5}$, NO_2, SO_2 and CO are consistent between Queensland, NSW and Victoria, therefore these goals have been adopted as Project assessment goals. Air quality goals for PM_{10} are consistent between NSW and QLD, however Victoria provides a stricter statutory goal. The PM_{10} air quality goal for NSW and QLD has been adopted for the Project rather than the more stringent Victoria goal. This is also consistent with federal legislation.

Table 3.1 shows that there is variation between jurisdictions for air quality goals for VOC species (benzene, toluene, xylene). Assessment criterion for VOCs of 1-hour are generally only provided in Victoria and NSW as 99.9th percentile values at or beyond the boundary of the facility. As such the most recently published criteria (in Victoria) has been adopted for the purpose of this assessment. It is noted however that the 1-hour 99.9th percentile criteria for benzene are more stringent. Therefore, while the Victorian criteria has been adopted, assessment against the NSW criteria for identified sensitive receptors has also been discussed in Section 7.2.1.

The air quality goals adopted for the Project are presented in Section 3.1.4.

[1] The Draft Guideline for assessing and minimising air pollution in Victoria is currently being finalised following consultation with industry reference groups and is expected to be finalised in late 2021.

3.1.3 Annual average incremental $PM_{2.5}$ goal

The annual average $PM_{2.5}$ goal of 8 µg/m³ as prescribed by the Queensland, NSW and Victorian Governments is being approached or exceeded at ambient air quality monitoring stations in most major Australian capital cities (including Darwin, refer Section 5.2). It is therefore becoming increasingly difficult to show compliance with the annual average $PM_{2.5}$ goals for new projects which need to assess cumulative concentrations. $PM_{2.5}$ is not a threshold pollutant, meaning that any increase in concentration would result in a proportional increase in health impacts on the population i.e., larger increases in $PM_{2.5}$ concentration would result in more serious health impacts that a small increase.

Air quality impact assessment criteria in Australia are based around the principle of ensuring predicted concentrations of pollutants are below a level which regulatory authorities are comfortable that adverse health effects would not occur. These values are conservative when compared to health risk criteria and are not indicative of potential changes to health risk. To assess the risk of effects on health from a project, a development must undertake a health risk assessment which uses epidemiological data to examine the likely health effects experienced by a particular population due to a change in pollutant concentration. This health risk methodology is different to air quality studies which commonly examine the cumulative pollutant concentrations at receptor locations as opposed to the potential changes in health risk as a result of incremental pollutant contributions directly attributed to a project.

The rationale behind the health risk approach is that a population would be living with a certain air pollution level and the risk of experiencing health effects is based on that particular level of pollution. Any change to the air-shed's pollutant load would result in a change in the risk of an adverse effect on health experienced by that population, (whether that change is an increase or decrease in pollutant concentration). The risk of an adverse health outcome is assessed in terms of the increased (or decreased) risk of harm to a population (commonly expressed as a ratio e.g., 1 in 10,000 chance of increased mortality etc.). Regulatory authorities in other jurisdictions outside the NT have examined the effects of annual average $PM_{2.5}$ and have identified concentrations which are considered by that jurisdiction to represent an "acceptable risk of additional harm".

Currently, no incremental $PM_{2.5}$ air quality exists in the NT for the assessment of incremental risk, so criteria from other states were sourced for this purpose. The three sources of data used for the assessment were as follows:

- The South Australian Department of Planning, Transport and Infrastructure (DPTI) lists a "delta $PM_{2.5}$" annual average screening criteria of 1.8 µg/m³ (DPTI 2017).
- In NSW, there are no official incremental criteria for annual average $PM_{2.5}$. However, a criterion of 1.8µg/m³ was used for the WestConnex M4-M5 Link AQIA (RMS 2017a).
- The Victorian Guideline for assessing and minimising air pollution states that as a general rule, an increment of 4% of the relevant air quality assessment criteria can be applied at the most impacted sensitive location.

Both the DPTI and WestConnex criteria were based on an increase in human health risk of mortality of 1 in 10,000. There is no specific guideline in Australia for the calculation of, or a recommendation of, a level of risk considered to be acceptable in a particular jurisdiction, however, the 1 in 10,000 level is generally adopted by health authorities as a point above which the risk is no longer acceptable. This level is adopted as "not acceptable" for carcinogenic risks associated with the exposure to toxic air pollutants in the NSW approved methods for modelling (NSW EPA 2017). The Victorian Guideline for assessing and minimising air pollution generalisation on incremental criteria is given with the caveat that when particulate plumes are likely to impact on a large population (greater than 25,000 people), a criteria pollutant health risk assessment may be required to evaluate risks from incremental contributions. Therefore, this criterion is not considered in the calculation of the $PM_{2.5}$ incremental average

This level of risk was adopted in the WestConnex Human Health Risk Assessment (RMS 2017b) as a trigger value for potential associated health impacts with predicted increases of annual average $PM_{2.5}$ concentrations of 1.8µg/m³ or above. The value of 1.8 µg/m³ was calculated based on a risk level of 1 in 10,000 for all-cause mortality in the age group of 30 years and over, which was determined to be the key metric in the human health risk assessments for the WestConnex project and other similar tunnel projects in the Sydney area. The risk level is calculated as follows:

$R = \beta \times \Delta PM_{2.5} \times B$

Where

R = additional risk

β = slope coefficient for the % change in response to a 1 µg/m³ change in exposure (a value of $\beta = 0.0058$ was used in the WestConnex AQIA and was taken from an American study linking particulate air pollution and mortality (Krewski et. al. 2009).

$\Delta PM_{2.5}$ = change in $PM_{2.5}$ concentration at the point of exposure

B = baseline incidence of a given health effect per person, e.g., annual mortality rate. A value of 976.6 per 100,000 for mortality all causes ≥30 years was adopted for the WestConnex study (2010 NSW morbidity rates provided in Golder Associates (2013)). A value of 984.2 per 100,000 is provided in Golder Associates (2013) for Victoria.

The equation can be rewritten to calculate the $\Delta PM_{2.5}$ for a given additional risk:

$\Delta PM_{2.5} = R / (\beta \times B)$

For the WestConnex project, the value of $\Delta PM_{2.5}$ is:

$\Delta PM_{2.5} = 0.0001 / (0.0058 \times 0.009766) = 1.765 = 1.8$ µg/m³

For the Project, using the Darwin baseline incidence rate of 677.6 per 100,000 (from Golder Associates 2013), the value of $\Delta PM_{2.5}$ is:

$\Delta PM_{2.5} = 0.0001 / (0.0058 \times 0.006776) = 2.544 = 2.5$ µg/m³

The calculated $\Delta PM_{2.5}$ of 2.5 µg/m³ is intuitively fairly high, and a lower, more stringent criteria would be beneficial to adopt for the Project as a conservative measure. A risk level of 1 in 20,000 was therefore adopted for the Project which gives a $\Delta PM_{2.5}$ of:

$\Delta PM_{2.5} = 0.00005 / (0.0058 \times 0.006776) = 1.272 = 1.3$ µg/m³

An incremental $\Delta PM_{2.5}$ criterion of 1.3 µg/m³ is considered appropriate and has been adopted for this air quality assessment.

It is acknowledged that the criteria listed above is not currently approved or listed in any guidance document by NT EPA. In the absence of any other criteria or advice, however, this criterion is considered to provide a reasonable indication of current state of the science in terms of $PM_{2.5}$ health risk assessment and is therefore used in this report to provide an indication of the potential impacts from Project $PM_{2.5}$ emissions.

3.1.4 Adopted air quality goals

The air quality goals adopted for the Project are presented in Table 3.2.

The air quality goals adopted for, $PM_{2.5}$, NO_2, SO_2 and CO are those which are prescribed by Queensland, NSW and Victoria (which all prescribe the same numeric values for each pollutant and averaging time). The air quality goal for PM_{10} is prescribed by Queensland and NSW and supported by federal legislation (NEPM).

For VOC pollutant species, the adopted air quality goal for each pollutant and averaging time is the lowest of those recommended by Queensland or Victoria.

Based on current uncertainties regarding the proportion of VOC species emitted (refer Section 2.3.5), the assessment has VOCs conservatively via a screening assessment of total VOC emissions. Further discussion of the method adopted for the assessment of VOCs is provide in Section 5.3.1.

Table 3.2 Adopted Air Quality Goals for the Project

Pollutant	Averaging Period	Air Quality Goal (µg/m^3)
PM_{10}	24 hour maximum	50
	Annual average	25
$PM_{2.5}$	24 hour maximum	25
	Annual average	8
	Incremental annual average	1.3
NO_2	1 hour maximum	226
	Annual average	56
SO_2	1 hour maximum	523
	24 hour maximum	209
	Annual average	52
CO	8 hour maximum	10,000
Benzene	1 hour 99.9th percentile	580
	24 hour maximum	29
	Annual average	6.4
Toluene	30 minutes maximum	1,100
	24 hour maximum	3,700
	Annual average	376
Xylenes	1 hour maximum	22,000
	24 hour maximum	1,100
	Annual average	100

3.1.5 NT EPA Guideline: Recommended Land Use Separation Distances

The NT EPA *Guideline: Recommended Land Use Separation Distances* (NT EPA, 2017) does not provide air quality goals but does provide guidance with respect to air quality impacts and the separation distance required between emission sources and sensitive land uses.

The purpose of *Guideline: Recommended Land Use Separation Distances* is to recommend separation distances between industry and sensitive land uses to ensure off-site emissions of offensive odour, noise, smoke, dust or fumes do not adversely impact on people. Separation distances acknowledge that for some industry/land use types residual emissions (once best practice environmental management techniques have been applied) may have the potential to cause impact on adjacent, sensitive land uses if located too closely.

The guideline is primarily intended to be used by the NT EPA when preparing advice to planning authorities on development applications and strategic land use plans. However, the guideline states that “separation distances recommended in the guideline would also provide greater certainty for all persons that may be involved in approving or undertaking activities that may be incompatible with existing land uses”, and therefore it is appropriate to consider the guideline in this impact assessment.

Specifically, recommended separation distances for operational activities associated with the Project are discussed in Section 4.2.3.1.

3.1.6 Brisbane City Council Air Quality Planning Scheme Policy (2014)

Air quality impact assessments within the Brisbane City Council (BCC) local authority area in Queensland are undertaken following the assessment methodology outlined in the City Plan 2014 Air Quality Planning Scheme Policy (AQPSP). The AQPSP is a robust technical assessment guideline and although not geographically relevant to the Project, has been considered in the assessment methodology adopted for the Project in the absence of similar planning legislation for City of Darwin.

3.2 Greenhouse gas

The following sections describe the international, Australian and NTG legislation, policy, and management frameworks applicable to the Project with respect to GHG.

3.2.1 International

Australia has committed to two key international agreements, the Kyoto Protocol (1997), which is no longer in force and the Paris Agreement (2016). These overarching international agreements target GHG emission reduction and limiting this century's global temperature rise to under 2ºC above pre-industrial levels.

3.2.1.1 Kyoto Protocol

The Kyoto Protocol was concluded and agreed in 1997 by the United Nations Framework Convention on Climate Change (UNFCCC) and enforced in 2005. Australia ratified the Kyoto Protocol in 2007. The Kyoto Protocol aims to reduce the impact of human-induced climate change by setting nation-specific GHG emissions targets.

The Kyoto Protocol involves the reduction of emissions of six specific GHGs; CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.

The Protocol designated two commitment periods for emissions targets; the first commitment period started in 2008 and ended in 2012 and the second commitment period (Doha Amendment) began in 2013 and ended in 2020. In the second commitment period Australia set a target to reduce GHG emissions to five per cent below 2000 levels by the end of 2020, and this emissions reduction target was achieved. Australia's commitments to the Kyoto Protocol are no longer current as the second commitment period has ended. The current international commitment is the Paris Agreement.

3.2.1.2 Paris Agreement

The Paris Agreement was finalised and entered into force in 2016, with the objective to build upon the mechanisms and targets put forward by the Kyoto Protocol. The Paris Agreement has been ratified by 189 of the 197 Parties to the UNFCCC and has effectively replaced the Kyoto Protocol

The goal of the Paris Agreement is to limit the increase in the global average temperature to below 2°C above pre-industrial levels and reduce GHG emissions by encouraging technological innovation and clean energy.

3.2.2 Commonwealth Government

3.2.2.1 National Greenhouse and Energy Reporting Act 2007

The NGER Act introduces a single national framework for reporting and disseminating company information about GHG emissions, energy production, and energy consumption. The NGER Act was most recently updated in 2019.

The NGER Act requires that individuals or corporations who exceed certain GHG emission thresholds publicly report their GHG emissions, energy consumption and energy production each financial year.

The current GHG reporting thresholds for corporations are as follows:

- emission of more than 50,000 tonnes (t) of carbon dioxide equivalent (CO_2-e)
- production of 200 terajoules (TJ) or more of energy, or
- consumption of more than 200 TJ of energy.

3.2.2.2 National Greenhouse and Energy Reporting (Measurement) Determination 2008

The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER (Measurement) Determination) (DAWE, 2020a) provides methods, criteria and measurement standards for calculating GHG emissions and energy data under the NGER Act. It covers Scope 1 and Scope 2 emission sources, including energy production and consumption.

The NGER (Measurement) Determination is updated annually to reflect improvements in emission estimation methods and changes made in response to industry feedback.

The version of NGER (Measurement) Determination as issued on 1 July 2021 (Compilation No. 13) has been used to develop the GHG inventory for the Project.

3.2.2.3 National Greenhouse Accounts Factors (2021)

The National Greenhouse Accounts Factors (NGA Factors) (2021) (DAWE, 2021) are designed for use by companies and individuals to estimate GHG emissions.

The NGA Factors are not published for the purposes of reporting under the NGER Act. While drawing on the NGER (Measurement) Determination, the methods described in the NGA Factors have a general application to the estimation of a broader range of GHG emissions inventories.

Where relevant, the GHG emissions in this inventory have been estimated in accordance with the emission factors provided in this instrument. The version of the NGA Factors as issued in August 2021 has been considered for this inventory.

3.2.2.4 Emissions Reduction Fund

To meet its targets set under the Kyoto Protocol and Paris Agreement, the Department of Agriculture, Water and Energy (DAWE) has commissioned the Emissions Reduction Fund (ERF). The ERF is a voluntary scheme which provides incentives for Australian businesses, farmers, land holders and citizens to reduce their GHG emissions by adoption of more efficient practices and technologies.

Key elements of the ERF are as follows

- crediting emissions reductions that go beyond business as usual standards
- selling emission reductions in the form of Australian Carbon Credit Units (ACCU), and
- a Safeguard Mechanism that provides a framework for Australia’s largest emitters to measure, report and manage emissions.

3.2.2.5 Direct Action Plan

The Commonwealth Government’s policy, the Direct Action Plan, targets to reduce GHG emissions by 26 to 28 per cent below 2005 levels by 2030. This builds on previous targets set out by the Kyoto Protocol to reduce emissions by five per cent below 2000 levels by 2020.

3.2.3 State Government

3.2.3.1 Northern Territory Climate Change Response: Towards 2050

Climate Change Response: Towards 2050 (the Response) provides a policy framework for the NTG’s strategic management of climate change risks and opportunities.

The Response identifies four key objectives to inform future actions and guide development of mitigation and adaptation strategies:

- achieve net zero GHG emissions by 2050
- build resilience to climate change in the most vulnerable aspects of the Territory’s communities, economy and environment
- unlock opportunities for Territorians, industries and businesses in the transition to a low carbon future, and
- inform and involve all Territorians so that all Territorians would understand the potential impacts from climate change, know what they can do to contribute to the response, and take advantage of any opportunities it provides.

To achieve net zero GHG emissions by 2050, the NTG has committed to achieving 50% renewable energy by 2030 for electricity consumed from grid-connected installations in accordance with the Governments Roadmap to Renewables (2017).

There are no requirements within the Response which relate to the estimation of GHG emissions.

3.2.3.2 Three-Year Action Plan

A Three-Year Action Plan has been developed to guide the NTG's delivery of the Response. The Plan identifies the NTG's actions over the next three years to establish the foundations required to deliver an enduring and effective climate change response.

There are no requirements within the Three-Year Action Plan which relate to the estimation of GHG emissions.

4.0 Assessment methodology

This assessment identifies potential impacts to the surrounding air environment due to air emissions from construction and operational activities, as well as estimates of GHG emissions during both construction and operation.

4.1 Study area

For the purpose of the assessment, the assessment study area is defined as the area within a 15 km by 12 km area surrounding the Project. This was chosen as the area encompassing the surrounding existing emissions sources (see Section 5.4 and monitoring stations (see Section 5.0) near the Project). The study area is presented above in Figure 2.1.

4.2 Air quality

Potential impacts on air quality due to construction and operation of the Project were assessed via air dispersion modelling. The CALPUFF modelling suite was selected as the model of choice for this assessment. A summary of the methodology used for the modelling is presented in this section.

4.2.1 Model selection and settings

The CALPUFF modelling suite is a well-known and understood air dispersion model that has been used for regulatory applications throughout Australia for many years. CALPUFF is known to perform well on coastlines were the boundary between air over water and land affects meteorology. The location of the Project along the coastline means that CALPUFF is well suited for use in this assessment. To predict pollutant dispersion, CALPUFF requires a three-dimensional meteorological data set, which was developed via a combination of surface observations from a nearby weather station, and prognostic upper air data generated by The Air Pollution Model (TAPM). The methods and settings used to generate the meteorological data set and run CALPUFF are presented in this section.

4.2.1.1 TAPM meteorological model

TAPM is a prognostic model that predicts three-dimensional meteorology, including terrain-induced circulation effects. 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. TAPM is used to predict meteorological parameters at both ground level and at heights of up to 8,000 m above the surface; these data are required by the CALPUFF model. For this assessment, only the upper profile data was extracted from TAPM for use in CALMET.

TAPM was run without any surface observation files using the input parameters presented in Table 4.1. An analysis of several years of meteorological data from BoM Darwin Airport was performed, and 2019 was found to be the most appropriate year, and thus selected for use in the model. A detailed meteorological comparison against recorded BoM data is provided in Appendix C.

Table 4.1 TAPM input parameters

Parameter	Input
TAPM version	4.0.4
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 0.3 km)
Number of grid points	25
Number of vertical levels	25
Terrain height database	9 second DEM
Year of analysis	January 2019 to December 2019
Grid centre point (mx,my) UTM Zone 52	706.484; 8,618,337

4.2.1.2 CALPUFF air dispersion model suite

CALPUFF is a Lagrangian puff model and is used for regulatory air quality dispersion assessments throughout Australia. The CALPUFF modelling system consists of three main components and a set of pre-processing and post-processing programs. The main components of the modelling system are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (an air quality dispersion model), and CALPOST (a post-processing package). The main CALPUFF related software package programs are described in the following sections.

4.2.1.3 CALMET

CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. CALMET produces a meteorological file that is used within the CALPUFF model to predict the movement of pollution.

Two upper air profiles were extracted from the innermost TAPM grid for input as upper air data into CALMET. Surface observations from the Bureau of Meteorology (BoM) Darwin Airport station (wind speed and direction, air pressure, temperature, and relative humidity) were used in CALMET to supplement the TAPM synoptic data at the surface. CALMET input parameters are presented in Table 4.2.

Table 4.2 CALMET input parameters

Parameter	Input
CALMET Version	6.42
Meteorological domain	24 km by 44 km
Meteorological grid resolution	200 m (120 x 120 grid cells)
Grid centre point (mx, my) UTM Zone 56	706,473; 8,618,738
Meteorological data period	1 January 2019 to 31 December 2019
Surface observational data	BoM Darwin Airport (mx, my UTM Zone 52): • 705,722; 8,625,840
Upper meteorological data	Extracted from TAPM at two locations (mx, my UTM Zone 52): • 712,852; 8,625,000 • 709,155; 8,611,050
RMAX1 (Radius of influence of meteorological stations: surface)	2 km
RMAX2 (Radius of influence of meteorological stations: aloft)	3 km
R1 (Observation weighting: surface)	1.5 km
R2 (Observation weighting: aloft)	2.3 km
IEXTRP (Vertical extrapolation of surface wind observation)	- 4 (extrapolate using similarity theory, exclude upper air observations from layer 1)
Radius of terrain influence (TERRAD)	6 km
BIAS (NZ) (Layer dependent weighting factor for initial guess field)	-1, -0.985, -0.964, -0.92, -0.839, -0.734, -0.606, -0.442, -0.241, 0.27

Parameter	Input
Number of vertical levels	10
Terrain data	30 m SRTM terrain data Available within the CALPUFF View modelling suite
Land use data	ABARES converted to USGS Sourced from: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-of-australia-update-december-2018 accessed on 16/12/2020

When using a single year of meteorological data as input into a dispersion model, it is necessary to demonstrate that the data are representative of long-term (greater than 12-months) meteorological conditions the Project area and of long-term regional behaviour. The main features of the generated meteorological data set are presented in **Appendix C**. The generated meteorological data set was considered representative of long-term meteorological conditions and expected regional behaviour; therefore, was suitable for use in this assessment.

4.2.1.4 CALPUFF

Prediction of ground level pollutant concentrations was made using the CALPUFF air dispersion model. The site-specific meteorological data set developed with TAPM and CALMET was used as input into CALPUFF. Sources were defined in CALPUFF in terms of location, size, and pollutant emission rates. Ground level concentrations were calculated by CALPUFF for each pollutant of interest across a sample grid covering the Project site for each hour in the modelled period. The post processing tool CALPOST was used to calculate ground level concentrations for the relevant averaging periods at each grid point and sensitive receptor. Contour plots of ground level concentrations were created using interpolation of grid point values.

General CALPUFF modelling parameters used in the assessment are presented in Table 4.3. The model was run in accordance with Barclay and Scire (2011).

Table 4.3 General CALPUFF input parameters

Parameter	Input
CALPUFF version	7.2.1
Computational domain	15 km x 12 km
Sampling domain	14 km by 11.4 km
Sampling grid	0.2km by 0.2km
Receptors	4653
Dispersion algorithm	Turbulence computed from micrometeorology and PDF method
Hours modelled	8760 hours
Meteorological data period	1 January 2019 – 31 December 2019

4.2.2 Construction Phase

4.2.2.1 Modelling scenario

A single 'worst-case' construction phase modelling scenario was developed to assess potential impacts due to air emissions from construction of the Project. The number and type of sources were designed to represent a small number of many different machines operating over a period of several weeks. It should be noted that equipment with the same or similar emissions or tasks were classified as a single type of machine for simplicity and therefore the modelling scenario may not accurately detail each of the different types of machinery operating at any time. Activities included in the modelling scenario are described in Table 4.4.

Table 4.4 Summary of construction modelling scenario assumptions

Activity	Inputs
Dredging (based on Option 1)	• 1 x BHD and barge within wet berth and manoeuvring areas • 1 x CSD within wet berth and manoeuvring areas • 4 x work boats (Multicat) assisting the BHD • Activity hours: 24 hours/day, 7 days/week, for the entire modelled year
Piling	• 2 x land-based and barge based rigs[b] within land reclamation area • Activity hours: 7am to 7pm
Importing fill	• 400,000 m^3 (520,000 t) imported fill for land reclamation, occurring 24 hours/day using triple road trains • 90,000 m^3 (117,000 t) imported pavement and subgrade material, occurring between 7am to 7pm importing using triple road trains
Land handling of materials	• Imported material to be unloaded from road trains, and then reloaded to tipper trucks for distribution across the Project site • 3 x dozers/bobcats[a] for material shaping and forming • 3 x graders for site levelling • Activity hours: 7am to 7pm
Table note: Emissions for dozers and bobcats are calculated on the basis of amount of material moved, and for the purpose of the assessment have been included in the model under the assumption that the same amount of material is moved by each machine. As a conservative estimate, the higher emissions factor for the dozer has been applied to both machines in the model for simplicity.[b]Land based and barge-based drill rigs are assumed to have the same emissions and therefore not defined as separate machinery items in the model.	

4.2.2.2 Combustion engine emissions

Combustion engine emissions are not typically assessed in detail for construction activity as emissions of exhaust gases are typically significantly lower in magnitude than construction dust emissions. However, as some construction activity required for the Project is required to be undertaken 24 hours per day, and requires large equipment, the potential for air quality impacts from combustion engines has been investigated. It is noted that due to the significant separation distance between construction activity areas and sensitive receptors (refer Section 6.0), the risk of significant air quality impacts resulting from combustion engines is considered to be low.

To investigate the potential for air quality impacts from combustion engines, emissions from the largest items of construction equipment and those which will operate for the longest durations have been assessed. Combustion engine emissions which have been assessed in detail include dredging operations and piling operations due to the engine size of this equipment and that dredging activity will occur 24 hours per day.

Combustion emissions from smaller items of equipment and items which will operate for shorter durations (e.g. trucks, dozers, graders, and construction-related vehicles) have not been considered in the assessment as emissions from these equipment items are not expected to be significant in comparison to emissions from larger engines such as those used in dredges and drill rigs. Similarly, emissions from road trains used to deliver material to site will also not generate significant emissions comparatively due to the short residence time on-site. Overall, investigation of emissions from dredging and piling operations is considered to provide a representative assessment of the potential for air quality impacts.

Emissions were estimated for two dredges (CSD and BHD) and workboats operating simultaneously within the ship lift area, as well as land-based and barge-based drilling rigs.

Emission rates were estimated based on rated engine power. Emission and load factors for the CSD, BHD and workboats were referenced from the United States Environmental Protection Agency

(USEPA) *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories, April 2009 (*USEPA, 2009). Emission and load factors for the backhoe on the BHD and the drilling rigs have been sourced from the NPI *Emissions estimation technique manual for combustion engines v3.0* (NPI, 2008). A summary of the emission factors is presented in Table 4.5. Modelled emission rates are presented in Table 4.6.

VOC emissions from combustion engines are typically sufficiently low to avoid exceedance of air quality goals. On this basis, assessment of VOC emissions for the construction phase has been undertaken as a conservative screening assessment. The screening assessment has been undertaking by assessing predicted total VOC concentrations at sensitive receptors against the strictest air quality goals for either benzene, toluene or xylene, considering both the air quality goal and the existing background concentration for each VOC species. Further discussion on the selection of the strictest air quality goal for the VOC screening assessment is provided in Section 5.3.1.

