MINERAL RESOURCES

APPENDIX H

MINERAL RESOURCES LOCKYER DEVELOPMENT – 250TJ AIR DISPERSION MODELLING ASSESSMENT (RAMBOLL 2023)

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MINERAL RESOURCES – LOCKYER DEVELOPMENT 250 TJ - AIR DISPERSION MODELLING ASSESSMENT

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MINERAL RESOURCES – LOCKYER DEVELOPMENT
250 TJ - AIR DISPERSION MODELLING ASSESSMENT

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CONTENTS

1. INTRODUCTION

The Lockyer Development (the Project) is proposed to be developed in the mid-west region of Western Australia, approximately 30 km east of Dongara, by Energy Resources Limited (ERL), a wholly owned subsidiary of Mineral Resources Limited (MinRes).

The field was discovered by MinRes in October 2021 in Exploration Permit-368 and is believed to host economic volumes of prospective gas resources. Further exploration and appraisal is ongoing over the ~100 km2 prospective resource area.

The Project will collect gas from multiple wells and direct it via gas collection hubs to a Central Processing Facility (CPF) where the gas will be treated, and product gas routed via an export pipeline to the Dampier Bunbury Natural Gas Pipeline (DBNGP) for domestic use. Associated condensate liquids will be treated on site and then transported by truck off site for sale. The foundation project will be capable of producing 250 TJ/d sales gas.

The MinRes project is located in proximity to five other gas projects including Waitsia, Mondarra, Xyris, Hovea and West Erregulla (Figure 1) and emissions from the Project were assessed cumulatively with these sources. It is understood that there are a number of the other sources that are planned, operational, under construction or on care and maintenance, however it was conservatively assumed that all of these sources were operational with the exception of the Hovea gas processing facility which is currently being removed.

Ramboll Australia Pty Ltd (Ramboll) has been engaged by MinRes to undertake air dispersion modelling to assess the potential air quality impacts of atmospheric emissions from the Project, comparing the Ground Level Concentrations (GLCs) predicted at sensitive receptor locations against the relevant ambient air quality criteria. This report presents the approach, methodology and results of air dispersion modelling for the Facility operating under the nominated scenarios.

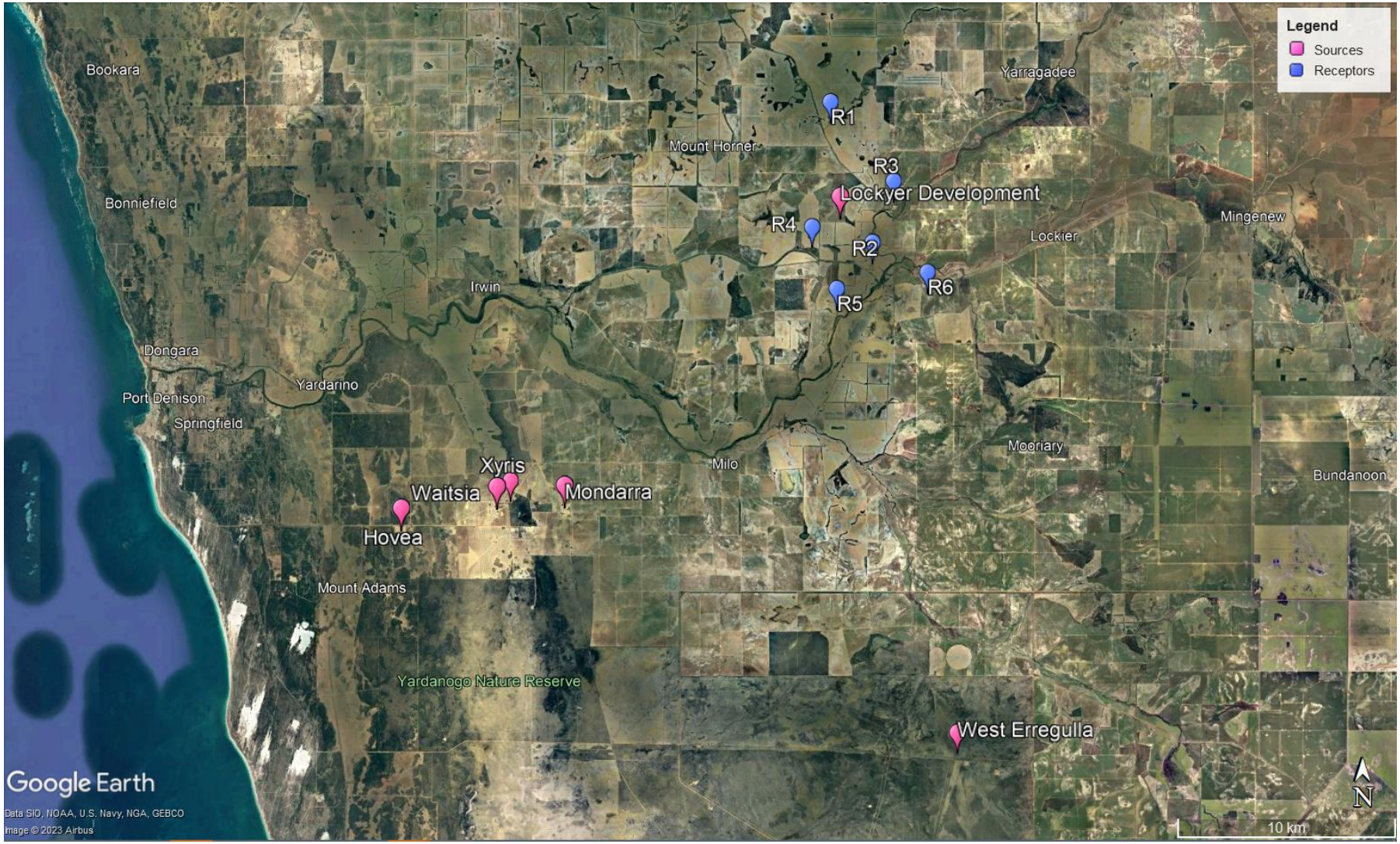

Figure 1: Overview of Project Location

2. ATMOSPHERIC EMISSIONS

2.1 Introduction

This section provides details on the atmospheric emissions of concern from the Project and other sources in the region. Emissions of concern included in this assessment of the Project are carbon monoxide (CO), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), fine particulates ($PM_{2.5}$), hydrogen sulfide (H_2S), mercury (Hg) and VOCs (including benzene, ethylbenzene, toluene, and xylene) (BTEX).

Besides the sources emitted from the Project, other potential emission sources in the region include:

- APA Group (APA) – Mondarra Gas Storage and Processing Facility (Mondarra) – Operational
- Australian Gas Infrastructure Gas Group (AGIG) – West Erregulla Gas Project (West Erregulla) – In Planning
- Mitsui E&P Australia (MEPAU) – Hovea Production Facility (Hovea) – Decommissioned
- Mitsui E&P Australia (MEPAU) – Waitsia Gas Project (Waitsia) – In Construction
- Mitsui E&P Australia (MEPAU) – Xyris Gas Plant (Xyris) – Operational

2.2 Lockyer Development

Emission sources at the Project will comprise:

- Gas generators – Power will be supplied by five 3,300 kW generators. Emissions of concern are primarily NO_X;
- Heating medium package – A heating medium package will be installed but will not operate continuously due to the high waste heat recovery compared to the heating medium load;
- Thermal oxidiser (TOX) – A thermal oxidiser will be in use to incinerate acid gases removed during processing. Emission of concern are primarily considered to be SO_2;
- Diesel generator – A diesel generator will also supply power during emergencies. Emissions of concern are primarily considered to be NO_X;
- Firewater diesel pump – Cumulative emission of four co-located operating fire water pumps. Emissions are primarily considered to be NO_X; and
- Continuous flares (x2) – flares will operate with a pilot light under normal operations. Emissions of concern are primarily considered to be NO_X and $PM_{2.5}$; and
- Emergency flare – gas will be rerouted to the flare under an emergency scenario. Emissions of concern are primarily considered to be NO_X and $PM_{2.5}$.

It is noted that MinRes advised that emissions of mercury and BTEX from the evaporation pond would be negligible as mercury and BTEX from the produced water and condensate stream would be actively removed (pers comms. 15th June 2023).

2.3 Other Regional Sources

Other sources considered as part of this assessment include the Mondarra, West Erregulla, Hovea, Xyris and Waitsia Gas Facilities.

2.3.1 APA – Mondarra

Mondarra operates approximately 18 km to the southwest of the Project as shown in Figure 1. Mondarra is located between two major pipelines that service Perth: The Parmelia Pipeline and the Dampier to Bunbury Natural Gas Pipeline (DBNGP).

The Mondarra facility includes the following sources of emissions to air:

- Flare – A small quantity of gas is vented through a permanently lit flare. The gas that reaches the flare is used to maintain a blanket of gas over the liquids, effectively preventing ingress of air into the vessels. The flare can operate under either normal conditions, whereby the facility is in injection mode for 2/3 of the time and in withdrawal mode for 1/3 of the time, or under blow-out conditions, expected to only occur under extreme circumstances on a less that one hour per year basis.
- A vent is maintained at the site for emergency purposes and for purging gas from equipment prior to maintenance.
- Power Generation and Compressors – Mondarra has two natural gas powered 3.2 MW compressor reciprocating engines as well as two 300 kVA natural gas powered GEAs operating.

All emissions information was obtained from a previous modelling assessment as supplied by the APA Group (Synergetics, 2011).

2.3.2 AGIG - West Erregulla

West Erregulla, located 25 km south of the Project, is not yet operational however is planned to start commercial production in 2024 with an expected export flow of 87 TJ/day.

Emission sources from the proposed West Erregulla facility have been considered as part of this assessment and include the following:

- Gas Engine Alternators (GEA) (x3) – for power generation. Emissions of concern are primarily considered to be NO_X and CO;
- Hot Oil Heater/Thermal Oxidiser Stack – to dispose of gas from Amine Reflux Drum/Amine Flash Drum and from burning fuel gas. Emissions of concern are primarily considered to be NO_X and CO;
- Diesel Engine Alternator (DEA) – used in the event of the GEA's being unavailable (such as during a black start scenario), but this is also expected to be rare occurrence (< 1% annually). Emissions of concern are primarily considered to be NO_X;
- Storage/Evaporation Pond - ponds can contain some trace amounts of mercury and so have been included as a fugitive emission source.
- Gas Chromatograph vents; and
- Maintenance vents (x2) – Operation of these vents is expected to be a very rare occurrence with the Facility being blown down to flare as part of normal shutdown procedures.

