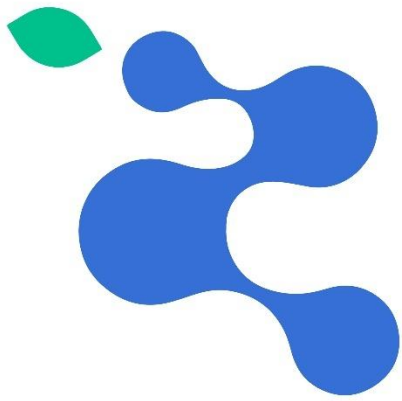


Appendix I

Air Quality and Greenhouse Gas Assessment



Zephyr

Environmental

Supagas Carbon Dioxide Plant at the Wilga Park Power Station at the Wilga Park Power Station

Air Quality and Greenhouse Gas Assessment

Project Number.: 0372

Date: 20 April 2026



SUPAGAS
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Zephyr Environmental is committed to contributing to the achievement of the UN Sustainable Development Goals (SDG) through the work we do. This report incorporates the themes of SDG 8 and 13.



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Acronyms and Abbreviations

Name	Description
AAQ-NEPM	National Environment Protection (Ambient Air Quality) Measure
AERMAP	Terrain pre-processor for AERMOD
AERMET	Meteorological data pre-processor for AERMOD
AERMOD	Air Quality Dispersion Modelling
AHD	Australian Height Datum
AQGHGA	Air Quality and Greenhouse Gas Assessment
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CO ₂	Carbon dioxide
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EIS	Environmental Impact Statement
GHG	Greenhouse gas
IAQM	Institute of Air Quality Management
IPCC	Intergovernmental Panel on Climate Change
KL	Kilolitres
m/s	Metres per second
NASA	National Aeronautics and Space Administration
NEPC	National Environment Protection Council Service Corporation
NEPM	National Environment Protection Measures
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
NO	Nitric oxide
NO _x	Nitrogen oxides
NO ₂	Nitrogen dioxide
NSW	New South Wales
NSW EPA	(NSW) Environment Protection Authority
O ₃	Ozone
SO ₂	Sulfur dioxide
SPCC	State Pollution Control Commission of NSW
SRTM	Shuttle Radar Topography Mission
US EPA	United States Environmental Protection Agency
WHO	World Health Organisation
WPPS	Wilga Park Power Station
WRF	Weather Research and Forecasting Model
µg/m ³	Micrograms per cubic metre

EXECUTIVE SUMMARY

Zephyr Environmental (Zephyr) has been commissioned by Onward Consulting Pty Ltd (Onward) on behalf of Supagas Pty Ltd (Supagas) to prepare an air quality and greenhouse gas assessment (AQGHGA) for the Supagas carbon dioxide (CO₂) plant. Supagas is seeking to construct and operate a CO₂ plant, which would connect to the adjacent Wilga Park Power Station (WPPS) operated by Santos. The CO₂ plant would capture and process exhaust gases from the WPPS gas generators and output a high purity CO₂ product for export and use in the food, beverage, and other markets (the Project).

The assessment has considered impacts during both the construction phase and the operational phase of the Project. The assessment was prepared in accordance with the NSW EPA “*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*” (Approved Methods) (EPA, 2022).

The construction dust assessment identified that there are no sensitive residential receivers within a 250 m distance (the nominated buffer distance), with the closest of these receivers being 980 m away. Given that there are no human receivers within 250 m of the development footprint, the screening assessment (Step 1) notes that there is no need for a detailed assessment for the construction phase. Good practice mitigation measures have been provided in this report for completeness. Additional guidance on the control of dust at construction sites in NSW is provided as part of the NSW EPA Local Government Air Quality Toolkit.

A review of proposed and existing emissions to air for the Project and the adjacent WPPS during the operational phase have identified six pollutants for consideration: nitrogen oxides (NO_x) / nitrogen dioxide (NO₂), ammonia (NH₃), carbon monoxide (CO), benzene, toluene and hydrogen sulfide (H₂S). All of the mentioned pollutants have been included in the dispersion modelling. For NO₂ and CO, available background concentrations have been included as part of a cumulative assessment.

The dispersion modelling accounts for the local meteorology and terrain information and uses emission estimates to predict the air quality impacts for operations. The results of the dispersion modelling indicate that all pollutants and averaging periods assessed show compliance with assessment criteria for gridded and discrete sensitive receptors, including background concentrations where available.

For the greenhouse gas assessment, there is only Scope 2 emissions from electricity consumption. The proposed Project contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the operations (approximately 0.007 Mt CO₂-e) would represent approximately 0.002% of Australia's commitment under the Paris Agreement.

Based on its planned operational throughput and design, this project does not emit above the threshold of 25,000 tonnes of CO₂-e scope 1 and 2 GHG emissions in any financial year during its operational life and is therefore not regarded as a large emission project.

Overall, this quantitative air quality and greenhouse gas assessment concludes that the proposed Project is not anticipated to result in adverse air quality impacts.

1 INTRODUCTION

Zephyr Environmental (Zephyr) has been commissioned by Onward Consulting Pty Ltd (Onward) on behalf of Supagas Pty Ltd (Supagas) to prepare an air quality and greenhouse gas assessment (AQGHGA) for the Supagas carbon dioxide plant.

Supagas is seeking to construct and operate a carbon dioxide (CO₂) plant, which would connect to the adjacent Wilga Park Power Station (WPPS). The CO₂ plant would capture and process exhaust gases from the WPPS gas generators and output a high purity CO₂ product for export and use in the food, beverage, and other markets (the Project).

This assessment report covers the following:

- Project description and assessment overview (Section 2)
- Local setting (Section 3)
- Air quality assessment criteria (Section 4)
- Local meteorology (Section 5)
- Baseline air quality (Section 6)
- Construction assessment (Section 7)
- Emissions to air during operations (Section 8)
- Operational impact assessment (Section 9)
- Greenhouse gas assessment (Section 10)
- Conclusions (Section 11)

2 PROJECT DESCRIPTION AND ASSESSMENT OVERVIEW

2.1 Project description

The Project would be located wholly within Lot 12 of DP 1171292 in the Narrabri Local Government Area (LGA), approximately 12 km south-west of Narrabri, NSW.

The Project includes the construction and operation of a CO₂ plant, which would capture and process exhaust gas from gas generators within the WPPS.

This exhaust gas would be treated to produce a CO₂ product of food grade quality for export and use in the food, beverage, and other markets (the Project). The Project would produce approximately 72 tonnes per day (tpd) of liquid CO₂, with allowance for storage of approximately 800 tonnes (t) of liquid CO₂ prior to delivery off-site.

The key activities for the Project are as follows:

- clearing and earthworks for site preparation and to enable construction of the Project
- construction of the Project
- operation of the Project, including export of the CO₂ product via road transport

The main emissions to air from this project will be:

- particulate matter during the construction phase
- nitrogen (N₂), oxygen (O₂), nitric oxide (NO), ammonia (NH₃), benzene, toluene and hydrogen sulfide during the operational phase.

The Project would be designated development and require approval under Part 4 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act). Further, the Project meets the requirements for Regionally Significant Development under the State Environmental Planning Policy (Planning Systems) 2021 (SEPP Planning Systems). An Environmental Impact Statement (EIS) is being prepared for the Project, lodged with the Narrabri Shire Council and determined by the Northern Regional Planning Panel. This air quality and greenhouse gas assessment will form part of the EIS.

2.2 Assessment overview

This air quality and greenhouse gas assessment will form part of the EIS and will assess impacts during both the construction phase and operational phase of the Project.

The methodology for the construction assessment involved the application of a semi-quantitative risk-based approach following the guidance developed by the UK Institute of Air Quality Management (IAQM).

The assessment of the operational phase included preparation of an emissions inventory and dispersion modelling to predict pollutant concentrations at sensitive receptors. The operational assessment focuses on the following pollutants, which have all been identified as being released to air during a review of the proposed stack data:

- Nitrogen oxides (NO_x) / nitrogen dioxide (NO₂)
- Ammonia (NH₃)
- Carbon monoxide (CO)
- Benzene
- Toluene
- Hydrogen sulfide (H₂S)

The greenhouse gas assessment provides a calculation of scope 1 and 2 GHG emissions during the construction phase, and also for each year of operation for the life of the Project.

3 LOCAL SETTING

The Project would be located wholly within Lot 12 of DP 1171292 in the Narrabri Local Government Area (LGA), approximately 12 km southwest of Narrabri, NSW.

Table 3-1 presents the sensitive receptor locations. Figure 3-1 presents the proposed operation location and sensitive receptors.

Table 3-1: Sensitive receptor locations

ID	MGA Zone 55 Easting (m)	MGA Zone 55 Northing (m)
1	756350	6643302
2	758425	6642812
3	761373	6639339
4	760901	6639684
5	756895	6632962
6	756848	6633297
7	759787	6634050
8	753846	6635023
9	760129	6636618
10	754215	6636842
11	761232	6636996
12 (existing agreement with Santos)	758042	6637268
13 (existing agreement with Santos)	757990	6637341
14	761610	6637317
15	753747	6637685
16	759730	6637599
17 (WPPS)	757303	6637940
18	754214	6638017
19	754285	6638301
20	759689	6638967
21	761617	6639025
22	756319	6639188
23	754429	6639348
24	755703	6639581
25	759348	6639586
26	758923	6639648
27	758217	6639709
28	761418	6639646
29	759970	6639739
30	761903	6639793
31	760383	6639890

ID	MGA Zone 55 Easting (m)	MGA Zone 55 Northing (m)
32	757488	6639966
33	752147	6640094
34	757095	6640082
35	760366	6640199
36	760200	6640240
37	758681	6640313
38	761640	6640250
39	760725	6640291
40	759758	6640316
41	758943	6640356
42	755404	6640488
43	756377	6640467
44	760122	6640384
45	760944	6640418
46	761528	6640441
47	759386	6640546
48	754508	6640697
49	761229	6640549
50	756174	6640742
51	759576	6641032
52	760724	6641858