Table 4.5 Combustion engine emission factors

Plant	Engine Power (kW)	Emission Factor (kg/kWhr)						Load Factor	No.
		NOx	CO	Total VOC	PM_{10}	$PM_{2.5}$	SO_2		
CSD	503	$1.00E^{-02}$	$1.50E^{-03}$	$2.70E^{-04}$	$3.00E^{-04}$	$2.91E^{-04}$	$6.30E^{-04}$	1.00	1
BHD	2200	$1.30E^{-02}$	$2.50E^{-03}$	$2.70E^{-04}$	$3.00E^{-04}$	$2.91E^{-04}$	$6.30E^{-04}$	0.43	1
Work boats	390	$1.32E^{-02}$	$1.10E^{-03}$	$1.10E^{-03}$	$4.70E^{-04}$	$4.30E^{-04}$	$7.50E^{-06}$	0.43	4
BHD Backhoe	1900	$1.88E^{-02}$	$4.06E^{-03}$	$1.37E^{-03}$	$1.34E^{-03}$	$1.31E^{-03}$	$1.25E^{-03}$	0.50	1
Drill rig	392	$1.88E^{-02}$	$4.06E^{-03}$	$1.37E^{-03}$	$1.34E^{-03}$	$1.31E^{-03}$	$1.25E^{-03}$	1.00	2

Table 4.6 Modelled combustion engine emission rates

Plant	Engine Power (kW)	Emission Rate (g/s)					
		NOx	CO	Total VOC	PM_{10}	$PM_{2.5}$	SO_2
CSD	503	1.398	0.210	0.038	0.042	0.041	0.088
BHD	2200	3.416	0.657	0.071	0.079	0.076	0.166
Work boats	390	2.460	0.205	0.205	0.088	0.080	0.001
BHD Backhoe	1900	4.961	1.071	0.362	0.354	0.346	0.330
Drill Rig	392	2.048	0.442	0.149	0.146	0.143	0.136

4.2.2.3 Material handling emissions

Land based material handling emission rates for PM_{10} and $PM_{2.5}$ were estimated based on published emission factors listed in the NPI *Emissions estimation technique manual for mining v3.1* (NPI, 2012), the USEPA AP-42 *11.9 Western Surface Coal Mining (USEPA, 1995)*, USEPA AP-42 *13.2.5 Industrial Wind Erosion (USEPA, 2006)*.

A summary of adopted emissions factors and mitigation controls for each activity is presented in Table 4.7. PM_{10} to $PM_{2.5}$ correction factors were applied to $PM_{2.5}$ emission rates due to the absence of published emission factors for $PM_{2.5}$ for some emission sources.

Table 4.7 Construction material handling emission factors

Activity	Emission Factor - TSP	Emission Factor - PM_{10}	$PM_{2.5}$ Ratio[a]	Units	Variables	Mitigation Measure Control Factor
Loading material to trucks	Default of 0.025 for TSP	Default of 0.012 for PM_{10}	1.9 %	kg/t	-	-
Trucks unloading material	Default of 0.012 for TSP	Default of 0.0043 for PM_{10}	1.9 %	kg/t	-	-
Bulldozers	$EF_{TSP} = 2.6 \times \left((s)^{1.5} / (M)^{1.4} \right)$	$EF_{PM_{10}} = 0.34 \times \left((s)^{1.5} / (M)^{1.4} \right)$	1.9 %	kg/h/vehicle	s = silt content of material in % M = moisture content of material in %	-
Graders	$EF_{TSP} = 0.0034 \times S^{2.5}$	$EF_{PM_{10}} = 0.0034 \times S^{2.0}$	10 % *	kg/VKT	S = grader speed in km/h VKT = vehicle kilometres travelled	-
Wheel generated dust from unpaved roads	$EF_{TSP} = \frac{0.4536}{1.6093} \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	3.5 %	kg/VKT	s = material silt content in % W = weight of vehicle in t	Level 1 watering (< 2 litres per square metre per hour (L/m^2/h), emission reduction of 50%
Wind erosion	Default of 0.4 TSP	Default of 0.2 for PM_{10}	7.5 %	kg/ha/hr	-	-

Table notes:
[a] TSP/$PM_{2.5}$ Ratio sourced from USEPA AP-42 1995
*Graders use PM_{10}/$PM_{2.5}$ emission

Emissions were estimated for each emission source based on the following assumptions:

- estimated equipment utilisation rates (percentage of shift time operating, e.g. 80% of 12 hour shift, etc) were provided by NTG
- assumed exposed area for estimating wind erosion emissions of 147,000 m^2, conservatively estimated to cover the entire construction footprint
- assumed average travel speed for the grader of 5 km/h, and
- assumed silt content for the haul routes of 8.5%.
- estimated construction schedule of between 24 and 36 months.

Haul truck parameters used to estimate wheel generated dust emissions are presented in Table 4.8.

Table 4.8 Haul truck parameters

Parameter	Imported Fill	Import of Pavements and Subgrade	Internal Haulage of Material
Vehicle	Triple road train	Triple road train	Tipper Trucks
Empty weight (tonnes)	52	52	33.4
Load capacity (tonnes)	61	61	41
Per hour	1.5	0.3	3.5
Total daily trips	36.6	8.2	42.7
Annual vehicles	13,334	2999	15,537
Annual material transport quantity (t)	520,000	117,00	637,000
Haul road length (one way, m)	200	200	475
Total annual vehicle kilometres travelled (VKT)	1,815,376	408,303	4,977,377

A summary of the modelled emission rates for each source is presented in Table 4.9. The emission rates were applied to the model according to the times listed in Table 4.9.

Table 4.9 Summary of modelled material handling emission rates

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Imported fill/ material haul (7am -7pm)	0.16984	0.00594
Imported fill/ material haul (7pm-7am)	0.11713	0.0041
Dumping to stockpiles (7am to 7pm)	0.0185	0.00098
Dumping to stockpiles (7pm -7am)	0.01276	0.00068
Transfer to tipper trucks (7am-7pm)	0.08725	0.00345
Tipper truck haul (7am-7pm)	0.51978	0.00820
Dumping from tipper trucks (7am-7pm)	0.01563	0.00083

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Grader (7am-7pm)	0.02509	0.00251
Dozers (7am-7pm)	0.24202	0.01907
Wind erosion	$6.39E^{-06}$ [a]	$8.33E^{-07}$ [a]

Table note:
a. Emission rate in grams per square metre per second ($g/m^2/s$)

4.2.2.4 Odour

Dredging

Dredging activities have the potential to generate odour emissions and nuisance impacts, dependent on the type of material being dredged and the dredge material placement methodology.

The potential for significant odour emissions and resulting nuisance impacts as a result of the main works dredging required to be undertaken for the construction of the Project is considered to be low, due to the nature of the material which would be dredged (which is predominantly unconsolidated muds and consolidated rocky material) and the significant separation distance between the Project and the nearest sensitive receptors (refer Section 6.0).

It is understood that previous dredging projects undertaken near the Project have not resulted in complaints or nuisance impacts with respect to odour emissions. It is expected that there may be some acid sulfate soils which are required to be dredged, but it is anticipated that disposal methodologies will ensure that no significant odour impacts occur.

On the basis of the above, odour emissions from dredging during the construction phase have not been considered in this assessment.

Burning of material

Burning of material (vegetation, waste, etc) would not be undertaken during the construction phase of the Project and therefore no odour emissions would occur from burning.

4.2.3 Operation phase

The only emissions source of concern for the operation phase of the Project is the blast and paint facility. Air emissions from the blast and paint facility are assessed in detail below.

Combustion emissions would most likely be generated during operation from vehicle traffic and other diesel engine powered equipment such as cranes and generators. However, these are not considered to be significant air emission sources and do not have the potential to generate significant air quality impacts at sensitive receptors and therefore have not been assessed.

4.2.3.1 Blast and paint facility VOC emissions

Operational phase emissions were estimated for the blast and paint facility. At the time of writing, specific details on the exact usage of the facility, including key information such as duration of blasting, paint and materials consumption, etc, was unavailable. Due to the information available, emissions from the blast and paint facility have been estimated based on total VOC emissions from similar existing facilities. Further assessment once the facility is operational may be required depending on variation of completed facility and assessed design, in order to appropriately re-assess impacts and ensure mitigation measures are still sufficient. Mitigation measures for blast and paint facility are detailed in Section 9.1.2 .

As discussed in Section 3.1 the NPI is regulated by the Australian Government and is tasked with tracking pollution across Australia, ensuring that the community has access to information about the emission and transfer of toxic substances which may affect them locally. All major polluters are required by the Australian Government to submit annual reports of their emissions to air.

Emissions data for the BAE Systems Henderson Shipyard in Western Australia, and the BAE Systems Williamstown Facility in Victoria, were sourced from the NPI for the reporting years 2013/14 to 2018/19. A summary of total VOC and xylene emissions for each facility is presented in Table 4.10.

The highest annual reported VOC emission rate of 36,165 kg/year (highlighted in Table 4.10) reported in 2013/14 for the Henderson Shipyard was used to estimate VOC emissions for the blast and paint facility for the Project. This is considered a conservative assessment, based on the average VOC emission rate for BAE Henderson (27,997 kg/year). It is noted that most recently reported VOC emissions are generally lower in concentration.

For the purpose of the assessment it has been assumed (based on Project design configuration) that fumes (VOCs) that are generated within the blast and paint facility would be ventilated to atmosphere via 12 exhaust vents located on the roof of the building. Parameters used in the modelling for the exhaust vents are presented in Table 4.11.

Ventilation rates were assumed based on achieving 12 air changes per hour and meeting a minimum in-building cross flow rate of 0.25 meters per second for full down draught spray booths (as required in *Australian Standard 4114:2020 Spray painting booths, designated spray painting areas and paint mixing rooms*). The blast and paint facility building was included in CALPUFF with calculations for building wake effects switched on.

Due to the limited information available with respect to emissions from the blast and paint facility, assessment of VOC emissions has been undertaken as a conservative screening assessment. The screening assessment has been undertaking by assessing predicted total VOC concentrations at sensitive receptors against the strictest air quality goals for either benzene, toluene or xylene, considering both the air quality goal and the existing background concentration for each VOC species. Further discussion on the selection of the strictest air quality goal for the VOC screening assessment is provided in Section 5.3.1.

Air filtration would be installed as part of the mechanical ventilation system to minimise emissions to air. It is expected that this filtration would significantly reduce particulate matter emissions from the exhaust stacks to a level which is not significant and does not pose a risk to surrounding sensitive receptors. It is noted that the NPI emission reports for the BAE Systems Henderson Shipyard and the BAE Systems Williamstown Facility do not include particulate matter emissions. On this basis, particulate matter emissions from the blast and paint facility have not been assessed.

Table 4.10 Summary of NPI reported VOC emissions for existing shipyard facilities

Year	BAE Henderson Total VOCs (kg)	BAE Williamstown Total VOCs (kg)
2013/14	**36,165**	11,940
2014/15	31,985	8,579
2015/16	24,217	3,141
2016/17	23,632	Not reported
2017/18	Not reported	Not reported
2018/19	23,986	Not reported
Average	**27,997**	**7,887**

Table 4.11 Exhaust vent parameters including VOC emission rate

Parameter	Value	Units
Operating hours per day	24	hours
Operating days per week	6	days
Number of exhaust vents	12	-

Parameter	Value	Units
Stack height above ground	33	m
Stack diameter	1.13	m
Exhaust velocity	20	m/s
Exhaust Flow rate (total)	240	m^3/s
Building Dimensions	80 long x 30 wide x 30 high	m
Building Volume	72,000	m
Air changes per hour	12	Changes per hour
Cross sectional velocity	0.27	m/s
VOC Emission rate (total)	1.40	g/s
VOC emission rate (per vent)	0.1163	g/s

4.2.3.2 Blast and paint facility odour emissions

Odour emissions from the blast and paint facility would be associated with VOCs emissions.

As discussed in Section 3.1.4 NT EPA *Guideline: Recommended Land Use Separation Distances* (NT EPA, 2017) provides guidance with respect to air quality and odour impacts and the separation distance required between emission sources and sensitive land uses.

The recommended separation distance for boat building and maintenance, metal coating and metal finishing, where organotin compounds (used in anti-fouling paints) are used or removed from vessels, is 1,000 m (NT EPA, 2017). As discussed in Section 6.0 the nearest sensitive receptors are more than 5 km from the blast and paint facility, which is well beyond the NT EPA recommended separation distance.

VOC emissions from the blast and paint facility have been investigated in detail. As odour is primarily linked to VOC emissions, odour impacts at the receptors are expected to be negligible if predicted VOC concentrations are well below the adopted air quality goals.

Odour emissions and potential impacts have therefore not been included in the modelling assessment individually but have been considered based on the results of the assessment for VOCs.

4.2.4 Conversion of NO_x to NO_2

NO_x 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 would generally comprise 95 % of the NO_x by volume at the point of emission. The remaining NO_x would consist of NO_2. Over time, NO_x emitted into the atmosphere is oxidised to NO_2 and the fraction of NO_2 would generally increase the further from the point of emissions due to the increased time for oxidisation.

When modelling NO_x emissions, some conversion between NO_x at the source and NO_2 at the receptor must be made. There are several methods that can be adopted to estimate NO_2 concentration, with varying degrees of conservatism. For the purpose of this assessment the Ozone Limiting Method (OLM) was adopted. OLM assumes that approximately 10 per cent of the initial NO_x emissions are emitted as NO_2. If the O_3 concentration is greater than 90 per cent of the predicted NO_x concentrations, all the NO_x is assumed to be converted to NO_2, otherwise NO_2 concentrations are predicted using the equation:

$NO_2 = 46/48 \times$ [ambient O_3 concentration] + [ambient NO_2 concentration (background)]

This method assumes instant conversion of NO to NO_2 in the plume, which can lead to overestimation of concentrations close to the source since conversion would usually occur over a period of hours. The OLM is described in detail in the NSW EPA (2017) and has been used around Australia for regulatory modelling purposes. The OLM uses hourly measurements of background O_3 and NO_2, which are available from the NT EPA monitoring stations. The OLM is known to retain some conservatism in the estimates of NO_2 and is considered suitable for use in this assessment.

Background data was gathered from the nearest three NT EPA air quality monitoring stations (Palmerston, Winnelie, and Stokes Hill), and used to convert the modelled NO_x concentrations in accordance with the OLM methodology. Background data from the year 2019 was used to match the meteorological data year used for the dispersion modelling.

Background data for 2019 from Palmerston was prioritised for both O_3 and NO_2. This was supplemented with 2019 data from Winnelie, and then Stokes Hill if the hour of monitoring data at Palmerston was considered unreasonable. In the event that data from all three stations was unreasonable for a particular hour, the annual average across all stations for 2019 was used for this hour. Further detail about the NT EPA air quality monitoring stations is provided in Section 5.2.1.

4.2.5 Limitations

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on several different 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, and 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 wind speeds less than 1 m/s) 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.

While the models contain a large number of variables that can be modified to increase the accuracy of the predictions under any given circumstances, the constraints of model use in a commercial setting, as well as the lack of data against which to compare the results in most instances, typically precludes extensive testing of the impacts of modification of these variables. Model developers typically specify a range of default values for model variables that are applicable under most modelling circumstances. These default values are recommended for use unless there is sufficient evidence to support their modification.

As a result, the results of dispersion modelling 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. As stated above, however, the model predictions are typically conservative, and tend to over predict maximum pollutant concentrations at receiver locations.

4.3 Greenhouse gas

4.3.1 Emissions inventory scenarios

Emissions inventories have been developed for the construction and operation phases of the Project. The emissions inventory scenarios are described as follows:

- Construction scenario: GHG emissions estimated for the entirety of the construction program. Emissions were estimated for fuel consumption for the equipment described in Section 4.2.2. No grid electricity usage is expected during the construction phase.
- Operation scenario: GHG emissions based on a typical 12 months of operation. Emissions estimated for fuel consumption required ship lift cranes and diesel generators, in addition to the consumption of grid electricity.

4.3.2 Emission sources

The emission sources for the Project which have been considered in this inventory are summarised as follows:

- Scope 1:
  - Diesel fuel combustion for transport engines stationary energy (dredges, mobile construction plant, cranes)
  - Diesel fuel combustion for stationary engines (diesel generators)
- Scope 2:
  - Mains grid electricity consumption (shore power for vessels, general electrical demand).

Scope 1 emissions from the clearing of vegetation have not been considered in the development of the emissions inventory. The area of vegetation clearing required for the Project is minimal (approximately 1 ha), and GHG emissions from land clearing are not expected to be significant.

Scope 3 emissions, such as embodied energy, combustion emissions from transport of construction materials and breakdown of waste, have been excluded from this assessment.

4.3.3 Emission calculations

The NGER (Measurement) Determination GHG emission factors for the sources considered for the Project, are summarised in Table 4.12.

It is noted that for the calculation of Scope 2 GHG emissions for grid electricity consumption, the current NGA Factors (2021) GHG emission factor for electricity consumption in the Darwin Katherine Interconnected System (DKIS) has been used (0.54 kg CO_2-e/kWh). With the transition to a target of 50% renewably sourced energy across the NT energy supply sector, this emission factor may decrease in future years, which would in turn, decrease Scope 2 GHG emissions from this source. Therefore, estimation of Scope 2 emissions from operation of the Project are considered conservative.

Table 4.12 Emission factors for Scope 1 and 2 GHG emission sources

Emissions Scope	Emission Source	Energy Content Factor	GHG emission factor				Emission Factor Units
			CO_2	CH_4	N_2O	Total	
Scope 1	Diesel use - stationary energy	38.6 GJ/kL	69.9	0.1	0.2	70.2	kg CO_2-e/GJ
	Diesel use - transport energy	38.6 GJ/kL	69.9	0.1	0.4	70.4	kg CO_2-e/GJ
Scope 2	Electricity consumption (DKIS)	N/A	-	-	-	0.54	kg CO_2-e/kWh

4.3.4 Emission inventory inputs and assumptions

GHG emissions were estimated based on total potential working hours for each plant or equipment item, and estimated diesel fuel consumption rate or engine power.

A summary of total potential working hours for each construction works package is presented in Table 4.13.

Table 4.13 Total potential working hours for construction work packages

Works	Works Duration (Weeks)	Working Days/Fortnight	Working Days Total	Working Hours/Day	Total Potential Working Hours
Land Preparation	2	13	13	12	156
Dredging	56	13	364	24	8,736

Works	Works Duration (Weeks)	Working Days/Fortnight	Working Days Total	Working Hours/Day	Total Potential Working Hours
Land Reclamation (excluding filter rock)	56	13	364	12	4,368
Filter Rock and Hardstand (pavements and aggregates)	36	13	234	12	2,808
Revetments	56	13	364	12	4,368
Piling and Waterside Infrastructure	-	-	260	12	3,120

A summary of parameters used to calculate GHG emissions for each type of plant is presented in Table 4.14 for construction and Table 4.15 for operation. Assumed hourly diesel fuel consumption rates used to estimate GHG emissions were sourced from the similar studies where available (and are referenced in Table 4.15). Dredging emission rates were calculated based on the engine power requirements of the dredges (including all onboard engines) and the calorific value for diesel.

Indirect Scope 2 GHG emissions from electricity consumption during operation were estimated based on an assumed annual usage rate of 1,440,000 kWh provided by NTG.

Table 4.14 Parameters used in the construction phase GHG emissions inventory calculations (Scope 1)

Construction Stage	Plant	Engine Power	Quantity	Total Hours (per item of equipment)	Total Hours	Diesel Usage Rate	Diesel Usage Rate Ref.	Diesel Fuel Used Total	Energy Content
		kW		hours	hours	L/hr		kL	GJ
Land Preparation	Excavator	not required	1	125	125	40	PoT (2016)	5	193
	Bulldozer	not required	1	125	125	40	PoT (2016)	5	193
Dredging	BHD (Woomera BHD)	2,200	1	7,426	7,426	382	Calculated based on engine power and diesel calorific value[1]	2,839	109,602
	CSD (Warraber CSD)	505	1	7,426	7,426	47		349	13,456
	Work boats	not required	4	7,426	29,702	50	PoT (2016)	1,485	57,326
Land Reclamation	Swamp dozer	not required	2	3,058	6,115	80	PoT (2016)	489	18,884
	Excavator	not required	1	3,058	3,058	40	PoT (2016)	122	4,721
	Articulated Trucks	not required	2	3,058	6,115	40	PoT (2016)	245	9,442
	Dozer	not required	1	3,058	3,058	40	PoT (2016)	122	4,721
	Roller	not required	2	437	874	20	DLP (2011)	17	674
Revetments	Excavator	not required	2	3,494	6,989	40	PoT (2016)	280	10,791
	Articulated Trucks	not required	2	3,494	6,989	40	PoT (2016)	280	10,791
	Crane	not required	2	3,494	6,989	20	DLP (2011)	140	5,395
Piling and Waterside Infrastructure	Land-based rig	not required	2	2,808	5,616	20	DLP (2011)	112	4,336
	Barge-based rig	not required	1	2,808	2,808	20	DLP (2011)	56	2,168

Construction Stage	Plant	Engine Power	Quantity	Total Hours (per item of equipment)	Total Hours	Diesel Usage Rate	Diesel Usage Rate Ref.	Diesel Fuel Used Total	Energy Content
		kW		hours	hours	L/hr		kL	GJ
	Work boats	not required	2	2,808	5,616	50	PoT (2016)	281	10,839
	Cranes	not required	4	780	3,120	20	East Arm	62	2,409
Filter Rock and Hardstand (pavements and aggregates)	Grader	not required	3	2,387	7,160	36	PoT (2016)	258	9,950
	Roller	not required	4	2,387	9,547	20	DLP (2011)	191	7,370
	Water truck	not required	3	2,387	7,160	10	PoT (2016)	72	2,764
	Tipper	not required	4	2,387	9,547	20	PoT (2016)	191	7,370
	Backhoe	not required	2	2,387	4,774	20	PoT (2016)	95	3,685
	Skid steer	not required	2	2,387	4,774	8	PoT (2016)	38	1,474
	loader	not required	2	2,387	4,774	40	PoT (2016)	191	7,370
	Excavator	not required	4	2,387	9,547	40	PoT (2016)	382	14,741

Table notes:

1. Diesel calorific value of 38.6 GJ/kL used to calculate hourly diesel fuel usage

Table 4.15 Parameters used in the operation phase GHG emissions inventory calculations (Scope 1)

Plant	Number of	Diesel Usage Rate	Utilisation Rate	Shift Length	Shifts per Day	Days per Week	Weeks per Year	Diesel Fuel	Energy Content
		L/hr	%	hr				kL/year	GJ
Cranes	4	20	10%	12	1	6	50	28.8	1,112
Diesel Generators	10	2	20%	12	1	6	50	14.4	556

5.0 Existing environment

5.1 Meteorology

5.1.1 Meteorological monitoring stations

The BoM operates a network of meteorological monitoring stations within Australia. Long term meteorological data is available from the BoM monitoring station at Darwin Airport. Information on this meteorological station is provided in Table 5.1. The location of the monitoring station is shown in Table 5.1.

Table 5.1 BoM Darwin Airport meteorological monitoring station details

BoM Station ID	BoM Station Name	Coordinates (UTM) (GDA Zone 52)	Distance and orientation from Project
014015	Darwin Airport	X: 705,722 Y: 8,625,840	7 km north

Figure 5.1 shows that the Darwin Airport monitoring station is located approximately 7 km inland from the inner shore of the Darwin Harbour and from the Study area. Due to the close proximity of the BoM station, wind speeds are likely to be comparable and therefore representative, however it is likely that the Project area experiences slightly more sheltered conditions than those measured at the BoM station. Monitoring data from the Darwin Airport station is considered appropriate for use in this assessment.

Summaries of long-term monitoring data for meteorological conditions measured at the BoM Darwin Airport station are available from the BoM website. In addition to this summary data, AECOM has obtained hourly wind speed and direction monitoring data for the period between 2001 and 2019, which represents 20 years of recent monitoring data.

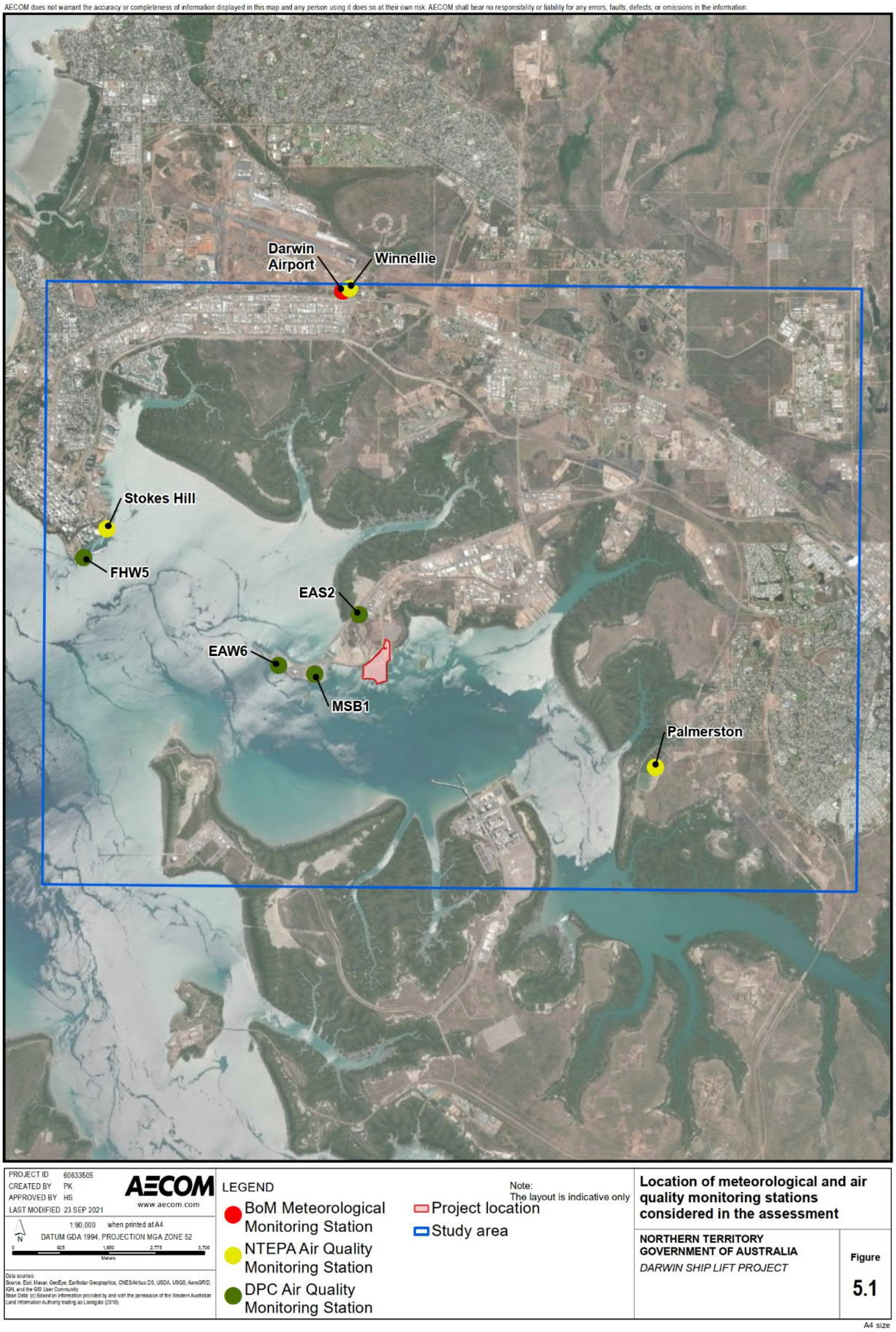

Figure 5.1 Location of meteorological and air quality monitoring stations considered in the assessment

5.1.2 Wind speed and direction

Suspended particles and gases are transported by wind and therefore wind speed and direction are important considerations when assessing the potential for air quality impacts to sensitive receptors.