All emissions information was obtained from a previous modelling assessment as supplied by AGIG (EAQ Consulting, 2021).

2.3.3 MEPAU - Hovea

The Hovea Production Facility is located approximately 25 km to the southwest of the Project as shown in Figure 1. It is currently decommissioned with no known plans to operate into the future.

The Hovea Production Facility does still have an evaporation pond and a sump where stored water can contain some trace amounts of hydrocarbon. The evaporation ponds have been included in this assessment as fugitive sources.

2.3.4 MEPAU - Waitsia

The Waitsia Gas Project is located 20 km southwest of the Project (Figure 1).

Emission sources from Waitsia include the following:

- Compressor gas engines – Compression will be undertaken by two sets of three 2,600kw compressors. Each set of compressors will operate on an n+1 basis and so only 4 compressors will be operating at any one time. Emissions of concern are primarily considered to be NO_X;
- Gas Engine Alternator (GEA) – Power will be supplied by four 2,100kw generators. Then generators will be operating on an n+1 basis and so only three generators will operate at any one time. Emissions of concern are primarily considered to be NO_X;
- Heating Medium Boiler – A 15,000kw Heating Medium Boiler will operate continuously. Emissions of concern are primarily considered to be NO_X;
- Incinerator – An incinerator will be used to incinerate acid gases removed during processing. Emissions of concern are primarily considered to be NO_X;
- Flare – A flare will operate with a pilot light under normal operations and gas will be rerouted to the flare under an emergency scenario. In the event that the incinerator is not operational, the acid gas emissions will be redirected to the flare.
- Evaporation Pond – A process water pond will be used which can contain some trace amounts of hydrocarbon and so has been included as fugitive emissions sources. Emissions of concern are primarily considered to be BTEX and mercury;
- Vehicular combustion sources – Motor vehicles are considered a negligible source of atmospheric emissions (during both construction and operation), though they can result in relatively high ground level concentrations (GLCs) immediately adjacent to highly trafficked roads under stable, light wind conditions; and
- Fugitive dust from motor vehicle traffic and nearby exposed surfaces. This source is difficult to quantify accurately and therefore model and is considered best addressed through a monitoring and management program.

All emissions information was obtained from a previous modelling assessment conducted by Ramboll (Ramboll, 2019).

2.3.5 MEPAU – Xyris

Xyris currently processes 10 TJ/day however there are plans to increase the production of the facility to ~30TJ/day.

Emission sources from the proposed expansion of Xyris have been considered as part of this assessment and include the following:

- Compressor gas engine – Compression will be undertaken by a 750kw CAT G3512 LE Lean burn four stroke. Emissions of concern are primarily considered to be NO_X;
- Gas Engine Alternator (GEA) – Power will be supplied by a 100kw Cummins CG6L-8G1 lean burn four stroke model engine. Emissions of concern are primarily considered to be NO_X;

- Vents – The vents include a gas breakout tank vent, a liquids storage tank vent, and a plant vent. The plant vents are only used during plant maintenance when the plant needs to be de-pressured. Emissions of concern include BTEX and Mercury.
- Two process water ponds including an evaporation pond and a turkey nest. Both ponds can contain some trace amounts of hydrocarbon and so have been included as fugitive emissions sources.
- Vehicular combustion sources – Motor vehicles are considered a negligible source of atmospheric emissions (during both construction and operation), though they can result in relatively high ground level concentrations (GLCs) immediately adjacent to highly trafficked roads under stable, light wind conditions; and
- Fugitive dust from motor vehicle traffic, construction activities and nearby exposed surfaces. This source is difficult to quantify accurately and therefore model, and is considered best addressed through a monitoring and management program.

2.4 Emission Scenarios

The following emission scenarios, assess the Project emission cumulatively with the normal operations of the surrounding gas projects (Mondarra, West Erregulla, Hovea, Waitsia and Xyris).

Normal Operations - Normal operations at the Project includes emissions from the gas generators, heating medium package, thermal oxidiser, diesel generator, firewater pumps and continuous flares.

Emergency Shut Down– During a plant emergency shut down the Project will shut down and cease normal operations. This will cause emissions to atmosphere due to emergency flaring using the HP Flare for a period of minutes. Note that the modelling under the emergency scenario was conducted using a full year of hourly meteorological data. Given the infrequency of an emergency event, the predicted concentrations represent potential worst case and would likely be considered very conservative.

2.5 Emissions Rates

Emission rates for the Project sources were derived from information provided by MinRes. A summary of the source parameters and emissions rates for the Project utilised in the air dispersion modelling are presented in Table 1 to Table 5.

Table 1: Source Parameters and Emission Rates for the Project under Normal and Emergency Conditions (HP Flare)

Emission Source	Thermal Oxidizer (TOX)	Diesel Genset	Firewater Pumps (Diesel)	Gas Genset (x5)	HP Flare (Cont)	HP Flare (Emergency)	LP Flare (Cont)
Emission Type	Continuous	Emergency	Emergency	Continuous	Continuous	Emergency	Continuous
Stack Height (m)	39.6	4.3	4.3	10.5	53.6 (55.26)	53.6 (119.44)	53.6 (55.26)
Stack Internal Diameter (m)	0.5	0.3	0.3	0.7	0.79 (0.32)[1]	0.79 (14.87)	0.1 (0.12)
Exit Velocity (m/s) [per unit]	17.1	22.5	47.3	17.8	20[1]	20[1]	20[1]
Temp (K)	923.15	828.15	828.15	698.15	1,273.15	1,273.15	1,273.15
Mass Emission Rate Per Unit - Grams / Second							
$PM_{2.5}$	0.00E+00	2.45E-02	5.16E-02	9.86E-03	1.23E-02	6.83E+00	1.80E-03
NO_x	1.05E+00	7.86E-01	1.65E+00	1.61E+00	3.10E-02	1.72E+01	4.52E-03
SO_2	2.32E+00	2.48E-01	5.21E-01	7.88E-03	5.72E-04	3.17E-01	8.36E-05
Benzene	3.62E-05	0.00E+00	0.00E+00	7.54E-04	1.24E-04	6.85E-02	1.80E-05
Toluene	4.40E-05	0.00E+00	0.00E+00	5.00E-04	8.20E-05	4.55E-02	1.20E-05
Ethylbenzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xylene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BTEX Total	8.03E-05	0.00E+00	0.00E+00	1.25E-03	2.06E-04	1.14E-01	3.00E-05
Hg	1.45E-10	0.00E+00	0.00E+00	1.15E-10	1.89E-11	1.05E-08	2.76E-12
H_2S	4.44E-05	0.00E+00	0.00E+00	3.79E-05	6.20E-06	3.44E-03	9.08E-07
CO	6.06E-01	2.09E-01	4.39E-01	2.07E+00	1.42E-01	7.84E+01	2.06E-02

Notes:

1. Values in brackets for the flares are the pseudo stack heights and diameters that have been calculated based on the combustion of the flow of gas to the flare, in accordance with the procedures presented in the "Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants" (US EPA, 1992) for calculating the effective release height above ground for flare sources. The method assumes an exit velocity of 20 m/s.
2. The HP Flare is only expected to operate for 15 minutes during an emergency scenario.

Table 2: Source Parameters and Emission Rates for Waitsia under Normal Conditions

Emission Source	Gas Engine Generator (x4)	Export/ Inlet Gas Compressor Turbine (x6)	Acid Gas Incinerator (x2)	Heating Medium (x2)	Flare (Normal)	Evaporation Pond
Stack Height (m)	3.5	9.8	18.5	8	18	0
Stack Internal Diameter (m)	0.35	1.27	1.4	0.9	0.058	-
Exit Velocity (m/s) [per unit]	63.8	31.4	16.3	30	20	-
Temperature (°C)	673.15	723.15	1088.15	673.15	1273	-
Mass Emission Rate Per Unit - Grams / Second						
NOx	6.57E-01	7.93E+00	1.66E+00	2.04E+00	9.04E-04	-
CO	1.48E+00	6.53E-01	3.14E-01	8.12E-01	4.96E-03	-
$PM_{2.5}$	2.05E-04	1.49E-02	2.85E-02	7.37E-02	-	-
SO_2	2.06E-03	4.04E-03	9.36E-04	2.42E-03	3.77E-06	-
Benzene	1.17E-03	9.32E-05	1.49E-01	2.05E-03	-	4.27E-07
Toluene	1.08E-03	1.03E-03	1.26E-01	3.26E-03	-	2.08E-07
Ethylbenzene	1.05E-04	2.52E-04	1.10E-01	-	-	7.46E-09
Xylene	4.89E-04	4.97E-04	1.10E-01	-	-	1.55E-07
Hg	-	-	-	-	-	3.04E-10
H_2S	-	-	-	-	-	-

Table 3: Source Parameters and Emission Rates for Xyris under Normal Conditions

Emission Source	Gas Engine Generator	Export Gas Compressor Engine	Gas Breakout Tank	Liquids Storage Tank	Plant Vent	Sump	Turkeys Nest
Stack Height (m)	2	5	8	8	5	-	-
Stack Internal Diameter (m)	0.114	0.179	0.29	0.146	0.1	-	-
Exit Velocity (m/s)	9.6	24.5	0.09	0.01	245	-	-
Temperature (°C)	300-400	300-400	23	20-30	0 to -5	24025	25
Dimensions	-	-	-	-	-	33mx33mx2.5m	35mx25mx2.5m
Mass Emission Rate Per Unit - Grams / Second							
NOx	1.30E-01	8.28E-01	-	-	-	-	-
CO	8.54E-02	5.44E-01	-	-	-	-	-
$PM_{2.5}$	1.18E-05	7.53E-05	-	-	-	-	-
PM_{10}	1.18E-05	7.53E-05	-	-	-	-	-
SO_2	1.19E-04	7.58E-04	-	-	-	-	-
Benzene	2.75E-03	1.73E-02	1.67E-04	4.70E-06	5.40E-02	2.37E-04	3.46E-04
Toluene	2.16E-03	1.36E-02	1.31E-04	3.69E-06	4.24E-02	1.08E-04	1.61E-04
Ethylbenzene	1.83E-04	1.15E-03	1.11E-05	3.12E-07	3.58E-03	3.88E-06	5.76E-06
Xylenes	8.46E-04	5.32E-03	5.13E-05	1.44E-06	1.66E-02	8.31E-05	1.25E-04
Hg	4.67E-08	2.94E-07	2.83E-09	7.98E-11	9.17E-07	4.14E-07	4.39E-07
H_2S	-	-	-	-	-	-	-

