Trinity Consultants Australia

RESIDENTIAL DEVELOPMENT CAR PARK VENTS

299 Coronation Drive, Milton

Air Quality Assessment

Silverstone Developments

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Report
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1. INTRODUCTION

1.1 Overview

Trinity Consultants Australia was commissioned by Silverstone Developments to complete an air quality assessment for a proposed car park exhaust vent at the multiple dwelling development at 299 Coronation Drive, Milton.

The proposed development comprises two (2) car park exhaust vents, one of which is located within 15 metres of the nearest onsite sensitive receivers and therefore does not comply with the 15-metre setback defined as an acceptable outcome in the relevant Brisbane City Plan codes.

A detailed air quality modelling assessment has been undertaken, in accordance with the Brisbane City Council (BCC) Air Quality Planning Scheme Policy, to evaluate potential impacts and demonstrate compliance with the relevant air quality criteria. The assessment considers cumulative impacts from both exhaust vents and modelled road traffic emissions from Coronation Drive.

1.2 Scope

This report describes the assessment of the air quality impacts, which is based on the following tasks:

- Review the project and associated potential air emissions.
- Review existing air quality monitoring data applicable to the project site.
- Estimate pollutant emissions from the carpark exhaust vents.
- Model meteorological conditions using the GRAMM model.
- Model the dispersion of expected air pollutants using GRAL to estimate pollutant levels at sensitive receptors and develop concentration contours across the modelling domain.
- Analyse the results of the meteorological and dispersion modelling and compare predicted concentrations with the relevant air quality criteria.

To aid in the understanding of terms in this report a glossary is included in **Appendix A**.

2. PROPOSED DEVELOPMENT

2.1 Site Location

The development site is located at 299 Coronation Drive, Milton, on lot 1 on RP211215, currently occupied by a four-story commercial building. The subject site is situated within a Mixed use (Inner city) zone under the Brisbane City Plan 2014 Zoning Overlay and with the Priority Infrastructure Area.

The site is bounded by the following land uses:

- North: Graham Street, with commercial uses and an early childcare centre located on the opposite side of the road, 50 metres north.
- East: Coronation Drive, Bicentennial Bikeway and the Brisbane River.
- South-west: Commercial uses and a service station.
- West: Commercial uses.
- South: Commercial uses. Nearest residential use area located approximately 250 metres south-southeast.

Figure 2.1 presents the site location, surrounding land uses and zoning.

Figure 2.1: Site Location and Zoning

2.2 Project Description

The proposed development comprises of a high-density 29-storey residential apartment complex with associated basement and podium car parking and building services. In total, the development will accommodate 192 residential apartments across a mix of 2- and 3-bedroom dwellings and a ground-floor café.

Car parking for residents and visitors is provided across three basement levels, the ground level and three podium levels. Specific commercial car parking incorporation is not currently proposed.

The level 4 and level 5-27 plans are provided in **Figure 2.2** and **Figure 2.3**. Building elevation is provided in **Figure 2.4**.