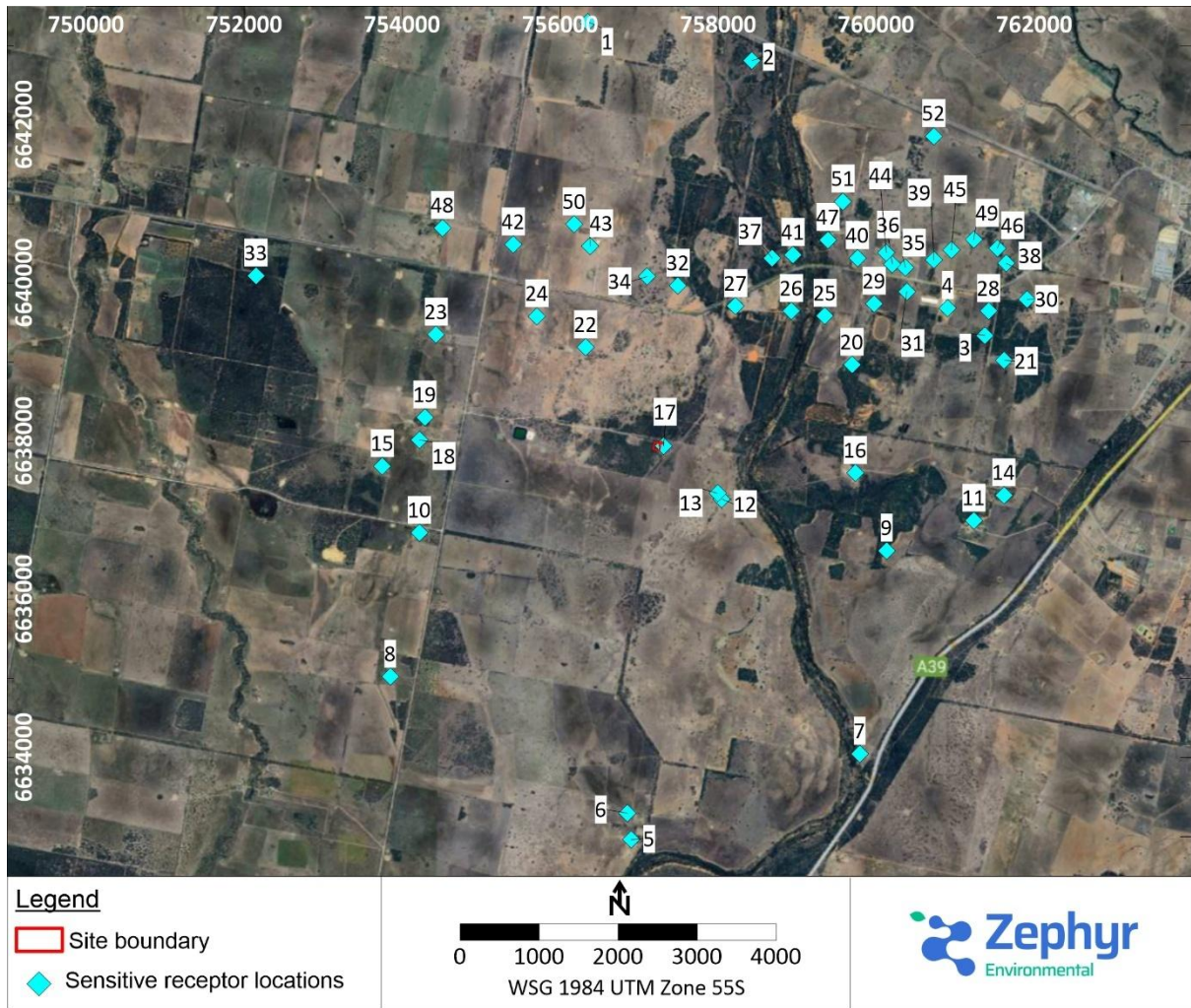


Figure 3-1: Sensitive receptor locations in proximity to existing and proposed operations

4 AIR QUALITY ASSESSMENT CRITERIA

Air quality is assessed in relation to criteria for the pollutants that are set out in the legislation. Regulated air pollutants are divided into 'criteria' pollutants and 'air toxics'.

The 'criteria' pollutants relevant to this study are:

- NO₂
- Carbon monoxide (CO)

The 'air toxics' for this project are:

- Ammonia (NH₃)
- Benzene
- Toluene

In addition, another pollutant for consideration in this assessment is hydrogen sulfide which is not classed as a 'criteria' pollutant or an 'air toxic'. This is discussed further below.

The NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (Approved Methods) specifies air quality criteria relevant for assessing impacts from these air pollutants (EPA, 2022). These criteria are health-based and for NO₂ are consistent with the revised National Environment Protection Measure for Ambient Air Quality (referred to as the AAQ-NEPM).

Table 4-1 presents the air quality criteria for concentrations of pollutants that are relevant to this study. The criteria selected are for cumulative impacts and existing background concentrations have been included in the predicted results, where available.

Table 4-1: NSW EPA impact assessment criteria

Pollutant	Averaging period	Criterion
NO ₂	Maximum 1-hour average	164 µg/m ³
	Annual average	31 µg/m ³
Carbon monoxide (CO)	1 hour	30 mg/m ³
	8 hours	10 mg/m ³
Ammonia (NH ₃)	1 hour	0.33 mg/m ³
Benzene	1 hour	0.029 mg/m ³
Toluene	1 hour	0.36 mg/m ³

For hydrogen sulfide, the Approved Methods provides a summary of appropriate impact assessment criteria as a function of population density and this is provided in Table 4-2. Whilst the Project is located away from large urban areas, to be conservative the 1.38 µg/m³ assessment criteria has been used.

Table 4-2: Hydrogen sulfide impact assessment criteria

Population of affected community	Impact assessment criteria ($\mu\text{g}/\text{m}^3$)
Urban (≥ 2000)	1.38
~500	2.07
~125	2.76
~30	3.45
~10	4.14
Single residence ($\leq \sim 2$)	4.83

5 LOCAL METEOROLOGY

5.1 Climatic conditions

Table 5-1 presents the temperature and rainfall data for the Bureau of Meteorology site located at Narrabri Airport Automatic Weather Station (AWS) (Site number 54038), approximately 20 km northeast of the proposed plant. Temperature data are presented as monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the mean number of rain days per month.

The annual average maximum and minimum temperatures recorded at the AWS are 26.9°C and 12.2°C respectively. On average, January is the hottest month, with an average maximum temperature of 35.0°C. July is the coldest month, with average minimum temperature of 4.1°C.

Rainfall data collected at the AWS shows that November and December are the wettest months, with the highest mean monthly rainfall (76.6 mm) in November, and highest mean number of rain days (5.6) in December. The average annual rainfall is 587 mm over an average of 53 rain days per year.

Table 5-1: Climate averages for the Narrabri Airport AWS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Daily Maximum Temperature (°C)													
Mean	35.0	33.7	31.1	26.8	22.3	18.4	18.2	20.3	24.2	28.2	31.0	33.6	26.9
Daily Minimum Temperature (°C)													
Mean	20.5	19.4	17.0	12.3	7.5	5.6	4.1	4.8	8.1	12.2	16.1	18.6	12.2
Rainfall (mm)													
Mean	65.0	57.5	70.8	30.5	26.7	51.1	29.7	31.5	34.4	43.3	76.6	68.3	587
Rain days (number)													
Mean	5.2	4.8	5.3	3.3	3.2	4.9	3.5	3.4	3.6	4.7	5.5	5.6	53

5.2 Wind speed and direction

A representative meteorological dataset was chosen by analysing the most recent six years' worth of data, 2019-2024, from the Bureau of Meteorology's Narrabri Airport AWS.

As nearby data could not be sourced, prognostic data has been used in the modelling and is discussed further in Section 9.

Table 5-2 presents the average annual wind speeds and percentage calms at Narrabri Airport AWS across this time period.

Table 5-2: Narrabri Airport AWS average wind speeds and calms

Year	Narrabri Airport AWS	
	Average wind speed (m/s)	Calms (%)
2019	4.1	2.5
2020	4.0	2.7
2021	3.8	3.3
2022	3.7	3.9
2023	3.6	3.6
2024	3.8	2.9
Period average	3.8	3.1

Figure 5-1 presents the annual windroses from 2019 to 2024 from the Narrabri Airport AWS. This analysis shows that wind speed and direction are reasonably consistent from year to year. Based on the wind roses and the preference to focus on the most recent year as possible, 2024 has been chosen for this assessment. Figure 5-2 presents the seasonal variations for 2019-2024.

On an annual basis, there is a strong dominance by winds from the south southeast. This is the most frequent wind direction across all seasons, with the strongest dominance in autumn. Frequency of northerlies and north northeasterlies increases throughout spring and summer. There are relatively few easterlies and westerlies throughout the year.

The majority of stronger winds are from the north and north northeast, with some strong winds from the south southeast. Spring and summer show a higher frequency of strong winds, as well as higher mean wind speeds and lower percentage of calms.