Table 4: Source Parameters and Emission Rates for West Erregulla under Normal Conditions

Emission Source	Inlet Header facility Vent	Amine Vent	Regen Tower Reflux Vent	GEA (x3)	Gas Breakout Tank Vent	Water Setting Tank Vent	Atmospheric Vent	Thermal Oxidiser Stack	DEA (standby)	GC Hut Vent	Storage/ Evaporation Pond
Stack Height (m)	4	31	31	10	9	8.5	4	12	10	4	0.5
Stack Internal Diameter (m)	0.027	0.038	0.194	0.3	0.303	0.102	0.154	0.6	0.2	0.02	-
Exit Velocity (m/s)	50	50	50	26.7	0.03	0.06	0.03	50	24.9	6.12	-
Temperature (°C)	303.55	341.15	322.95	723.15	351.55	313.15	313.15	673.15	573.15	303.55	-
Dimensions	-	-	-	-	-	-	-	-	-	-	180mx180mx3m
Mass Emission Rate - Grams / Second											
NOx	-	-	-	3.67E-01	-	-	-	4.76E+00	8.60E-01	-	-
CO	-	-	-	2.98E-01	-	-	-	3.31E+00	2.05E-02	-	-
$PM_{2.5}$	-	-	-	-	-	-	-	-	-	-	-
SO_2	-	-	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	-	2.31E-01	2.86E-02	-	-
Toluene	-	-	-	-	-	-	-	2.31E-01	2.86E-02	-	-
Ethylbenzene	-	-	-	-	-	-	-	2.31E-01	2.86E-02	-	-
Xylene	-	-	-	-	-	-	-	2.31E-01	2.86E-02	-	-
Hg	-	-	-	-	-	-	-	-	-	-	4.63E-07
H_2S	2.34E-02	1.20E+00	-	-	3.00E-04	3.00E-04	5.04E-02	1.25E-02	1.00E-04	-	2.69E-05

Table 5: Source Parameters and Emission Rates for Hovea under Normal Conditions

Emission Source	Evaporation Pond	Turkeys Nest
Temperature (°C)	25	25
Dimensions	45mx35mx1m	29mx24mx1.5m
Mass Emission Rate - Grams / Second		
Benzene	5.47E-04	2.08E-04
Toluene	2.85E-04	1.00E-04
Ethylbenzene	1.03E-05	3.59E-06
Xylenes	2.11E-04	7.66E-05
Hg	2.40E-07	1.59E-07

2.6 Background Concentrations

In the absence of monitoring data for each of the pollutants of concern, estimates of regional pollutant concentrations were obtained from the CAMS global reanalysis (Copernicus, 2020) for the 2022 year. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset.

No specific guidance for selection of an appropriate background level is provided in Western Australia. Accordingly, in Victoria, the State Environment Protection Policy (Ambient Air Quality) (SEPP (AQM)) (EPA VIC, 2001) states that the 70th percentile concentration (concentration which is exceeded by 30% of concentrations for that averaging period) should be adopted as the background level.

The background concentration values adopted for this study as adapted from the CAMs dataset for the cumulative assessment of the various pollutants across the region are presented in Table 6.

Table 6: CAMS Derived Background Concentrations 2022

Pollutant	Criteria Type	Averaging Period	Background
NO_2	Human Health	1-hour Max	1.53E+00
		Annual Av	1.08E+00
	Workplace Exposure	15-Minute	2.02E+00
		8-hour	1.26E+00
SO_2	Human Health	1-hour Max	2.60E-01
		24-hour Max	1.70E-01
		Annual Av	1.80E-01
	Workplace Exposure	15-Minute	3.40E-01
		8-hour	2.10E-01
CO	Human Health	1-hour Max	1.16E+02
		8-hour Max	9.55E+01

Pollutant	Criteria Type	Averaging Period	Background
	Workplace Exposure	8-hour Max	9.55E+01
$PM_{2.5}$	Human Health	24-hour Max	4.65E+00
		Annual Av	4.81E+00

Notes

1. Referenced to 25ºC, and 101.3 kPa

2.7 Receptors

Ground Level Concentrations (GLCs) for all relevant compounds and averaging periods were predicted at six farmhouses surrounding the facility, as show in Figure 2, to assess ambient air quality criteria. Table 7 presents the locations of the dwellings.

Table 7: Receptor Locations (UTM coordinates)

Receptor	Type	mE	mN
R1	Primary Residence	329113	6773896
R2	Primary Residence	331127	6767527
R3	Unoccupied Residence	332056	6770334
R4	Primary Residence	328358	6768195
R5	Unoccupied Residence	329528	6765396
R6	Primary Residence	333668	6766213

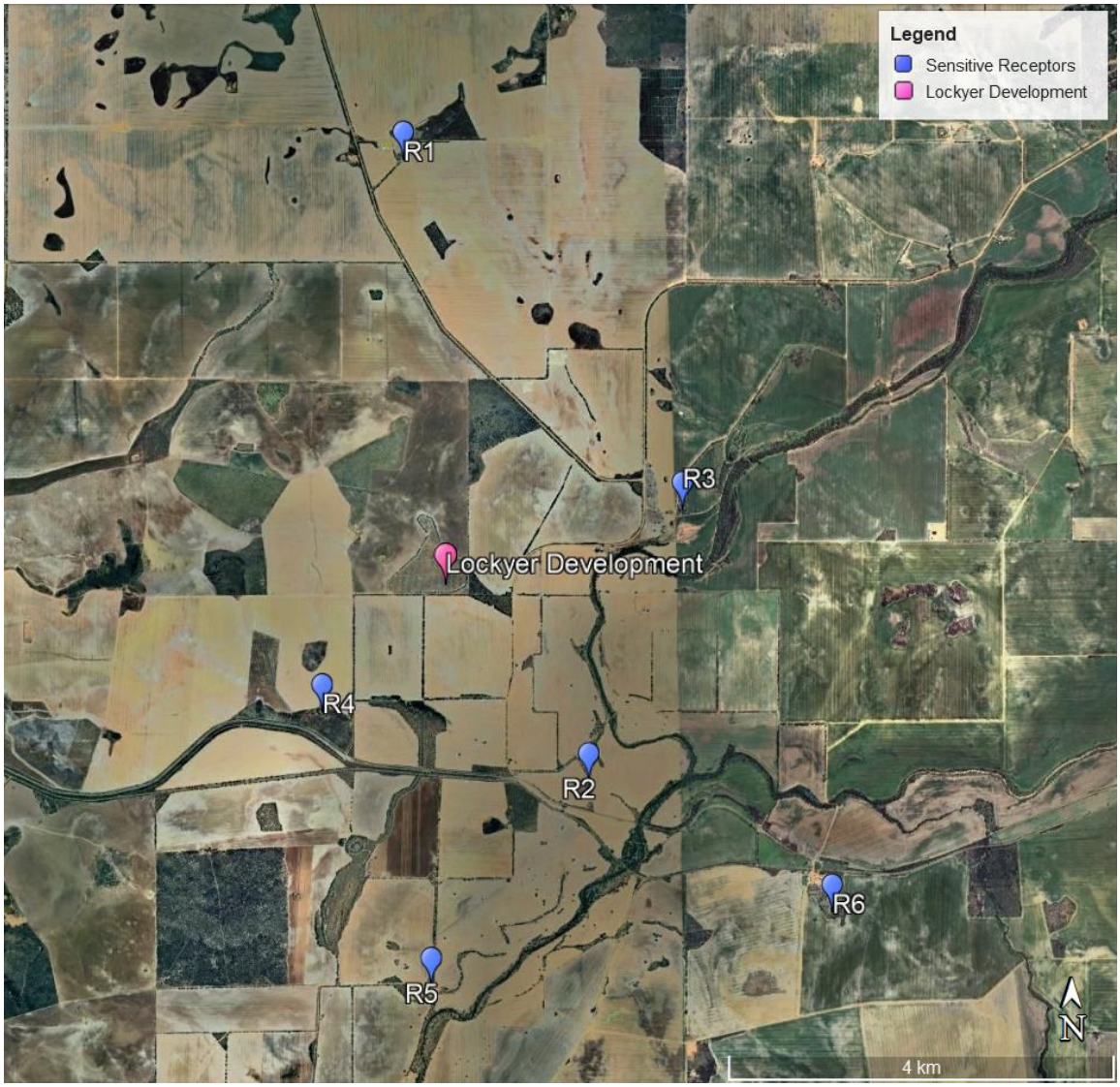

Figure 2: Sensitive Receptor Locations

3. IMPACT ASSESSMENT CRITERIA

3.1 Ambient Air Quality

The publications containing air quality criteria relevant to this assessment include:

- National Environment Protection (Ambient Air Quality) Measure (NEPM) (National Environment Protection Council (NEPC), 2016);
- NEPM (Air Toxics) (NEPC, 2011); and
- Air Emissions Guideline (DWER, 2019).

The Western Australian Department of Water and Environmental Regulation (DWER) has issued draft Air Quality Guideline Values (AGVs) to assess the level of risk associated with emissions to air (DWER, 2019). This contains AGVs for a number of the compounds of interest. These AGVs are supplemented by values outlined in the NEPC criteria. It should be noted that on the 18th of May 2021, the NEPC modified ambient standards for a number of pollutants, based on international guidance (NEPC, 2021).

Following public consultation federal Ministers agreed to several changes to the AAQ NEPM criteria including:

- significantly strengthening the NO_2 reporting standards for 1-hour and annual average NO_2 to 80 ppb and 15 ppb respectively from 120 ppb and 30 ppb;

The implemented changes bring forward standards initially proposed for 2025 (NEPC, 2021). The ambient air quality NEPM specifies standards and goals for a range of pollutants, the pollutants relevant to this assessment are carbon monoxide and nitrogen dioxide (NO_2) (Table 8). The updated values for NO_2 are more stringent than the values outlined in the DWER's Air Emissions Guideline (2019) and so the NEPM values have been applied for this assessment. Considering hydrogen sulfide is not included with the NEPC (2011), the DWER Air Emissions Guidelines were adopted for this pollutant Table 10.

Table 8: National Environment Protection (Ambient Air Quality) Measure Ambient Air Quality Standards and Goals

Pollutant	Averaging period	Maximum concentration standard (ppm)	Maximum concentration standard (µg/m³)[1]
Carbon Monoxide	8-hour	9	10,304
Nitrogen Dioxide	1-hour	0.08	151
	1 year	0.015	28
Sulfur Dioxide	1-hour	0.10	262
	1 day	0.02	52
Particles as $PM_{2.5}$	1-hour	-	23
	1 day	-	7

Notes:

1. Referenced to 25ºC, and 101.3 kPa.

The National Environment Protection (Air Toxics) Measure specifies monitoring investigation levels for several key pollutants relevant to this assessment, including formaldehyde and BTX, established for use in assessing the significance of monitored levels of air toxics with respect to protection of human health as outlined in Table 9.