Figure 2.2: Level 4 Plan

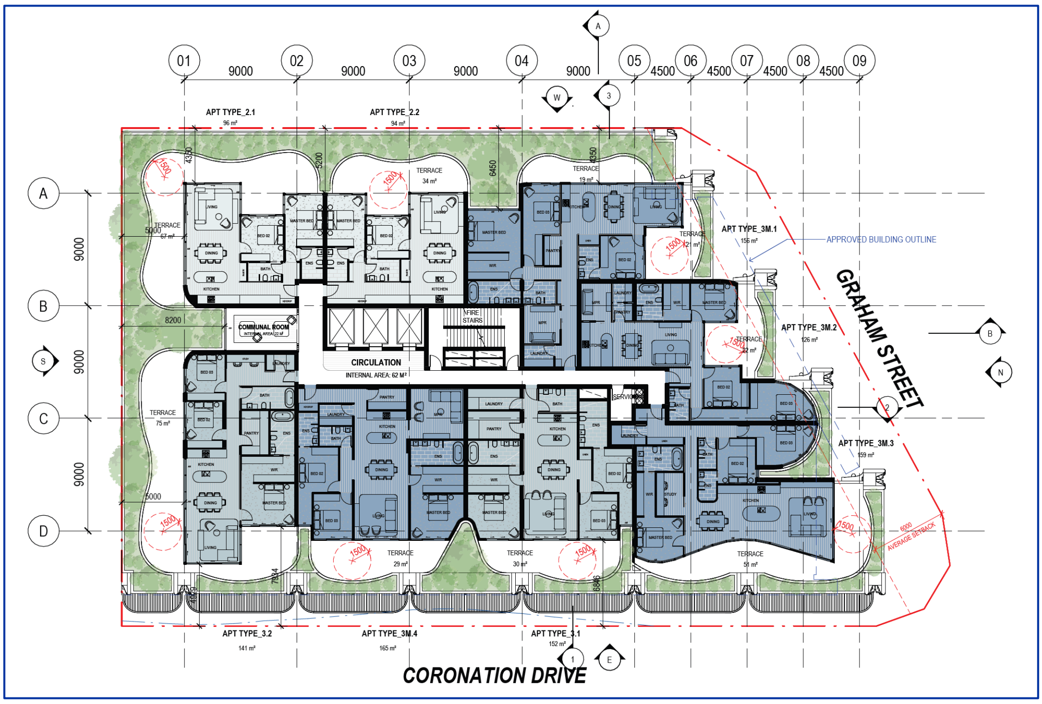


Figure 2.3: Level 5-27 Plan