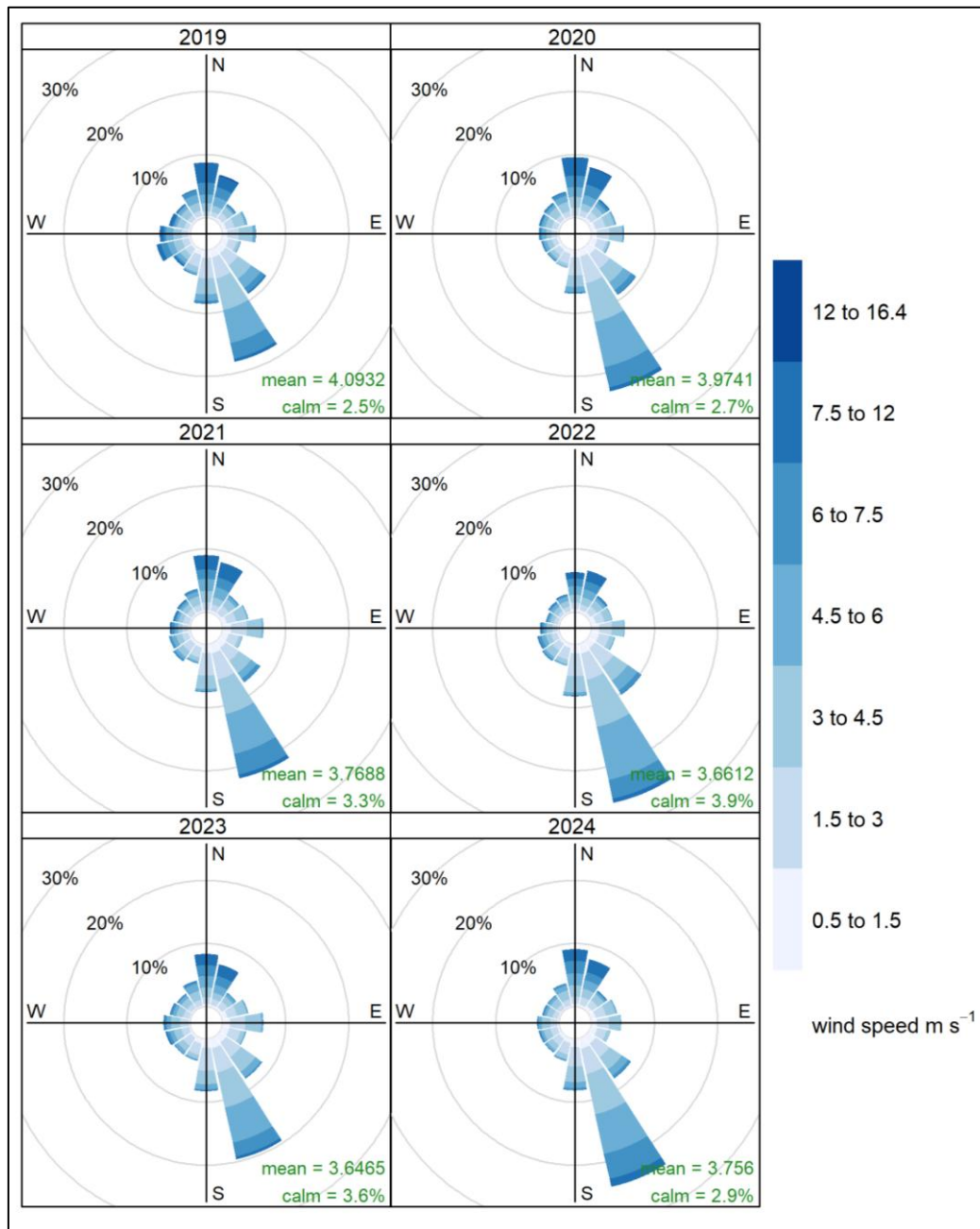


Figure 5-1: Annual wind roses for Narrabri Airport AWS meteorological station – 2019-2024

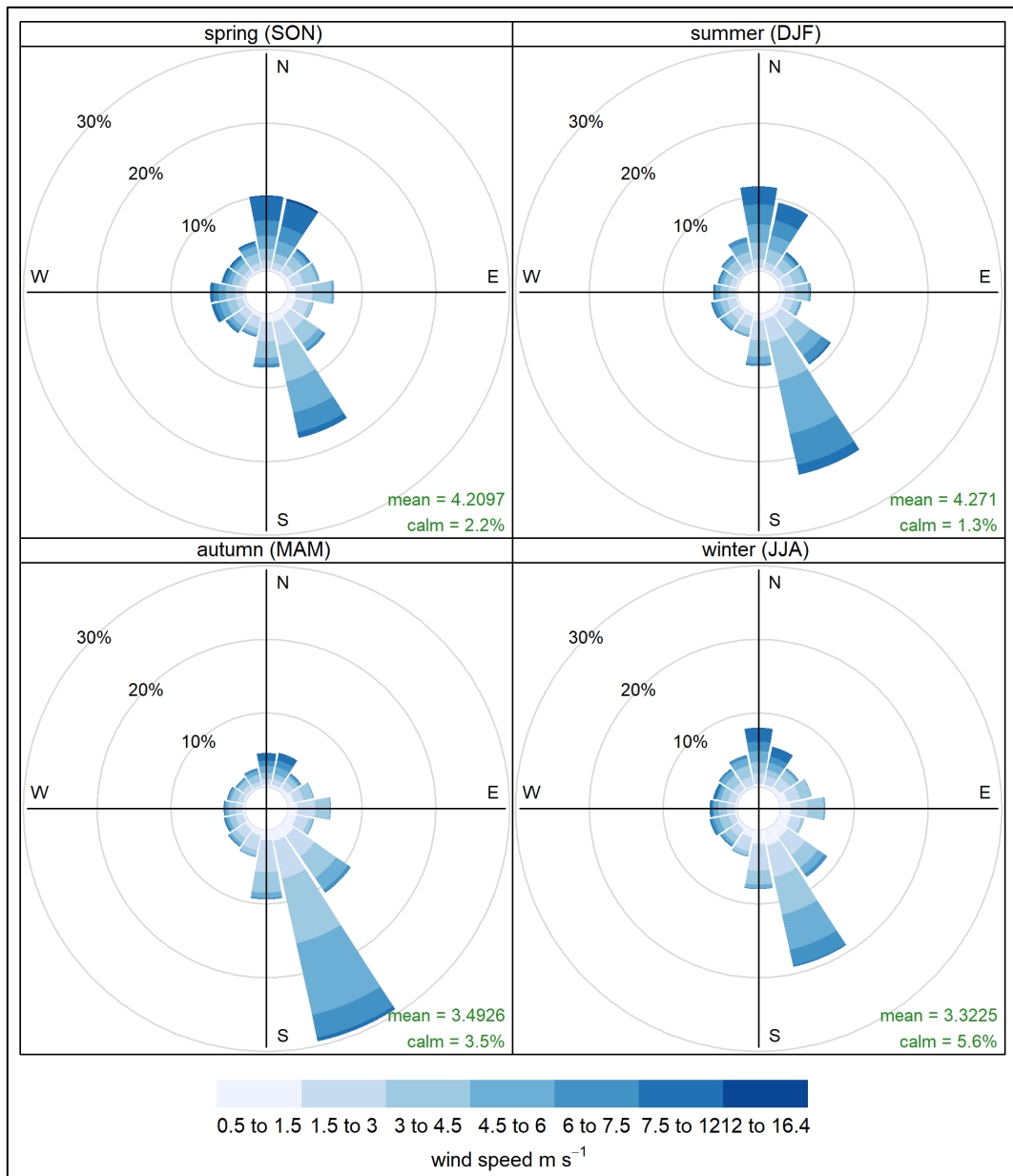


Figure 5-2: Seasonal wind roses for Narrabri Airport AWS meteorological station – 2019-2024

5.3 Atmospheric stability

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere. Highly stable conditions lead to poor dispersion while unstable conditions enable more effective dispersion of pollutants.

Figure 5-3 presents the diurnal variation in atmospheric stability at the proposed operations from the prognostic modelling data.

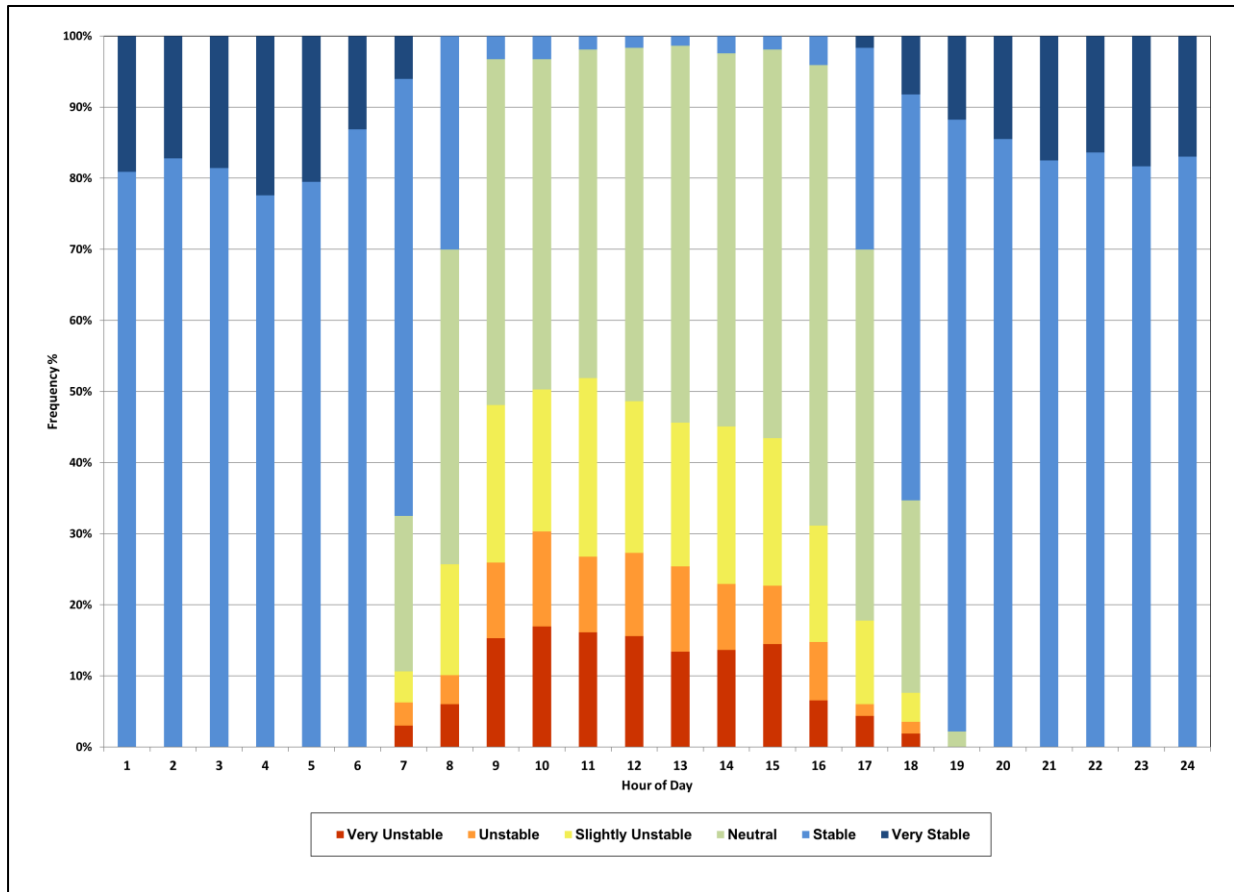


Figure 5-3: Diurnal variation in stability at the proposed plant site for 2024

6 BASELINE AIR QUALITY

6.1 Overview

Air quality criteria refer to cumulative air quality concentrations which include existing and proposed sources. To fully assess impacts against all the relevant air quality criteria (detailed in Section 4) it is necessary to have information on existing NO, NO_x, NO₂ and CO concentrations in the vicinity of the site.