Table 9: National Environment Protection (Air Toxics) Measure Ambient Air Quality Monitoring Investigation Levels

Pollutant	Averaging period	Monitoring investigation level (ppm)	Monitoring investigation level (µg/m³)[1]	Goal
Benzene	Annual	0.003	9.6	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
Toluene	24-hour	1	3,766	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
	Annual	0.1	377	
Xylenes (as total of ortho, meta and para isomers)	24-hour	0.25	1,085	8-year goal is to gather sufficient data nationally to facilitate development of a standard.
	Annual	0.2	868	

Notes:

1. Referenced to 25ºC, and 101.3 kPa.

Table 10: Department of Water and Environmental Regulation (DWER)

Pollutant	Averaging period	Maximum (ambient) concentration (ppm)	Maximum (ambient) concentration (µg/m³) [1]
Carbon Monoxide	1-hour	25	30,000
	8-hour	9	10,000
Nitrogen Dioxide	1-hour	0.12	226
	Annual	0.03	56
Sulfur Dioxide	1 day	0.2	524
	24-hour	0.08	210
	Annual	0.02	52
Particles as $PM_{2.5}$	1 day	-	23
	1 year	-	7
Ethylbenzene	1-hour	-	8,000
	Annual	-	270
Benzene	1-hour	0.009	29
	Annual	0.003	9.6
Toluene	24-hour	1	3770
	Annual	0.1	377
Xylene	24-hour	0.25	1080
	Annual	0.2	870
Mercury	1-hour	-	0.55
	Annual	-	0.19
Hydrogen Sulphide	1-day	-	2,560
	24-hour	-	137
	Annual	-	1.8

Notes:

1. Referenced to 25ºC, and 101.3 kPa.

A summary of the standards applicable for this assessment are summarised in Table 11 below.

Table 11: Ambient Air Quality Standards Applicable to the Project

Pollutant	Averaging Period	Ambient Air conc. ppm	Ambient Air conc. (µg/m³)[1]	Type	Reference
Carbon Monoxide	1-hour	25	30,000	human health	DWER (2019)
	8-hour	9	10,000	human health	NEPC (2016) & DWER (2019)
Nitrogen Dioxide	1-hour	0.08	151	human health	NEPC (2021)
	Annual	0.015	28	human health	NEPC (2021)
Sulphur dioxide	1 hour	0.10	262	human health	NEPC (2021)
	1 day	0.02	52	human health	NEPC (2021)
	1 year	0.02	52	human health	DWER (2019)
Particles as $PM_{2.5}$	1 day	-	23	human health	NEPC (2011) & DWER (2019)
	1 year	-	7	human health	NEPC (2011) & DWER (2019)
Ethylbenzene	1-hour	-	8,000	human health	DWER (2019)
	Annual	-	270	human health	DWER (2019)
Benzene	1-hour	0.009	29	human health	DWER (2019)
	Annual	0.003	9.6	human health	NEPC (2011) & DWER (2019)
Toluene	24-hour	1	3770	human health	NEPC (2011) & DWER (2019)
	Annual	0.1	377	human health	NEPC (2011) & DWER (2019)
Xylene	24-hour	0.25	1080	human health	NEPC (2011) & DWER (2019)
	Annual	0.2	870	human health	NEPC (2011) & DWER (2019)
Mercury	1-hour	-	0.55	human health	DWER (2019)
	Annual	-	0.19	human health	DWER (2019)
Hydrogen Sulphide	1 day	-	2560	human health	DWER (2019)
	24-hour	-	137	human health	DWER (2019)
	Annual	-	1.8	human health	DWER (2019)

Notes:

1. Referenced to 25ºC, and 101.3 kPa.

3.2 Workplace Exposure Standards

Workplace exposure standards for approximately 700 substances and mixtures have been established in Australia by Safe Work Australia, an Australian government statutory body. These are legal concentration limits that must not be exceeded. Workplace exposure standards are generally less conservative than ambient air quality standards to account for the general health of the workforce and shorter exposure times. Relevant workplace exposure standards are presented in Table 12.

Table 12: Workplace Exposure Standards

Pollutant	Averaging Period	Criteria (ppm)	Criteria (µg/m^3)[1]	Criteria Reference
NO_2	15-Minute	5	9400	Safe Work Australia (2022)
	8-Hour	3	5,600	Safe Work Australia (2022)
CO	8-hour	30	34,000	Safe Work Australia (2022)
SO_2	15-Minute	5	13,000	Safe Work Australia (2022)
	8-hour	2	5,200	Safe Work Australia (2022)
H_2S	15-Minute	15	21,000	Safe Work Australia (2022)
	8-hour	10	14,000	Safe Work Australia (2022)
Ethylbenzene	15-Minute	125	125,000	Safe Work Australia (2022)
	8-hour	100	543,000	Safe Work Australia (2022)
Benzene	8-hour	1	3,200	Safe Work Australia (2022)
Toluene	15-Minute	150	574,000	Safe Work Australia (2022)
	8-Hour	50	191,000	Safe Work Australia (2022)
Xylene	15-Minute	150	655,000	Safe Work Australia (2022)
	8-Hour	80	350,000	Safe Work Australia (2022)
Mercury	8-Hour	0.003	25	Safe Work Australia (2022)

Notes:

1. Referenced to 25ºC, and 101.3 kPa.

4. ATMOSPHERIC DISPERSION MODELLING

4.1 Model Selection

The CALPUFF dispersion model was used for this assessment. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model. It utilises three-dimensional wind fields to simulate the effects of the temporal and spatial meteorological conditions on pollutant transport, transformation, and removal. CALPUFF also allows for three-dimensional characterisation of land use and surface characteristics such as height and density of vegetation.

The meteorological information used in the modelling was derived from the prognostic meteorological component of The Air Pollution Modelling (TAPM) in conjunction with site specific meteorological monitoring undertaken at a number of monitoring stations in the region. The prognostic data from TAPM was used as input into the CALMET meteorological pre-processing program used to generate meteorological files for CALPUFF.

4.2 Model Processing

4.2.1 TAPM

The closest meteorological monitoring stations with data available for use in this study were Morawa (~75 km away), Carnamah (~84 km away) and Mullewa (~73 km away). Due to the distances these datasets were not considered suitable for inclusion in this assessment.
In the absence of suitable monitored data, the TAPM (The Air Pollution Model) prognostic meteorological model developed by CSIRO was used to generate a gridded meteorological dataset for the modelling domain for 2022. The TAPM output was used as inputs into the CALMET meteorological processor to develop a meteorological data file suitable for use in CALPUFF.

TAPM was developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) and consists of coupled prognostic meteorological and air pollution dispersion model components. The meteorological component of TAPM predicts the local-scale meteorological features, such as sea breezes and terrain-induced circulations, using the larger-scale synoptic meteorology as boundary conditions combined with other data including terrain, land use, soil, and surface types. TAPM has been used extensively throughout Australia for generating site specific meteorological files for use in air dispersion modelling studies.

4.2.2 Meteorological Validation

To validate the use of the TAPM gridded meteorological dataset for the current modelling assessment, three statistical measures comparing wind speed and wind direction from TAPM-predicted and Bureau of Meteorology (BoM) observed data for the year 2022 have been evaluated. The closest meteorological monitoring station- Morawa was utilised as the observed data, and the TAPM data was extracted at the closest grid point to the Morawa station and input as the predicted data. The statistical measures for evaluation include:

- Wind Speed –Root Mean Square Error (RMSE): This is an acceptable average measure of the difference or error between predicted and observed values. Low RMSE values in a model indicate that the model is explaining most of the variation in the observations. The benchmark for wind speed RMSE of <2 m/s has been extracted from Emery et al., 2001.
- Wind Speed – Index of Agreement (IOA): IOA reflects the ratio of the total RMSE to the sum of two differences – between each prediction and the observed mean, and each observation and

the observed mean. Hurley (2000) suggests that an IOA of 60% or greater represents a good correlation. An IOA of 1 means a perfect correlation between predicted and observed.

- Wind Direction – Gross Error: calculated as the mean absolute difference in prediction-observation pairings with valid data within a given analysis region and for a given time period (hourly or daily). A benchmark for wind direction gross error of ≤30 degrees has been utilised from Emery et al., 2001.

The benchmarks, derived from Emery et al., 2001, were based upon the evaluation of the Pennsylvania State University/ National Centre for Atmospheric Research (PSU/NCAR) Fifth generation Mesoscale Model (MM5) and the Regional Atmospheric Modelling System (RAMS) application reported by Tesche et al. (2001b). They provide context, when comparing predicted results to observed results, for the reviewer. A result which does not meet the benchmark does not necessarily determine the strength of the predicted values and critical evaluation is therefore imperative when understanding the results.

A summary of the TAPM performance evaluation results is presented Table 13. A scatterplot of predicted and observed wind speed is displayed in Figure 3. The model evaluation results indicate that TAPM is predicting the wind speed in the study area with reasonable skill. The performance of TAPM is comparable to its performance elsewhere for near-surface meteorology.

Annual wind roses of TAPM predicted winds and observations from the Morawa meteorological monitoring station in 2022 are presented in Figure 4. The wind roses demonstrate that winds are predominantly occurring from an east to south direction (within the southeast quadrant) for both the observed and predicted dataset. However, compared with winds monitored at the Morawa monitoring station, the TAPM predicted winds have predicted slightly lower wind speeds. The wind direction gross error indicates that the benchmark has been met for wind direction.