Annual and seasonal wind roses for the BoM Darwin Airport station are presented in Figure 5.2 and Figure 5.3 respectively based on measurement data recorded between 2001 to 2019.

The annual wind rose in Figure 5.2 show that westerly, easterly, and west-north-westerly winds are the predominant wind directions. Average annual wind speed is reported as 3.8 m/s where 2.3% of the time are reported as calm conditions (wind speed <0.5 m/s).

Seasonal variations in wind direction are evident (refer Figure 5.3), with noticeable variation between the wet season (spring and summer) and the dry season (autumn and winter). Wind direction variability is highest in spring, with strongest winds from the north-west and west. Easterly and south-easterly winds are frequent during winter and autumn, however strongest winds are recorded from the west and north-west during Summer. Autumn has the weakest wind conditions, and the highest frequency of calms (3%) which is expected due to the effect of the tropical coastal outline (BoM, 2020). The seasonal average wind speed varies from 3.8 m/s in winter (2.6% calms) to 4.2 m/s in summer (1.5%).

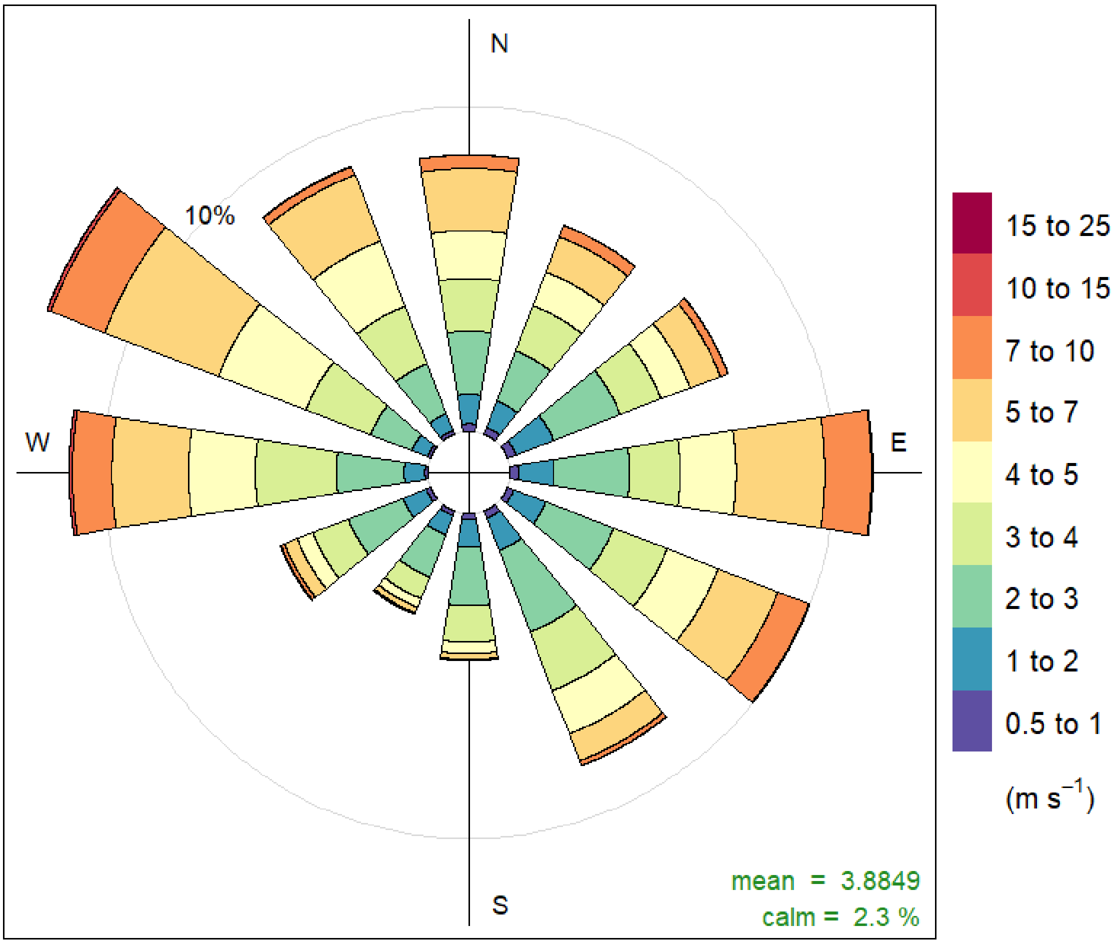

Figure 5.2 Wind rose for BoM Darwin Airport monitoring station (2001 to 2019)

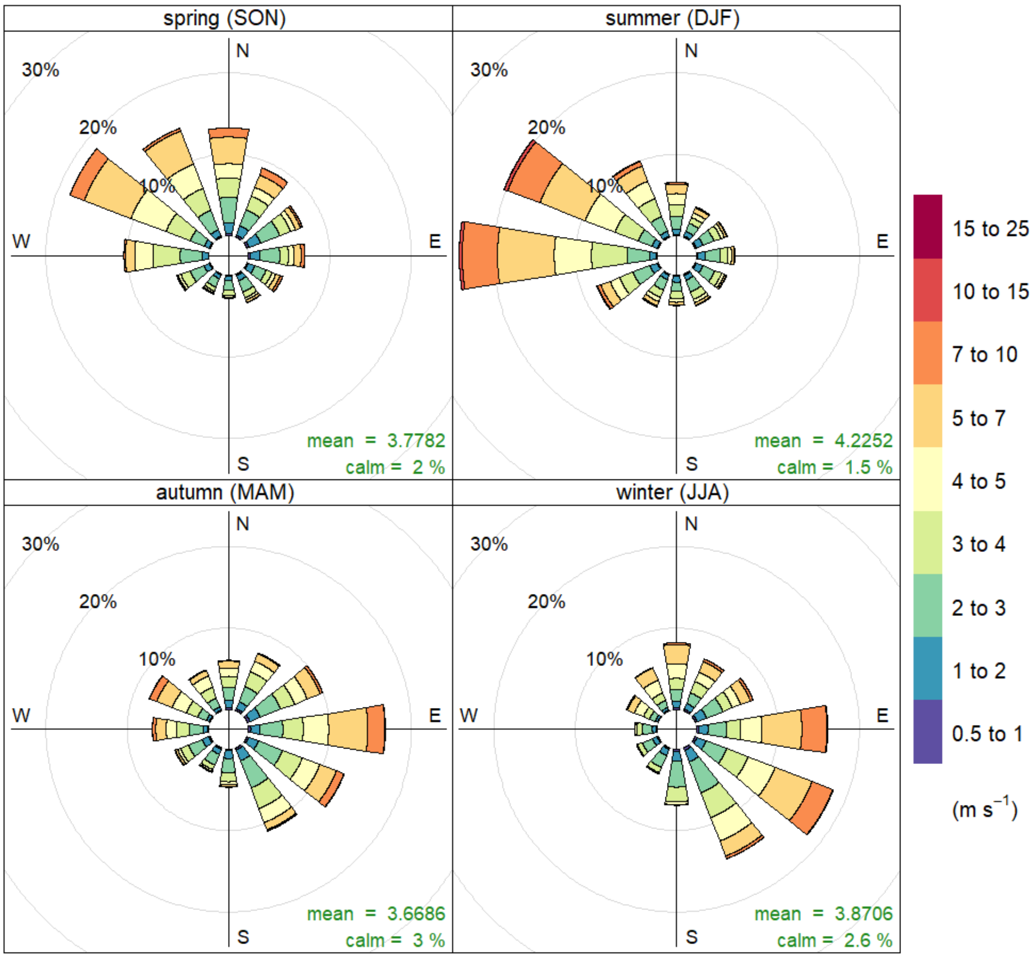

Figure 5.3 Seasonal wind roses for BoM Darwin Airport monitoring station (2001 to 2019)

A detailed meteorological analysis of the most five recent years of available data between 2015 and 2019 is also provided in Appendix C.

5.1.3 Temperature

Table 5.2 presents temperature statistics for measurements recorded at the BoM Darwin Airport station from 1941 to 2021. Warmest temperatures are recorded during spring months, with the highest average maximum temperatures recorded in November (33.4°C), and lowest average maximum in July (30.6°C).

Average minimum temperatures are highest in November and December (25.3°C) and lowest in July (19.3°C). Monthly average maximum and minimum temperature do not vary greatly on an annual basis with a variance of 2.8°C in the mean maximum and a 6°C variance in the mean minimum.

Table 5.2 Temperature statistics for BoM station Darwin Airport (1941 to 2021)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug[a]	Sep[a]	Oct[a]	Nov[a]	Dec[a]
Mean maximum temperature (°C)	31.8	31.5	32.0	32.8	32.1	30.7	**30.6**	31.4	32.7	33.3	**33.4**	32.7
Mean minimum temperature (°C)	24.9	24.8	24.6	24.0	22.2	20.0	**19.3**	20.3	23.0	24.9	**25.3**	**25.3**

Table notes:
Maximum and minimum temperatures are represented in red and blue respectively
[a]2021 data is only available for months Jan-Jul at time of writing

5.1.4 Rainfall

The Darwin area experiences a tropical climate with distinctly wet summers and dry winters (BoM, 2020). Table 5.3 presents mean rainfall statistics for measurements recorded at the BoM Darwin Airport station from 1941 to 2020. The highest periods of rainfall are recorded in summer months, with the maximum monthly rainfall recorded in January (432 mm). Relatively low rainfall is recorded in the months of May to September, with the lowest mean rainfall month being July (1.1 mm). Table 5.3 shows a clear pattern of wet and dry seasons, as expected for the Darwin area (BoM, 2020).

Table 5.3 Rainfall statistics for BoM Darwin Airport station (1941 to 2021)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean rainfall (mm)	**431.8**	369.3	312.4	101.6	20.7	1.8	1.1	4.5	16.5	70.8	142.0	250.4
Table notes: Maximum monthly mean rainfall measurement shown in **bold** [a]2021 data is only available for months Jan-Jul at time of writing												

5.1.5 Relative humidity

Table 5.4 presents relative humidity statistics recorded at Darwin Airport BoM monitoring stations from 1954 to 2010. Relative humidity data is not available from Darwin Airport BoM station for the period of 2011 onwards. Relative humidity percentages at 9.00 am vary from 60% in July to 83% in January, with respective monthly values of 37% to 72% at 3.00 pm.

Table 5.4 Relative Humidity statistics for BoM station Darwin Airport (1954 to 2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean 9am relative humidity (%)	81	**83**	82	74	65	**60**	**60**	64	68	69	72	76
Mean 3pm relative humidity (%)	70	**72**	67	52	43	38	**37**	40	47	52	58	65
Table note: Maximum and minimum temperatures are represented in red and blue respectively												

5.2 Background air quality

5.2.1 NT EPA air quality monitoring

The NTEPA monitors ambient air quality data at numerous monitoring stations in the State for various pollutants of concern for the Project. There are three monitoring stations located nearby to the Study area located at Stokes Hill, Winnellie and Palmerston. The location of these stations is shown in Figure 5.1 and coordinates and proximity to the Project site are provided in Table 5.5.

Details for the air quality monitoring stations considered in the assessment are provided in Table 5.5. Monitoring data for the period from 2015 to 2019 is presented in Table 5.8 to Table 5.10. At the time of writing, 2020 data was available but had not yet been validated, so was not used to inform the background for the assessment.

VOC species are not monitored at any of the NT EPA stations. However, to assess the cumulative impact from operational emissions of VOCs of the Project, a background concentration was inferred from monitoring data at a similar location.

Monitoring data was used from Queensland's Department of Environment and Science (DES) Memorial Park monitoring station in Gladstone, QLD, to determine a background concentration that is representative of conditions surrounding the Project. Gladstone is a heavily industrialised town on Queensland's East coast and could be considered similar to the Darwin Port area. Overall, ambient air quality monitoring data from the Memorial Park site could be considered a conservative representation of ambient air quality conditions due to the higher level of industrial development and operation at

Gladstone. However, in the absence of more appropriate data for the Study area, VOC concentrations from Memorial Park are considered appropriate for the assessment to consider cumulative impacts.

In accordance with the BCC AQPSP (2014) the 70th percentile concentration was selected as the adopted background concentration for assessment of the 1 hour and 24 hour air quality goals, and therefore the 70th percentile measured concentrations are presented for these averaging periods where appropriate.

Table 5.5 Air quality monitoring stations included in the assessment

Monitoring site	Operator	Operation dates	Coordinates (UTM) (GDA Zone 52)	Distance and orientation from Site	Pollutants monitored
Stokes Hill	NT EPA	2017 to current	X: 701,126 Y: 8,621,140	6 km north-west	CO, NO_2, PM_{10}, $PM_{2.5}$, SO_2
Winnellie	NT EPA	2012 to current	X: 705,813 Y: 8,625,830	7 km north	CO, NO_2, PM_{10}, $PM_{2.5}$, SO_2
Palmerston	NT EPA	2011 to current	X: 711,740 Y: 8,616,520	6 km south-east	CO, NO_2, PM_{10}, $PM_{2.5}$, SO_2
Memorial Hill (Gladstone, QLD)	QLD DES	2009 to current	X: 321, 955 Y: 7,361,912	2,488 km south-east	NO_2, O_3, SO_2, benzene, toluene, formaldehyde, xylene

Monitoring of NO_2 and SO_2 commenced at Stokes Hill in May 2017, with monitoring of $PM_{2.5}$ and PM_{10} starting in July 2017. Monitoring data from 2017 for these pollutants is presented but it has not been used to assess background air quality as the data capture rate for 2017 was well below the minimum recommended rate of 90%.

Measured PM_{10} concentrations at the three NT EPA monitoring stations are presented in Table 5.6. The highest measured 24 hour concentrations exceeded the air quality goal at all stations in most recent years. Bushfire smoke during the dry season is often attributable to these high concentrations. While generally a seasonal occurrence particulate concentration during extreme events are generally not considered representative of typical background particulate concentrations. Measured 70th percentile 24 hour average and annual concentrations (adopted for the Project background) were below the air quality goals at all stations. The highest measured 70th percentile 24 hour concentration of 29.5 µg/m^3, and highest annual average of 23 µg/m^3 were adopted as the background concentrations for the assessment for PM_{10}.

Table 5.6 Measured PM_{10} concentrations at air quality monitoring stations

Station	Averaging Period and Statistic	Air Quality Goal (µg/m³)	Measured PM_{10} Concentration (µg/m³)				
			2015	2016	2017	2018	2019
Stokes Hill[a]	24 hour maximum	50	n/a	n/a	47.2	**63.6**	**91.5**
	24 hour 70th percentile		n/a	n/a	23.7	29.5	25.8
	Annual average	25	n/a	n/a	d/c	22.4	22.4
Winnellie	24 hour maximum	50	**103.1**	**50.9**	**54.9**	**77.8**	**80.1**
	24 hour 70th percentile		26.5	19.3	19.6	16.0	28.5
	Annual average	25	22.3	16.4	15.4	13.2	23.0
Palmerston	24 hour maximum	50	**62.4**	**71.1**	**60.4**	**147.0**	**81.5**
	24 hour 70th percentile		22.9	16.7	23.9	25.1	25.7
	Annual average	25	19.5	15.4	19.5	19.9	22.0

Table notes:
Measured concentrations which exceed the relevant air quality goal are shown in **bold**
a. monitoring started at Stokes Hill in July 2017
n/a not measured at this station in this year
d/c data capture for this year was less than 75% and therefore the annual average has not been calculated

Measured $PM_{2.5}$ concentrations at the three NT EPA monitoring stations are presented in Table 5.7. The highest measured 24 hour concentrations exceeded the air quality goal at all stations for all years with available data. Annual averages also exceeded the air quality goal for most years. Bushfire smoke during the dry season is often a cause of the high $PM_{2.5}$ concentrations and as discussed above elevated particulate concentrations as a result of bushfires are not considered representative of typical background concentrations

Measured 70th percentile 24 hour average concentrations (adopted for the Project background) were below the air quality goals at all stations. The highest measured 70th percentile 24 hour concentration of 11.9 µg/m³, and annual average of 9.8 µg/m³ were adopted as the background concentrations for the Project. As the annual average $PM_{2.5}$ concentration is often above the air quality goal, an incremental air quality goal was derived to assess the Project's contribution to annual average $PM_{2.5}$ concentrations, as discussed in Section 3.1.2.

Table 5.7 Measured $PM_{2.5}$ concentrations at air quality monitoring stations

Station	Averaging period and statistic	Air quality goal (µg/m³)	Measured $PM_{2.5}$ concentration (µg/m³)				
			2015	2016	2017	2018	2019
Stokes Hill[a]	24 hour maximum	25	n/a	n/a	**27.6**	**42.9**	**41.8**
	24 hour 70th percentile		n/a	n/a	9.5	10.6	11.2
	Annual average	8	n/a	n/a	d/c	**8.3**	**9.2**
Winnellie	24 hour maximum	25	**73.8**	**41.0**	**41.9**	**58.4**	**48.6**
	24 hour 70th percentile		10.9	7.9	8.3	11.3	11.1
	Annual average	8	**8.7**	6.5	6.7	**9.0**	**8.9**
Palmerston	24 hour maximum	25	**41.5**	**60.9**	**43.9**	**115.4**	**61.6**
	24 hour 70th percentile		9.6	7.9	8.8	9.9	11.9
	Annual average	8	7.4	7.4	7.3	**8.9**	**9.8**

Table notes:
Measured concentrations which exceed the relevant air quality goal are shown in **bold**
a. monitoring started at Stokes Hill in July 2017
n/a not measured at this station in this year
d/c data capture for this year was less than 75% and therefore the annual average has not been calculated

Measured NO_2 concentrations at the three NT EPA monitoring stations are presented in Table 5.8. Measured concentrations were well below the air quality goal at all stations for both 1 hour and annual averaging periods. The highest measured 1-hour concentration was 116.4 µg/m^3, and highest annual average was 7.8 µg/m^3, however as the OLM has been used for NO_x to NO_2 conversion, these were not used directly as background concentrations for the Project. The OLM used for NO_x to NO_2 conversion is explained in more detail in Section 4.2.4.

Table 5.8 Measured NO_2 concentrations at air quality monitoring stations

Station	Averaging period and statistic	Air quality goal (µg/m^3)	Measured NO_2 concentration (µg/m^3)				
			2015	2016	2017	2018	2019
Stokes Hill[a]	1 hour maximum	226	n/a	n/a	49.6	45.8	49.9
	1 hour 70th percentile		n/a	n/a	5.9	4.8	4.6
	Annual average	56	n/a	n/a	d/c	4.1	3.8
Winnellie	1 hour maximum	226	49.3	57.7	52.7	53.6	45.8
	1 hour 70th percentile		6.2	5.6	7.8	4.4	4.2
	Annual average	56	5.4	5.0	6.4	3.6	3.5
Palmerston	1 hour maximum	226	67.5	36.6	42.8	116.4	41.3
	1 hour 70th percentile		9.8	4.8	5.5	5.6	5.5
	Annual average	56	7.5	3.7	4.6	4.9	4.4

Table notes:
n/a not measured at this station in this year
a. monitoring started at Stokes Hill in May 2017
d/c data capture for this year was less than 75% and therefore the annual average has not been calculated

Measured SO_2 concentrations at the three NT EPA monitoring stations are presented in Table 5.9. Measured concentrations were well below the air quality goal at all stations for 1 hour, 24 hour and annual averaging periods. The highest 70th percentile 1 hour concentration of 1.9 µg/m^3, 70th percentile 24 hour average of 2.0 µg/m^3 and annual average of 1.7 µg/m^3 were adopted as the background concentrations for the Project.

Table 5.9 Measured SO_2 concentrations at air quality monitoring stations

Station	Averaging period and statistic	Air quality goal (µg/m^3)	Measured SO_2 concentration (µg/m^3)				
			2015	2016	2017	2018	2019
Stokes Hill[a]	1 hour maximum	523	n/a	n/a	27.4	83.7	88.1
	1 hour 70th percentile		n/a	n/a	0.9	1.1	1.9
	24 hour maximum	209	n/a	n/a	2.9	5.0	12.3
	24 hour 70th percentile		n/a	n/a	1.1	1.2	2.0
	Annual average	52	n/a	n/a	d/c	0.7	1.6
Winnellie	1 hour maximum	523	19.1	6.8	11.9	n/p	7.8
	1 hour 70th percentile		1.0	0.9	1.5	n/p	1.6
	24 hour maximum	209	3.6	2.0	3.9	n/p	4.7
	24 hour 70th percentile		1.0	0.9	1.5	n/p	1.6
	Annual average	52	0.9	0.8	1.3	n/p	1.3
Palmerston	1 hour maximum	523	13.8	20.4	6.4	29.5	12.8
	1 hour 70th percentile		1.1	0.9	1.0	1.4	1.9
	24 hour maximum	209	3.0	2.2	3.2	10.5	4.8

Station	Averaging period and statistic	Air quality goal (µg/m³)	Measured SO_2 concentration (µg/m³)				
			2015	2016	2017	2018	2019
	24 hour 70th percentile		1.1	0.9	1.0	1.4	1.9
	Annual average	52	1.0	0.6	0.9	1.1	1.7

Table notes:
a. monitoring started at Stokes Hill in May 2017
n/a not measured at this station in this year
d/c data capture for this year was less than 75% and therefore the annual average has not been calculated
n/p a high proportion of negative concentration values were measured for this year and therefore monitoring data for this year for Winnellie has not been presented.

Measured CO concentrations at the three NT EPA monitoring stations are presented in Table 5.9. Measured concentrations were well below the 8 hour air quality goal at all stations with the exception of Winnellie for 2018. The highest 70th percentile 8 hour concentration of 573 µg/m³ was adopted as the background concentration for the Project.

Table 5.10 Measured CO concentrations at air quality monitoring stations

Station	Averaging period and statistic	Air quality goal (µg/m³)	Measured CO concentration (µg/m³)				
			2015	2016	2017	2018	2019
Stokes Hill[a]	8 hour maximum	10,000	n/a	n/a	544	1024	1385
	8 hour 70th percentile		n/a	n/a	183	430	573
Winnellie	8 hour maximum	10,000	4,882	864	1,293	**18,745**	1,364
	8 hour 70th percentile		386	364	219	353	488
Palmerston	8 hour maximum	10,000	1,198	1,596	1,284	5,599	4,076
	8 hour 70th percentile		327	234	301	172	478

Table notes:
Measured concentrations which exceed the relevant air quality goal are shown in **bold**
a. monitoring started at Stokes Hill in July 2017
n/a not measured at this station in this year

5.2.2 QLD DES air quality monitoring for VOCs

Air quality monitoring data from Memorial Park in Gladstone was used to infer a background concentration for total VOCs in order to present a cumulative result.

Table 5.11 Measured VOC concentrations at Memorial Park monitoring station

Pollutant	Averaging period and statistic	Air quality goal (µg/m^3)	Measured VOC concentration (µg/m^3)				
			2015	2016	2017	2018	2019
Benzene	1 hour maximum	580	22.2	15.7	19.1	19.5	18.5
	1 hour 70th percentile		6.3	4.2	5.2	5.9	5.2
	24 hour maximum	29	6.7	5.8	7.0	6.9	8.2
	24 hour 70th percentile		5.3	4.0	5.1	5.4	5.0
	Annual average	5.4	5.1	3.6	4.3	5.1	4.5
Toluene	1 hour maximum	1,100	6.1	53.4	57.9	45.6	138.0
	1 hour 70th percentile		9.4	5.3	9.9	10.7	9.4
	24 hour maximum	4,100	11.7	11.8	17.1	17.0	26.8
	24 hour 70th percentile		8.5	5.2	9.5	9.7	7.7
	Annual average	400	7.8	4.7	7.9	8.9	8.1
Xylene	1 hour maximum	22,000	341.7	383.8	167.5	200.6	680.0
	1 hour 70th percentile		58.7	41.6	27.0	24.1	43.5
	24 hour maximum	1,200	86.8	93.1	49.2	57.5	124
	24 hour 70th percentile		50.8	39.8	31.1	24.1	36.3
	Annual average	950	47.7	35.7	24.5	22.1	36.3

5.2.3 Darwin Port Corporation monitoring

Darwin Port Corporation (DPC) undertakes monitoring of PM_{10} at four locations in the area near the Project site. The locations of the monitoring sites are shown in Figure 5.1. Details for each of the monitoring sites are presented in Table 5.12. The monitoring was conducted for discrete 24 hour periods at about monthly intervals, unlike the NT EPA monitoring which is continuous.