There is a DCCEE monitoring station at Narrabri, approximately 20 km from the Project; however, this station only records particulate matter and not the gases required for this project. Gunnedah, located approximately 90 km southwest of the Project, is the closest DCCEE monitoring station that records NO, NO_x and NO₂. Merriwa, located approximately 280 km northwest of the Project, is the closest DCCEE monitoring station that records CO.

There is no publicly available background monitoring data for ammonia, benzene, toluene or hydrogen sulfide.

The following sections provide a summary of the monitoring results.

6.2 Nitric oxide (NO) and nitrogen oxides (NO_x)

Table 6-1 presents the annual average and maximum 1-hour average NO, NO_x and NO₂ concentrations, respectively, at Gunnedah from 2019 to 2024. The annual average concentrations are consistent across the six years, in particular from 2020 to 2024. The maximums vary, as is to be expected, with 2021 showing the highest maximum concentrations. All years comply with the NO₂ annual average and maximum 1-hour average criteria.

Table 6-1: Measured annual average and maximum 1-hour average NO, NO_x and NO₂ (µg/m³) at Gunnedah

Year	Annual average			Maximum 1-hour average		
	NO	NO ₂	NO _x	NO	NO ₂	NO _x
2019	2.8	9.8	12.6	127	60	187
2020	2.8	7.7	10.5	64	35	99
2021	2.3	6.9	9.2	145	104	249
2022	2.2	5.9	8.1	91	31	122
2023	2.4	7.9	10.2	88	29	117
2024	2.1	7.4	9.5	91	21	112
Period Average	2.4	7.6	10.0	-	-	-
<i>Criteria</i>	-	31		-	164	-

6.3 Carbon monoxide (CO)

Table 6-2 presents the maximum 1-hour average and rolling 8-hour average CO concentrations available at Merriwa, noting there were no data recorded in 2019 or 2020. The highest maximum 1-hour average was recorded during 2023 with the lowest recorded in 2021 and 2024. All years are well below the maximum 1-hour average and rolling 8-hour average CO criteria.

Table 6-2: Measured maximum 1-hour average CO concentrations (mg/m³) at Merriwa

Year	Maximum 1-hour average	Maximum 8-hour rolling average
2019	*	*
2020	*	*
2021	0.4	0.1
2022	0.1	0.1
2023	1.1	0.6
2024	0.4	0.2
Period average	0.5	0.3
Criteria	30	10

6.4 Assumed background concentrations

Table 6-3 summarises all the background values adopted for the assessment together with the source of that data. To align with the meteorological year, the year of 2024 was chosen for background concentrations.

Regarding NO₂, the maximum rate of 100% conversion of NO_x to NO₂ has been applied to remain conservative. In other words, the modelled NO_x has been added to the background NO_x and then this concentrations has been assumed to be 100% NO₂.

Table 6-3: Assumed background values for the cumulative assessment

Metric	Background	Source
Maximum 1-hour average NO _x concentration	112 µg/m ³	Gunnedah, 2024
Annual average NO _x concentration	9.5 µg/m ³	
Maximum 1-hour average CO concentration	0.4 mg/m ³	Merriwa, 2024
Maximum rolling 8-hour average CO concentration	0.2 mg/m ³	

7 CONSTRUCTION ASSESSMENT

7.1 Overview and methodology

It is difficult to quantify dust emissions from construction activities (demolition, earthworks, construction and decommissioning, and track-out, refer Section 3.1 below) and dispersion modelling is therefore not always the best method for quantifying potential impacts.

Dust emissions can vary substantially from day to day depending on the level of activity, the operations being undertaken, and the local weather conditions (which may result in dust generation even when there is no construction activity at a site). It is difficult to predict what the weather conditions would be when specific construction activities are undertaken, and it is therefore very difficult to accurately quantify dust emissions from construction using a model. Any effects of construction on PM concentrations would also tend to be temporary and relatively short-lived.

The assessment and control of construction-related air quality therefore focused on identifying and managing risk.

The construction assessment methodology involved the application of a semi-quantitative risk-based approach following the guidance developed by the UK Institute of Air Quality Management (IAQM, 2024). The approach was tailored according to the nature of the Project and involved the following main steps:

- The identification of the construction activities that would be likely to occur in relation to the Project.
- The division of activities according to their different potential to cause impacts: demolition, earthworks, construction and vehicle track-out. Risks were assessed in relation to the size of the Project, the volume of traffic on unsealed roads, and the locations of sensitive receivers.
- The identification of project-specific management/mitigation measures to minimise the risk of any potential impacts.

The main air pollution and amenity issues at construction sites are:

- Annoyance impacts due to visible dust plumes and soiling of surfaces (including dust settling on cars, washing, swimming pools, roofs and rainwater tanks etc.).
- Elevated PM₁₀ concentrations due to dust-generating activities.
- Exhaust emissions from diesel-powered construction equipment.

Exhaust emissions from on-site plant and site traffic are unlikely to have a significant impact on local air quality, and in the majority of cases they will not need to be quantitatively assessed, which is the circumstance for this Project. Other potential impacts need to be considered on a site-by-site basis (IAQM, 2024).

The IAQM methodology noted above and discussed in more detail below, is predominantly concerned with dust emissions during the construction phase of the Project and the potential impacts on receivers. Dust emissions can occur during the preparation of the land (e.g. earth moving) and during construction itself and can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. A significant portion of the emissions result from site plant and road vehicles moving over temporary unsealed roads and open ground or disturbed areas. If dirt or mud is tracked onto public roads, dust emissions can occur at some distance from the construction site (IAQM, 2024).

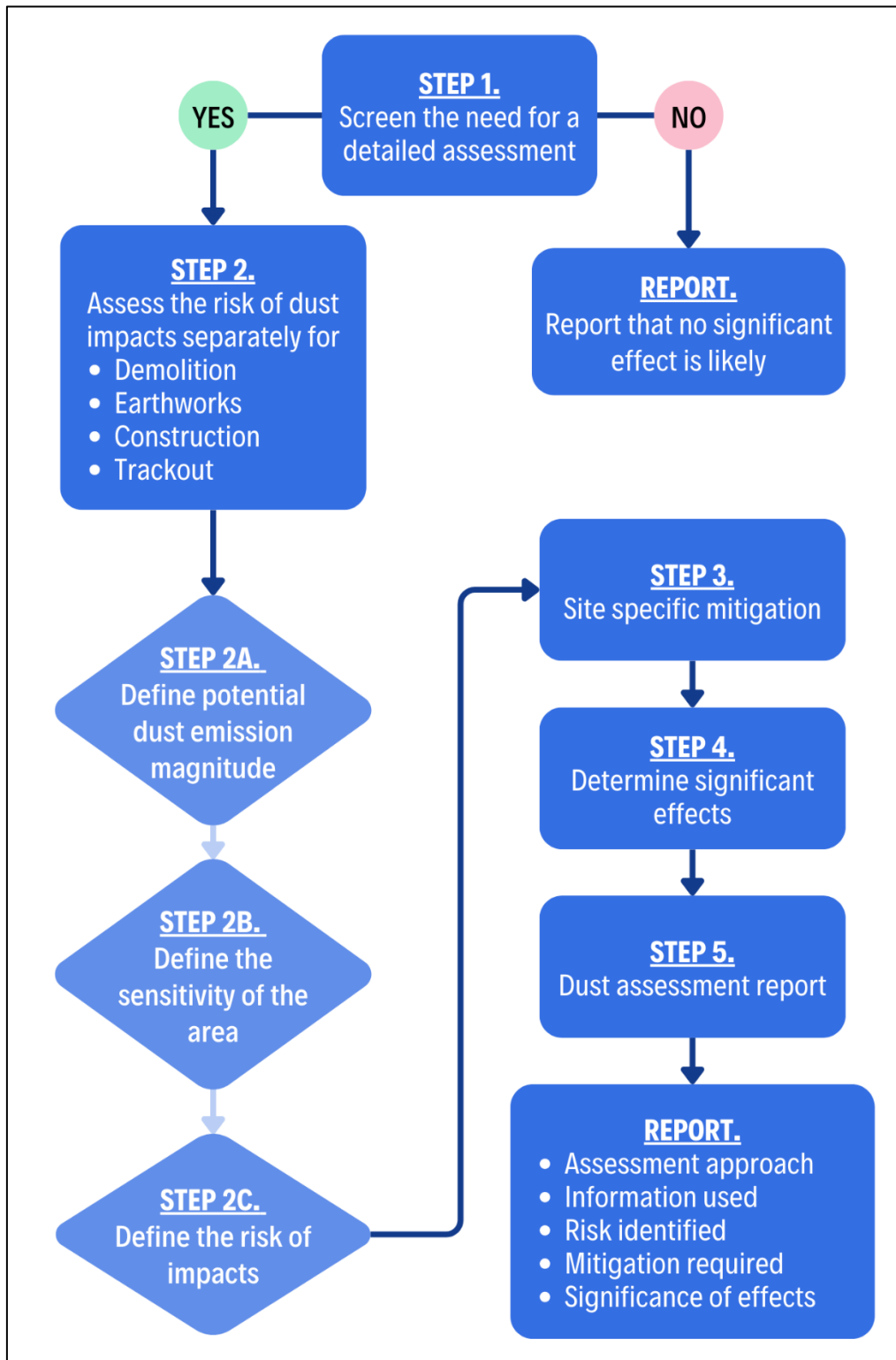
The risk of dust impacts from construction causing loss of amenity and / or health impacts is related to the following:

- the nature of the activities being undertaken
- the duration of the activities
- the size of the site and area disturbed
- the meteorological conditions (wind speed, wind direction and rainfall). Adverse impacts are more likely to occur downwind of the site and during drier periods
- the proximity of receivers to the activities
- the sensitivity of the receivers to dust
- the adequacy of the mitigation measures applied to reduce or eliminate dust.