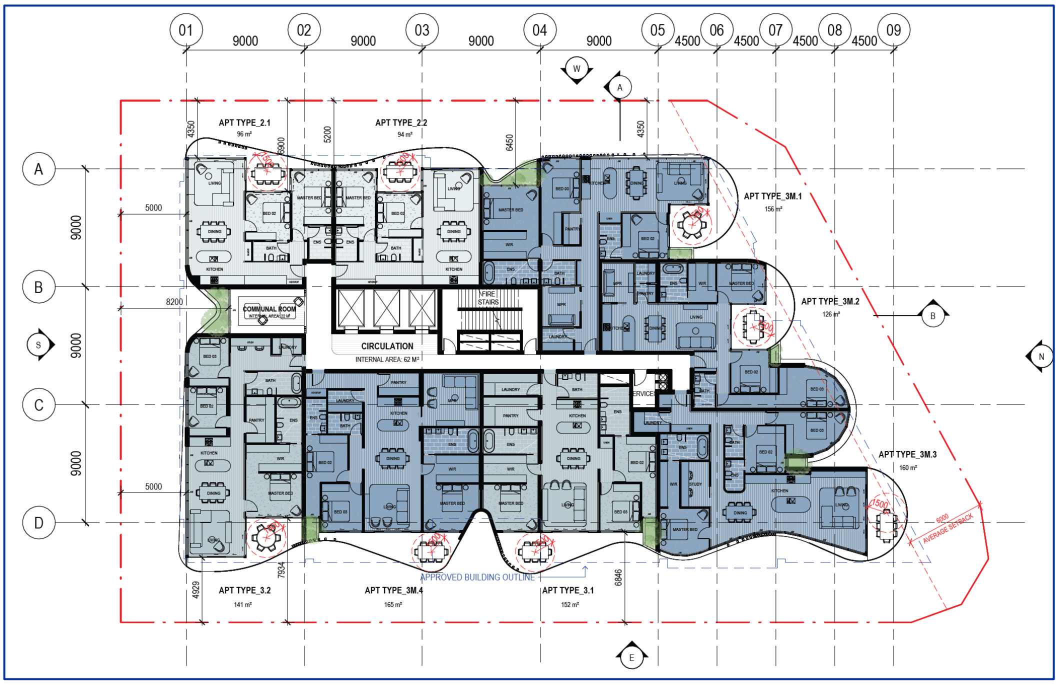
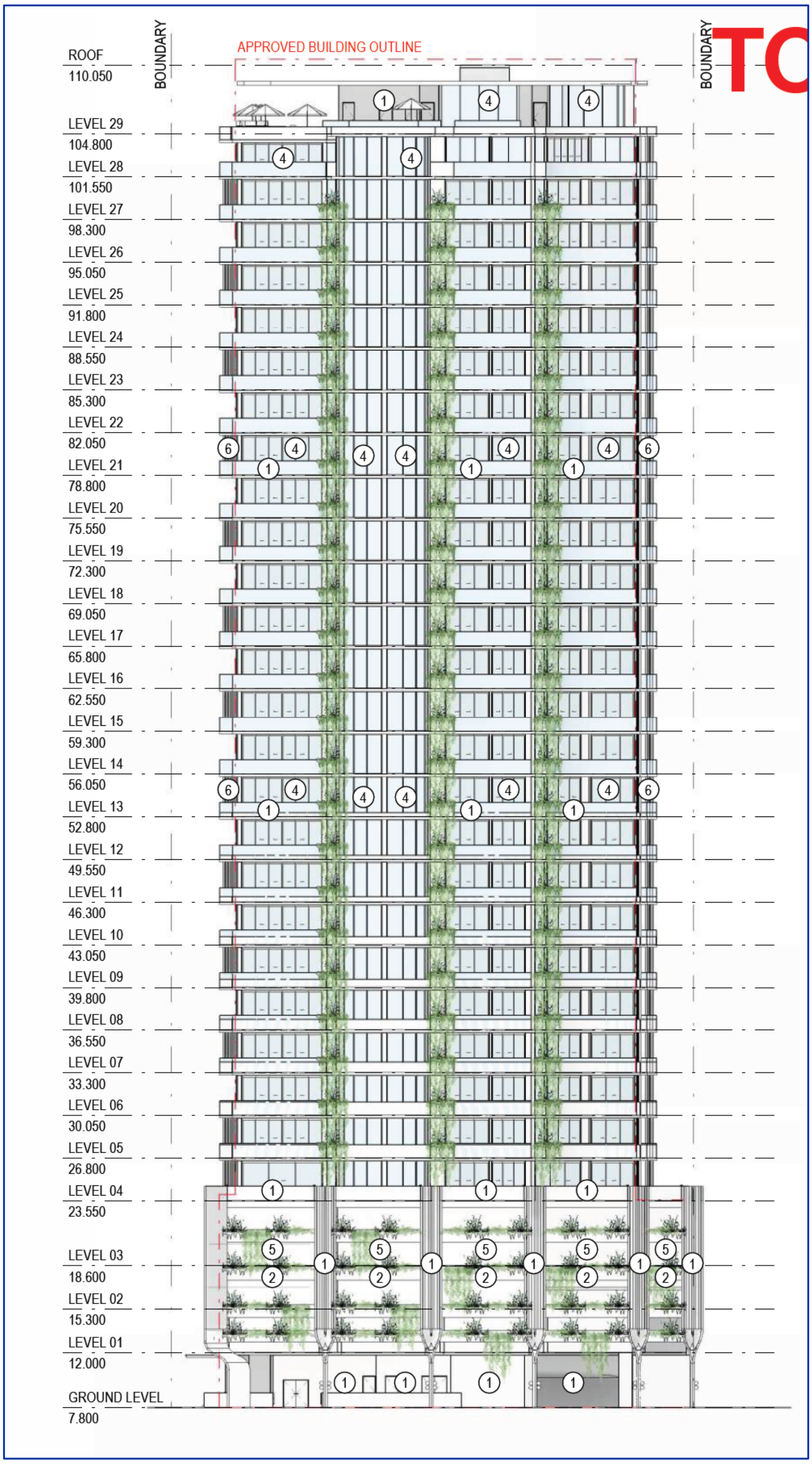