Table 5.12 DPC monitoring stations

Monitoring site	Coordinates (UTM) (GDA Zone 52)	Distance and orientation from Site	Site Description
EAS2	706,007; 8,619,490	5.8 km north-west	Between cement factory and manganese stockpile
EAW6	704,443; 8,618,513	1.6km west	Along main wharf quay line
MSB1	705,146; 8,618,339	1 km west	Within main port facilities
FHW5	700,670; 8,620,595	0.7 km north	Adjacent to tugboat dock

Results of the 2019 PM_{10} monitoring is presented in Table 5.13. The highest 24 hour PM_{10} concentration measured at these sites was 81.8 µg/m^3 at EAW6 on 7 June 2019. Concentrations were above the 24 hour air quality goal of 50 µg/m^3 at all four stations in early June 2019.The cause of this is attributed to exceptional regional events (e.g., bushfires)

Data from the NT EPA monitoring stations is compared with the DPC measurements for 2019 in Figure 5. 4. This shows that in all but one of the DPC samples (in March 2019), there was a good correlation with regional PM_{10} concentrations. Indicating that PM_{10} concentrations on East Arm mostly follows the regional trend, and that the use of the NT EPA data as a background is considered both suitable and representative for this assessment.

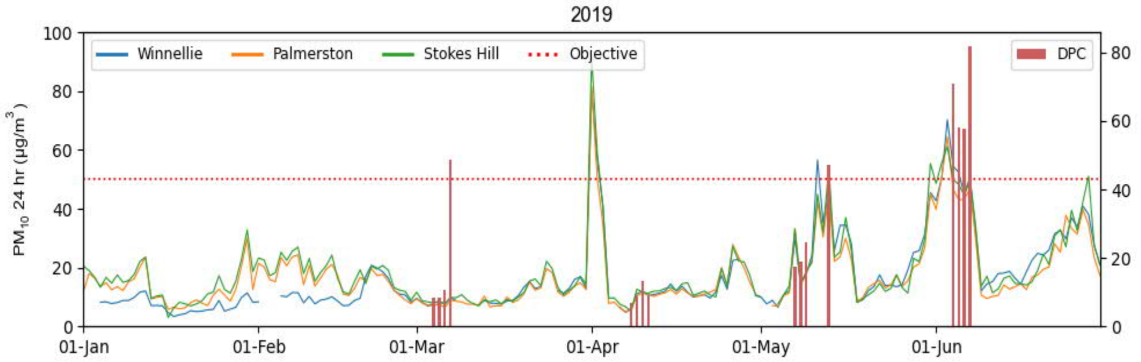

Figure 5.4 NT EPA 24-hour PM_{10} averages in 2019 compared with DPC monitoring

Table 5.13 24 hour PM_{10} concentrations measured at DPC monitoring locations

Site	Date	Measured concentration (µg/m^3)
EAS2	9/10/2018	60.2
	7/03/2019	48.6
	10/04/2019	13.5
	13/05/2019	47.3
	5/06/2019	58.1
Maximum		60.2
Average		45.5
Minimum		13.5
EAW6	10/10/2018	27.4
	5/03/2019	8.4
	8/04/2019	7.1
	8/05/2019	19.1
	7/06/2019	81.8
Maximum		81.8
Average		28.8
Minimum		7.1
MSB1	14/10/2018	23.4
	6/03/2019	10.8
	9/04/2019	8.7

Site	Date	Measured concentration (µg/m^3)
	7/05/2019	17.6
	6/06/2019	57.7
Maximum		57.7
Average		23.6
Minimum		8.7
FHW5	15/10/2018	21.2
	15/11/2018	13.2
	4/03/2019	8.3
	11/04/2019	8.9
	9/05/2019	24.8
	4/06/2019	71
Maximum		71
Average		24.6
Minimum		8.3

5.3 Adopted background concentrations

A summary of the adopted background concentrations is presented in Table 5.14. These background concentrations were added to predicted modelling results for the Project to provide a cumulative assessment of air quality impacts. Cumulative NO_2 predictions were assessed contemporaneously using the OLM, therefore the background concentration varies by the hour and has not been included in this table.

In accordance with the BCC AQPSP (2014) the 70th percentile concentration was selected as the adopted background concentration for assessment of 1 hour, 8 hour and 24 hour average air quality goals.

In addition to the adopted background concentration, Table 5.14 also presents the assimilative capacity for each pollutant of concern. Assimilative capacity of the receiving air environment can be quantified through the difference between the adopted background concentration and the air quality goal. In Table 5.14 the assimilative capacity is reported as both a concentration (µg/m^3) and as a percentage.

Table 5.14 Adopted background pollutant concentrations

Pollutant	Averaging Period	Air quality goal (µg/m³)	Adopted background concentration (µg/m³)	Assimilative capacity		Data Source
				(µg/m³)	(%)	
PM_{10}	24 hour	50	29.5	20.5	41.0%	Stokes Hill 2018
	Annual	25	23.0	2.0	8.0%	Winnellie 2019
$PM_{2.5}$	24 hour	25	11.9	13.1	52.4%	Palmerston 2019
	Annual	8	9.8	-1.8	-22.5%	Palmerston 2019
NO_2	1 hour	226	not applicable due to contemporaneous assessment using the OLM method			
	Annual	56				
SO_2	1 hour	523	1.9	521.1	99.6%	Stokes Hill 2019
	24 hour	209	2.0	207	99.0%	Stokes Hill 2019
	Annual	52	1.7	50.3	96.7%	Palmerston 2019
CO	8 hour	10,000	573	9427	94.3%	Stokes Hill 2019
VOC species	1 hour (benzene)	580	6.26	573.7	98.9%	Memorial Park 2015
	1 hour (xylene)	22,000	58.7	21941.3	99.7%	Memorial Park 2015
	1 hour (toluene)	1,100	10.7	1089.3	99.0%	Memorial Park 2018
	24 hour (toluene)	3,700	9.7	3690.3	99.7%	Memorial Park 2018
	24 hour (xylene)	1,100	50.8	1049.2	95.4%	Memorial Park 2015
	24 hour (benzene)	29	8.2	20.8	71.7%	Memorial Park 2019
	Annual (toluene)	376	8.9	367.1	97.6%	Memorial Park 2018
	Annual (xylene)	100	47.7	52.3	52.3%	Memorial Park 2015
	Annual (benzene)	5.1	4.6	0.5	9.8%	Memorial Park 2018

5.3.1 VOC screening assessment

As discussed in Section 4.3.1, assessment of VOC emissions has been undertaken as a conservative screening assessment considering predicted total VOC concentrations at sensitive receptors against the strictest air quality goals for either benzene, toluene or xylene.

Table 5.14 presents the assimilative capacity for each VOC species of concern. Based on the Table 5.14, the VOC air quality goals with the smallest assimilative capacity, and therefore the strictest goal, are as follows:

- 1 hour: benzene (adopted background of 6.3 µg/m^3, assimilative capacity of 573.7 µg/m^3)
- 24 hour: benzene (adopted background of 8.2 µg/m^3, assimilative capacity of 20.8 µg/m^3)
- annual average: benzene (adopted background of 4.6 µg/m^3, assimilative capacity of 20.8 µg/m^3).

Based on the adopted background concentrations, the strictest VOC air quality goals are those for benzene, and therefore assessment of total VOC predictions has been undertaken considering the adopted air quality goals for benzene.

5.4 Existing emission sources

There are a number of existing emission sources within the Darwin Harbour region. There are many significant industry sites utilising the local port and transport infrastructure and relative proximity to energy supplies and mineral export facilities (DERM, 2011). These industrial sources are significant emitters of air pollutants within the Darwin region and should be considered when assessing cumulative air quality impacts. The NPI was used as the primary tool to identify the main emission sources in the Study area.

The NPI as discussed in Section 3.2.2 is regulated by the Australian Government and is tasked with tracking pollution across Australia, ensuring that the community has access to information about the emission and transfer of toxic substances which may affect them locally. All major polluters are required by the Australian Government to submit annual reports of their emissions to air. The NPI has emission estimates for 93 toxic substances and the source and location of these emissions. These substances have been identified as important due to their possible effect on human health and the environment. The data comes from facilities like mines, power stations, and factories, as well as other sources.

An NPI search conducted within the Study area identified 10 facilities within a 6 km radius that report annual air pollutant emissions. A brief description of each source, the pollutants emitted, and its approximate distance from the Project Site is provided in Table 5.15. The location of these emission sources are presented in Figure 5.5.

Table 5.15 Existing NPI-listed sources of air pollution in the Study area

Source	Distance from Project	Pollutants
OM Manganese	< 1km	Manganese, copper, lead, zinc
VOPAK Darwin Industry Fuel Terminal	< 1km	VOCs
Berrimah Freight Terminal	3 km NE	VOCs
Darwin Chemicals	5 km NE	Chlorine
Downer Group EDI Berrimah	5 km NE	Fluoride
Darwin Galvanising	5 km NE	Hydrochloric acid, zinc
Palmerston Wastewater Stabilisation Ponds	5.5 km SE	Odour
INPEX Operations Wickham	4 km SE	PM_{10}, $PM_{2.5}$, NO_x, SO_2, CO, VOCs
Wickham Point Regulating Station	5 km SW	VOCs
Conoco Phillips Darwin LNG Plant Wickham	5 km SW	PM_{10}, $PM_{2.5}$, NO_x, SO_2, CO, VOCs

Many of the identified industrial sites listed in Table 5.15 do not emit any of the Project pollutants of interest and do not need to be considered further. Of the industries with similar air emissions to the Project, the Berrimah Freight Terminal (rail transport) has only minor emissions and would be unlikely to cumulatively impact sensitive receptors.

VOC emissions from VOPAK Darwin Industry Fuel Terminal, INPEX Wickham, and Conoco Phillips Wickham are significant in comparison with the Project. In the 2018/19 NPI reporting year 430,000 kg, 1,900,000 kg and 530,000 kg of VOC were emitted respectively from these three sites. VOC emissions from the three sites are almost exclusively via elevated point (stack) sources, meaning greater dispersion of pollutants into the atmosphere compared with ground-based sources. Considering this, along with the buffer distance between these sources and sensitive receptors (> 4 km), it is likely that VOC emissions would disperse to well below relevant air quality goals before reaching the receptors. In comparison with these three sites, the Project is estimated to emit only about 36,000 kg (see Section 4.2.3.1), or about 1.2 % of the total emissions for the three nearby sites. On this basis, it is considered acceptable to assess Project VOC emissions in isolation and not consider cumulative effects from nearby sources.

Similar to VOCs, emissions of NO_2, PM_{10}, $PM_{2.5}$, CO and SO_2 from INPEX Wickham and Conoco Philips Wickham are also significant but are primarily emitted from point sources. Emissions from these sources are included in the background monitoring data presented in Section 5.2 and were therefore not included as separate sources in the model.

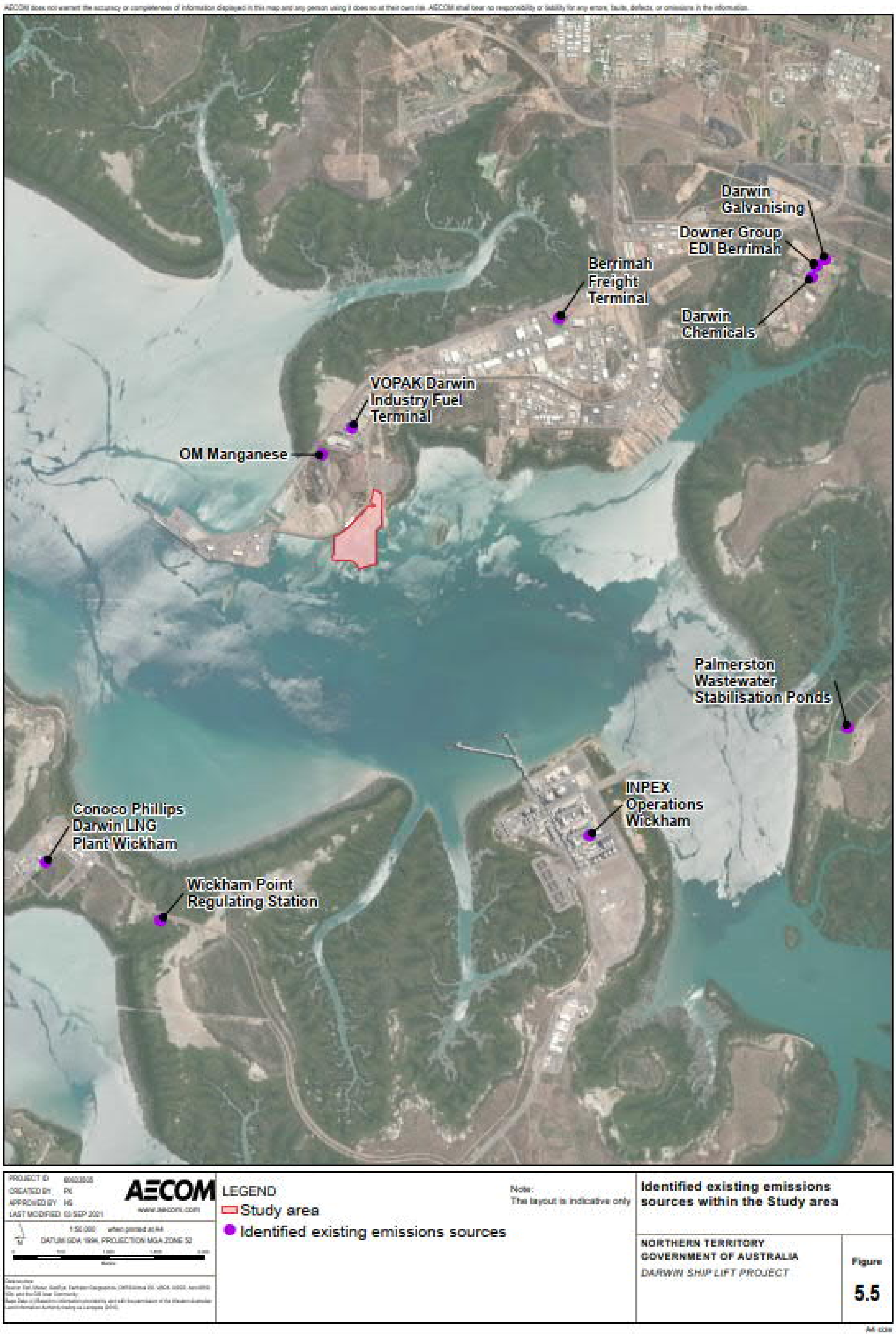

Figure 5.5 Identified existing emissions sources near the Study area

6.0 Sensitive receptors

6.1 Sensitive land uses

The NT EPA *Guideline: Recommended Land Use Separation Distances* states that "sensitive land uses are land uses where people live or regularly spend time, and which require a particular focus on protecting the health and well-being of humans and amenity values from the emissions of an activity". The Guideline does not provide a definition for sensitive uses, but states that "sensitive land uses may include but are not limited to residential premises, accommodation facilities such as hotels and nursing homes, hospitals, childcare centres, schools and some outdoor recreation facilities".

The Project area is located within the East Arm Wharf, which is an industrial area. It is acknowledged that the use of this area is expected to exceed the averaging period of 1 hour, 8 hours and potentially up to 24 hours, however these uses are not strictly defined as sensitive land uses under the definition provided by the NT EPA. Therefore, for the purpose of the assessment, land uses within the wharf area have not been considered as sensitive receptors and have not been considered further in the assessment.

6.2 Modelled receptors

Sensitive land uses which are located nearest to the Project area have been included in the dispersion model developed for the assessment. The locations of sensitive receptors included in the model are shown in Figure 6.1. Details for the sensitive receptors which have been modelled are presented in Table 6.1.

It is noted that there is a future planned residential development for Weddell, which would be located approximately 14 km south-east of the Project. This separation distance is significantly further than the separation distance for the sensitive receptors which have been included in the model (refer Table 6.1), which are between 5.1 km to 8.2 km from the Project. Due to the separation distance, it is expected that if predicted pollutant concentration levels are compliant at the modelled sensitive receptors, they would also be compliant at the future Weddell residential development.

Table 6.1 Sensitive receptors included in the assessment

Receptor ID	Description	UTM Coordinates	Distance and orientation from the Project
R1	Stokes Hill area (residential)	701,008m E; 8,621,030m S	5.8 km WNW
R2	Stuart Park area (residential)	701,249m E; 8,622,820m S	6.6 km NW
R3	Bayview area (residential)	702,237m E; 8,623,770m S	6.5 km NW
R4	The Narrows area (residential)	702,513m E; 8,625,610m S	7.8 km NNW
R5	Winnellie area (residential)	706,165m E; 8,625,000m S	6.1 km N
R6	Winnellie area (residential)	706,624m E; 8,625,130m S	6.3 km N
R7	Coonawarra area (residential)	707,675m E; 8,624,200m S	5.5 km NNE
R8	Hidden Valley Holiday Park (accommodation)	708,257m E; 8,624,390m S	5.8 km NNE
R9	Berrimah area (residential)	708,909m E; 8,623,400m S	5.1 km NE
R10	Darwin Free Spirit Resort (accommodation)	714,094m E; 8,622,050m S	8.2 km ENE
R11	Durack area (residential)	713,457m E; 8,620,870m S	7.2 km ENE
R12	Durack area (residential)	713,595m E; 8,619,650m S	7.1 km E

Receptor ID	Description	UTM Coordinates	Distance and orientation from the Project
R13	Marlow Lagoon area (residential)	713,388m E; 8,619,230m S	6.9 km E
R14	Marlow Lagoon area (residential)	712,898m E; 8,618,260m S	6.4 km E
R15	Marlow Lagoon area (residential)	712,188m E; 8,617,610m S	5.8 km ESE
R16	Moulden area (residential)	714,220m E; 8,616,130m S	8.0 km ESE
R17	Berrimah area (residential)	710,956m E; 8,623,400m S	6.4 km NE

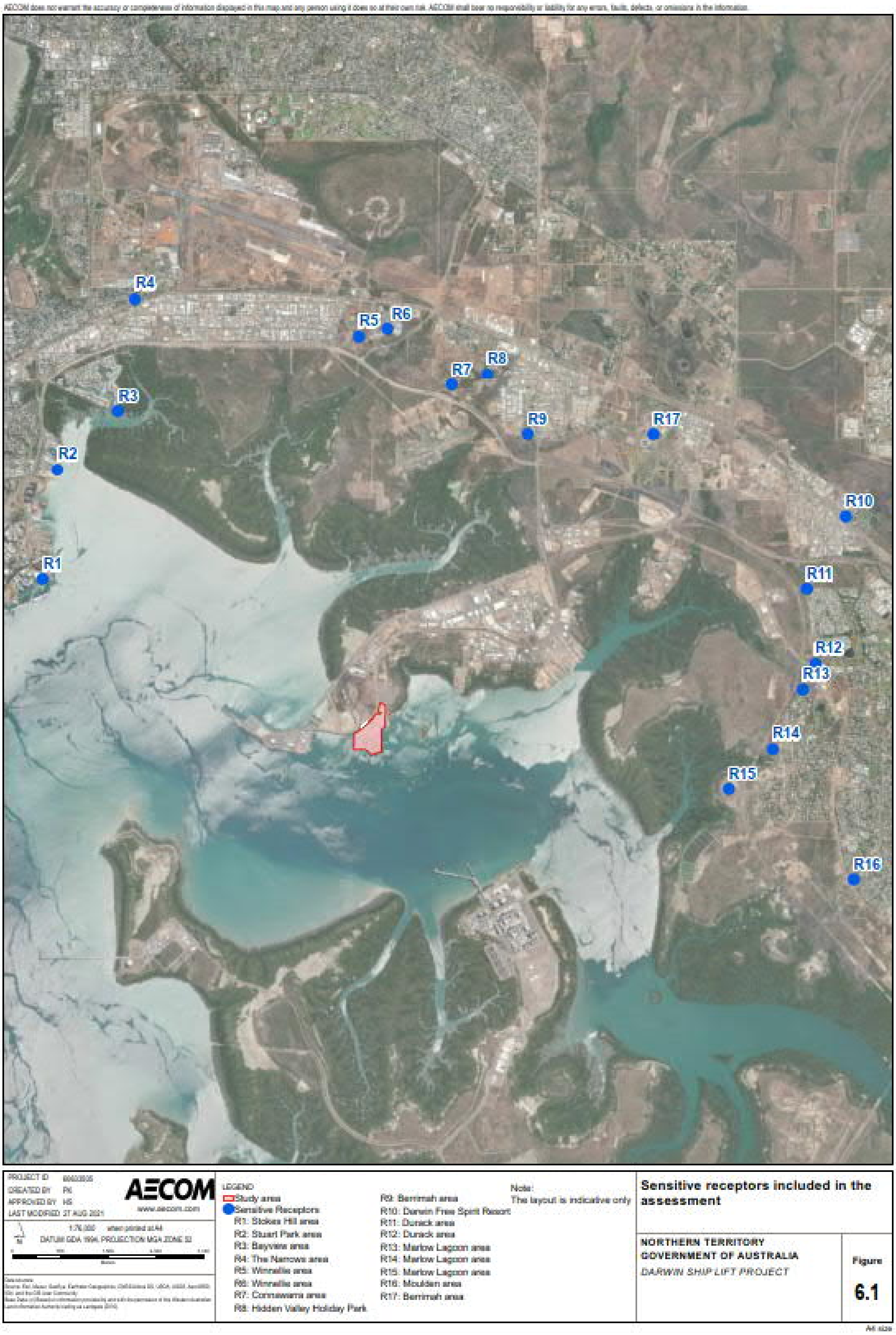

Figure 6.1 Sensitive receptors included in the assessment

6.3 Water-based receptors

Water-based receptors such as docks and watercraft have not been modelled specifically due to uncertainty of their location, and the likely short-term occupation. However, results for locations at water-based receptors can be inferred from the assessment by reviewing modelling results presented as concentration contour maps. Contour maps are presented in Appendix A and B and explained further in Section 7.1.

7.0 Assessment of air quality impacts

This section presents the modelling results as well as an analysis of these results for both the construction and operation phases of the Project.

7.1 Modelling results

7.1.1 Construction phase

Predicted pollutant concentrations at sensitive receptors for the construction phase assessment are presented in Table 7.1, Table 7.2 and Table 7.3. For all pollutants with the exception of NO_2, predictions at each modelled receptor are shown for the Project only contribution (concentration at the receptor resulting from Project emissions only), and the cumulative concentration (Project plus background). Potential NO_2 impacts have been assessed contemporaneously using the OLM method as such only cumulative impacts for NO_2 have been reported.

The predicted cumulative concentrations shown in Table 7.1, Table 7.2 and Table 7.3 are assessable against the air quality goals adopted for the assessment as discussed in Section 3.1.4. The adopted air quality goals are also presented in Table 7.1, Table 7.2 and Table 7.3.

Table 7.1 shows the predicted PM_{10}, $PM_{2.5}$ and NO_2 concentrations at all sensitive receptors. Predicted model results show:

- Cumulative PM_{10} and NO_2 concentrations are below the relevant air quality goals for all averaging periods.
- Cumulative 24 hour $PM_{2.5}$ maximum concentrations are below the air quality goal of 25 µg/m^3
- Cumulative annual average $PM_{2.5}$ concentrations exceed the air quality goal of 8 µg/m^3.
  - This is due to the elevated background concentration (9.8 µg/m^3) which already exceeds the air quality goal of 8 µg/m^3.
  - The incremental contribution from the Project is very small compared to the background with a maximum Project contribution of 0.18 µg/m^3 predicted to occur at receptor R1.
  - The maximum incremental annual average $PM_{2.5}$ concentration at the worst affected receptor is well below the derived incremental $PM_{2.5}$ air quality goal of a maximum increase of 1.3 µg/m^3.

Table 7.2 shows the predicted SO_2 and CO concentrations. Predicted cumulative SO_2 and CO concentrations are below the relevant air quality goals for all averaging periods respectively.

Table 7.3 shows the predicted total VOC concentrations, and the air quality goals for benzene adopted from Victoria and Queensland. Predicted cumulative total VOC concentrations, using the adopted background concentrations for benzene, are below the relevant adopted Victorian and Queensland air quality goals for all averaging periods for benzene at sensitive receptors.

Different to the NT and Queensland, in NSW and Victoria the air quality goals prescribed by these states (refer Table 3.1) are assessed at the boundary of the project site and not just at sensitive receptors. Although not shown in Table 7.3, a review of gridded model results has been undertaken to investigate predicted total VOC concentrations outside the boundary of the Project. The review determined that total VOC concentrations outside the boundary of the Project do exceed both the adopted Victorian goal for the 24 hour maximum of 29 µg/m^3 and the NSW 1 hour 99.9th percentile goal of 29 µg/m^3. However, the areas where concentrations exceed these goals are predominantly limited to locations over water. Therefore, although the most stringent VOC air quality goals for benzene are predicted to be exceeded beyond the boundary of the Project, the potential for impact to human health is not expected to be significant.

It is emphasised that the land use in the area surrounding the Project site is industrial in nature, and that in contrast to NSW and Victoria, the NT EPA assesses predicted impacts at sensitive receptors, rather than at the site boundary. Predicted total VOC concentrations at sensitive receptors are significantly below the adopted goals for benzene, which has the strictest criteria. As predicted concentrations are well below the goals at sensitive receptors, concentration contours are not shown for VOCs for the construction phase.

In addition to the results tables, cumulative concentration contour maps for the construction phase for PM_{10}, $PM_{2.5}$ and NO_2 are presented in Appendix A.