Activities on construction sites can be divided into four (4) types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. These activities are:

- **Demolition** – this refers to any activity that involves the removal of existing structures. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time. In the context of this assessment there is almost no demolition as the Project involves the construction of new infrastructure.
- **Earthworks** – this covers the processes of crushing and screening, clearing, soil stripping, ground levelling, excavation and landscaping. Earthworks would primarily involve excavating material, haulage, tipping and stockpiling.
- **Construction** – this is any activity that involves the provision of new structures (including roads), modification or refurbishment.
- **Track-out** – this involves the transport of dust and dirt by Heavy Duty Vehicles (HDVs) from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network.

The IAQM assessment procedure for assessing risk is shown in [Figure 7-1](#). Professional judgement is required in some steps, and where justification cannot be given a precautionary approach is adopted.



Source: adapted from IAQM (2024)

Figure 7-1: Steps in the assessment of construction dust

7.2 Assessment

The first part of the assessment is a screening exercise which states that a construction dust assessment will normally be required, where:

- *There are human receivers within 250 m of the development footprint and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).*

It should be noted that there are no sensitive residential receivers within a 250 m distance, the closest of these being 980 m away.

Given that there are no human receivers within 250 m of the development footprint, the screening assessment (Step 1) notes that there is no need for a detailed assessment for the construction phase.

Notwithstanding, [Table 7-1](#) provides the following good practice mitigation measures. Additional guidance on the control of dust at construction sites in NSW is provided as part of the NSW EPA Local Government Air Quality Toolkit.

Table 7-1: Summary of mitigation measures

Impact	Description
Impacts on local air quality during construction	Areas of exposed surface should be minimised to reduce the area of potential wind erosion sources.
	Water carts or sprays should be used on any unsealed road surfaces or other exposed areas such as stockpiles, as required.
	All trucks should cover their loads when transporting materials that are potential sources of wind-blown dust, to and from the Project.
	Work activities should be reviewed if the dust suppression measures are not adequately restricting dust generation.
	Rumble grids and wheel washes should be placed at site exit points to avoid the track-out of dirt and mud onto public roads.
Exhaust emissions	Construction plant and equipment should be maintained in good working condition to limit impacts on air quality.
	Where practicable, vehicles should be switched off when not in use.

8 EMISSIONS TO AIR DURING OPERATIONS

8.1 Overview

For this assessment, emissions to air have been reviewed for the following:

- Existing operations at the adjacent Wilga Park Power Station (WPPS)
- Proposed operations at the Supagas carbon dioxide plant

In total there are up to ten sources: six for the existing WPPS and four for the proposed plant.

Table 8-1 presents a summary of the modelled emission sources and their associated pollutants.

It is noted that the Project Approval for the WPPS only requires air quality monitoring of NO₂ or NO, or both (as NO_x) and this is currently being conducted annually. There may be other pollutants emitted from the WPPS, but on the basis that there is no requirement to monitor anything else, these are likely to be minor and have not therefore been included in this assessment.

In addition, the priority criteria pollutant for this assessment is NO_x / NO₂ and emissions for this pollutant has been considered from the WPPS and multiple CO₂ plant sources.

For ammonia (NH₃), benzene, toluene and hydrogen sulfide (H₂S), the Approved Methods considers these on an incremental impact basis rather than the cumulative impact and therefore consideration of the WPPS is not warranted.

Table 8-1: Modelled emission sources and associated pollutants

Pollutant	Proposed CO ₂ plant sources				Six WPPS sources
	Raw gas vent to atmosphere	Flue gas scrubber vent	Dehydrator vent	Purge gas vent	
NO _x	✓	✓	✗	✓	✓
CO	✓	✓	✗	✓	✗
NH ₃	✓	✗	✗	✗	✗
Benzene	✓	✓	✓	✗	✗
Toluene	✓	✓	✗	✗	✗
H ₂ S	✓	✓	✗	✗	✗

8.2 Point source emission summary

The emission estimates for the existing sources were taken from Assured Environmental stack testing (Assured Environmental, 2024). For the proposed sources, data was provided by Supagas.

Table 8-2 presents a summary of the parameters for existing and proposed sources.

As outlined in Section 8.1, for the existing sources only emissions NO_x are considered. The Project Approval for the WPPS only requires air quality monitoring of NO₂ or NO, or both (as NO₂) and this is currently being conducted annually.

Table 8-2: Estimated point source emissions for existing and proposed sources

Source ID	Stack height (m)	Stack diameter (m)	Exit velocity (m/s)	Temp (K)	Emission rate (g/s)					
					NOx	CO	NH ₃	Benzene	Toluene	H ₂ S
Existing sources										
G01A	12.5	0.58	38.7	665	0.007	*	*	*	*	*
G02A	12.5	0.58	37.7	662	0.008	*	*	*	*	*
G03B	12.5	0.58	37.1	668	0.008	*	*	*	*	*
G04B	12.5	0.58	38.3	649	0.008	*	*	*	*	*
G05B	12.5	0.58	35.3	653	0.005	*	*	*	*	*
G06B	12.5	0.58	37.7	672	0.008	*	*	*	*	*
Proposed sources										
Raw gas vent	38	0.51	2.1	335	0.031	0.160	0.013	<0.001	<0.001	<0.001
Flue gas scrubber vent	38	0.80	12.4	322	0.195	1.019	*	0.001	<0.001	<0.001
Dehydrator	6	0.10	0.10	423	*	*	*	<0.001	*	<0.001
Purge gas	6	0.10	0.01	249	<0.001	<0.001	*	*	*	<0.001

Notes: * = no emissions for that pollutant

9 OPERATIONAL IMPACT ASSESSMENT

9.1 Assessment process

The US EPA's model AERMOD was used for this assessment. This is considered to be the most suitable model for the source types, proximity of the sensitive receivers and local topography. AERMOD is accepted by the NSW EPA and used widely in Australia.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data. Terrain data was sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (1 arc second (~30m) resolution). This terrain dataset was then processed within AERMAP to create the necessary input files.

As mentioned in Section 5, the closest meteorological station is at Narrabri Airport Automatic Weather Station which is approximately 20 km northeast of the Project. As nearby data could not be sourced, prognostic data has been used in the modelling.

With the meteorological year chosen, meteorological modelling was first undertaken using Weather Research and Forecasting model (WRF). WRF is a widely used three-dimensional numerical meteorological model which contains non-hydrostatic dynamics, and a variety of physics options for parameterizing cumulus clouds, microphysics, the planetary boundary layer, and atmospheric radiation.

The process of developing the output required for applications such as atmospheric dispersion models using WRF requires the use of a nested approach. 1 km is the highest resolution that it is recommended WRF be used for such applications. Where higher resolution is required, WRF output can be passed through diagnostic models to further resolve higher resolution terrain and land use, however this would require alternative output formats.

The selected initialisation dataset was the ERA5 dataset, and this has an initial resolution of approximately 27 km. The WRF user guide recommends that the factor for nested grids is between 3 and 5, however a grid with the resolution equal to the initialisation data is not required. Thus, the modelled grids corresponded to resolutions of 9 km, 3 km and 1 km.

WRF modelling was completed for 2024 and data was extracted for the Project site. In addition, WRF data was extracted at the location of Narrabri Airport Automatic Weather Station so that the observations at this location could be compared with the WRF extract. Appendix B provides the wind rose comparison which shows that WRF is replicating well the conditions observed at Narrabri Airport. On that basis, WRF was chosen to provide data at the site.

9.2 Results

The dispersion model was run to predict pollutant concentrations across a grid and at the discrete receptors provided in Section 3.

The full table of results for the discrete receptors are provided in Appendix A, with each table as follows:

- Table A-1: Annual average NO₂ predictions at sensitive receptors (µg/m³)
- Table A-2: Maximum 1-hour average NO₂ predictions at sensitive receptors (µg/m³)
- Table A-3: Maximum 1-hour average CO predictions at sensitive receptors (mg/m³)
- Table A-4: Maximum rolling 8-hour average CO predictions at sensitive receptors (mg/m³)
- Table A-5: 99.9th percentile 1-hour average ammonia, toluene and benzene predictions at sensitive receptors (µg/m³)

- Table A-6: 99 percentile 1-hour average hydrogen sulfide predictions at sensitive receptors ($\mu\text{g}/\text{m}^3$)

The tables below present the maximum concentrations across a grid (6 km by 6 km at 50 m resolution) and the maximum concentrations at discrete receptors. All pollutants and averaging periods show compliance with assessment criteria.

On that basis, no contour plots have been provided for the pollutants.

Table 9-1: Annual average NO_2 model predictions ($\mu\text{g}/\text{m}^3$)

Parameter	Annual NO_x			Cumulative annual NO_2
	Existing sources	Proposed sources	Background	
Max across grid	0.11	0.20	9.5	9.77
Max at discrete receptors	0.01	0.09	9.5	9.60
Criteria	-	-	-	31

Table 9-2: Maximum 1-hour average NO_2 model predictions ($\mu\text{g}/\text{m}^3$)

Parameter	Maximum 1-hour average NO_x			Cumulative maximum 1-hour average NO_2
	Existing sources	Proposed sources	Background	
Max across grid	1.8	14.5	112	127
Max at discrete receptors	1.6	6.1	112	119
Criteria	-	-	-	164

Table 9-3: Maximum 1-hour average CO model predictions (mg/m^3)

Parameter	Maximum 1-hour average CO		
	Proposed sources	Background	Cumulative
Max across grid	0.08	0.40	0.48
Max at discrete receptors	0.03	0.40	0.43
Criteria	-	-	30

Table 9-4: Maximum rolling 8-hour average CO model predictions (mg/m³)

Parameter	Maximum 1-hour average CO		
	Proposed sources	Background	Cumulative
Max across grid	0.014	0.20	0.214
Max at discrete receptors	0.010	0.20	0.210
Criteria	-	-	10

Table 9-5: 99.9th percentile 1-hour average ammonia, toluene and benzene model predictions (µg/m³)

Parameter	Ammonia	Toluene	Benzene
Max across grid	1.18	0.03	0.12
Max at discrete receptors	0.43	0.01	0.04
Criteria	330	360	29

Table 9-6: 99th percentile 1-hour average hydrogen sulfide predictions (µg/m³)

Parameter	Ammonia
Max across grid	0.04
Max at discrete receptors	0.04
Criteria	1.38

10 GREENHOUSE GAS ASSESSMENT

The NSW Environment Protection Authority's (EPA) has released new guidance for GHG assessment requirements for large emitters. Based on its planned operational throughput and design, this project does not emit above the threshold of 25,000 tonnes of CO₂-e scope 1 and 2 GHG emissions in any financial year during its operational life and is therefore not regarded as a large emission project.