Table 13: Performance Evaluation Summary – Wind Speed and Wind Direction

Pollutant	Units	Performance Evaluation Criteria	TAPM Predicted for Morawa Airport
Wind Speed total RMSE	m/s	<2	1.41
Wind Speed IOA	%	>60%	70%
Wind Direction Gross Error	degrees	≤30	7.82

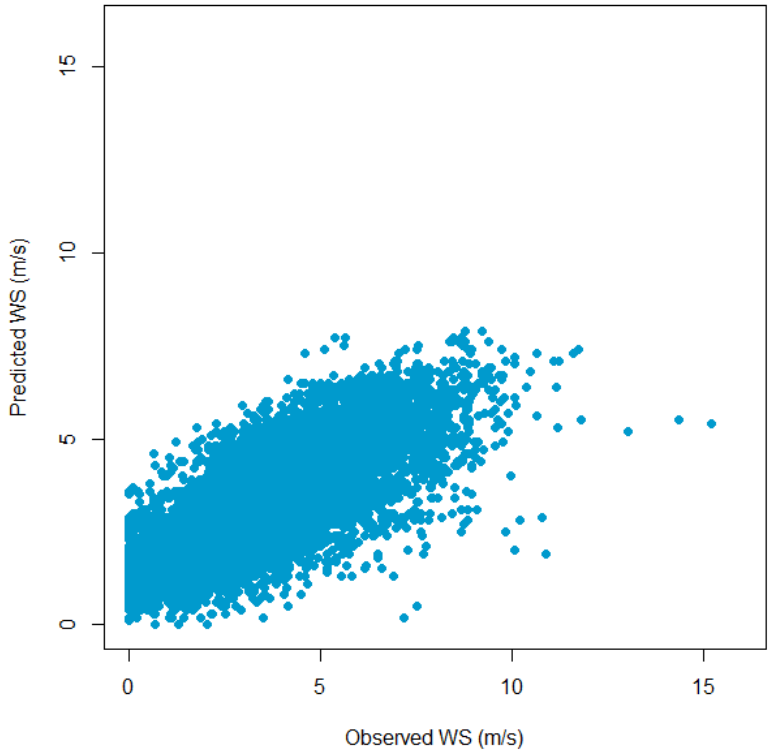

Figure 3: Scatterplot of Observed vs Predicted Wind Speed at Morawa Monitoring station.

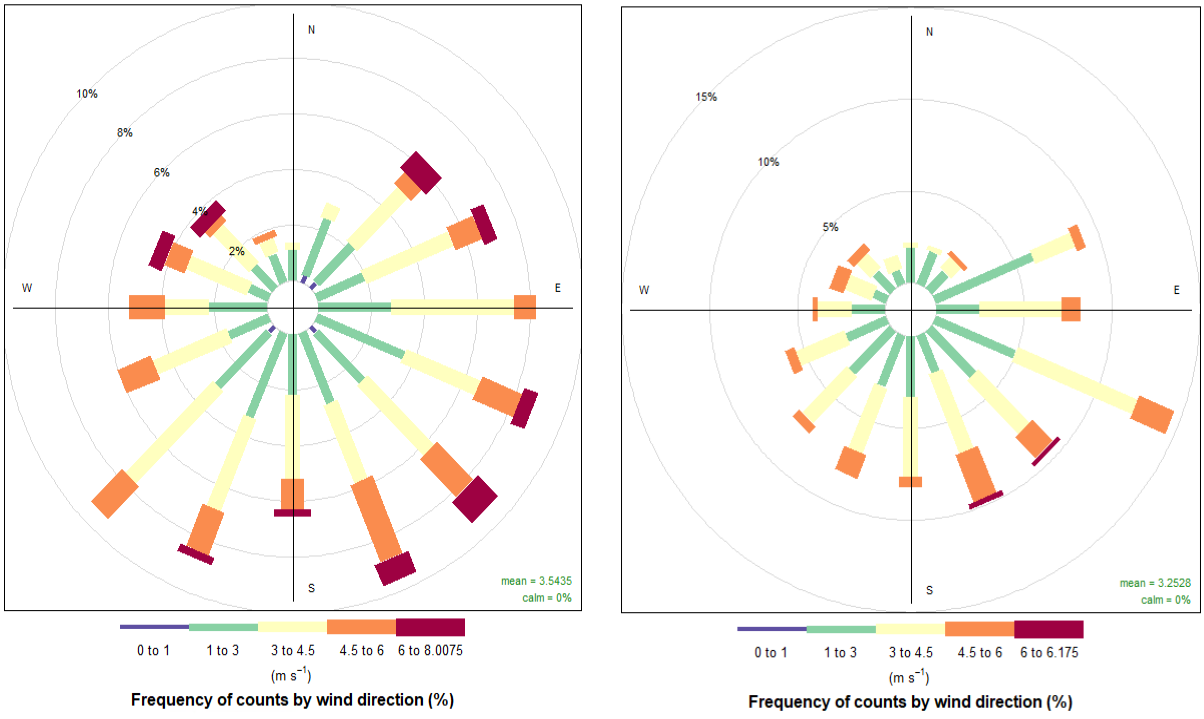

Figure 4: Morawa Monitoring Station Wind Roses for BOM – Measured (left) and TAPM – Predicted (right).

4.2.3 CALMET

The CALMET meteorological processor was used to develop a meteorological file for input into the CALPUFF model. CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterised treatments of terrain effects such as slope flows and terrain blocking effects. Fine scale terrain effects were determined using the diagnostic wind module in CALMET.

4.2.4 CALPUFF

The CALPUFF modelling system was used to predict ambient concentrations associated with emissions from operations associated with the Project. CALPUFF provides a non-steady state modelling approach which evaluates the effects of spatial changes in the meteorological and surface characteristics and has been listed by the United States Environmental Protection Agency (USEPA) as an alternative model for situations involving complex terrain and wind conditions (sea breezes), where typical steady-state plume dispersion models (such as AERMOD) have limited capability.

4.3 CALPUFF Model Parameterisation

The following model set up options within CALPUFF were used:

- Meteorological and sampling grid of 44 km by 44 km encompassing the Project in the region, with grid spacings of 1 km;
- No chemical transformation;
- Partial Plume Penetration;
- Puff modelling method; and
- Default partial plume path adjustment.

4.4 Short Term Averaging Periods

Some workplace exposure standards are based on short term (15-minute) averages. However, air dispersion modelling is generally undertaken in 1-hour time steps and in order to compare the predicted concentrations against the nominated standards, a simple averaging-time scaling factor was used to estimate short-term peak concentrations. This adjustment primarily addresses the effect of meandering (fluctuations in the wind about the mean flow for the hour) on the average lateral distribution of material. The scaling factor used to adjust the lateral dispersion coefficient for averaging time is the $1/5^{th}$ power law:

$$Cl = Cs\ (60 / tl)^{0.2}$$

Where:
Cl = Concentration for new averaging period;
Cs = Concentration for the 1-hour average period;
tl = the averaging time (min.) of interest

4.5 Treatment of Oxides of Nitrogen

A key element in assessing the potential environmental impacts from ground level NO_2 concentrations is estimating NO_2 concentrations from modelled NO_x emissions. The final NO_2 concentration is a combination of the NO emitted as NO_2 from the source stacks and the amount of NO that is converted to NO_2 by oxidation in the plume after release.

Generally, after the NO_x is emitted from the stack, additional NO_2 is formed as the plume mixes and reacts with the surrounding air. There are several reactions that both form and destroy NO_2, but the primary reaction is oxidation with ozone according to the following reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$

This reaction is essentially instantaneous as the plume entrains the surrounding air. It is limited by the amount of ozone available and by how quickly the plume mixes with the surrounding air. Thus, the ratio of NO_2 to NO_x increases as the plume disperses downwind. After release, the NO is converted to NO_2 by chemical reactions, primarily involving ozone in the presence of sunlight and to a lesser extent due to other reactive gases.

Ramboll has applied the Ozone Limiting Method (OLM) to predict ground level concentrations of NO_2 as specified by the USEPA (see Cole and Summerhays 1979) and NSW Environment Protection Authority (NSW EPA, 2022). This method assumes that all the available ozone in the atmosphere will react with nitrogen oxide (NO) in the plume until either all the available ozone or all the NO is used up. This approach is conservative in that it assumes that the atmospheric reaction is instant when in reality, the reaction takes place over a number of hours.

Similar to the attainment of the background concentration data for each pollutant, in the absence of ozone monitoring data, regional ozone concentrations were adapted from the CAMS global reanalysis dataset similarly to the background concentrations of all the pollutants of concern. The 70^{th} percentile ozone concentration (19.6 ppb) for the region in 2022 was obtained from the CAMS data set and utilised in this assessment.

5. PREDICTED CONCENTRATIONS

5.1 Results Summary

The following section presents the predicted concentrations of CO, SO_2, NO_2, H_2S, Hg and BTEX using the CALPUFF model. GLCs of the modelled compounds have been predicted within the modelling domain. The predicted cumulative GLCs for the Project and surrounding operations operating under normal conditions are summarised in Table 14 and Table 15. The predicted GLCs for the Project operating during an emergency shut down scenario along with the cumulative emission from surrounding operations are presented in Table 16 and Table 17.

The results of the air dispersion modelling assessment show that predicted GLCs for all compounds are below the relevant ambient air quality standard criteria at all locations including the sensitive receptor locations during both normal operations and the emergency scenario.

The pollutant that most closely approached the guideline was the annual average for $PM_{2.5}$ however this was a function of the assumed background concentrations and the contribution from the plant to the predicted concentrations was considered negligible. The main pollutant of concern was considered to be NO_2 and predicted cumulative concentrations including all regional sources under normal operations were predicted to be well below the nominated guidelines at sensitive receptor locations.