Table 7.1 Predicted PM_{10}, $PM_{2.5}$ and NO_2 concentrations

Receptor ID	PM_{10}				$PM_{2.5}$				NO_2	
	24 hour maximum (µg/m³)		Annual average (µg/m³)		24 hour maximum (µg/m3)		Annual average (µg/m³)		1 hour maximum (µg/m³)	Annual average (µg/m³)
	Project Only	Cumulative	Project Only	Cumulative	Project Only	Cumulative	Project Only	Cumulative	Cumulative	Cumulative
Goal	**-**	**50**	**-**	**25**	**-**	**25**	**1.3**	**8[a]**	**226**	**56**
R1	3.04	32.5	0.18	23.2	1.30	13.2	0.18	**10.0**	84.0	4.49
R2	2.23	31.7	0.15	23.1	0.96	12.9	0.15	**9.95**	86.4	4.38
R3	1.90	31.4	0.10	23.1	0.74	12.6	0.10	**9.90**	77.6	3.87
R4	1.33	30.8	0.06	23.1	0.51	12.4	0.06	**9.86**	56.7	3.49
R5	1.12	30.6	0.05	23.1	0.44	12.3	0.05	**9.85**	53.5	3.44
R6	1.04	30.5	0.05	23.0	0.40	12.3	0.05	**9.85**	54.7	3.41
R7	1.30	30.8	0.06	23.1	0.47	12.4	0.06	**9.86**	68.7	3.49
R8	1.36	30.9	0.05	23.0	0.51	12.4	0.05	**9.85**	68.9	3.42
R9	1.82	31.3	0.06	23.1	0.61	12.5	0.06	**9.86**	80.9	3.51
R10	1.13	30.6	0.04	23.0	0.38	12.3	0.04	**9.84**	46.7	3.31
R11	1.87	31.4	0.06	23.1	0.61	12.5	0.06	**9.86**	59.1	3.55
R12	1.70	31.2	0.08	23.1	0.67	12.6	0.08	**9.88**	67.1	3.75
R13	2.03	31.5	0.08	23.1	0.71	12.6	0.08	**9.88**	67.6	3.85
R14	1.65	31.2	0.09	23.1	0.63	12.5	0.09	**9.89**	77.1	3.98
R15	3.57	33.1	0.10	23.1	1.18	13.1	0.10	**9.90**	83.8	4.01
R16	1.28	30.8	0.04	23.0	0.48	12.4	0.04	**9.84**	58.9	3.38
R17	1.18	30.7	0.04	23.0	0.47	12.4	0.04	**9.84**	60.5	3.33

Table note:
Exceedances of the relevant air quality goals are highlighted in **bold.**
[a]The adopted annual average background concentration for $PM_{2.5}$ is 9.8 µg/m³, higher than the adopted air quality goal.

Table 7.2 Predicted SO_2 and CO concentrations

Receptor ID	SO_2						CO	
	1 hour maximum(µg/m³)		24 hour maximum (µg/m³)		Annual average(µg/m³)		8 hour maximum (µg/m³)	
	Project Only	Cumulative	Project Only	Cumulative	Project Only	Cumulative	Project Only	Cumulative
Goal	-	**523**	-	**209**	-	**52**	-	**10,000**
R1	13.9	15.8	1.15	3.15	0.16	1.86	13.2	586
R2	9.8	11.7	0.86	2.86	0.13	1.83	11.0	584
R3	4.7	6.58	0.69	2.69	0.09	1.79	8.79	582
R4	3.6	5.54	0.45	2.45	0.05	1.75	4.77	578
R5	4.6	6.54	0.40	2.40	0.04	1.74	4.81	578
R6	3.9	5.78	0.36	2.36	0.04	1.74	4.36	577
R7	7.4	9.28	0.46	2.46	0.05	1.75	6.12	579
R8	7.8	9.74	0.51	2.51	0.04	1.74	6.73	580
R9	13.4	15.3	0.62	2.62	0.05	1.75	8.06	581
R10	4.1	6.04	0.31	2.31	0.03	1.73	3.78	577
R11	8.4	10.30	0.56	2.56	0.05	1.75	7.17	580
R12	9.6	11.5	0.57	2.57	0.06	1.76	8.10	581
R13	10.6	12.51	0.62	2.62	0.06	1.76	8.76	582
R14	8.1	9.99	0.59	2.59	0.07	1.77	7.87	581
R15	21.5	23.4	1.15	3.15	0.08	1.78	14.9	588
R16	5.2	7.10	0.44	2.44	0.03	1.73	5.45	578
R17	4.0	5.89	0.43	2.43	0.03	1.73	4.90	578

Table 7.3 Predicted VOC concentrations

Receptor ID	Total VOCs					
	1 hour 99.9th percentile (µg/m³)		24 hour maximum (µg/m³)		Annual average(µg/m³)	
	Project Only	Cumulative	Project Only	Cumulative	Project Only	Cumulative
Benzene goal	-	**580[a]**	-	**29**	-	**6.4**
R1	10.07	16.33	1.38	9.58	0.19	4.79
R2	8.29	14.55	1.05	9.25	0.16	4.76
R3	4.95	11.21	0.83	9.03	0.10	4.70
R4	2.90	9.16	0.57	8.77	0.06	4.66
R5	3.59	9.85	0.48	8.68	0.05	4.65
R6	3.48	9.74	0.43	8.63	0.05	4.65
R7	4.61	10.87	0.58	8.78	0.05	4.65
R8	4.06	10.32	0.64	8.84	0.05	4.65
R9	4.96	11.22	0.77	8.97	0.06	4.66
R10	2.50	8.76	0.42	8.62	0.04	4.64
R11	3.75	10.01	0.74	8.94	0.06	4.66
R12	4.52	10.78	0.75	8.95	0.07	4.67
R13	5.11	11.37	0.79	8.99	0.08	4.68
R14	6.05	12.31	0.75	8.95	0.09	4.69
R15	6.39	12.65	1.51	9.71	0.10	4.70
R16	3.31	9.57	0.58	8.78	0.04	4.64
R17	3.57	9.83	0.52	8.72	0.04	4.64

Table note-
[a]NSW VOC goals (99.9th percentile at 29 µg/m³) are lower than the adopted goals of 580 µg/m³

7.1.2 Operation phase

Predicted total VOC concentrations at sensitive receptors for the operation phase assessment are presented in Table 7.4. Predictions at each modelled receptor are shown for the Project only contribution (concentration at the receptor resulting from Project emissions only), and the cumulative concentration (Project plus background). The adopted air quality goals for benzene are also presented in Table 7.4.

Table 7.4 shows that the predicted total VOC concentrations at each receptor, adopting the background concentration for benzene, are below the air quality goals for benzene for each averaging period.

Cumulative concentration contour maps for the operation phase for total VOC concentrations are presented in Appendix B.

Table 7.4 Predicted total VOC concentrations

Receptor ID	Total VOCs - Project Only			Total VOCs – Cumulative[1]		
	1 hour 99.9th percentile(µg/m³)	24 hour maximum (µg/m³)	Annual average (µg/m³)	1 hour 99.9th percentile (µg/m³)	24 hour maximum (µg/m³)	Annual average (µg/m³)
Goal	**-**	**-**	**-**	**580[a]**	**29**	**6.4**
R1	6.30	1.05	0.13	12.56	9.25	4.73
R2	4.64	1.00	0.14	10.90	9.20	4.74
R3	3.78	0.59	0.09	10.04	8.79	4.69
R4	3.03	0.59	0.06	9.29	8.79	4.66
R5	4.16	0.66	0.05	10.42	8.86	4.65
R6	3.75	0.54	0.05	10.01	8.74	4.65
R7	3.70	0.59	0.05	9.96	8.79	4.65
R8	3.52	0.47	0.05	9.78	8.67	4.65
R9	4.48	0.72	0.06	10.74	8.92	4.66
R10	2.99	0.61	0.05	9.25	8.81	4.65
R11	4.44	0.82	0.07	10.70	9.02	4.67
R12	4.52	0.91	0.10	10.78	9.11	4.70
R13	5.44	0.89	0.11	11.70	9.09	4.71
R14	4.47	0.58	0.10	10.73	8.78	4.70
R15	4.38	0.64	0.08	10.64	8.84	4.68
R16	3.10	0.68	0.04	9.36	8.88	4.64
R17	3.23	0.56	0.04	9.49	8.76	4.64

Table note:
1. Cumulative concentrations have been estimated by adding predicted total VOC concentrations from the model to the adopted background concentration for benzene for 1 hour, 24 hour and annual averages respectively.
[a]NSW VOC goals (99.9th percentile at 29 µg/m³) are lower than the adopted goals of 580 µg/m³

7.2 Discussion

7.2.1 Construction phase

The results of the construction phase assessment are summarised on an individual pollutant basis.

PM_{10}

The highest predicted cumulative concentration for PM_{10} 24 hour average is 33.1 µg/m³ at R15 (representing the Marlow Lagoon area), and highest annual average concentration for PM_{10} is 23.2 µg/m³ which occurred at R1 (location representing the Stokes Hill area).

Predicted PM_{10} concentrations are below adopted 24 hour (50 µg/m³) and annual average (25 µg/m³) air quality goals for all receptors and therefore no significant impact is predicted.

$PM_{2.5}$

The highest predicted cumulative concentrations for $PM_{2.5}$ 24 hour average is 13.2 µg/m³ at R1, and highest annual average concentration for $PM_{2.5}$ is 10 µg/m³ at the same receptor. The highest Project only contribution for $PM_{2.5}$ 24 hour average and $PM_{2.5}$ annual average is 1.30 µg/m³ and 0.18 µg/m³ respectively at R1.

Although the cumulative annual average concentration exceeds the air quality goal (8 µg/m³) the Project only contribution to the predicted concentration is minor (1.8% of the cumulative concentration) and is well below the incremental $PM_{2.5}$ air quality goal (1.3 µg/m³) derived for the assessment. It is noted that the construction phase of the Project is temporary, and the predicted Project contribution attributed to construction phase emissions would be short-term, and can be managed by mitigation measures (see Section 9.0).

Based on the above, the construction of the Project is not considered to significantly impact air quality with respect to $PM_{2.5}$ concentrations.

NO_2

The highest predicted cumulative 1 hour concentration for NO_2 is predicted at receptor R2 (location representing the Stuart Park area), with predicted concentration of 86.4 µg/m³. The highest predicted cumulative annual average concentration was predicted at R1 at 4.49 µg/m³.

Predicted NO_2 concentrations are below the adopted 1 hour (226 µg/m³) and annual average (56 µg/m³) air quality goals for all receptors and therefore no significant impact is predicted.

SO_2

The highest predicted cumulative 1 hour concentration for SO_2 is predicted at receptor R1, with a predicted concentration of 15.8 µg/m³. The highest predicted 24 hour average was 3.15 µg/m³ predicted at R1 and R15 (location representing the Marlow Lagoon area). The highest predicted cumulative annual average SO_2 concentration was predicted at R1 at 1.86 µg/m³.

Predicted SO_2 concentrations are below the adopted 1 hour (523 µg/m³), 24 hour (209 µg/m³) and annual average (52 µg/m³) air quality goals for all receptors and therefore no significant impact is predicted.

CO

The highest predicted cumulative concentration for CO 8 hour average was 588 µg/m³ at R15. CO concentrations are well below the adopted air quality goal (10 mg/m³) and therefore no significant impact is predicted.

VOC

Predicted cumulative total VOC concentrations, using the adopted background concentrations for benzene, are below the relevant air quality goals for all averaging periods (1 hour, 24 hour, annual average) for benzene, which is the pollutant with the lowest assimilative capacity.

As cumulative total VOC concentrations (using benzene as a background) are predicted to be compliant with the air quality goals for the VOC species with the lowest assimilative capacity (strictest goal) no significant impact is predicted from VOC emissions.

The adopted 1 hour VOC goal (580 µg/m³) has been selected from prescribed Victoria air quality criteria, however it is noted that NSW prescribed goals are significantly lower.

Although the NSW goals have not been adopted due to their currency, the VOC results have been evaluated against the NSW criteria, which sets concentration criteria for pollutants at any point outside the Project boundary. This approach has also been enforced by Victoria.

Results of the modelling show that the 1-hour 99.9th percentile criteria of 29 µg/m³ and 24 hour maximum goal of 29 µg/m³ extends beyond the boundary of the construction site However, high concentrations are largely limited to the area over the water, and all identified sensitive receptors are well below the respective air quality criteria.

It is also noted the boundary of the construction site is indicative only due to the placement and movement of the dredges and may be subject to change during actual construction.

7.2.2 Operation phase

The only modelled pollutant of concern during the operation phase is VOCs.

Predicted total VOC concentrations at each receptor, adopting the background concentration for benzene, are below the air quality goals for benzene for each averaging period.

The averaging period which is closest to the air quality goal is the annual average, with a maximum predicted cumulative concentration for total VOCs of 4.73 µg/m³ at R1, compared to the air quality goal of 6.4 µg/m³. However, it is noted that the Project contribution to this cumulative concentration is 0.13 µg/m³, which represents less than 3% of the total predicted concentration.

Predicted model VOC concentrations for the operation phase were also evaluated against the more stringent NSW criteria. Results of the modelling show that the 1-hour 99.9th percentile criteria of 29 µg/m³ and 24 hour maximum goal of 29 µg/m³ extends beyond the boundary of the construction site However, high concentrations are largely limited to the area over the water, and all identified sensitive receptors are well below the respective air quality criteria.

Results of the model show that the more stringent criteria is also exceeded past the boundary of the Project site, however these higher concentrations are limited to over the water, and concentrations at sensitive receptors are well below that of the more stringent criteria.

Based on the predicted minor contribution from the operation of the Project to air quality at sensitive receptor locations, no significant air quality impact is predicted as a result of the operation of the paint and blast facility and resulting emissions from VOCs. As such the predicted VOC concentrations, the risk of odour impacts at sensitive receptors resulting from the operation of the paint and blast facility is considered to be low.

8.0 Greenhouse gas emissions

8.1 Assessment of emissions

8.1.1 Construction phase

Construction phase GHG emissions for the Project are presented in Table 8.1. All GHG emissions associated with the construction phase are Scope 1 emissions from the combustion of fuels from both stationary and mobile equipment. Scope 2 emissions are not able to be quantified at this stage of the Project therefore are not included in the assessment, however, are expected to be minor. Hourly assumptions for usage of equipment and electricity were provided to AECOM by the client.

Total GHG emissions are estimated to be 22,575 t CO_2-e across the entire construction phase of the Project.

Table 8.1 Estimated construction phase GHG emissions

Construction Stage	Plant/Mobile Equipment	GHG emissions kg CO_2-e
Land Preparation	Excavator	13,565
	Bulldozer	13,565
Dredging	BHD	7,715,971
	CSD	947,272
	Work boats	4,035,724
Land Reclamation	Swamp dozer	1,329,415
	Excavator	332,354
	Tipper Trucks	664,708
	Dozer	332,354
	Roller	47,479
Revetments	Excavator	759,666
	Tipper Trucks	759,666
	Crane	379,833
Piling and Waterside Infrastructure	Land-based rig	305,223
	Barge-based rig	152,611
	Work boats	763,057
	Cranes	169,568
Filter Rock and Hardstand	Grader	700,486
	Roller	518,879
	Water truck	194,580
	Tipper Trucks	518,879
	Backhoe	259,439
	Skid steer	103,776
	Loader	518,879
	Excavator	1,037,758
Total (kg CO_2-e)- construction		**22,574,707**
Total (tonnes CO_2-e) construction		**22,575**

8.2 Operation phase

Operation phase GHG emissions for the Project are presented in Table 8.2 based on a single year of operation for the Project. Emissions for the operation phase of the Project include both Scope 1 and Scope 2 emissions. On an annual basis, Scope 1 emissions are estimated to total 117.3 t CO_2-e per year, while Scope 2 emissions are estimated to be 777.6 t CO2-e per year. The alignment of Project GHG mitigation measures with the NT's current strategy toward net-zero emissions means emissions from embedded electricity are expected to reduce as a target of 50 % renewably sourced grid power is reached. Mitigation measures are provided in more detail in Section 9.2.

Total emissions for the operation phase are estimated to be 894.9 t CO_2^{-e}

Table 8.2 Predicted operation phase greenhouse gas emissions

Activity	Emissions Scope	Annual GHG emissions (kg CO_2-e)	Annual GHG emissions (t CO_2-e)
Cranes	1	78,262	78.3
Diesel Generators	1	39,020	39.0
Electricity Consumption	2	777,600	777.6
Total (Scope 1)		**117,282**	**117.3**
Total (Scope 2)		**777,600**	**777.6**
Total annual GHG contribution-operation		**894,882**	**894.9**

8.3 Discussion

A discussion of greenhouse gas emissions from the Project is provided below.

8.3.1 Comparison to NT and Federal GHG contribution

A review of the most recently reported year of NGER data was undertaken to determine the Project contribution compared to reported state/territory and federal emissions. GHG emissions from 2019 for NT and Australia-wide were gathered from the National Greenhouse Accounts National Inventory Report 2019. Emissions reporting thresholds for facilities and corporations are detailed in 3.2.2.1.

Construction emissions were compared against territory/national totals, whereas operation emissions were compared against those reporting to the Industrial Processes and Product sector also, however it is noted that this is a broad category defining a range of industries.

Emissions comparisons are presented in Table 8.3 below.

Table 8.3 Comparison of Project emissions against Northern Territory and Australia reported emissions for 2019

Comparison against territory and federal reported emissions		Project contribution against benchmark-construction phase (%)	Annual Project against benchmark-operation phase (%)
Sector emissions (t CO_2-e)		22,575 t CO_2-e	894.9 t CO_2-e
NT GHG emissions- Industrial Processes and Product Sector	130,000	-	0.688%
Australia GHG emissions Industrial Processes and Product Sector	31,750,000	-	0.003%
NT GHG emissions- all sectors	20,650,000	0.109%	0.004%
Australia GHG emissions - all sectors	529,300,000	0.004%	0.0002%

8.3.1.1 Construction phase

The total GHG contribution from the construction phase of the Project is estimated to be approximately 0.1 % compared to all reported NTGHG emissions in 2019, and 0.004 % of Australia's total reported emissions.

8.3.1.2 Operation phase

The total GHG emissions contribution from the first year of the operation phase of the Project is expected to be approximately 0.004 % of NT reported GHG emissions, and 0.0002 % of Australia's reported GHG emissions, compared to 2019 NGER data. Project GHG emissions are expected to be 0.7 % of NT's reported GHG emissions from the Industrial Processes and Product sector, as well as 0.003 % of Australia's emissions from the same sector.

The construction and operation phases of the Project are not expected to contribute majorly to either territory or nation-wide GHG emissions totals.

9.0 Mitigation measures

Air quality and GHG emissions from construction and operation of the Project are not expected to cause a significant impact, however the application of appropriate mitigation measures will further reduce the likelihood and consequence of impact. A number of mitigation strategies are recommended for the Project. These are discussed separately below for construction and operational phases of the Project for both air quality and greenhouse gases.

9.1 Air quality

9.1.1 Construction phase

Construction mitigation strategies have been identified considered the NT EPA *Guidelines to Prevent Pollution from Building Sites* (NT EPA 2015*)*. The recommended mitigation strategies are as follows:

- develop and implement a Construction Air Quality Management Plan (CAQMP) specific to the Project, to be incorporated into the CEMP, prior to the start of construction activity
- inform adjoining neighbours of intended construction activities
- limit the intensity of the movement of dusty materials and construction work such as earth moving during periods of high levels of bushfire smoke
- where possible for concrete cutting and drilling, use concrete and drilling equipment that is fitted with extraction devices or misting devices to eliminate dust production at the source
- use a water truck to regularly apply water to unsealed roads or vehicle paths. At minimum, application of water at a rate of up to 2 litres per square metre per hour ($L/m^2/h$) is required
- regularly and lightly water dust-prone areas, ensuring not to over-water areas as it can cause damage and erosion. This is recommended for stockpiles and unsealed areas
- minimise drop heights of materials (e.g., from loaders into tipper trucks)
- removal of topsoil and the importing or storing of soil and other materials must be done with due care to avoid dust
- cover materials during transport into the Project site.
- Limit travel speed on site noting that slower speeds produce less dust. Travel speeds in excess of 10 km/h are not recommended on unsealed areas or paths. Speed limits should be sign-posted.
- operate machinery, equipment, vehicles, ships and dredges efficiently to minimise exhaust emissions
- clean up residues and spills in a timely manner
- seal permanent roads and areas planned to be sealed as soon as practicable.

9.1.2 Operation phase

Mitigation strategies for air emissions during the operation phase were identified for ships at berth, maintenance activities and the blast and paint facility. Due to the uncertainty of emissions from the blast and paint facility and design of operational layout, it is recommended that a validation study be undertaken following commissioning of the facility to determine impacts and necessary mitigation measures.

- all ships berthed at the Project shall make use of the available shore power. Auxiliary engines should not be in use when ships are at berth
- operate machinery, equipment, vehicles, ships or dredges efficiently to minimise exhaust emissions.

The following mitigation measures are recommended for the blast and paint facility considering the recommendations of the South Australia Environment Protection Authority (SA EPA) *Code of Practice for Vessel and Facility Management* (SA EPA, 2019):

- the blast and paint facility shall be maintained under negative pressure to ensure air emissions are only released via the roof vents
- air released to atmosphere via the roof exhaust stacks shall be passed through particulate, VOC and odour capturing filters (e.g., activated carbon) prior to exhaust to the atmosphere.

The following mitigation strategies are also recommended for abrasive blasting:

- test for presence of lead paint before blasting
- when removing tough hull stains, minimise the use of stain removers and consider more abrasive rubbing or polishing compounds
- place material collected from blasting, sanding and scraping operations in disposal containers to prevent emissions to the atmosphere as soon as practical.

The following mitigation strategies are also recommended for painting:

- maximise efficiency of antifouling paint by selecting the most appropriate product for a particular vessel
- when spray painting is required to occur partly outdoors (e.g., to accommodate a vessel larger than the building), fully enclose the vessel (sides, top and floor) or item being painted with temporary screening materials. Weight the edges of the screens to keep them in place
- use efficient spray equipment (transfer efficiency >65%) such as high volume spray guns
- where appropriate, consider using possible use electrostatic spraying methods. These require less pressure, produce little overspray, and use relatively little paint
- Where appropriate, consider using low-VOC, high solids content and water-based paints or surface preparations instead of traditional paint and primer
- keep spray guns and lines clean and well maintained to reduce emissions
- prevent evaporation of solvents by using tight-fitting lids or stoppers.

9.2 Greenhouse Gas

The NTG is currently developing a climate response policy framework (‘Towards 2050’) with the goal of achieving net zero emissions by 2050. NTG has already outlined strategies aimed at reducing GHG emissions, such as the uptake of electric vehicles for personal and public use, improved land management practices, and investment in renewable energy. By 2030, NTG aims to achieve 50 % of total electricity to be generated from renewable energy sources such as solar and wind power. The Project would support the goals of the Policy through efforts to reduce GHG emissions during both the construction and operation phases.

A range of measures aimed at reducing greenhouse gas emissions for the Project were identified and are summarised below.

9.2.1 Construction

The primary method for reducing greenhouse gas emissions during the construction phase would be through the efficient use of fuel for equipment, plant and vehicles. Mitigation strategies include:

- maintain equipment and vehicles to ensure engine efficiency and use fuel efficient equipment where able
- reduce travel distances off-site by sourcing imported materials from local areas
- reduce travel distances on-site by planning internal haul roads and staging of related activities efficiently
- minimise idling time of plant and equipment and switch engines off when not in use.
- minimise the extent of vegetation cleared during construction

- look for opportunities to add vegetation; where possible and plant species selected should be both drought tolerant and fast growing
- where possible prioritise the selection and use of electric equipment (over fuel combustion engines)
- recycle any waste produced where feasible.

9.2.2 Operation

GHG mitigation strategies for the operation phase of the Project have been recommended considering NTG's Towards 2050 policy, and are as follows:

- shore power during the operation phase should be procured from renewable energy suppliers where possible. By 2030, a minimum of 50 % of electricity used by the Project may be able to be sourced from renewable sources. In addition, look for opportunities to generate power on-site (e.g., solar arrays, etc).
- prioritise the selection and use of electric vehicles and equipment (over fuel combustion engines) as much as possible. This would include mobile plant such as forklifts and light vehicles for onsite use.

As for the construction stage, equipment and vehicles should be maintained to ensure engine efficiency and use fuel efficient equipment where able.

9.3 Air quality monitoring

Air quality impacts at sensitive receptors due to construction and operation of the Project are not predicted to be significant due to the separation distance between the Project and sensitive receptors. Sensitive receptors are well outside the recommended separation distances listed in NT EPA *Guideline: Recommended Land Use Separation Distances*.

Based on the result of the assessment, no air quality monitoring is deemed to be required for the construction of operation phases of the Project.

10.0 Cumulative impacts

When numerous projects occur within close proximity to each other they can cause cumulative impacts. The EIS for the Project requires an assessment of cumulative impacts.

Air quality impact assessments are inherently cumulative assessments as they are required to consider background air quality in addition to project-related air emissions when assessing against air quality goals (which are assessable against cumulative concentrations). The air quality assessment identified background concentrations for each pollutant species of interest for the construction and operation phases of the Project, predominantly using NT EPA air quality monitoring station data. The assessment of air quality impacts for both the construction and operation phases has considered background air quality when assessing against the adopted air quality goals.

The air quality assessment for the Project has also considered existing emission sources in the Study area as discussed in Section 5.4.

In addition to the review of background air quality and existing emission sources, the potential for cumulative impacts has also been reviewed for future projects, considering:

- projects that have been approved but construction has not commenced
- projects that have commenced construction
- projects that are currently being assessed.

Projects which fit the criteria above have been assessed for the potential for significant cumulative air quality impacts in Table 10.1. The locations of the assessed projects are shown in Figure 10.1. Further information is provided in Chapter 6: Assessment methodology.

It is noted that the assessment in Table 10.1 considers cumulative air quality impacts only and does not consider cumulative GHG impacts. The construction and operation of all the projects listed in Table 10.1 will result in GHG emissions, with the magnitude of emissions varying depending on the project. Although global warming is a cumulative impact of GHG emissions, there is no recognised method to assess the cumulative impact of GHG emissions from two or more spatially or temporally related projects. The only possible exception being comparison against GHG emission reduction targets on a Territory or State level, which is outside the ToR requirements for the Project. Therefore, assessment of cumulative impacts of GHG emissions has not been considered in detail.

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1:208,706 when printed at A4
DATUM GDA 1994, PROJECTION MGA ZONE 52
0 2,100 4,200 6,300 8,400
Meters

Data sources:
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Base Data: (c) Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).