Figure 2.4: Building North Elevation

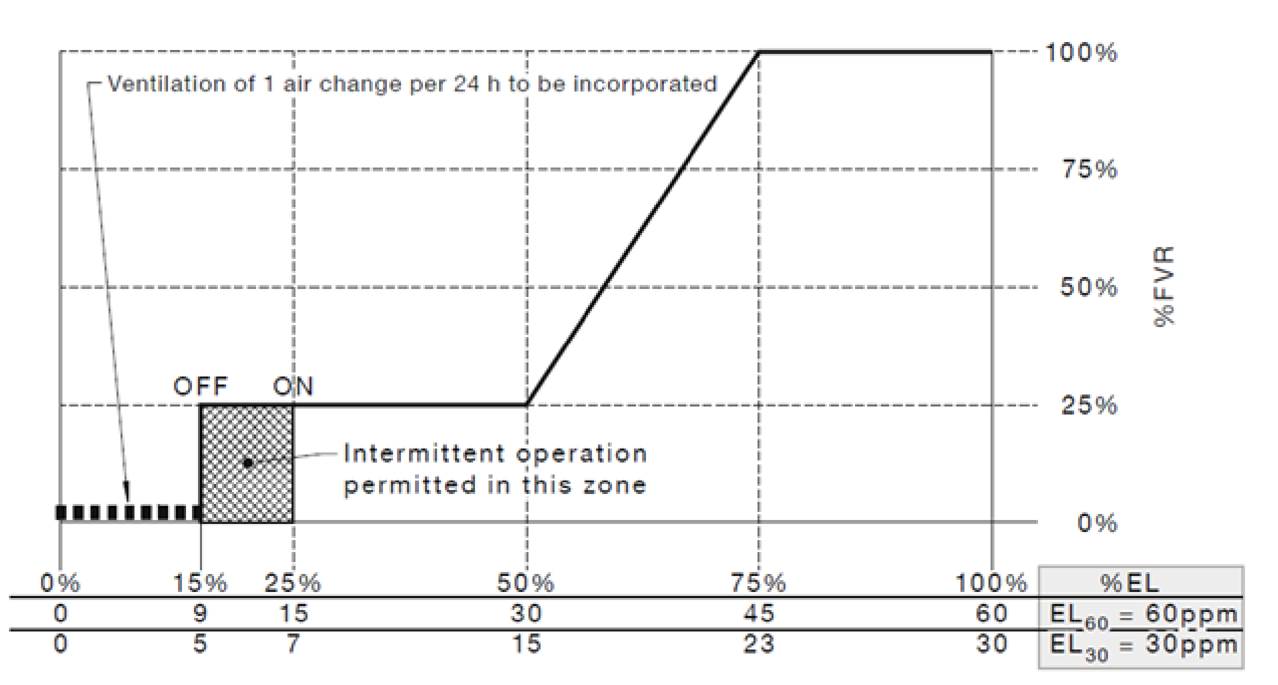


3. CAR PARK VENTILATION SYSTEM

Two (2) car park exhaust vents will be installed across the completed development. Vent 1, servicing the Basement Levels 1 to 3, is located on the northeast side of the building at ground height and will discharge horizontally through fixed louvres oriented toward Coronation Drive, at an approximate distance of 2.5 m from the site boundary. Vent 2, servicing the Podium Levels 1 to 3, is located on the northeast corner of the building beneath the Level 2 slab and will discharge toward Graham Street, with a separation distance of approximately 6.5 m from the northern site boundary.

Ventilation flow rates within the car park will be controlled by carbon monoxide (CO) sensors and will operate at a minimum of 25% of the full ventilation rate (FVR) once 15% of the exposure limit (EL) is reached, in accordance with AS1668.2 [1] (refer to **Figure 3.1**).