Table 14: Cumulative Maximum Predicted Concentrations at Sensitive Receptors (R1 to R4) for the Project – During Normal Operations

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R1		R2		R3		R4	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
NO_2	Human Health	1-hour Max	1.51E+02	1.53E+00	4.89E+01	32.40%	3.95E+01	26.17%	2.84E+01	18.78%	4.68E+01	30.96%
		Annual Av	2.80E+01	1.08E+00	2.44E+00	8.73%	1.42E+00	5.06%	1.58E+00	5.64%	2.12E+00	7.56%
	Workplace Exposure	15-Minute	9.40E+03	2.02E+00	6.46E+01	0.69%	5.21E+01	0.55%	3.74E+01	0.40%	6.17E+01	0.66%
		8-hour	5.60E+03	1.26E+00	2.24E+01	0.40%	1.19E+01	0.21%	2.07E+01	0.37%	3.34E+01	0.60%
SO_2	Human Health	1-hour Max	2.62E+02	2.60E-01	1.37E+01	5.23%	1.03E+01	3.92%	6.56E+00	2.50%	1.19E+01	4.55%
		24-hour Max	5.20E+01	1.70E-01	1.74E+00	3.35%	7.71E-01	1.48%	1.98E+00	3.82%	3.19E+00	6.14%
		Annual Av	5.20E+01	1.80E-01	3.59E-01	0.69%	2.04E-01	0.39%	2.32E-01	0.45%	3.12E-01	0.60%
	Workplace Exposure	15-Minute	1.30E+04	3.40E-01	1.81E+01	0.14%	1.36E+01	0.10%	8.66E+00	0.07%	1.57E+01	0.12%
		8-hour	5.20E+03	2.10E-01	3.89E+00	0.07%	1.71E+00	0.03%	5.56E+00	0.11%	6.16E+00	0.12%
CO	Human Health	1-hour Max	3.00E+04	1.16E+02	1.85E+02	0.618%	1.54E+02	0.512%	1.43E+02	0.476%	1.66E+02	0.554%
		8-hour Max	1.00E+04	9.55E+01	1.20E+02	1.20%	1.02E+02	1.02%	1.15E+02	1.15%	1.27E+02	1.27%
	Workplace Exposure	8-hour Max	3.40E+04	9.55E+01	1.20E+02	0.35%	1.02E+02	0.30%	1.15E+02	0.34%	1.27E+02	0.37%
$PM_{2.5}$	Human Health	24-hour Max	2.30E+01	4.65E+00	4.79E+00	20.84%	4.68E+00	20.35%	4.73E+00	20.58%	4.85E+00	21.09%
		Annual Av	7.00E+00	4.81E+00	4.83E+00	68.933%	4.81E+00	68.739%	4.81E+00	68.762%	4.82E+00	68.839%
Mercury	Human Health	1-hour Max	5.50E-01	0.00E+00	6.64E-03	1.21%	6.49E-03	1.18%	5.48E-03	1.00%	9.05E-03	1.65%
		Annual Av	1.90E-01	0.00E+00	1.50E-04	0.08%	1.83E-04	0.10%	1.56E-04	0.08%	2.11E-04	0.11%
	Workplace Exposure	8-hour	2.50E+01	0.00E+00	2.85E-03	0.01%	3.98E-03	0.02%	3.16E-03	0.01%	3.77E-03	0.02%
Benzene	Human Health	1-hour Max	2.90E+01	0.00E+00	2.00E-01	0.69%	1.60E-01	0.55%	1.28E-01	0.44%	1.84E-01	0.63%
		Annual Av	9.60E+00	0.00E+00	4.73E-03	0.05%	3.52E-03	0.04%	3.25E-03	0.03%	4.78E-03	0.05%
	Workplace Exposure	8-hour	3.20E+03	0.00E+00	1.11E-01	0.003%	1.09E-01	0.003%	7.87E-02	0.002%	1.11E-01	0.003%
Toluene	Human Health	24-hour Max	3.77E+03	0.00E+00	5.23E-02	0.001%	3.33E-02	0.001%	3.52E-02	0.001%	4.25E-02	0.001%
		Annual Av	3.77E+02	0.00E+00	4.09E-03	0.001%	2.99E-03	0.001%	2.78E-03	0.001%	4.05E-03	0.001%
		15-Minute	5.74E+05	0.00E+00	1.72E-01	0.00003%	1.37E-01	0.00002%	1.10E-01	0.00002%	1.58E-01	0.00003%

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R1		R2		R3		R4	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
	Workplace Exposure	8-hour	1.91E+05	0.00E+00	9.54E-02	0.00%	8.48E-02	0.00%	6.25E-02	0.00%	8.82E-02	0.00%
Ethylbenzene	Human Health	1-hour Max	8.00E+03	0.00E+00	1.31E-01	0.002%	1.01E-01	0.001%	8.46E-02	0.001%	1.15E-01	0.001%
		Annual	2.70E+02	0.00E+00	2.44E-03	0.0009%	1.44E-03	0.0005%	1.39E-03	0.0005%	1.94E-03	0.0007%
	Workplace Exposure	15-Minute	1.25E+05	0.00E+00	1.72E-01	0.00014%	1.33E-01	0.00011%	1.12E-01	0.00009%	1.52E-01	0.00012%
		8-hour	5.43E+05	0.00E+00	6.74E-02	0.0000%	4.61E-02	0.0000%	4.61E-02	0.0000%	5.10E-02	0.0000%
Xylene	Human Health	24-hour Max	1.08E+03	0.00E+00	3.29E-02	0.0030%	1.67E-02	0.0015%	2.61E-02	0.0024%	2.22E-02	0.0021%
		Annual Av	8.70E+02	0.00E+00	2.91E-03	0.0003%	1.97E-03	0.0002%	1.84E-03	0.0002%	2.61E-03	0.0003%
	Workplace Exposure	15-Minute	6.55E+05	0.00E+00	1.37E-01	0.00002%	1.08E-01	0.00002%	8.87E-02	0.00001%	1.22E-01	0.00002%
		8-hour	3.50E+05	0.00E+00	7.30E-02	0.00002%	4.61E-02	0.00001%	4.85E-02	0.00001%	5.88E-02	0.00002%
H_2S	Human Health	1-hour Max	2.56E+03	0.00E+00	6.76E-01	0.03%	6.02E-01	0.02%	4.30E-01	0.02%	4.57E-01	0.02%
		24-hour Max	1.37E+02	0.00E+00	1.06E-01	0.08%	1.08E-01	0.08%	8.10E-02	0.06%	1.06E-01	0.08%
		Annual Av	1.80E+00	0.00E+00	9.81E-03	0.54%	7.87E-03	0.44%	7.08E-03	0.39%	8.83E-03	0.49%
	Workplace Exposure	15-Minute	2.10E+04	0.00E+00	8.92E-01	0.004%	7.94E-01	0.004%	5.67E-01	0.003%	6.03E-01	0.003%
		8-hour	1.40E+04	0.00E+00	3.07E-01	0.002%	3.01E-01	0.002%	2.09E-01	0.001%	2.94E-01	0.002%

Notes
1. Referenced to 25ºC, and 101.3 kPa.

Table 15: Cumulative Maximum Predicted Concentrations at Sensitive Receptors (R5 - R6) for the Project - During Normal Operations

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R5		R6	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
NO_2	Human Health	1-hour Max	1.51E+02	1.53E+00	2.90E+01	19.19%	3.19E+01	21.12%
		Annual Av	2.80E+01	1.08E+00	1.39E+00	4.96%	1.38E+00	4.92%
	Workplace Exposure	15-Minute	9.40E+03	2.02E+00	3.82E+01	0.41%	4.21E+01	0.45%
		8-hour	5.60E+03	1.26E+00	1.20E+01	0.22%	1.71E+01	0.31%
SO_2	Human Health	1-hour Max	2.62E+02	2.60E-01	6.56E+00	2.50%	4.40E+00	1.68%
		24-hour Max	5.20E+01	1.70E-01	1.08E+00	2.08%	5.47E-01	1.05%
		Annual Av	5.20E+01	1.80E-01	1.98E-01	0.38%	1.92E-01	0.37%
	Workplace Exposure	15-Minute	1.30E+04	3.40E-01	8.65E+00	0.07%	5.80E+00	0.04%
		8-hour	5.20E+03	2.10E-01	2.38E+00	0.05%	1.27E+00	0.02%
CO	Human Health	1-hour Max	3.00E+04	1.16E+02	1.33E+02	0.444%	1.32E+02	0.439%
		8-hour Max	1.00E+04	9.55E+01	1.07E+02	1.07%	1.03E+02	1.03%
	Workplace Exposure	8-hour Max	3.40E+04	9.55E+01	1.07E+02	0.31%	1.03E+02	0.30%
$PM_{2.5}$	Human Health	24-hour Max	2.30E+01	4.65E+00	4.70E+00	20.42%	4.69E+00	20.39%
		Annual Av	7.00E+00	4.81E+00	4.81E+00	68.735%	4.81E+00	68.730%
Mercury	Human Health	1-hour Max	5.50E-01	0.00E+00	8.22E-03	1.50%	7.82E-03	1.42%
		Annual Av	1.90E-01	0.00E+00	2.13E-04	0.11%	2.06E-04	0.11%
	Workplace Exposure	8-hour	2.50E+01	0.00E+00	4.61E-03	0.02%	3.38E-03	0.01%
Benzene	Human Health	1-hour Max	2.90E+01	0.00E+00	1.63E-01	0.56%	1.75E-01	0.60%
		Annual Av	9.60E+00	0.00E+00	3.95E-03	0.04%	2.96E-03	0.03%
	Workplace Exposure	8-hour	3.20E+03	0.00E+00	1.28E-01	0.004%	9.63E-02	0.00%
Toluene	Human Health	24-hour Max	3.77E+03	0.00E+00	3.85E-02	0.001%	3.07E-02	0.00%
		Annual Av	3.77E+02	0.00E+00	3.34E-03	0.001%	2.54E-03	0.00%
	Workplace Exposure	15-Minute	5.74E+05	0.00E+00	1.40E-01	0.00002%	1.50E-01	0.00003%
		8-hour	1.91E+05	0.00E+00	9.88E-02	0.00%	8.23E-02	0.00%

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R5		R6	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
Ethylbenzene	Human Health	1-hour Max	8.00E+03	0.00E+00	9.90E-02	0.001%	1.13E-01	0.001%
		Annual	2.70E+02	0.00E+00	1.59E-03	0.0006%	1.32E-03	0.0005%
	Workplace Exposure	15-Minute	1.25E+05	0.00E+00	1.31E-01	0.00010%	1.49E-01	0.00012%
		8-hour	5.43E+05	0.00E+00	4.36E-02	0.0000%	5.80E-02	0.0000%
Xylene	Human Health	24-hour Max	1.08E+03	0.00E+00	1.65E-02	0.0015%	2.34E-02	0.0022%
		Annual Av	8.70E+02	0.00E+00	2.19E-03	0.0003%	1.74E-03	0.0002%
	Workplace Exposure	15-Minute	6.55E+05	0.00E+00	1.07E-01	0.00002%	1.20E-01	0.00002%
		8-hour	3.50E+05	0.00E+00	4.36E-02	0.00001%	6.32E-02	0.00002%
H_2S	Human Health	1-hour Max	2.56E+03	0.00E+00	6.08E-01	0.02%	5.22E-01	0.02%
		24-hour Max	1.37E+02	0.00E+00	1.08E-01	0.08%	9.29E-02	0.07%
		Annual Av	1.80E+00	0.00E+00	8.68E-03	0.48%	7.90E-03	0.44%
	Workplace Exposure	15-Minute	2.10E+04	0.00E+00	8.03E-01	0.004%	6.89E-01	0.003%
		8-hour	1.40E+04	0.00E+00	2.77E-01	0.002%	2.66E-01	0.002%

Notes
1. Referenced to 25ºC, and 101.3 kPa.