LEGEND
- Project footprint
- Projects considered in the cumulative impact assessment

Darwin Ship Lift: Projects considered in the cumulative air quality impact assessment

NORTHERN TERRITORY GOVERNMENT OF AUSTRALIA
DARWIN SHIP LIFT PROJECT

Figure 9.15

Table 10.1 Assessment of cumulative air quality impacts for future projects

Project Name and Proponent	Location	Description	Approval Status and Development Timeframe	Relationship to Project	Assessment of cumulative air quality impacts
HMAS Coonawarra and Larrakeyah Defence Precinct Redevelopment (Department of Defence)	Larrakeyah, approximately 8.5 km west of the Project	Construction of new wharf, fuel tanks, buildings, entry and upgrades of services.	Approved (Defence/Commonwealth). Development timeframe estimated to be 2020 – 2024.	Temporal and spatial	HMAS Coonawarra and Larrakeyah Defence Precinct Redevelopment will generate emissions during its construction and operation. Larrakeyah is located to the west of Stokes Hill, which is represented in the dispersion model developed for the assessment by receptor R1. The predicted contribution from the Project to pollutant concentrations at sensitive receptor R1 are not significant and therefore there is considered to be low risk of significant cumulative air quality impacts.
Northcrest Residential Development	Berrimah Farm, approximately 5 km north-east of the Project	Staged new residential development and neighbourhood facilities with connection to Stuart Highway.	Approved. Stage 1 within the northern part of the Project site is complete. Staged development by DA according to market conditions. Stage 2 planning underway. In total 11 stages over 15 years.	Temporal and spatial	Northcrest Residential Development will generate emissions during its construction. The dispersion model developed for the assessment includes receptors R9 and R17 which are located near the Northcrest Residential Development site. Based on the predicted contribution from the Project to pollutant concentrations at sensitive receptors R9 and R17 for the construction phase, there is considered to be low risk of significant cumulative air quality impacts. The Northcrest Residential Development will represent a sensitive receptor, however this area is represented by sensitive receptors R9 and R17.
Middle Arm Industrial Precinct – civil enabling works for Kittyhawk Estate	Middle Arm Peninsula (Kittyhawk Estate), approximately 8 km south-east of the Project	Civil enabling works for three industrial lots (Stage 1) completed late 2020. Later stages either by DA or EIA process.	Civil works approved by DA. Development timeframe estimated to be 2020 - 2030.	Temporal and spatial	Civil enabling works for the Middle Arm Industrial Precinct will generate dust emissions. Due to the separation distance between the projects and the nearest sensitive receptors significant cumulative air quality impacts are not anticipated.

Project Name and Proponent	Location	Description	Approval Status and Development Timeframe	Relationship to Project	Assessment of cumulative air quality impacts
Rustlers Roost and Quest 29 Redevelopment (Primary Gold)	Mount Bundey – not shown on extents of Figure 10.1	Mining and processing gold at existing care and maintenance sites	Draft EIS submitted Public consultation Feb to April 2021 Development timeframe estimated to be 2022 - 2029	Temporal	The Rustlers Roost and Quest 20 redevelopment will generate emissions during its construction and operation. Due to the significant separation distance between the projects, there is considered to be low risk of significant cumulative air quality impacts.
Finniss Lithium Project (Core Lithium)	Bynoe, Cox Peninsula, approximately 20 km south-west of the Project	Mining of lithium-rich ore from several defined deposits with ore/concentrate transported to East Arm Wharf by road trains.	Mine Management Plan approved April 2020. Federal Government awarded Major Project Status (March 2021) Development timeframe estimated to be 2021 – 2024 (Grants and BP33 deposits). Longer-term development potential.	Temporal and spatial	The Finniss Lithium Project will generate emissions during its construction and operation. Due to the significant separation distance between the projects, there is considered to be low risk of significant cumulative air quality impacts.
Wishart Estate (Land Development Corporation)	Wishart Road / Tiger Brennan Drive, approximately 4.5 km north-east of the Project	Commercial and light industrial development including truckstop development and service station complete. Focus to develop the area as a data services centre.	Notice of Intent approved 2014. Truckstop development and service station construction completed. Staged market driven development by DA process.	Temporal and spatial	Wishart Estate will generate dust emissions during its construction. Emissions will also be generated during the estates operation but these are not expected to be significant based on the type of land uses (light industrial) proposed. The nearest sensitive receptors to the Wishart Estate are sensitive receptors R9 and R17. Based on the predicted contribution from the Project to pollutant concentrations at sensitive receptors R9 and R17, there is considered to be low risk of significant cumulative air quality impacts.
Middle Arm Industrial Precinct – long term expansion/development for Spitfire Estate	Middle Arm Peninsula (Spitfire Estate and adjacent blocks),	600-hectare precinct for large strategic industries for downstream gas processing and gas related	Formal Environmental Impact Assessment (EIA) process to be undertaken, with this	Spatial	The EIA process for the Middle Arm Industrial Precinct will include detailed consideration of emissions to air associated with this project. In comparison to the Project, emission sources

Project Name and Proponent	Location	Description	Approval Status and Development Timeframe	Relationship to Project	Assessment of cumulative air quality impacts
	approximately 6.5 km south-east of the Project	industries, with potential further development adjacent blocks along Channel Island Road and Jenkins Road.	expected to be completed by 2030.		associated with the Middle Arm Industrial Precinct are expected to be larger in magnitude and the overall contribution from the Project at shared sensitive receptors is expected to be relatively minor. Due to its location, the Middle Arm Industrial Precinct has good separation distance to sensitive receptors.
Mandorah Jetty Redevelopment (Department of Infrastructure, Planning and Logistics)	Mandorah, Cox Peninsula, approximately 15 km west of the Project	Construction of new ferry terminal and recreational boat ramp requiring construction of new breakwaters and dredging program.	Approved by Development Application (DA) process. Development timeframe estimated to be 2022– 2024.	Temporal and spatial	Mandorah Jetty Redevelopment will generate emissions during its construction and operation. Due to the separation distance between the projects there is considered to be low risk of significant cumulative air quality impacts.
Australia-ASEAN Power Link Project (Sun Cable)	Elliot/ Gunn Point Peninsula. The battery at Murrumujuk is approximately 30 km south-east of the Project	Capture of solar energy through solar array plant near Elliott. Power transferred to battery at Murrumujuk then submarine high voltage direct current (HVDC) cable to Singapore, where possible following existing cable and pipeline corridors.	Draft EIS in development. Construction expected 2024 - 2029, subject to approvals and funding.	Temporal and spatial	The Australia-ASEAN Power Link Project will generate dust emissions during its construction. However, due to the distance between the project and the nearest sensitive receptors, significant cumulative air quality impacts are not anticipated. Emissions generated during the operation of the Australia-ASEAN Power Link Project are expected to be negligible.

In summary, the cumulative impact assessment found that although there are several cumulative projects relating to the Project both spatially and temporally, all are considered to have a low cumulative air quality impact when assessed alongside the emissions from the Project.

There are sufficient land separation distances between the majority of projects considered in the cumulative impact assessment and the Project area. Those that are related spatially (in close proximity) are not considered to have a significant cumulative impact, as they are either not expected to emit the same pollutants as the Project, or will emit the same pollutants but the quantities are not considered significant in the context of the findings of the AQIA for the Project.

11.0 Risk assessment

Assessments of the risks of potential impacts on air quality and greenhouse gas emissions are summarised in Table 11.1. Risks were assessed both prior to mitigations and following the implementation of mitigation to provide and assessment of residual risk.

Table 11.1 Initial and residual risk assessment for air quality and greenhouse gas emissions

Factor	Phase	Potential impact	Unmitigated risk			EIS mitigation	Residual Risk		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
Air Quality	Construction	Dust emissions from activities, including reclamation, dredge spoil placement and stockpiles	Likely	Minor	Medium	Incorporation of a CAQMP into the CEMP. Inform adjoining neighbours of construction activities. Dust management controls including limiting movement of dusty materials when bushfire smoke levels are high, eliminating dust production at the source, use of water trucks and covering materials during transport.	Unlikely	Minor	Low
Air Quality	Construction	Emissions from plant and vessels	Likely	Minor	Medium	Incorporation of a CAQMP into the CEMP. Limit vehicle speed on site. Seal permanent roads and areas planned to be sealed as soon as practicable. Efficient operation of machinery, equipment, vehicles, ships and dredges to minimise emissions. Clean up residues and spills in a timely manner.	Unlikely	Minor	Low

Factor	Phase	Potential impact	Unmitigated risk			EIS mitigation	Residual Risk		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
Air Quality	Operations	Emissions from sandblasting and paint spraying	Likely	Minor	Medium	Incorporation of a CAQMP into the OEMP. Blast and paint facility to operate under negative pressure to ensure air emissions are released via roof vents. Air released to atmosphere via the roof exhaust stacks shall be passed through particulate, VOC and odour capturing filters prior to exhaust to the atmosphere. Test for lead paint before blasting. Develop procedures for spray painting and managing anti fouling paint. Minimise the use of hull stain removers. Storage of solvents and waste material in containers to prevent emissions . Keep spray guns and lines clean and well maintained.	Unlikely	Minor	Low
Air Quality	Operations	Emissions from operational traffic, vessels and plant	Likely	Minor	Medium	Incorporation of a CAQMP into the CEMP. Use of shore power while ships are at berth. Operate machinery and equipment to minimise exhaust emissions.	Unlikely	Minor	Low

Factor	Phase	Potential impact	Unmitigated risk			EIS mitigation	Residual Risk		
			Likelihood	Consequence	Risk		Likelihood	Consequence	Risk
Greenhouse Gas	Construction	Increase in greenhouse gas emission resulting in global warming	Possible	Moderate	Medium	Maintain equipment and vehicles to ensure engine and fuel efficiency. Reduce travel distances both on-site and off-site. Minimise idling time of plant and equipment and switch engines off when not in use. Minimise the extent of vegetation cleared during construction. Recycle any waste produced where feasible.	Unlikely	Moderate	Low
Greenhouse Gas	Operations	Increase in greenhouse gas emission resulting in global warming	Possible	Moderate	Medium	Consider NTG's towards 2050 policy. Procure power from renewable energy suppliers wherever possible. Prioritise the selection and use of electric vehicles and equipment if possible. Maintain equipment and vehicles to ensure engine and fuel efficiency.	Unlikely	Moderate	Low

12.0 Conclusion

This technical report presents the results of the AQIA and GHG assessment for the Project forming part of the EIS. Potential impacts to the surrounding air environment due to air emissions from construction and operational activities associated with the Project have been assessed, as well as estimates of GHG emissions during both construction and operation.

A quantitative air quality assessment using the air dispersion model CALPUFF was undertaken for the Project in accordance with the ToR and appropriate guidelines. Both construction and operational impacts were modelled for the Project to assess the potential impacts on the receiving existing environment at nearby sensitive receptors. A baseline assessment was conducted to identify existing meteorology, air quality conditions as well as the location of surrounding sensitive receptors. Background concentrations for pollutant species of concern have been adopted for the assessment considering available monitoring data from NT EPA air quality monitoring stations.

Emission sources for each scenario were identified and emission rates estimated based on published emission factors and Project specific data.

There were no exceedances of the identified goals for construction or operation for any pollutant or averaging period, and no significant impact was predicted for any pollutant at sensitive receptors.

Relevant mitigation commitments were identified and applied to the emission rates where applicable. Overall, the air quality assessment determined that no significant air quality or odour impacts are likely to occur as a result of the construction of operation phases of the Project and air quality monitoring is not deemed to be required for the Project.

GHG emission sources were identified for both the construction and operation phases, with Scope 1 and Scope 2 emissions estimated using NGER guidance and reference material. A comparison to the NT and Australian benchmark for reported emissions from 2019 data estimated a less than 1% contribution to total NGER reported emissions across the Industrial Processes and Product sector and all sectors.

The air quality and GHG impact assessment has found that air quality and GHG impacts from construction and operation of the Project are not expected to cause significant impact. Mitigation strategies have been recommended to further reduce pollutant emissions and GHG emissions.

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Appendix A

Construction contour maps

Appendix A Construction contour maps

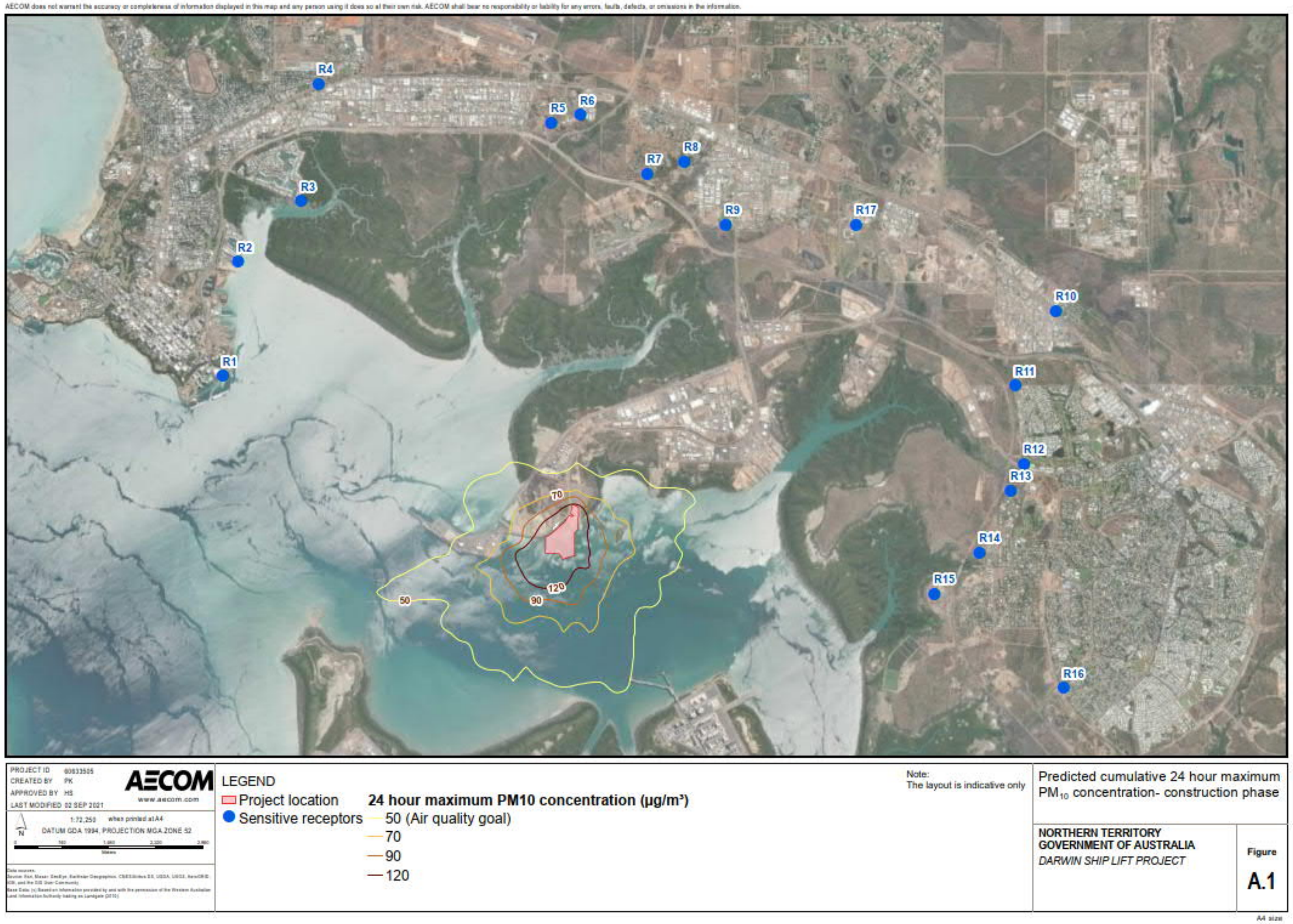


Figure A.1 Predicted cumulative 24 hour maximum PM_{10} concentration -construction phase

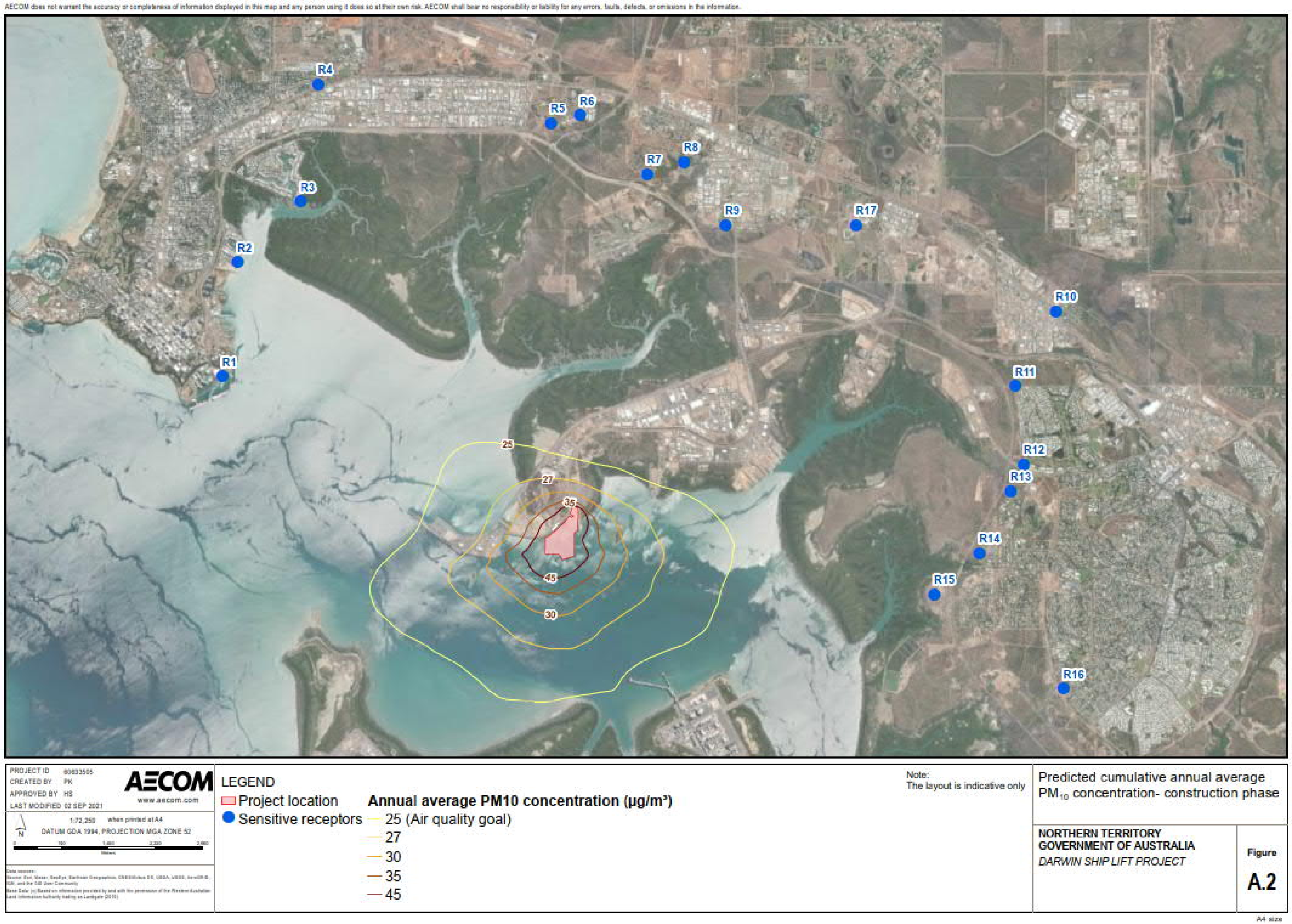


Figure A.2 Predicted cumulative annual average PM_{10} concentration -construction phase

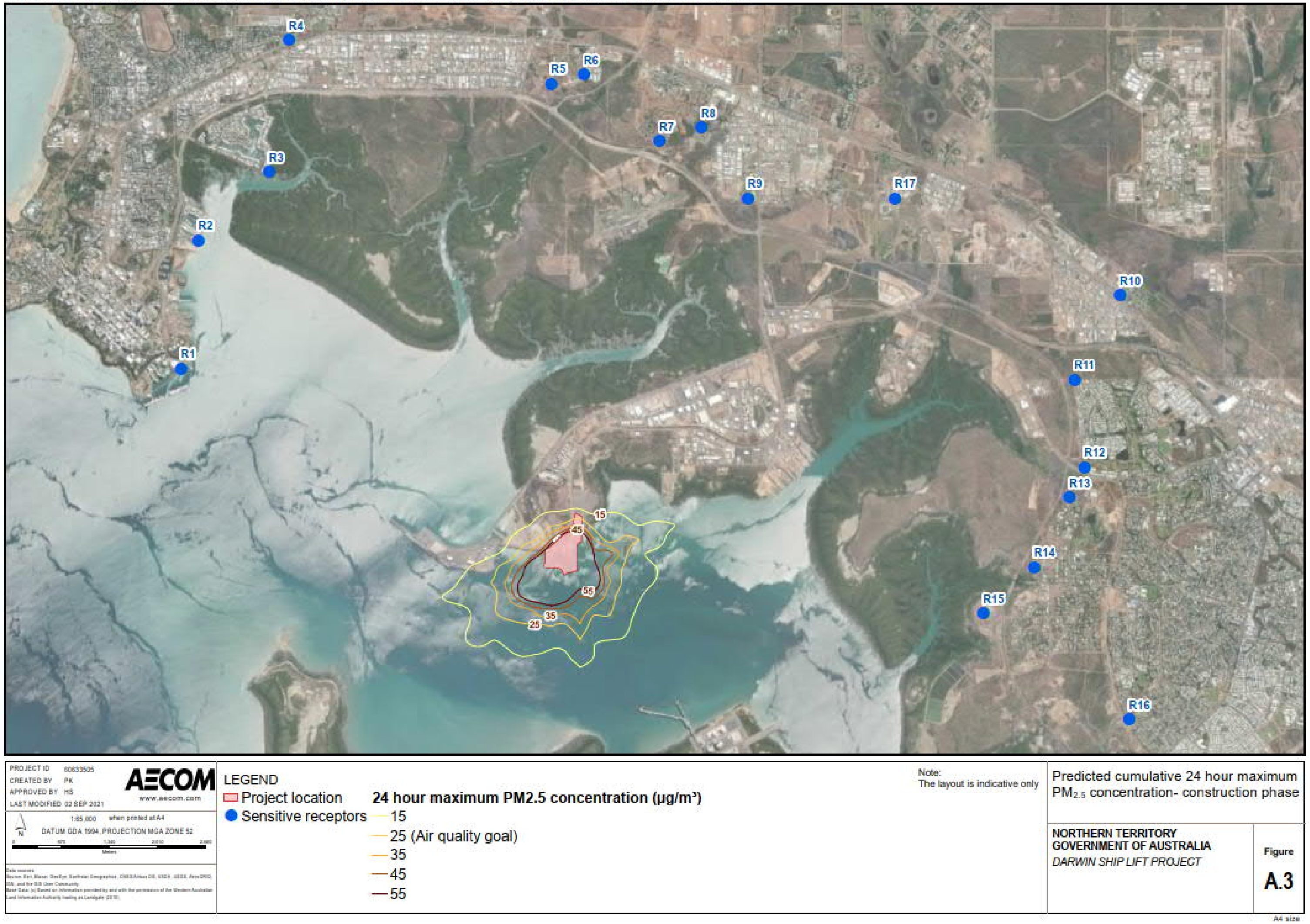


Figure A.3 Predicted cumulative 24 hour maximum $PM_{2.5}$ concentration -construction phase

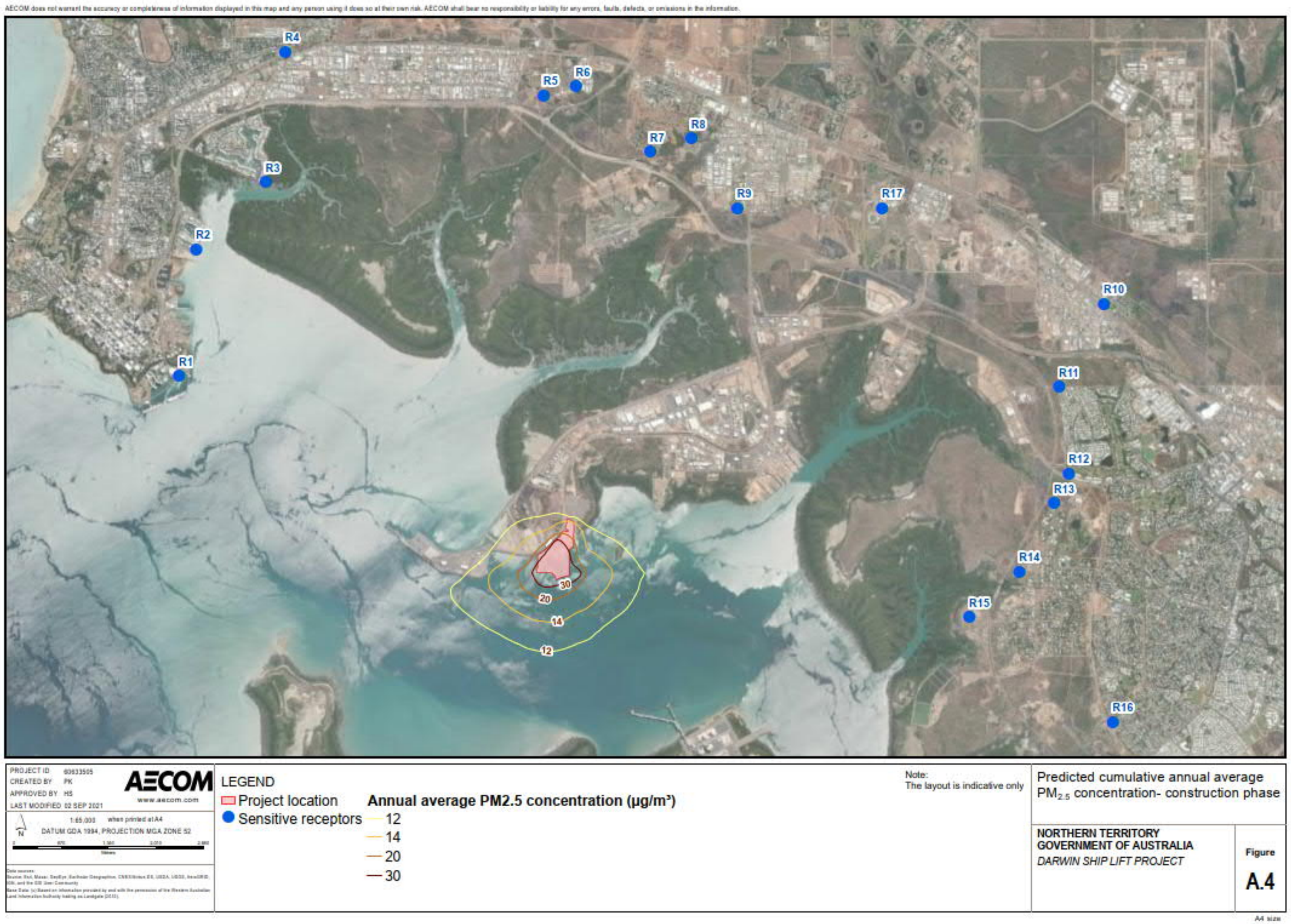


Figure A.4 Predicted cumulative annual average $PM_{2.5}$ concentration -construction phase