Figure 3.1: Ventilation Control System



Details regarding the exhaust vents are provided in **Table 3.1**.

Table 3.1: Car Park Exhaust Vent Details

Level	Dimensions (m)	Max Flow Rate (m^3/s)	Exit Velocity[a] (m/s)
Basement 1 – 3	5.2 x 1.2	13.48	0.54
Podium 1 – 3	2.5 x 2.5	13.29	0.53

[a] based on louvre dimensions and 25% of the maximum flow rate

Figure 3.2 and **Figure 3.3** illustrate the basement and podium level exhaust vent locations.

[1] AS 1668.2 - The use of ventilation and airconditioning in buildings. Part 2: Mechanical ventilation in buildings

Figure 3.2: Basement Exhaust Vent Location (Vent 1)

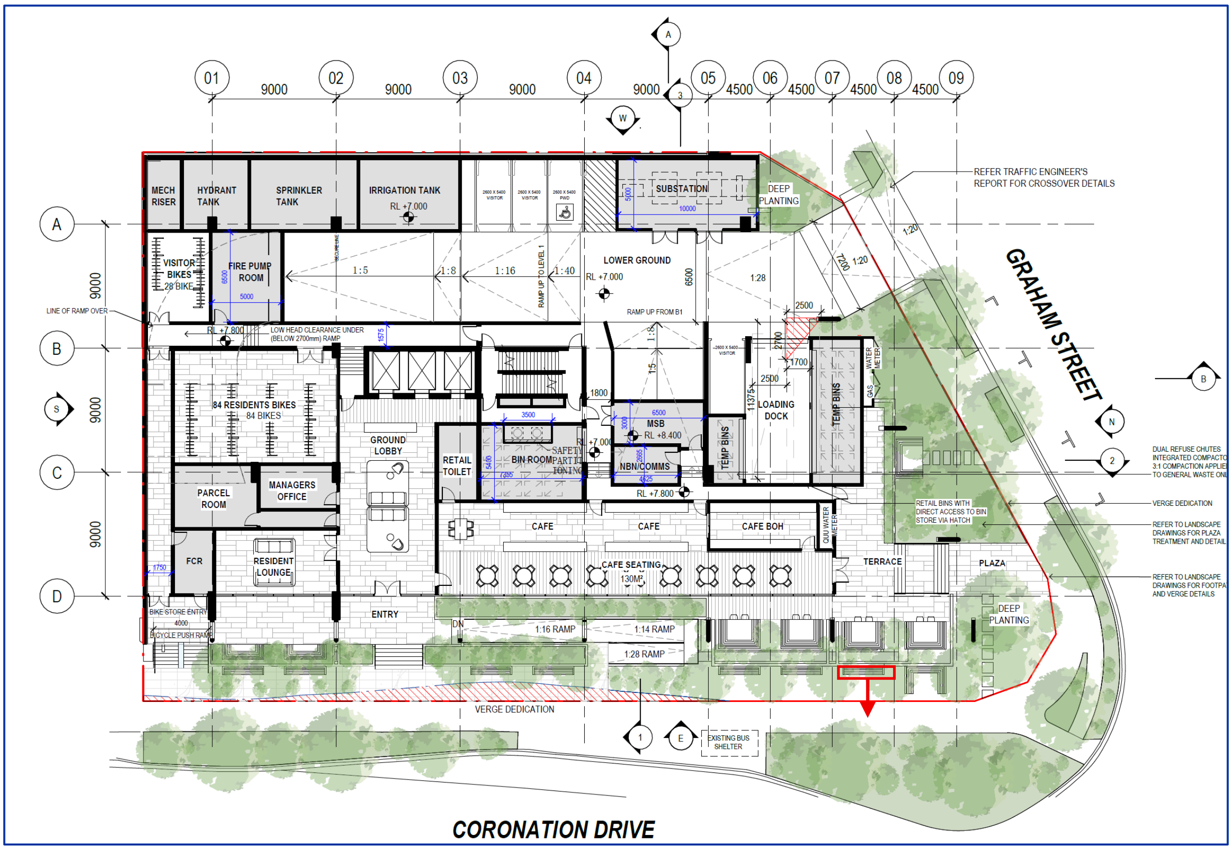
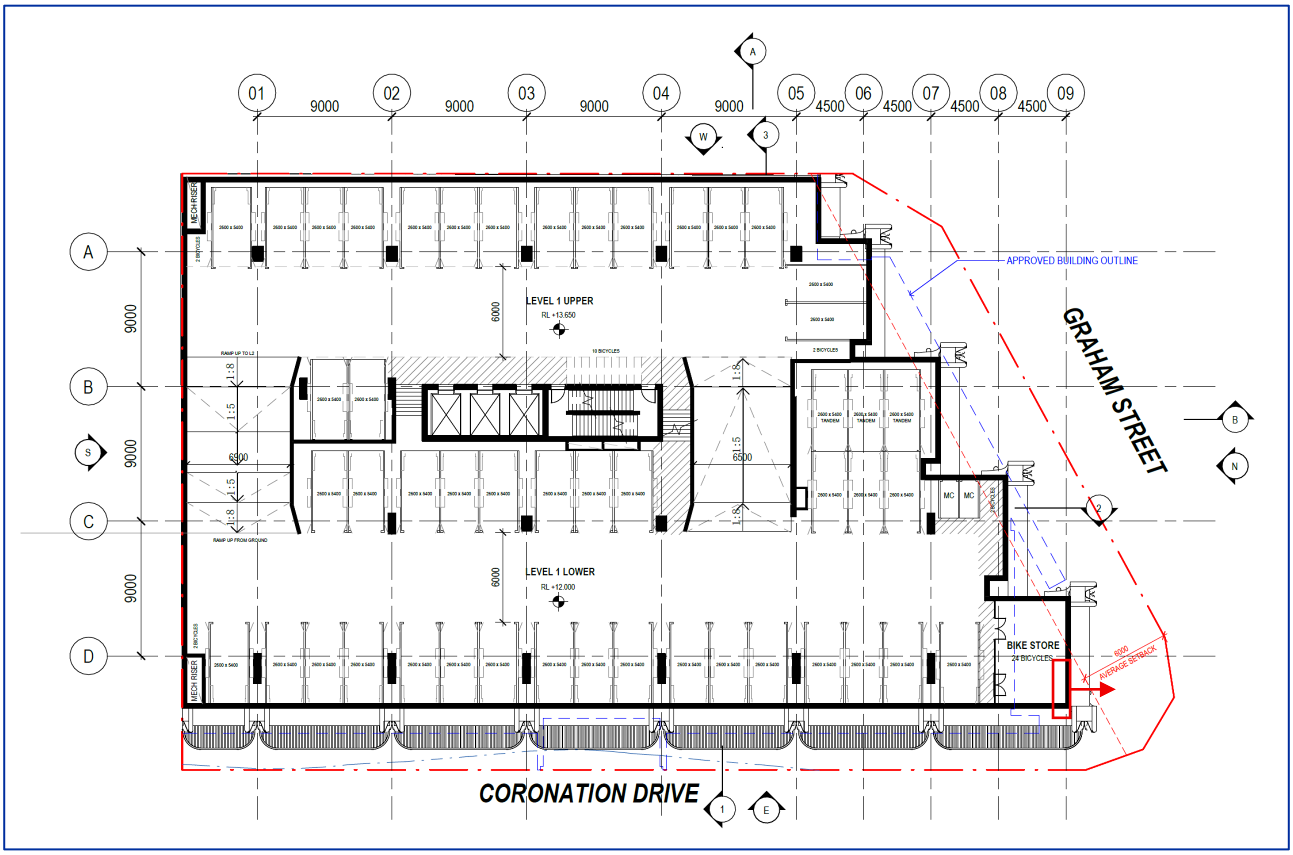