10.1 Methodology

Quantification of greenhouse gas (GHG) emissions has been completed in accordance with the GHG Protocol (WRI & WBCSD, 2004), IPCC and Australian Government GHG accounting/classification systems.

This GHG assessment is also guided by the emission estimation methodologies endorsed under the National Greenhouse and Energy Reporting Regulations 2008 (the NGER Regulations) (as amended in 2019). These describe the detailed requirements for reporting under the NGER framework and also provide a basis for estimating emissions from proposed activities.

The Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (the NGER Guidelines) (DCCEWW, 2019) support reporting under the NGER Act. They have been designed to assist corporations in understanding and applying the NGER Measurement Determination.

The NGER Guidelines are reporting year specific, and outline calculation methods and criteria for determining GHG emissions, energy production, energy consumption and potential GHG emissions embodied in combusted fuels. The latest published NGER Guidelines (at the time of writing) have been referenced.

10.1.1 The GHG protocol

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organization for Standardisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Under this protocol, three "scopes" of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. These are represented visually in [Figure 10-1](#). Scope 3 is not relevant for this Project so only scopes 1 and 2 are addressed. The definitions for scope 1 and scope 2 are provided in the following sections.

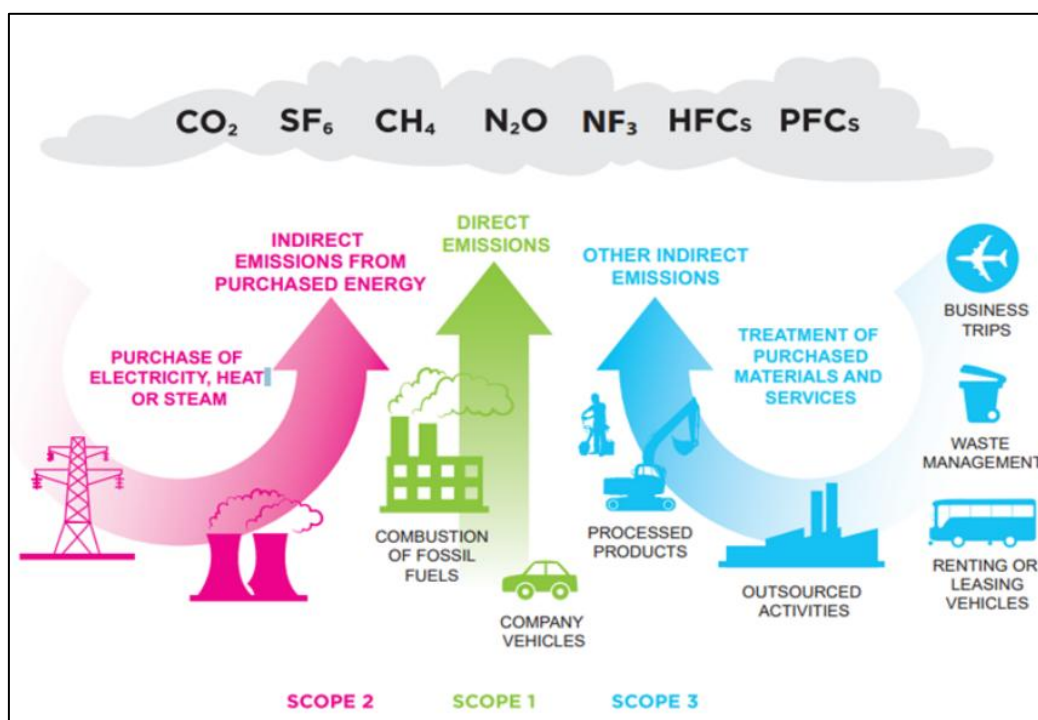


Figure 10-1: Overview of scope and emissions across a reporting entity

10.1.1.1 Scope 1: Direct greenhouse gas emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources;
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc;
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, e.g., trucks, trains, ships, aeroplanes, buses and cars; and
- Fugitive emissions. These emissions result from intentional or unintentional releases, e.g., equipment leaks from joints, seals, packing, and gaskets; HFC emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport.

10.1.1.2 Scope 2: Energy product use indirect greenhouse gas emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 covers purchased electricity defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the facility where electricity is generated. Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as Scope 2.

10.1.2 Assessment approach

GHG emissions have been estimated for the operations based upon the methods outlined in the following documents:

- The National Greenhouse and Energy Reporting (Measurement) Amendment Determination 2008 (as amended 2019)
- Site specific information
- The NGER Guidelines
- The National Greenhouse Accounts (NGA) Factors.

There is no proposed diesel consumption as part of this Project and therefore there are no Scope 1 emissions.

10.2 Scope 2 emissions – Electricity consumption

Consumption of electricity has been provided by Supagas. Emissions for Scope 2 electricity consumption are calculated using the following method:

GHG emissions from electricity consumption were estimated using the following equation:

$$Y = Q \times \frac{EF}{1000}$$

Where:

Y	Scope 2 Electricity emissions	(CO ₂ -e tonnes)
Q	Quantity of electricity purchased from the electricity grid during the year	(kWh/annum) ¹
EF	Scope 2 emission factor for the State of Territory in which the consumption occurs	(kg CO ₂ -e/kWh) ²

¹ kWh/annum = kilowatt hours per annum

² kgCO₂-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

Scope 2 emissions have been calculated using an emission factor of 0.66 kg CO₂-e/kWh for New South Wales and Australian Capital Territory as sourced from the Australian National Greenhouse Accounts Factors (2024).

The estimated annual and total GHG emissions from electricity usage are presented in [Table 10-1](#).

Table 10-1: Projected electricity consumption and Scope 2 GHG emissions

Electricity consumption (kWh/y)	Scope 2 emissions (t CO ₂ -e)
9,986,400	6,591

The Project contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 2 emissions from the Project (approximately 0.007 Mt CO₂-e) would represent approximately 0.002% of Australia's commitment under the Paris Agreement.

11 CONCLUSIONS

Zephyr Environmental (Zephyr) has been commissioned by Onward Consulting Pty Ltd (Onward) on behalf of Supagas Pty Ltd (Supagas) to prepare an air quality and greenhouse gas assessment (AQGHGA) for the Supagas CO₂ plant. Supagas is seeking to construct and operate a CO₂ plant, which would connect to the adjacent Wilga Park Power Station (WPPS) operated by Santos. The CO₂ plant would capture and process exhaust gases from the WPPS gas generators and output a high purity CO₂ product for export and use in the food, beverage, and other markets (the Project).

The assessment has considered impacts during both the construction phase and the operational phase of the Project. The assessment was prepared in accordance with the NSW EPA “Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales” (Approved Methods) (EPA, 2022).

The construction dust assessment identified that there are no sensitive residential receivers within a 250 m distance (the nominated buffer distance), with the closest of these receivers being 980 m away. Given that there are no human receivers within 250 m of the development footprint, the screening assessment (Step 1) notes that there is no need for a detailed assessment for the construction phase. Good practice mitigation measures have been provided in this report for completeness. Additional guidance on the control of dust at construction sites in NSW is provided as part of the NSW EPA Local Government Air Quality Toolkit.

A review of proposed and existing emissions to air for the Project and the adjacent WPPS during the operational phase have identified six pollutants for consideration: nitrogen oxides (NO_x) / nitrogen dioxide (NO₂), ammonia (NH₃), carbon monoxide (CO), benzene, toluene and hydrogen sulfide (H₂S). All of the mentioned pollutants have been included in the dispersion modelling. For NO₂ and CO, available background concentrations have been included as part of a cumulative assessment.

The dispersion modelling accounts for the local meteorology and terrain information and uses emission estimates to predict the air quality impacts for operations. The results of the dispersion modelling indicate that all pollutants and averaging periods assessed show compliance with assessment criteria for gridded and discrete sensitive receptors, including background concentrations where available.

For the greenhouse gas assessment, there is only Scope 2 emissions from electricity consumption. The proposed Project contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the operations (approximately 0.007 Mt CO₂-e) would represent approximately 0.002% of Australia’s commitment under the Paris Agreement.

Based on its planned operational throughput and design, this project does not emit above the threshold of 25,000 tonnes of CO₂-e scope 1 and 2 GHG emissions in any financial year during its operational life and is therefore not regarded as a large emission project as defined in the *NSW Guide for Large Emitters* (EPA, 2025).

Overall, this quantitative air quality and greenhouse gas assessment concludes that the proposed Project is not anticipated to result in adverse air quality impacts.

12 REFERENCES

Assured Environmental (2024) Source Emissions Monitoring – Wilga Park Power Station, Project ID: 16090, 29/11/2024, Release: R_O

DCCEEW (2019). NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW), Air quality data services, Data download facility, <https://www.airquality.nsw.gov.au/air-quality-data-services/data-download-facility>

EPA (2022) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. NSW Environment Protection Authority – August 2005, minor revisions November 2016, minor revisions 2022, published August 2022.

EPA (2025) NSW Guide for Large Emitters: Guidance on how to prepare a greenhouse gas assessment as part of NSW environmental planning process. Published January 2025.

NEPC (2021). National Environment Protection (Ambient Air Quality) Measure, National Environment Protection Council, Canberra.

NEPM (1998). National Environmental Protection Measure and Impact Statement for Ambient Air Quality. National Environment Protection Council Service Corporation. Adelaide, SA. .

NEPM (2011). National Environmental Protection (Air Toxics) Measure. National Environment Protection Council Service Corporation. Adelaide, SA.

NGA (2023) National Greenhouse Accounts Factors – Australian National Greenhouse Accounts, published February 2023 by the Australian Government, Department of Climate Change, Energy, Environment and Water.

NGER (2008). National Greenhouse and Energy Reporting (Measurement) Determination. Amended 2019.