Table 16: Cumulative Maximum Predicted Concentrations at Sensitive Receptors (R1 to R4) for the Project - During Emergency Scenario

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R1		R2		R3		R4	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
NO_2	Human Health	1-hour Max	1.51E+02	1.53E+00	5.15E+01	34.13%	4.86E+01	32.22%	3.91E+01	25.88%	5.08E+01	33.67%
		Annual Av	2.80E+01	1.08E+00	2.16E+00	7.71%	1.45E+00	5.19%	1.68E+00	6.00%	2.18E+00	7.77%
	Workplace Exposure	15-Minute	9.40E+03	2.02E+00	6.80E+01	0.72%	6.42E+01	0.68%	5.16E+01	0.55%	6.71E+01	0.71%
		8-hour	5.60E+03	1.26E+00	2.14E+01	0.38%	1.19E+01	0.21%	3.03E+01	0.54%	2.28E+01	0.41%
SO_2	Human Health	1-hour Max	2.62E+02	2.60E-01	2.03E+00	0.78%	1.53E+00	0.58%	9.53E-01	0.36%	1.93E+00	0.74%
		24-hour Max	5.20E+01	1.70E-01	4.03E-01	0.77%	2.30E-01	0.44%	3.52E-01	0.68%	4.53E-01	0.87%
		Annual Av	5.20E+01	1.80E-01	1.93E-01	0.37%	1.83E-01	0.35%	1.86E-01	0.36%	1.92E-01	0.37%
	Workplace Exposure	15-Minute	1.30E+04	3.40E-01	2.68E+00	0.02%	2.01E+00	0.02%	1.26E+00	0.01%	2.55E+00	0.02%
		8-hour	5.20E+03	2.10E-01	6.75E-01	0.01%	3.81E-01	0.01%	7.46E-01	0.01%	6.07E-01	0.01%
CO	Human Health	1-hour Max	3.00E+04	1.16E+02	5.55E+02	1.851%	4.29E+02	1.430%	2.87E+02	0.958%	5.29E+02	1.763%
		8-hour Max	1.00E+04	9.55E+01	2.11E+02	2.11%	1.38E+02	1.38%	2.28E+02	2.28%	1.94E+02	1.94%
	Workplace Exposure	8-hour Max	3.40E+04	9.55E+01	2.11E+02	0.62%	1.38E+02	0.41%	2.28E+02	0.67%	1.94E+02	0.57%
$PM_{2.5}$	Human Health	24-hour Max	2.30E+01	4.65E+00	9.67E+00	42.02%	5.91E+00	25.71%	8.56E+00	37.20%	1.07E+01	46.70%
		Annual Av	7.00E+00	4.81E+00	5.08E+00	72.5%	4.86E+00	69.5%	4.93E+00	70.39%	5.06E+00	72.3%
Mercury	Human Health	1-hour Max	5.50E-01	0.00E+00	6.64E-03	1.21%	6.49E-03	1.18%	5.48E-03	1.00%	9.05E-03	1.65%
		Annual Av	1.90E-01	0.00E+00	1.50E-04	0.08%	1.83E-04	0.10%	1.56E-04	0.08%	2.11E-04	0.11%
	Workplace Exposure	8-hour	2.50E+01	0.00E+00	2.85E-03	0.01%	3.98E-03	0.02%	3.16E-03	0.01%	3.77E-03	0.02%
Benzene	Human Health	1-hour Max	2.90E+01	0.00E+00	4.37E-01	1.51%	2.73E-01	0.94%	1.50E-01	0.52%	3.61E-01	1.24%
		Annual Av	9.60E+00	0.00E+00	7.14E-03	0.07%	4.01E-03	0.04%	4.36E-03	0.05%	7.10E-03	0.07%
	Workplace Exposure	8-hour	3.20E+03	0.00E+00	1.11E-01	0.003%	1.09E-01	0.003%	1.16E-01	0.004%	1.11E-01	0.003%
Toluene	Human Health	24-hour Max	3.77E+03	0.00E+00	5.23E-02	0.001%	3.33E-02	0.001%	4.08E-02	0.001%	4.73E-02	0.001%
		Annual Av	3.77E+02	0.00E+00	5.69E-03	0.002%	3.32E-03	0.001%	3.51E-03	0.001%	5.59E-03	0.001%
	Workplace Exposure	15-Minute	5.74E+05	0.00E+00	3.09E-01	0.00005%	1.81E-01	0.00003%	1.10E-01	0.00002%	2.40E-01	0.00004%
		8-hour	1.91E+05	0.00E+00	9.54E-02	0.00%	8.48E-02	0.00%	7.67E-02	0.00%	8.82E-02	0.00%

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R1		R2		R3		R4	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
Ethylbenzene	Human Health	1-hour Max	8.00E+03	0.00E+00	1.31E-01	0.002%	1.01E-01	0.001%	8.46E-02	0.001%	1.15E-01	0.001%
		Annual	2.70E+02	0.00E+00	2.44E-03	0.0009%	1.44E-03	0.0005%	1.39E-03	0.0005%	1.94E-03	0.0007%
	Workplace Exposure	15-Minute	1.25E+05	0.00E+00	1.72E-01	0.00014%	1.33E-01	0.00011%	1.12E-01	0.00009%	1.52E-01	0.00012%
		8-hour	5.43E+05	0.00E+00	6.74E-02	0.0000%	4.61E-02	0.0000%	4.61E-02	0.0000%	5.10E-02	0.0000%
Xylene	Human Health	24-hour Max	1.08E+03	0.00E+00	3.29E-02	0.0030%	1.67E-02	0.0015%	2.61E-02	0.0024%	2.22E-02	0.0021%
		Annual Av	8.70E+02	0.00E+00	2.91E-03	0.0003%	1.97E-03	0.0002%	1.84E-03	0.0002%	2.61E-03	0.0003%
	Workplace Exposure	15-Minute	6.55E+05	0.00E+00	1.37E-01	0.00002%	1.08E-01	0.00002%	8.87E-02	0.00001%	1.22E-01	0.00002%
		8-hour	3.50E+05	0.00E+00	7.30E-02	0.00002%	4.61E-02	0.00001%	4.85E-02	0.00001%	5.88E-02	0.00002%
H_2S	Human Health	1-hour Max	2.56E+03	0.00E+00	6.76E-01	0.03%	6.02E-01	0.02%	4.30E-01	0.02%	4.57E-01	0.02%
		24-hour Max	1.37E+02	0.00E+00	1.07E-01	0.08%	1.08E-01	0.08%	8.10E-02	0.06%	1.06E-01	0.08%
		Annual Av	1.80E+00	0.00E+00	9.93E-03	0.55%	7.90E-03	0.44%	7.14E-03	0.40%	8.95E-03	0.50%
	Workplace Exposure	15-Minute	2.10E+04	0.00E+00	8.92E-01	0.004%	7.94E-01	0.004%	5.67E-01	0.003%	6.03E-01	0.003%
		8-hour	1.40E+04	0.00E+00	3.07E-01	0.002%	3.01E-01	0.002%	2.09E-01	0.001%	2.94E-01	0.002%

Notes

1. Referenced to 25ºC, and 101.3 kPa

Table 17: Cumulative Maximum Predicted Concentrations at Sensitive Receptors (R5 to R6) for the Project - During Emergency Scenario

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R5		R6	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
NO_2	Human Health	1-hour Max	1.51E+02	1.53E+00	2.90E+01	19.19%	3.19E+01	21.12%
		Annual Av	2.80E+01	1.08E+00	1.40E+00	5.01%	1.38E+00	4.93%
	Workplace Exposure	15-Minute	9.40E+03	2.02E+00	3.82E+01	0.41%	4.21E+01	0.45%
		8-hour	5.60E+03	1.26E+00	1.03E+01	0.18%	1.71E+01	0.31%
SO_2	Human Health	1-hour Max	2.62E+02	2.60E-01	6.95E-01	0.27%	6.54E-01	0.25%
		24-hour Max	5.20E+01	1.70E-01	2.46E-01	0.47%	2.01E-01	0.39%
		Annual Av	5.20E+01	1.80E-01	1.82E-01	0.35%	1.81E-01	0.35%
	Workplace Exposure	15-Minute	1.30E+04	3.40E-01	9.17E-01	0.01%	8.64E-01	0.01%
		8-hour	5.20E+03	2.10E-01	3.69E-01	0.01%	2.86E-01	0.01%
CO	Human Health	1-hour Max	3.00E+04	1.16E+02	2.24E+02	0.746%	2.14E+02	0.712%
		8-hour Max	1.00E+04	9.55E+01	1.35E+02	1.35%	1.14E+02	1.14%
	Workplace Exposure	8-hour Max	3.40E+04	9.55E+01	1.35E+02	0.40%	1.14E+02	0.34%
$PM_{2.5}$	Human Health	24-hour Max	2.30E+01	4.65E+00	6.28E+00	27.30%	5.32E+00	23.11%
		Annual Av	7.00E+00	4.81E+00	4.84E+00	69.2%	4.83E+00	69.0%
Mercury	Human Health	1-hour Max	5.50E-01	0.00E+00	8.22E-03	1.50%	7.82E-03	1.42%
		Annual Av	1.90E-01	0.00E+00	2.13E-04	0.11%	2.06E-04	0.11%
	Workplace Exposure	8-hour	2.50E+01	0.00E+00	4.61E-03	0.02%	3.38E-03	0.01%
Benzene	Human Health	1-hour Max	2.90E+01	0.00E+00	1.63E-01	0.56%	1.75E-01	0.60%
		Annual Av	9.60E+00	0.00E+00	4.25E-03	0.04%	3.15E-03	0.03%
	Workplace Exposure	8-hour	3.20E+03	0.00E+00	1.28E-01	0.004%	9.63E-02	0.00%
Toluene	Human Health	24-hour Max	3.77E+03	0.00E+00	3.85E-02	0.001%	3.07E-02	0.00%
		Annual Av	3.77E+02	0.00E+00	3.54E-03	0.001%	2.67E-03	0.00%
	Workplace Exposure	15-Minute	5.74E+05	0.00E+00	1.40E-01	0.00002%	1.50E-01	0.00003%
		8-hour	1.91E+05	0.00E+00	9.88E-02	0.00%	8.23E-02	0.00%