PROJECT ID 60633505
CREATED BY PK
APPROVED BY HS
LAST MODIFIED 02 SEP 2021
www.aecom.com
1:75,000 when printed at A4
DATUM GDA 1994, PROJECTION MGA ZONE 52
Metres

LEGEND
Project location
Sensitive receptors

1 hour maximum NO2 concentration (µg/m³)
- 90
- 100
- 120
- 160
- 200

Note:
The layout is indicative only

Predicted cumulative 1 hour maximum NO_2 concentration- construction phase

NORTHERN TERRITORY GOVERNMENT OF AUSTRALIA
DARWIN SHIP LIFT PROJECT

Figure **A.5**

A4 size

Figure A.5 Predicted cumulative 1 hour maximum NO_2 concentration -construction phase

Figure A.6 Predicted cumulative annual average NO_2 concentration -construction phase

Appendix B

Operation contour maps

Appendix B Operation contour maps

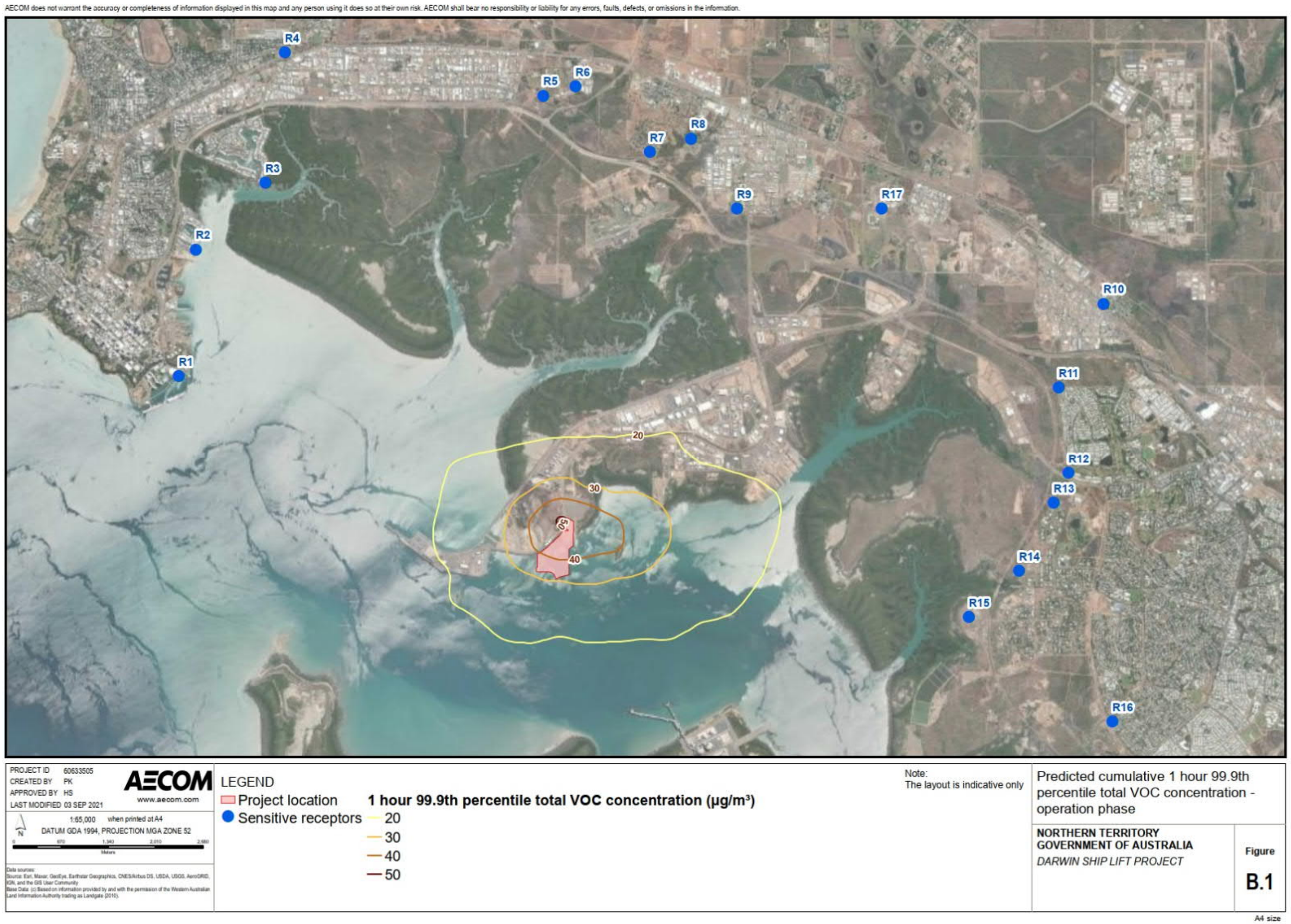


Figure B.1 Predicted cumulative 1 hour 99.9th percentile total VOC concentration- operation phase

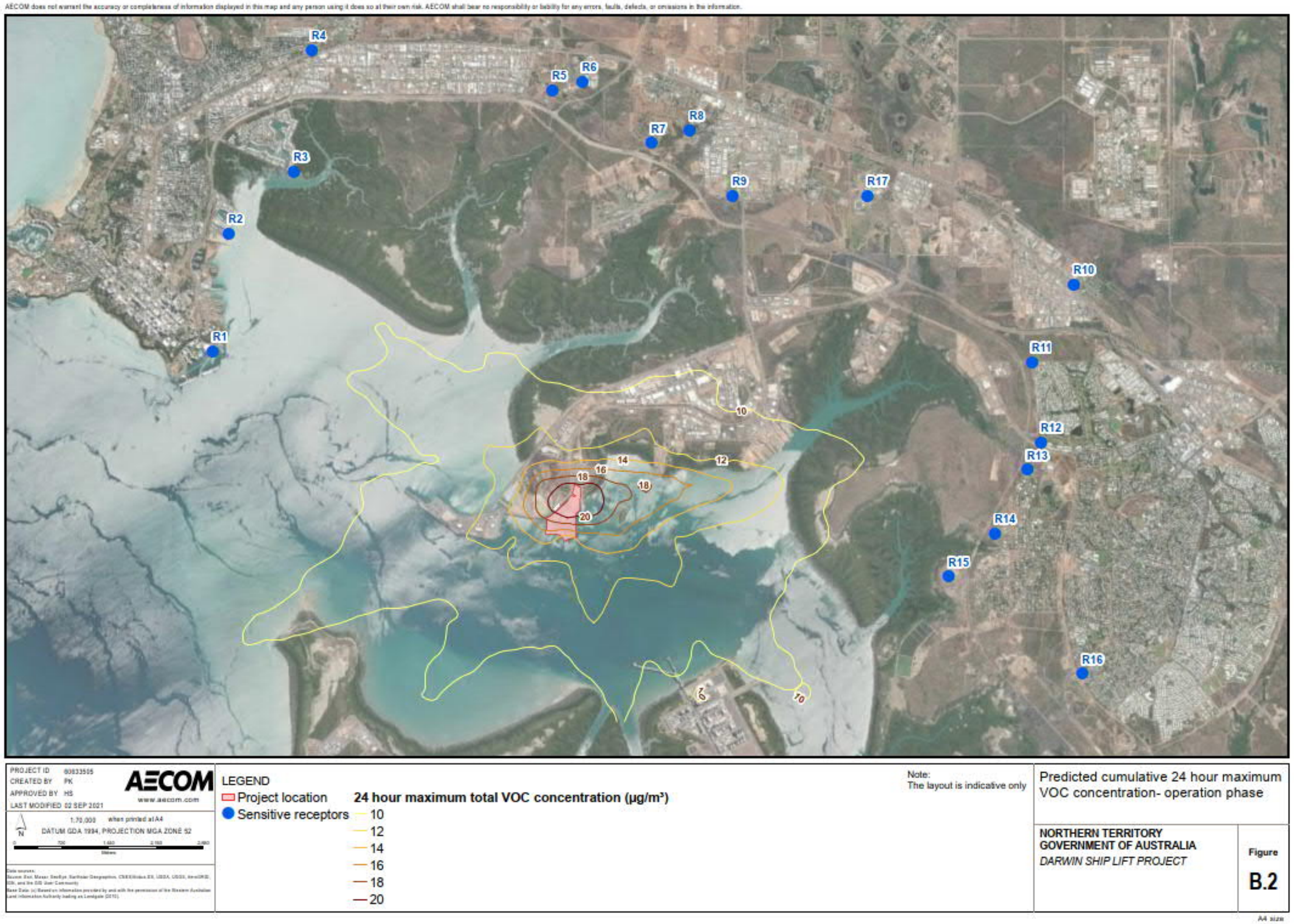


Figure B.2 Predicted cumulative 24 hour maximum VOC concentration- operation phase

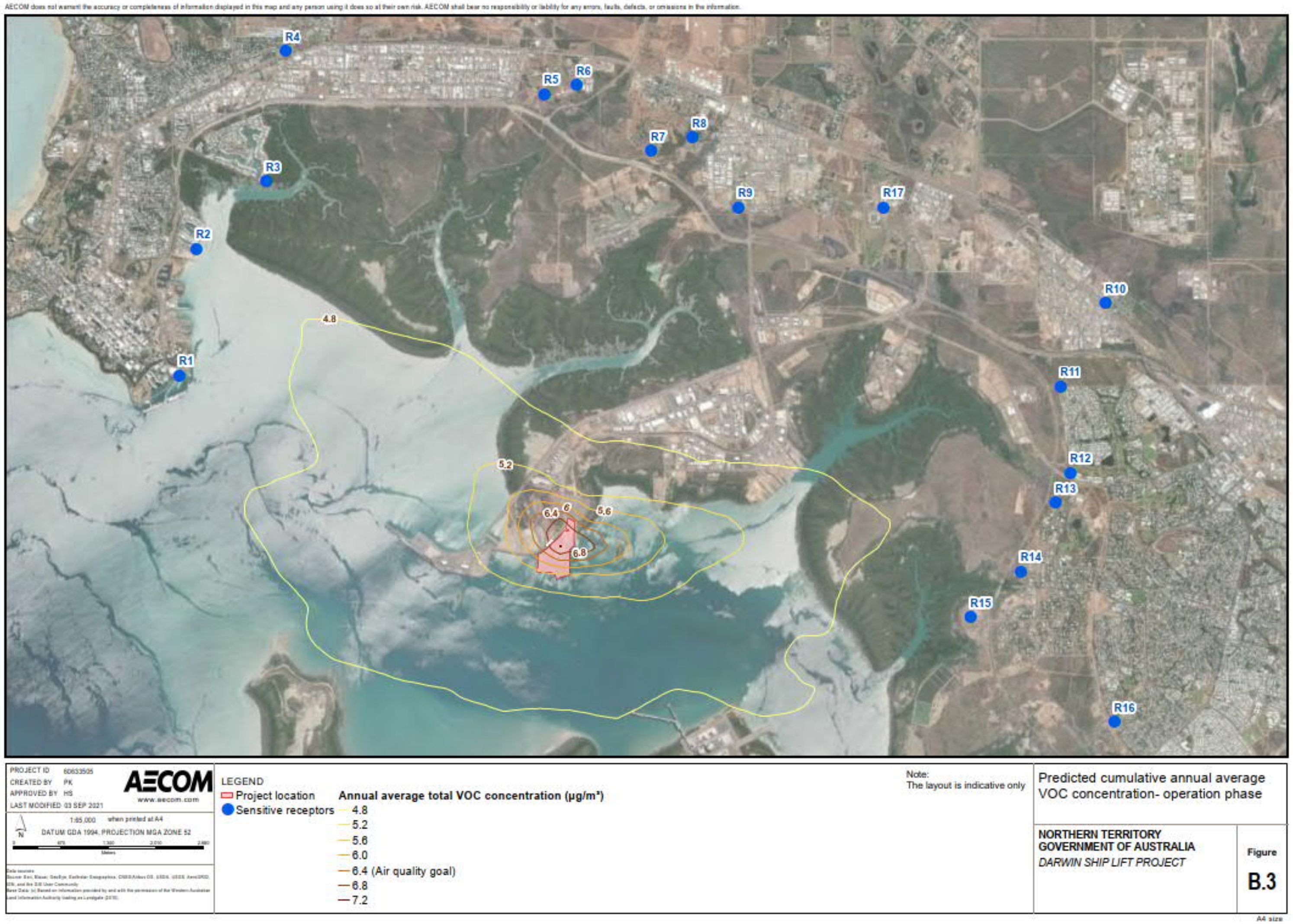


Figure B.2 Predicted cumulative annual average VOC concentration- operation phase

Appendix C

Meteorological Data Analysis

Appendix C Meteorological Data Analysis

Meteorological data

A full year of meteorological data (2019) was used to drive the air dispersion model, allowing predictions of potential air impacts due to Project construction and operational emissions for all diurnal and seasonal variations in meteorology. To ensure that the chosen year of meteorological data was representative of a typical year, the data were compared against long term trends in the region.

Meteorological data used in the dispersion modelling were developed with inputs from observational data measured at the nearby Bureau of Meteorology (BoM) Darwin Airport monitoring station. The BoM monitoring station is located approximately 7km to the north of East Arm; with the coordinates of the site are presented in **Table C.1**. Hourly meteorological data used in the modelling was averaged from one-minute data purchased from BoM. The data coverage periods reviewed are also presented in **Table C.1**.

Table C.1 Details of BoM stations included in the modelling

Station	Latitude/ Longitude	Distance from Project	Analysed data period
BoM Darwin Airport	-12.424 S, 130.893 E	7 km (north)	2001 - 2020

The nearby BoM Darwin Harbour monitoring station (7 km north west) was also considered for use in the modelling. Analysis of the wind roses for this station showed very few northern winds compared with Darwin Airport. To the north of the Darwin Harbour station is a headland that rises to about 40 m in elevation. This headland potentially blocks the winds from the north, channelling them around from either the northeast or north west. Based on this, the winds measured at this station may have caused unwanted bias against northerly winds in the CALMET model and the data was excluded from the modelling.

The main features of the generated data set and a comparison with long term meteorological data measured at the BoM Darwin Airport station is provided in this analysis. Note that the meteorological conditions for the single year of data used for the model would not match the long-term data exactly due to generally minor yearly variation in meteorology. The purpose of this section is to demonstrate that the general long-term trends are replicated satisfactorily by the 2019 data set.

Selection of the Meteorological Year

To select a representative year of meteorology for the assessment, CALMET was run for five years, 2015 to 2019. The predicted winds from each year of data were analysed, and the most suitable year selected for use in CALPUFF. At the time of data selection and meteorological analysis, data was available from the BoM Darwin Airport station for the period 2001 to 2019, however, running more than five years in CALMET is time-prohibitive and in general provides little benefit over a five-year period. Due to potential effects of climate change on meteorological patterns, the most recent five-year period was selected.

A review of the meteorological data from BoM Darwin Airport station for the years 2015 to 2019 was carried out to determine a representative year of data for use in the CALMET modelling. Consideration was given to a range of different parameters, including wind speed & direction, percentage of calms and their comparison to the long-term BoM trends.

Average wind speeds and calms frequency by hour of day for the BoM stations are for the period 2015 to 2020 are presented in **Figure C-1**. The year 2015 showed higher overall wind speeds and fewer calms both at night and during daytime hours than the other four years. Higher wind speeds tend to assist dispersion of pollutants more rapidly and may not provide the most conservative input data for the model. Of the remaining four years, there is little difference between them, although 2016 appears to have slightly higher wind speeds and fewer calm hours.

The years 2017, 2018 and 2019 were very similar, although 2019 does show a higher frequency of calms at around 5 am compared with all the other years. Overall, any of 2017, 2018 or 2019 would be a reasonable choice of year based on this preliminary analysis.

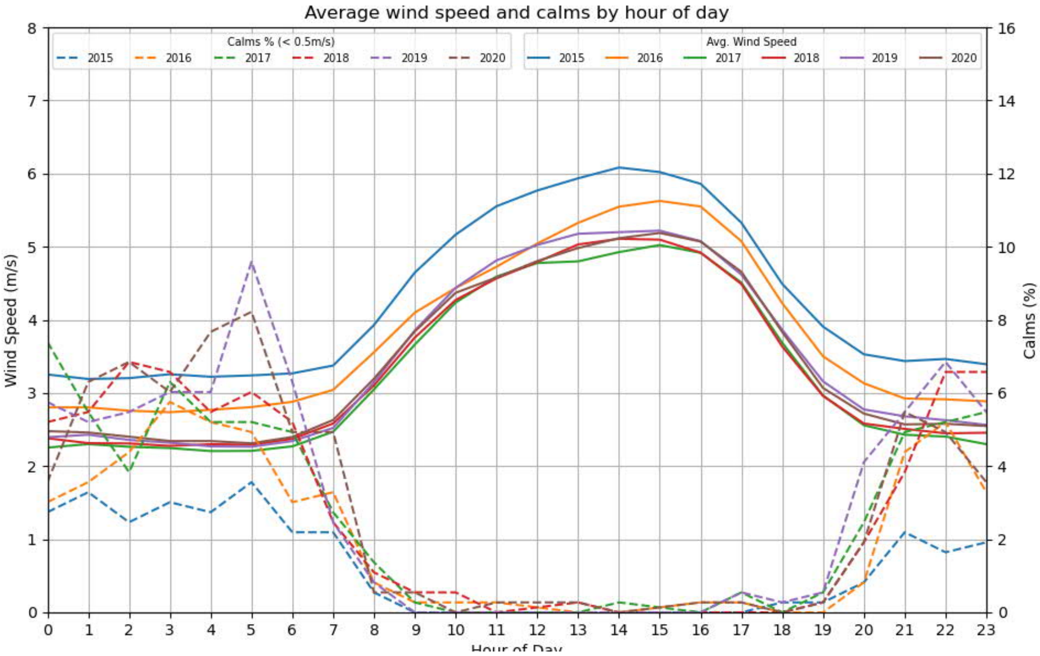


Figure C-1 Darwin Airport – wind speed and calms comparison by hours of day – 2015 to 2020

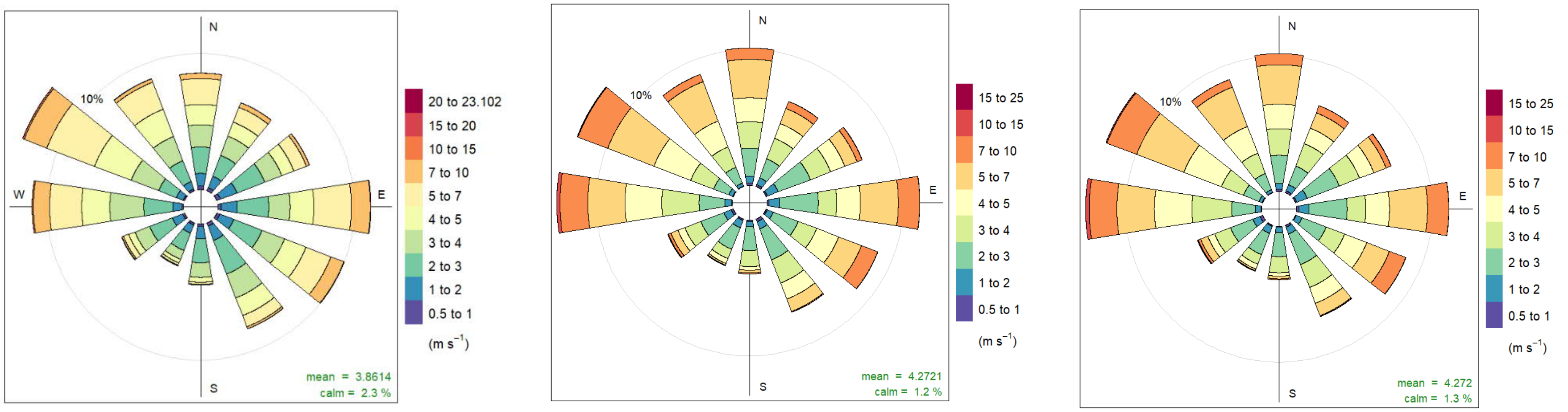
CALMET was run for the period 2015 to 2019 using surface observational data from the BoM Darwin Airport station and upper air data from TAPM. Wind data for each year were analysed to determine which year was performing best against long term trends. Wind data for each year (2015 to 2019) in the predicted CALMET data, extracted at the Darwin Airport BoM location and the Project location, are compared against the long term (2001 to 2020) observational data from Darwin Airport in **Figure C-2** to **Figure C-6**.

The comparison shows that both 2015 (4.3 m/s) and 2016 (3.8 m/s) displayed higher average wind speeds than the long-term Darwin Airport average of 3.8 m/s. The years 2017 (3.3 m/s), 2018 and 2020 (both 3.4 m/s) displayed lower average winds speeds, while 2019 was the closest with 3.6m/s.

The percentage of calms was highest in the 2019 CALMET data, with about 2.8 % at the Darwin Airport BoM location and 3.1 % at the Project site. This is slightly higher than the long-term average of 2.1 % in the BoM data. A higher percentage of calms is typically conservative in air dispersion models as pollutant dispersion is reduced (meaning higher concentrations further from the source) during calm conditions.

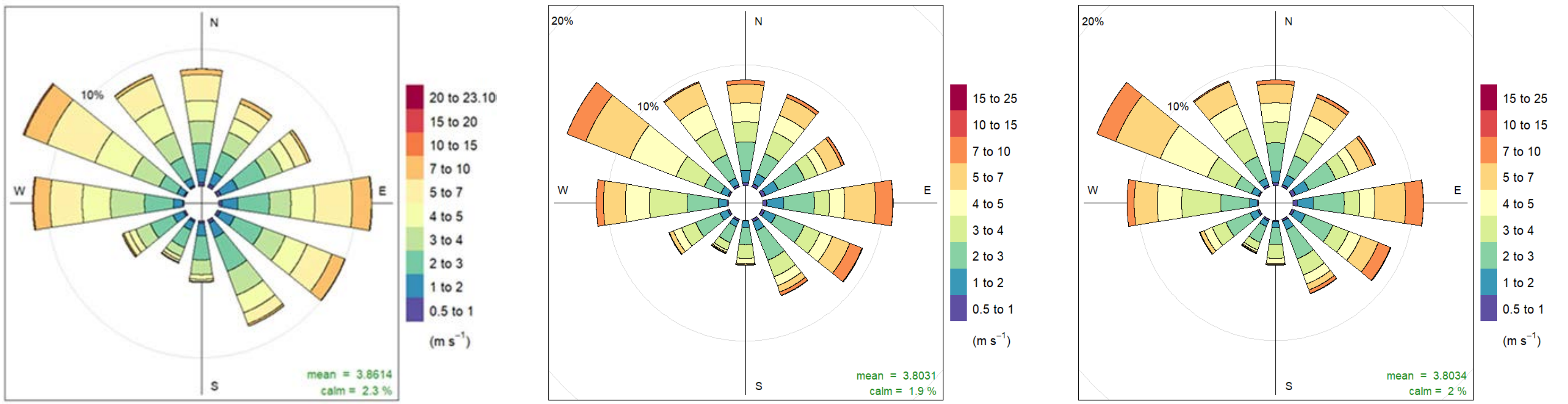
In terms of wind direction, annual wind frequency distribution for each of the five years examined, was relatively consistent with long term observations. There is a slightly higher frequency of westerly winds (compared with north-west winds) in the 2019 CALMET data, which could be slightly conservative given that west winds would blow emission from the Project more towards the receptors to the east of the Project site. This is also reflected in the meteorological data gathered from BoM. There are also fewer northerly winds in the 2019 CALMET data. There are no receptors to the south of the Project site, so the inclusion of less northerlies would be more conservative.

Based on this assessment of winds, the 2019 CALMET data appeared to be the most suitable and was selected for use in this assessment; and is considered both representative of local meteorological conditions and long-term data.