APPENDIX A: TABLE OF MODELLING RESULTS

Table A-1: Annual average NO₂ model predictions at sensitive receptors (µg/m³)

ID	Annual NO _x			Cumulative annual NO ₂
	Existing sources	Proposed sources	Background	
1	0.001	0.004	9.5	9.505
2	0.001	0.004	9.5	9.504
3	0.001	0.004	9.5	9.504
4	0.001	0.004	9.5	9.505
5	0.001	0.005	9.5	9.506
6	0.001	0.005	9.5	9.506
7	0.001	0.004	9.5	9.504
8	0.001	0.006	9.5	9.507
9	0.001	0.005	9.5	9.506
10	0.001	0.006	9.5	9.507
11	0.001	0.004	9.5	9.505
12	0.004	0.021	9.5	9.525
13	0.004	0.024	9.5	9.528
14	0.001	0.004	9.5	9.505
15	0.001	0.006	9.5	9.507
16	0.001	0.007	9.5	9.508
17	0.015	0.086	9.5	9.601
18	0.001	0.007	9.5	9.508
19	0.001	0.007	9.5	9.508
20	0.001	0.006	9.5	9.507
21	0.001	0.003	9.5	9.504
22	0.010	0.051	9.5	9.561
23	0.002	0.012	9.5	9.514
24	0.006	0.035	9.5	9.541
25	0.001	0.006	9.5	9.507
26	0.001	0.007	9.5	9.509
27	0.002	0.011	9.5	9.513
28	0.001	0.003	9.5	9.504
29	0.001	0.005	9.5	9.506
30	0.001	0.003	9.5	9.504
31	0.001	0.004	9.5	9.505
32	0.002	0.010	9.5	9.511
33	0.001	0.006	9.5	9.507
34	0.002	0.010	9.5	9.512

ID	Annual NO _x			Cumulative annual NO ₂
	Existing sources	Proposed sources	Background	
35	0.001	0.004	9.5	9.505
36	0.001	0.004	9.5	9.505
37	0.001	0.008	9.5	9.509
38	0.001	0.003	9.5	9.504
39	0.001	0.004	9.5	9.504
40	0.001	0.005	9.5	9.506
41	0.001	0.007	9.5	9.508
42	0.004	0.021	9.5	9.525
43	0.003	0.012	9.5	9.515
44	0.001	0.004	9.5	9.505
45	0.001	0.003	9.5	9.504
46	0.001	0.003	9.5	9.504
47	0.001	0.006	9.5	9.507
48	0.003	0.017	9.5	9.521
49	0.001	0.003	9.5	9.504
50	0.003	0.012	9.5	9.514
51	0.001	0.005	9.5	9.506
52	0.001	0.003	9.5	9.504
Max	0.015	0.086	9.5	9.505
<i>Criteria</i>	-	-	-	31

Table A-2: Maximum 1-hour average NO₂ model predictions at sensitive receptors (µg/m³)

ID	Maximum 1-hour NO _x			Cumulative maximum 1-hour NO ₂
	Existing sources	Proposed sources	Background	
1	0.273	0.643	112	112.710
2	0.136	0.702	112	112.838
3	0.158	0.647	112	112.729
4	0.265	0.772	112	112.772
5	0.105	0.890	112	112.932
6	0.103	0.885	112	112.914
7	0.153	0.868	112	112.868
8	0.177	0.619	112	112.676
9	0.141	0.887	112	113.028
10	0.185	1.139	112	113.194
11	0.291	0.670	112	112.719
12	0.596	2.432	112	115.028
13	0.572	2.454	112	114.872
14	0.162	0.611	112	112.691
15	0.135	0.822	112	112.881
16	0.267	0.789	112	112.864
17	1.553	6.131	112	118.988
18	0.192	1.195	112	113.380
19	0.175	0.931	112	112.932
20	0.313	1.080	112	113.269
21	0.134	0.599	112	112.638
22	0.290	1.478	112	113.699
23	0.310	0.714	112	112.782
24	0.235	1.359	112	113.505
25	0.202	1.133	112	113.182
26	0.169	1.436	112	113.438
27	0.196	1.206	112	113.354
28	0.174	0.556	112	112.631
29	0.301	0.866	112	112.917
30	0.144	0.539	112	112.622
31	0.294	0.720	112	112.803
32	0.254	1.436	112	113.690
33	0.209	0.658	112	112.699
34	0.282	1.270	112	113.420
35	0.302	0.895	112	112.929
36	0.242	0.960	112	113.010

ID	Maximum 1-hour NO _x			Cumulative maximum 1-hour NO ₂
	Existing sources	Proposed sources	Background	
37	0.183	0.976	112	113.159
38	0.207	0.623	112	112.650
39	0.311	0.740	112	112.760
40	0.147	1.052	112	113.054
41	0.215	1.094	112	113.106
42	0.135	0.837	112	112.875
43	0.272	0.883	112	113.090
44	0.150	0.914	112	112.987
45	0.301	0.687	112	112.706
46	0.199	0.562	112	112.653
47	0.227	1.209	112	113.242
48	0.230	0.795	112	112.889
49	0.297	0.619	112	112.683
50	0.275	0.958	112	113.147
51	0.216	0.973	112	113.077
52	0.137	0.950	112	112.971
Max	1.553	6.131	112	118.988
<i>Criteria</i>	-	-	-	164

Table A-3: Maximum 1-hour average CO model predictions at sensitive receptors (mg/m³)

ID	Maximum 1-hour CO		
	Proposed sources	Background	Cumulative
1	0.003	0.400	0.403
2	0.004	0.400	0.404
3	0.003	0.400	0.403
4	0.004	0.400	0.404
5	0.005	0.400	0.405
6	0.005	0.400	0.405
7	0.005	0.400	0.405
8	0.003	0.400	0.403
9	0.005	0.400	0.405
10	0.006	0.400	0.406
11	0.004	0.400	0.404
12	0.013	0.400	0.413
13	0.013	0.400	0.413
14	0.003	0.400	0.403
15	0.004	0.400	0.404
16	0.004	0.400	0.404
17	0.032	0.400	0.432
18	0.006	0.400	0.406
19	0.005	0.400	0.405
20	0.006	0.400	0.406
21	0.003	0.400	0.403
22	0.008	0.400	0.408
23	0.004	0.400	0.404
24	0.007	0.400	0.407
25	0.006	0.400	0.406
26	0.008	0.400	0.408
27	0.006	0.400	0.406
28	0.003	0.400	0.403
29	0.005	0.400	0.405
30	0.003	0.400	0.403
31	0.004	0.400	0.404
32	0.008	0.400	0.408
33	0.003	0.400	0.403
34	0.007	0.400	0.407
35	0.005	0.400	0.405
36	0.005	0.400	0.405

ID	Maximum 1-hour CO		
	Proposed sources	Background	Cumulative
37	0.005	0.400	0.405
38	0.003	0.400	0.403
39	0.004	0.400	0.404
40	0.006	0.400	0.406
41	0.006	0.400	0.406
42	0.004	0.400	0.404
43	0.005	0.400	0.405
44	0.005	0.400	0.405
45	0.004	0.400	0.404
46	0.003	0.400	0.403
47	0.006	0.400	0.406
48	0.004	0.400	0.404
49	0.003	0.400	0.403
50	0.005	0.400	0.405
51	0.005	0.400	0.405
52	0.005	0.400	0.405
Max	0.032	0.400	0.432
<i>Criteria</i>	-	-	-

Table A-4: Maximum rolling 8-hour average CO model predictions at sensitive receptors (mg/m³)

ID	Maximum 1-hour CO		
	Proposed sources	Background	Cumulative
1	0.001	0.200	0.201
2	0.001	0.200	0.201
3	0.001	0.200	0.201
4	0.001	0.200	0.201
5	0.001	0.200	0.201
6	0.001	0.200	0.201
7	0.001	0.200	0.201
8	0.001	0.200	0.201
9	0.001	0.200	0.201
10	0.001	0.200	0.201
11	0.001	0.200	0.201
12	0.002	0.200	0.202
13	0.002	0.200	0.202
14	0.001	0.200	0.201
15	0.001	0.200	0.201
16	0.001	0.200	0.201
17	0.010	0.200	0.210
18	0.001	0.200	0.201
19	0.001	0.200	0.201
20	0.001	0.200	0.201
21	0.001	0.200	0.201
22	0.004	0.200	0.204
23	0.001	0.200	0.201
24	0.003	0.200	0.203
25	0.001	0.200	0.201
26	0.001	0.200	0.201
27	0.002	0.200	0.202
28	0.000	0.200	0.200
29	0.001	0.200	0.201
30	0.000	0.200	0.200
31	0.001	0.200	0.201
32	0.002	0.200	0.202
33	0.001	0.200	0.201
34	0.002	0.200	0.202
35	0.001	0.200	0.201

ID	Maximum 1-hour CO		
	Proposed sources	Background	Cumulative
36	0.001	0.200	0.201
37	0.001	0.200	0.201
38	0.000	0.200	0.200
39	0.001	0.200	0.201
40	0.001	0.200	0.201
41	0.001	0.200	0.201
42	0.002	0.200	0.202
43	0.002	0.200	0.202
44	0.001	0.200	0.201
45	0.001	0.200	0.201
46	0.000	0.200	0.200
47	0.001	0.200	0.201
48	0.001	0.200	0.201
49	0.001	0.200	0.201
50	0.002	0.200	0.202
51	0.001	0.200	0.201
52	0.001	0.200	0.201
Max	0.010	0.200	0.210
<i>Criteria</i>	-	-	10

Table A-5: 99.9th percentile 1-hour average ammonia, toluene and benzene model predictions at sensitive receptors (µg/m³)

ID	Ammonia	Toluene	Benzene
1	0.041	0.001	0.002
2	0.048	0.001	0.003
3	0.046	0.001	0.003
4	0.048	0.001	0.003
5	0.045	0.001	0.003
6	0.044	0.001	0.003
7	0.046	0.001	0.004
8	0.045	0.001	0.003
9	0.049	0.001	0.004
10	0.053	0.001	0.004
11	0.051	0.001	0.003
12	0.117	0.002	0.008
13	0.141	0.002	0.008
14	0.048	0.001	0.003
15	0.049	0.001	0.004
16	0.074	0.001	0.004
17	0.434	0.012	0.041
18	0.068	0.001	0.005
19	0.075	0.001	0.005
20	0.059	0.001	0.004
21	0.041	0.001	0.003
22	0.089	0.002	0.008
23	0.072	0.001	0.004
24	0.083	0.002	0.006
25	0.060	0.001	0.004
26	0.064	0.001	0.004
27	0.069	0.002	0.006
28	0.041	0.001	0.003
29	0.053	0.001	0.003
30	0.040	0.001	0.003
31	0.053	0.001	0.003
32	0.075	0.002	0.005
33	0.052	0.001	0.003
34	0.073	0.002	0.006
35	0.052	0.001	0.003
36	0.052	0.001	0.003