Figure 3.3: Podium Exhaust Vent Location (Vent 2)



4. AIR QUALITY VALUES AND CRITERIA

The assessment has been undertaken with reference to the relevant air quality objectives and performance requirements applicable to the proposed development. The key planning instruments are the Brisbane City Plan 2014 – Centre or Mixed Use Code and Multiple Dwelling code, which specify both acceptable outcomes and performance outcomes for managing air quality impacts from development. Acceptable outcomes for both codes specify a minimum separation distance of 15 m between car park exhaust vents and sensitive uses; however, the proposed exhaust vent locations do not meet this separation distance, and as such, compliance must be demonstrated against the performance outcome. PO3 of the Centre or Mixed Use code and PO20 of the Multiple Dwelling code require the development to achieve compliance with the prescribed air quality (planning) criteria, as detailed within each code.

Table 4.1 and **Table 4.2** present a copy of the air quality performance outcomes detailed in both applicable codes.

Table 4.1: Centre or Mixed Use Code – Air Quality Performance and Acceptable Outcomes

Performance Outcomes	Acceptable Outcomes
PO3 Development: a. Avoids or minimised air emissions: b. complies with the air quality (planning) criteria in Table 9.3.3.3.I; Note—An air quality impact report prepared in accordance with the Air quality planning scheme policy can assist in demonstrating achievement of this performance outcome.	**AO3.3** Development ensures that exhaust vents from any car park or bus station are separated from any sensitive use by a minimum of 15m

Table 4.2: Multiple Dwelling Use Code – Air Quality Acceptable and Performance Outcomes

Performance Outcomes	Acceptable Outcomes
PO20 Development is located, designed and constructed to achieve the: a) air quality (planning) criteria in Table 9.3.14.3.G; … Note—An air quality impact report prepared in accordance with the Air quality planning scheme policy can assist in demonstrating achievement of this performance outcome.	**AO20.1** Development in a zone in the centre zones category or the Mixed use zone, including any outdoor air intakes for the development, is separated from: … b) exhaust vent outlets from car parks or bus stations, by a minimum of 15m.

The relevant air quality criteria adopted for this assessment are summarised in **Table 4.3**. These criteria apply to key pollutants expected from motor-vehicle related emissions, including carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), volatile organic compounds (benzene, toluene, xylenes, 1,3-butadiene), formaldehyde and benzo(a)pyrene.

Table 4.3: Adopted Air Quality Criteria

Pollutant	Criteria (µg/m³)	Averaging Time	Environmental Value
CO	11,000	8-hour	Health and wellbeing
PM_{10}	50	24-hour	Health and wellbeing
	25	Annual	Health and wellbeing
$PM_{2.5}$	25	24-hour	Health and wellbeing
	8	Annual	Health and wellbeing

Pollutant	Criteria (µg/m³)	Averaging Time	Environmental Value
NO_2	250	1-hour	Health and wellbeing
	62	Annual	Health and wellbeing
1,3 – butadiene	2.4	Annual	Health and wellbeing
Benzene	29	1-hour	Health and wellbeing
	10	Annual	Health and wellbeing
Benzo(a)pyrene	0.0003	Annual	Health and wellbeing
Formaldehyde	96	1-hour	Protecting aesthetic environment
	54	24-hour	Health and wellbeing
Toluene	958	1-hour	Odour
	4,100	24-hour	Health and wellbeing
	410	Annual	Health and wellbeing
Xylenes	1,200	24-hour	Health and wellbeing
	950	Annual	Health and wellbeing

5. BACKGROUND AIR QUALITY

5.1 Overview

To evaluate cumulative air quality impacts, background ambient pollutant concentrations have been incorporated into the assessment. Background levels represent existing air quality conditions influenced by regional sources, local traffic emissions, and other surrounding activities independent of the proposed development.