Darwin Airport 2001-2020 | CALMET Darwin Airport Location 2015 | CALMET Project Location 2015

Figure C-2 Annual wind rose comparison – CALMET 2015



Darwin Airport 2001-2020 | CALMET Darwin Airport Location 2016 | CALMET Project Location 2016

Figure C-3 Annual wind rose comparison – CALMET 2016

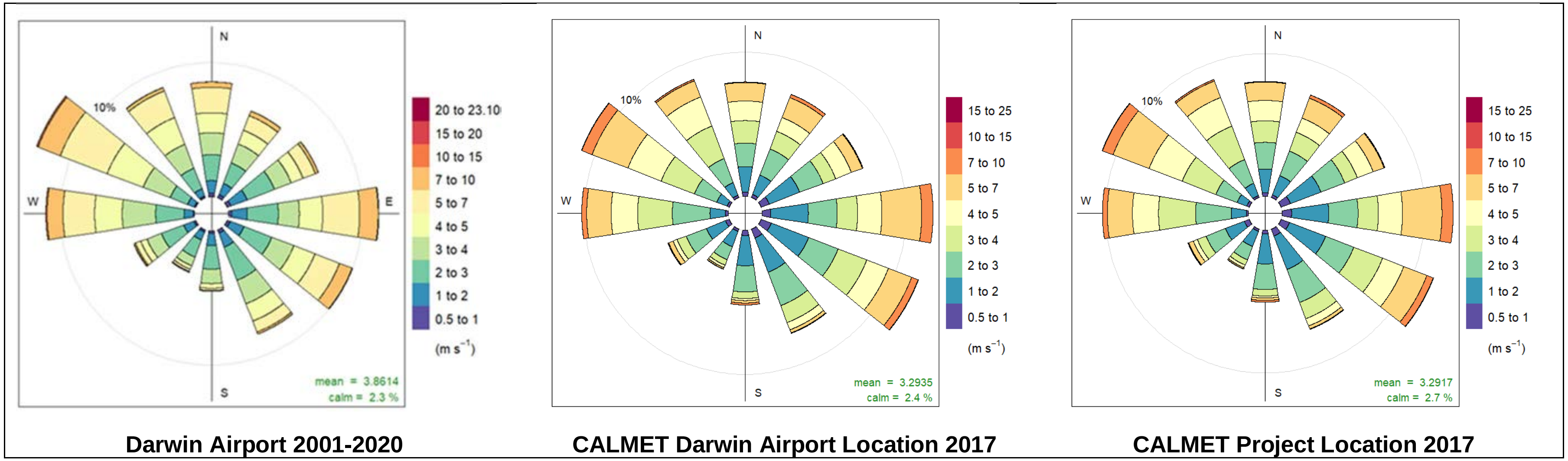


Figure C-4 Annual wind rose comparison – CALMET 2017

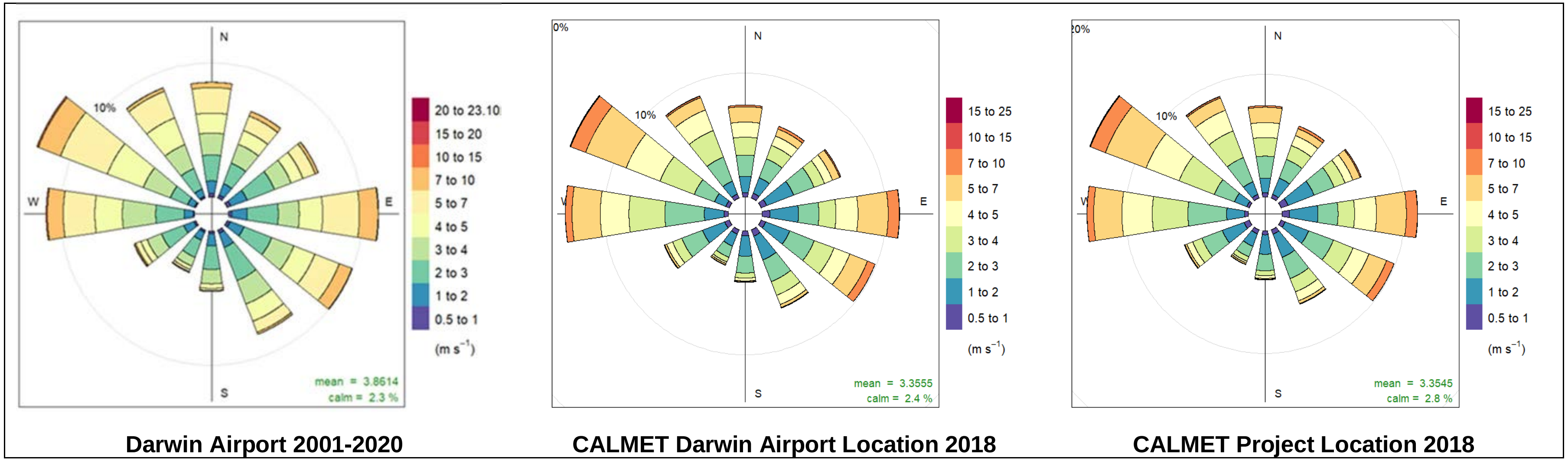


Figure C-5 Annual wind rose comparison – CALMET 2018

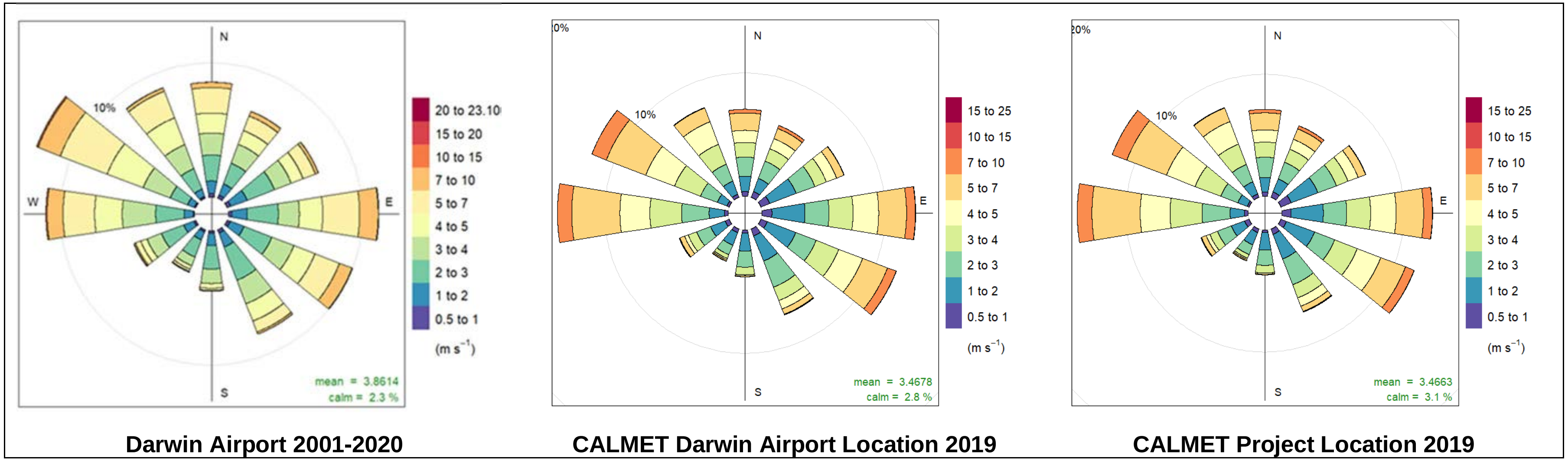


Figure C-6 Annual wind rose comparison – CALMET 2019

Monthly wind roses for Darwin Airport BoM (2001 to 2020) are presented in **Figure C-7**. The Darwin region shows a strong monsoonal wind pattern with winds blowing mostly from the west and north-west during the wet season (December to April), and from the east and south-east during the dry season (May to August). Winds in summer are slightly stronger than those in winter. The months of spring a charactered by are a transition period between wet and dry season meteorological characteristics.

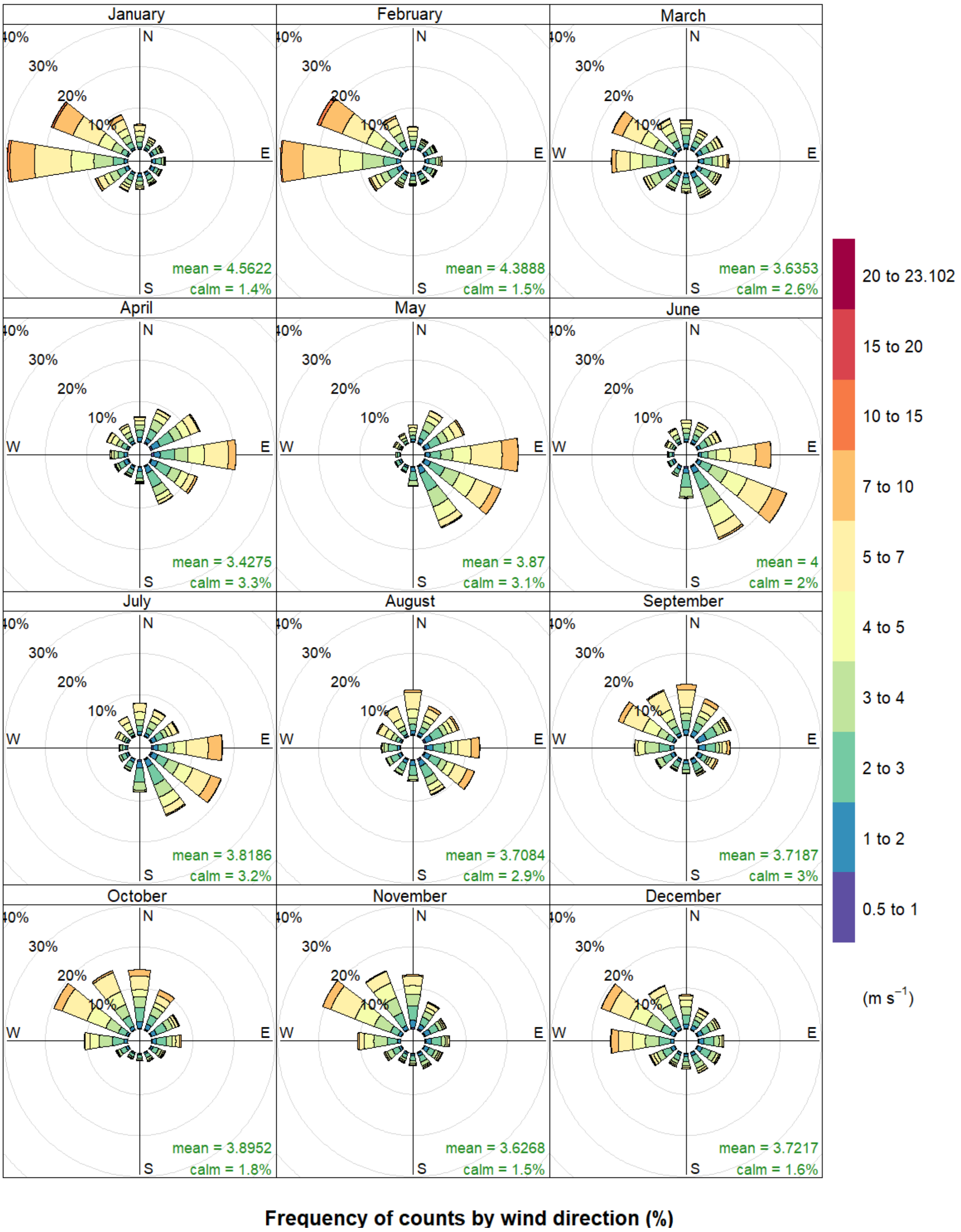


Figure C-7 Monthly wind roses – Darwin Airport BoM 2001-2020

Monthly CALMET 2019 wind roses are presented in **Figure C-8**. These show a good correlation to the long-term BoM wind roses showed in **Figure C-7**, with the strong monsoonal flows particularly apparent in January and February.

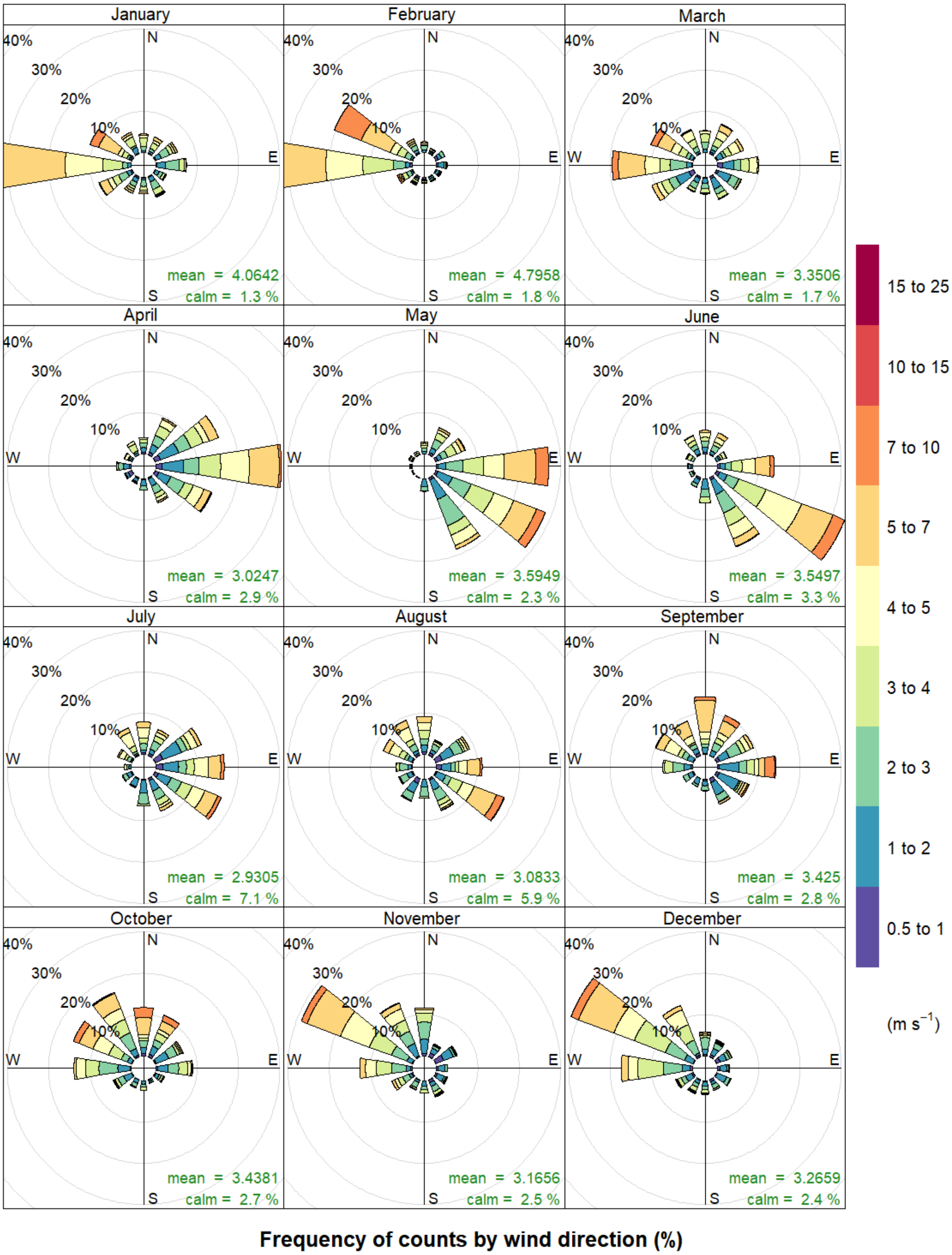


Figure C-8 Monthly wind roses – CALMET 2019 at the Project site

Atmospheric Stability

Stability is a measure of the convective properties of a parcel of air. Stable conditions occur when convective processes are low, while unstable conditions are associated with stronger convective processes, which are associated with potentially rapid changes in temperature. Stable atmospheres occur when a parcel of air is cooler than the surrounding environment, so the parcel of air (and any pollution within it) sinks. Conversely, unstable atmospheres occur when a parcel of air is warmer than the surrounding environment, making the parcel of air buoyant and, subsequently, leading to the parcel of air rising.

Stability class data extracted from the CALMET files at the Project location were analysed. The following chart shown in **Figure C-9** indicates stability classes designated as 1 to 6, which correspond to the Pasquill-Gifford A – F stability class designations (1 corresponds to A class and 6 corresponds to F class). Classes A, B and C (or 1, 2 and 3) represent unstable conditions, with class A representing very unstable conditions and C representing slightly unstable conditions. Class D (4) stability corresponds to neutral conditions, which are typical during overcast days and nights. Classes E and F (5 and 6) correspond to slightly stable and stable conditions respectively, which generally occur at night.

As expected, the stability classes indicate stable conditions during the night hours and neutral or unstable conditions during the day. The stability classes were then plotted by wind speed as shown in **Figure C-10**. As expected, the highest wind speeds (> 4 m/s) were associated with neutral conditions. Lower wind speeds (<3 m/s) are mostly associated with neutral or stable conditions. This represents a typical pattern of stability and shows that CALMET is performing well at the Project site.

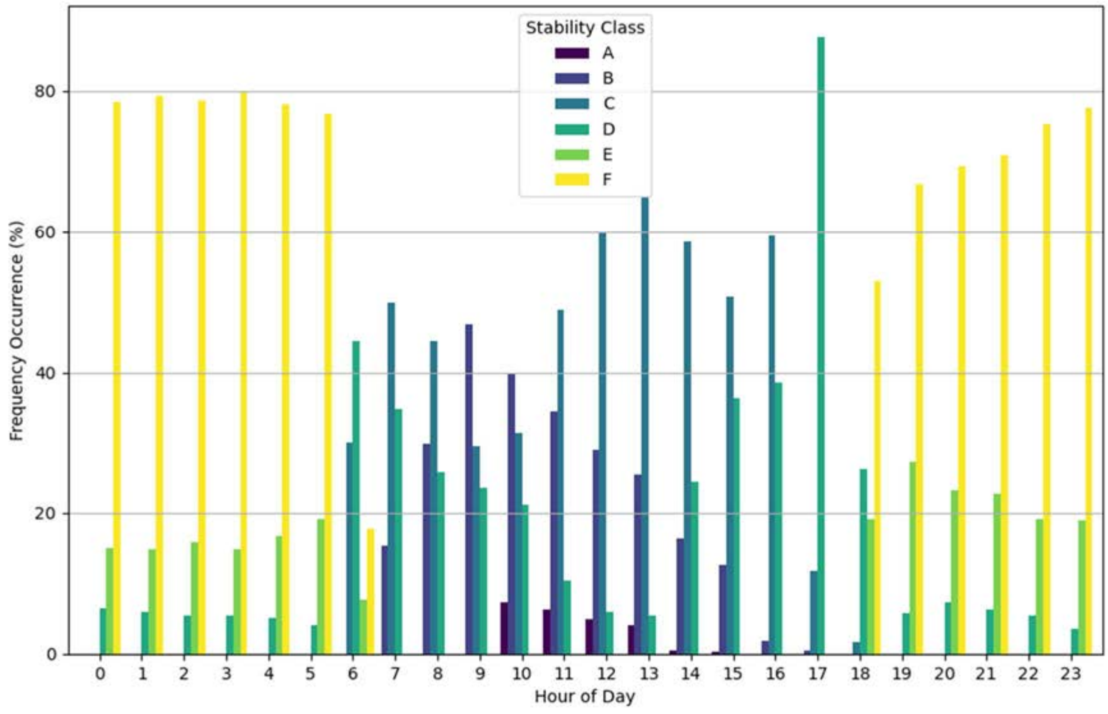


Figure C-9 CALMET hourly stability class frequency at the Project site

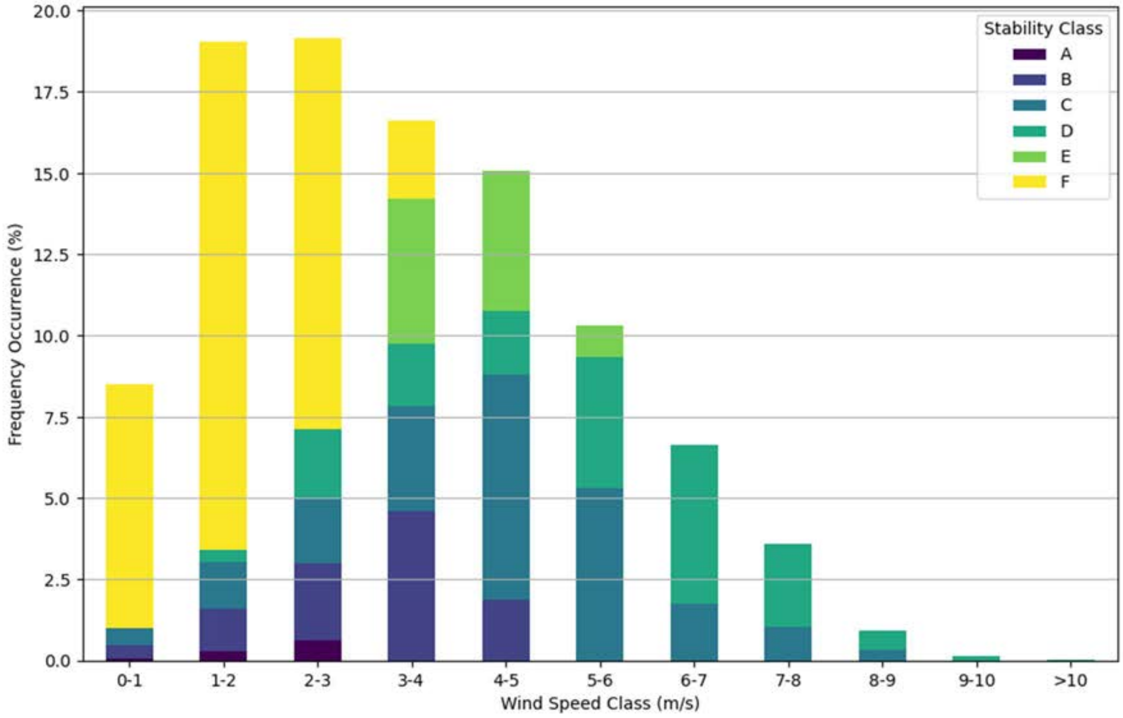


Figure C-10 CALMET stability class frequency by wind speed at the Project site

Mixing Height

Mixing height is estimated within CALMET for stable and convective conditions (respectively), with a minimum mixing height of 50 m. **Figure C-11** presents average mixing height by hour of day at the Project site, as generated by CALMET. These results are consistent with general atmospheric processes that show increased vertical mixing with the progression of the day, as well as lower mixing heights during night-time. In addition, peak mixing heights are consistent with typical ranges.

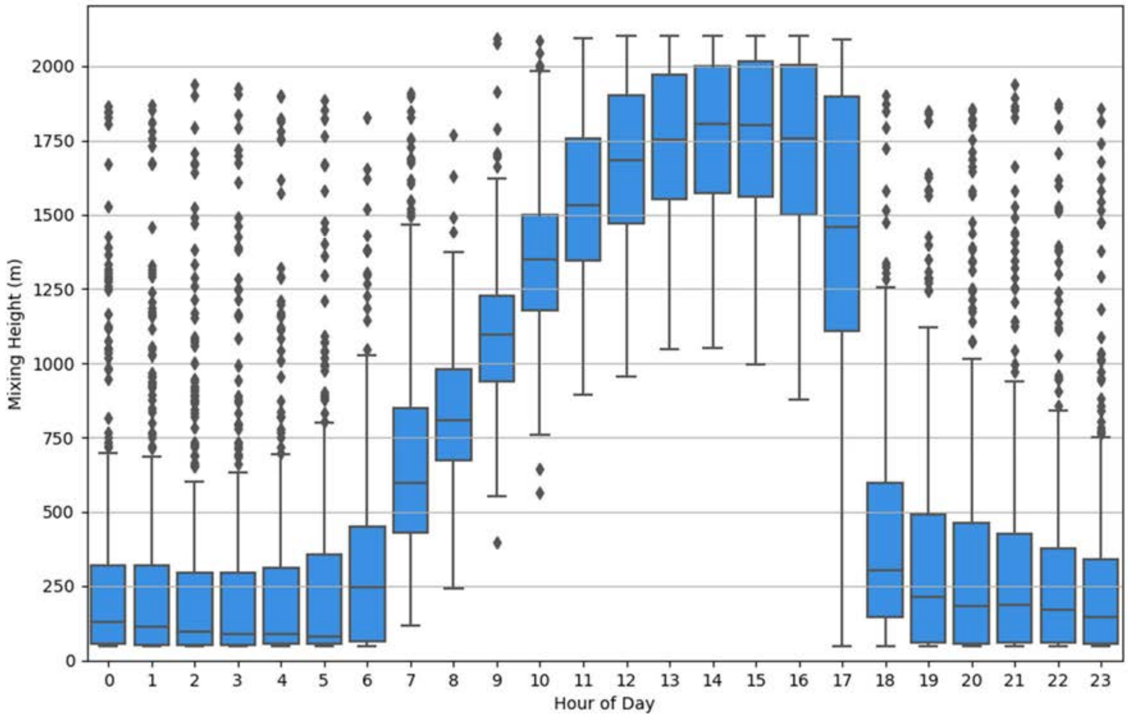


Figure C-11 CALMET average mixing height by hour of day at the Project site

Temperature

Temperature statistics for the CALMET data at the Project site are presented in **Figure C-12**. The data shows a typical pattern that is expected in the Darwin area, with only a small variation in average maximum temperatures across the year. Average minimum temperatures drop slightly during the dry season (May to August) with hourly temperature predictions ranging from around 14 degrees Celsius (on winter mornings) to about 37 degrees Celsius (summer afternoons). The average monthly minimum for BoM data, discussed in Section 5.1 is 19.3 degrees Celsius, which is reflected here

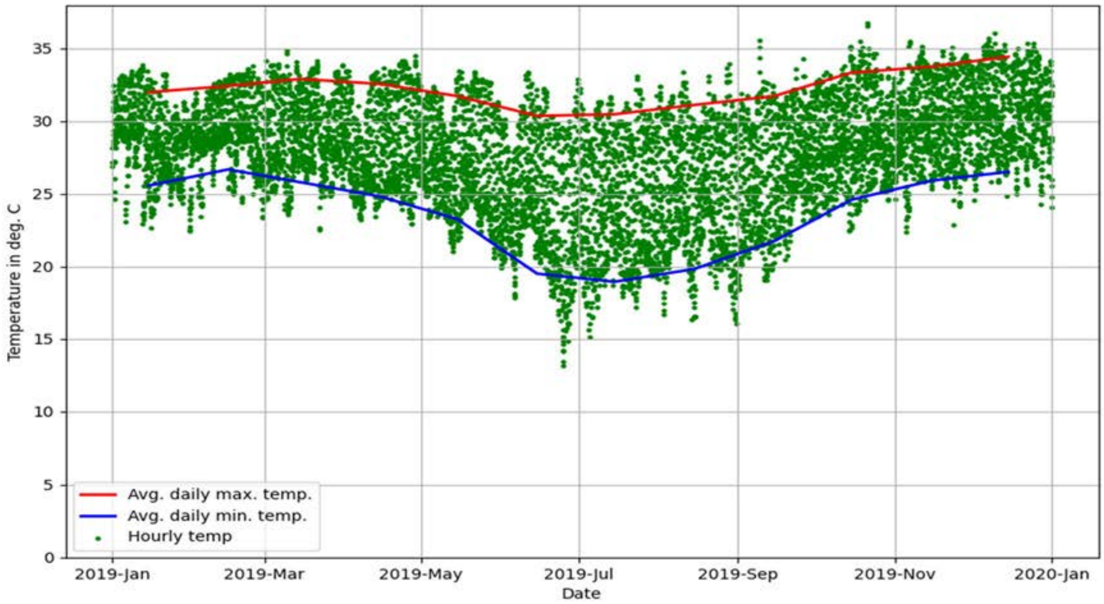


Figure C-12 CALMET temperature statistics by hour of day at the Project site

Summary of 2019 CALMET Dataset

The analysis of the 2019 CALMET dataset presented in this appendix shows that CALMET is performing well compared with long term weather observations at the nearby BoM Darwin Airport station. The CALMET dataset is expected to provide a representative description of meteorology at the Project site and is therefore suitable for use in CALPUFF for this assessment.