Pollutant	Criteria Type	Averaging Period	Criteria (µg/m3)	Background	R5		R6	
					Conc. (µg/m3)	% of Guide.	Conc. (µg/m3)	% of Guide.
Ethylbenzene	Human Health	1-hour Max	8.00E+03	0.00E+00	9.90E-02	0.001%	1.13E-01	0.001%
		Annual	2.70E+02	0.00E+00	1.59E-03	0.0006%	1.32E-03	0.0005%
	Workplace Exposure	15-Minute	1.25E+05	0.00E+00	1.31E-01	0.00010%	1.49E-01	0.00012%
		8-hour	5.43E+05	0.00E+00	4.36E-02	0.0000%	5.80E-02	0.0000%
Xylene	Human Health	24-hour Max	1.08E+03	0.00E+00	1.65E-02	0.0015%	2.34E-02	0.0022%
		Annual Av	8.70E+02	0.00E+00	2.19E-03	0.0003%	1.74E-03	0.0002%
	Workplace Exposure	15-Minute	6.55E+05	0.00E+00	1.07E-01	0.00002%	1.20E-01	0.00002%
		8-hour	3.50E+05	0.00E+00	4.36E-02	0.00001%	6.32E-02	0.00002%
H_2S	Human Health	1-hour Max	2.56E+03	0.00E+00	6.08E-01	0.02%	5.22E-01	0.02%
		24-hour Max	1.37E+02	0.00E+00	1.08E-01	0.08%	9.29E-02	0.07%
		Annual Av	1.80E+00	0.00E+00	8.69E-03	0.48%	7.91E-03	0.44%
	Workplace Exposure	15-Minute	2.10E+04	0.00E+00	8.03E-01	0.004%	6.89E-01	0.003%
		8-hour	1.40E+04	0.00E+00	2.77E-01	0.002%	2.66E-01	0.002%

Notes

1. Referenced to 25ºC, and 101.3 kPa

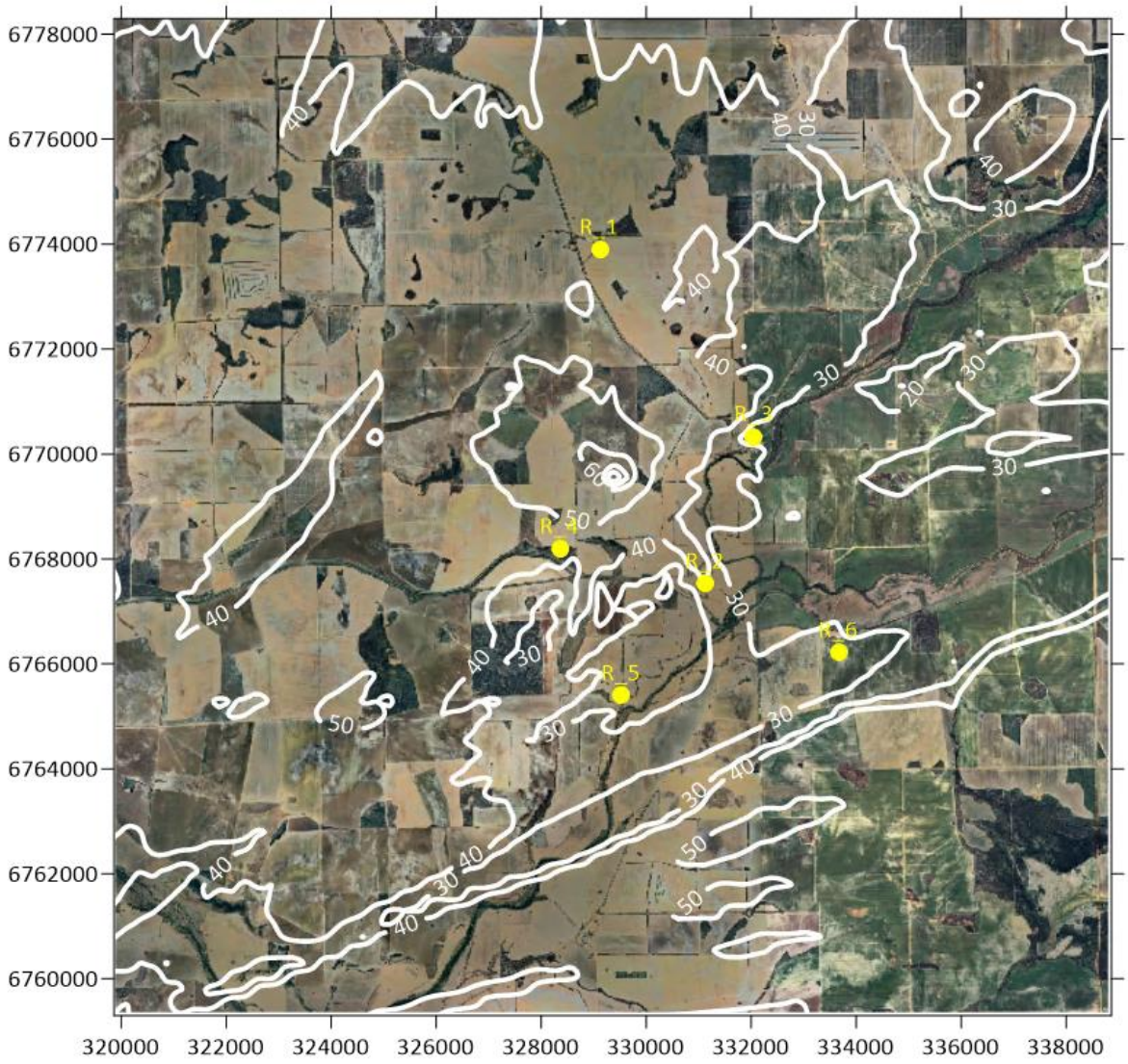

Figure 5: Cumulative Maximum Predicted 1-hour Average GLCs of NO_2 under Normal Operations

Notes

1. Guideline of 151 ug/m^3
2. Yellow Dots represent the Discrete receptors.

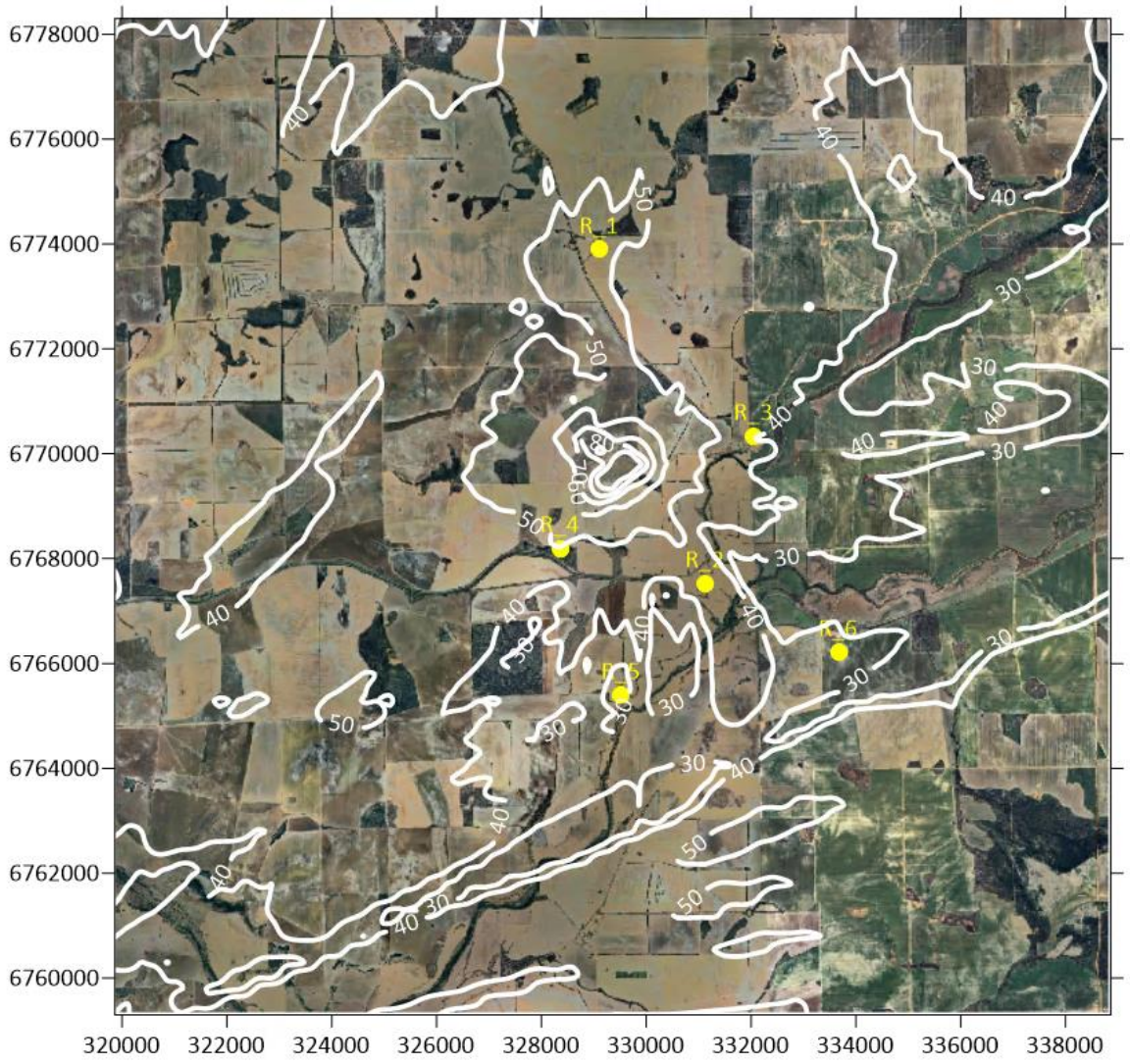

Figure 6: Cumulative Maximum Predicted 1-hour Average GLCs of NO_2 under Emergency Shut Down

Notes

1. Guideline of 151 ug/m^3
2. Yellow Dots represent the Discrete receptors.

6. CONCLUSIONS

MinRes manages the Project located approximately 30 km northeast of Dongara. Air dispersion modelling from the proposed operations in conjunction with other regional sources was undertaken to assess the potential air quality impacts of atmospheric emissions from the Project, comparing the GLCs predicted at sensitive receptor locations against the relevant ambient air quality criteria.

The modelling predicted cumulative GLCs for all pollutants below the corresponding ambient air quality and workplace exposure standard criteria at all locations including sensitive receptor locations for both scenarios. The pollutant that most closely approached the guideline was the annual average for $PM_{2.5}$ however this was a function of the assumed background concentrations and the contribution from the plant to the predicted concentrations was considered negligible. The main pollutant of concern was considered to be NO_2 and predicted cumulative concentrations including all regional sources under normal operations were predicted to be well below the nominated guidelines at sensitive receptor locations.

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