ID	Ammonia	Toluene	Benzene
37	0.063	0.001	0.005
38	0.040	0.001	0.003
39	0.044	0.001	0.003
40	0.053	0.001	0.004
41	0.058	0.001	0.004
42	0.062	0.001	0.004
43	0.063	0.002	0.005
44	0.046	0.001	0.003
45	0.042	0.001	0.003
46	0.045	0.001	0.003
47	0.055	0.001	0.004
48	0.060	0.001	0.004
49	0.043	0.001	0.003
50	0.061	0.001	0.005
51	0.048	0.001	0.004
52	0.046	0.001	0.003
Max	0.434	0.012	0.041
<i>Criteria</i>	330	360	29

Table A-6: 99th percentile 1-hour average hydrogen sulfide model predictions at sensitive receptors (in $\mu\text{g}/\text{m}^3$)

ID	Hydrogen sulfide
1	0.002
2	0.002
3	0.001
4	0.001
5	0.002
6	0.002
7	0.001
8	0.002
9	0.002
10	0.002
11	0.002
12	0.005
13	0.005
14	0.001
15	0.002
16	0.002
17	0.037
18	0.003
19	0.003
20	0.002
21	0.001
22	0.011
23	0.004
24	0.008
25	0.002
26	0.002
27	0.004
28	0.001
29	0.002
30	0.001
31	0.001
32	0.004
33	0.002
34	0.004
35	0.001
36	0.001

ID	Hydrogen sulfide
37	0.003
38	0.001
39	0.001
40	0.002
41	0.003
42	0.005
43	0.004
44	0.002
45	0.001
46	0.001
47	0.002
48	0.004
49	0.001
50	0.004
51	0.002
52	0.001
Max	0.037
<i>Criteria</i>	<i>1.38</i>

APPENDIX B: WRF MODEL

The Weather Research Forecasting (WRF) model can be used with reanalysis datasets to downscale data from global weather datasets to local conditions. Atmospheric data obtained from WRF can be used to evaluate meteorological conditions against site observations and can also serve as input for higher-resolution models.

As part of the air quality assessment it was necessary to use the WRF prognostic model to produce AERMET compatible files for a project location located at -30.363887° , 149.674777° . This WRF modelling was completed using WRF version 4.6.0 for the period 1 January 2024 to 31 December 2024 (inclusive).

The WRF model requires initialisation conditions to provide the boundary conditions for the model which are then processed to finer resolutions through an understanding of atmospheric physics, geospatial information and the interaction of the atmosphere with the land. Many datasets are available globally which can be used within the WRF model.

Our experience is that the data from the European Centre for Medium Weather Forecasts (ECMWF) global reanalysis dataset, known as ERA5 provides an output that compares well to observed data. This is because the ERA5 dataset is a reanalysis dataset which has assimilated a great deal of observational data, including surface pressure, sea level pressure, geopotential height, temperature, sea surface temperature, soil values, ice cover, relative humidity, u- and v- wind components, vertical motion, vorticity, winds and in-situ data such as moisture from radiosondes and pressure from surface observations. Also included in these datasets are additional precipitation data, profiler data, dropsondes, pilot balloons, aircraft temperatures and winds, land surface and moisture data and cloud motion vectors from geostationary satellites.

The ERA5 dataset provides information both for the surface conditions and 137 mandatory vertical levels. There are over 25 different variables including geopotential height, temperature, relative humidity and u- and v- wind components.

Data from the ERA5 dataset is available globally every hour on a 27 km grid, however data were extracted from the dataset every 3 hours to minimise download time without loss in fidelity of the data.

The process of developing the output required for applications such as atmospheric dispersion models using WRF requires the use of a nested approach. 1 km is the highest resolution that it is recommended WRF be used for such applications. Where higher resolution is required, WRF output can be passed through diagnostic models to further resolve higher resolution terrain and land use, however this will require alternative output formats.

As discussed, the selected initialisation dataset was the ERA5 dataset, and this has an initial resolution of approximately 27 km. The WRF user guide recommends that the factor for nested grids is between 3 and 5, however a grid with the resolution equal to the initialisation data is not required. Thus, the modelled grids corresponded to resolutions of 9 km, 3 km and 1 km.

The WRF model provides a three-dimensional output that is not directly compatible with dispersion models such as AERMOD. The Environment Protection Agency of the United States of America (USEPA) contracted a third party to develop a program that can process the output from the WRF model into compatible files with the AERMOD modelling system. This program is known as the Mesoscale Model Interface Program (MMIF).

The MMIF program has been used to process data centred on the project location (-30.363887° , 149.674777° for the 2024 calendar year.).

The default output from MMIF as an input file for AERMOD creates a version that does not account for the latest abilities of the AERMOD model to account for low wind speeds and assumes coarse level (1 km resolution) land use information. To overcome these issues, the AERMET output option in MMIF was therefore selected. This generates a series of files containing meteorological information which can be processed AERMET using an updated landuse profile surrounding the Site and use the latest version of the model to take advantage of the most up to date model developments.

To determine the extent to which these model limitations and uncertainties may influence model outputs, data was also extracted using MMIF for the location of the Bureau of Meteorology Narrabri station for the coincident years (2024) at -30.315456°, 149.830172° and a statistical analysis was completed between observed data provided by the Bureau of Meteorology and the results of the prognostic modelling.

The aspect of meteorology that most influences dispersion is wind speed and wind direction. Wind is a type of vector, meaning it has both a speed (how fast it is blowing) and a direction (where it is blowing from). Instead of looking at speed and direction separately, we can convert the wind into two parts: the U component (east–west) and the V component (north–south). These two numbers together describe the full wind vector incorporating both wind speed and wind direction.

Statistics were therefore prepared for the following parameters:

- U component of wind
- V component of wind
- Temperature
- Pressure.

The following statistical tests were used:

- Index of agreement (IOA) - A bounded measure (0 to 1) that evaluates how well the modelled values match observations, considering both error magnitude and variability. Values near 1 indicate strong agreement.
- Root mean squared bias (RMSE) - Quantifies the average magnitude of error between modelled and observed values. It penalises large deviations more heavily and is useful for understanding overall error magnitude.
- Pearson rank correlation coefficient (PRC) - Measures the strength and direction of the linear relationship between modelled and observed data. Higher values suggest stronger linear alignment.
- Spearman rank correlation coefficient (SRC) - Evaluates the consistency of the rank order between modelled and observed values, capturing monotonic relationships even if they are not strictly linear.

Table B-1 provides an indication of interpretation of these statistics, and Table B-2 provides the statistical results.

To evaluate how well the prognostic model aligns with observed meteorological data, a combined performance score for each variable was calculated based on the average of the IOA, PRC and SRC as three key metrics.

The results indicate that there is moderate to strong agreement between the WRF output and the observed data making suitable for use in dispersion modelling.

Figure B-1 provides a comparison of wind roses for observed and modelled data to further provide an understanding of similarity between the datasets.

Table B-1: Interpretation of statistics

Statistic	Interpretation
Index of Agreement (IOA)	≥ 0.8 = Good ≥ 0.6 = Acceptable
Root Mean Squared Error (RMSE)	Lower is better
Pearson Correlation Coefficient (PRC)	≥ 0.8 = Strong $0.6-0.8$ = Moderate
Spearman Rank Correlation Coefficient (SRC)	≥ 0.8 = Strong $0.6-0.8$ = Moderate
Combined performance	≥ 0.8 = Strong $0.6-0.8$ = Moderate

Table B-2: Statistical results

Component	Index of Agreement (IOA)	Root Mean Squared Error (RMSE)	Pearson Correlation (PRC)	Spearman Correlation (SRC)	Combined Performance
u-component of wind	0.79	2.00	0.63	0.56	0.66
v-component of wind	0.89	2.45	0.80	0.76	0.82
Temperature	0.98	2.41	0.96	0.96	0.96
Humidity	0.92	11.43	0.86	0.86	0.88
Pressure	0.98	1.63	0.97	0.97	0.97

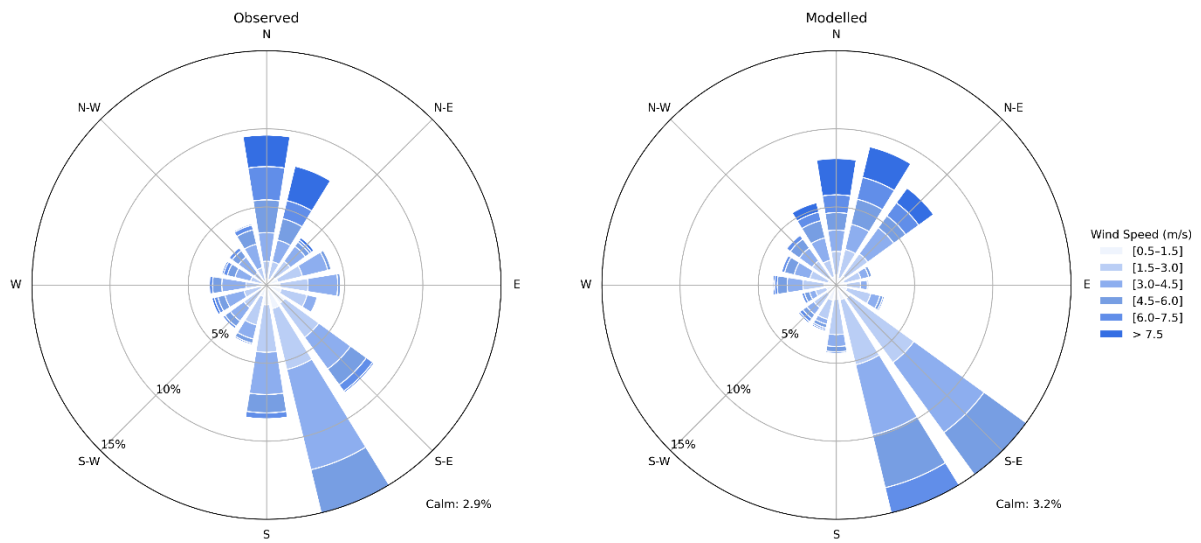


Figure B-1: Observed and modelled comparative wind roses for Narrabri for 2024