5.2 Existing Local Air Emission Sources

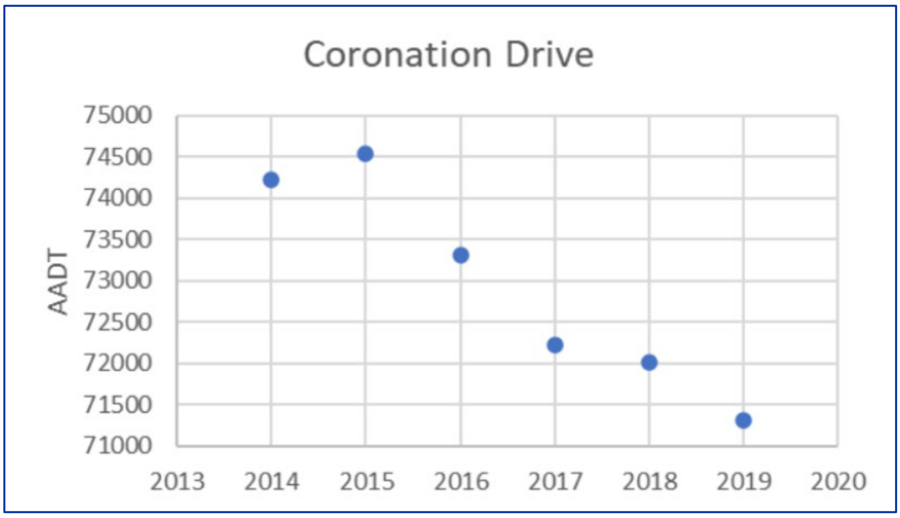
Background air quality in the vicinity of the subject site is influenced primarily by urban road traffic and nearby commercial activities. To assess cumulative impacts, associated traffic emissions from the surrounding road network have been modelled, and ambient monitoring data has been added to the predicted results. Traffic along Coronation Drive represents the main background air emission source, carrying approximately 75,000 vehicles per day. The BCC AQPSP requires consideration of nearby roads within 55 metres with more than 32,000 vehicles per day. Free-flowing traffic movements and queued/congested traffic have both been modelled.

It is noted that there is an existing service station to the south-west, with the nearest air emission sources (refuelling bowsers) approximately 80 metres from the 299 Coronation Drive site boundary. Based on the estimated annual throughput of 7 ML and presence of Phase 1 vapour recovery, the service station is compliant with the acceptable outcome distance of 50 metres as per the Industrial Amenity Overlay Code. This is discussed in detail in Trinity's report 237401.0063.L01V02 (21 February 2025). Furthermore, given the scale of the service station operation and separation distance, the potential for cumulative VOC impacts are expected to be low and therefore, emissions have not been included in the modelling.

5.2.1 Coronation Drive

Data from the Greater Brisbane key corridors performance report has been reviewed for the available years (2014-2019) [2]. **Figure 5.1** shows the annual average daily traffic (AADT) values for Coronation Drive between 2014 and 2019. It is noted that traffic volume growth has been minimum, with maximum AADT values occurring in 2015 (74,544 AADT).

Figure 5.1: Greater Brisbane key corridors performance AADT for Coronation Drive



[2] https://www.brisbane.qld.gov.au/traffic-and-transport/traffic-management/greater-brisbane-key-corridors-performance-report

To estimate current traffic volumes on Coronation Drive, traffic data from the TMR census[3] for the period 2019 to 2024 were reviewed. Site 130037, located on the Captain Cook Bridge and monitoring traffic on the Pacific Motorway, was analysed as it connects to Coronation Drive in the Milton area and is considered representative of comparable traffic trends over the same period. The data indicate a reduction in traffic volumes between 2019 and 2020 due to the COVID-19 pandemic. No census data were available for 2021 and 2022; however, traffic volumes in 2023 were comparable to those observed in 2019. A growth of 1.9% was recorded between 2023 and 2024, the most recent year of available data. To estimate current traffic levels on Coronation Drive, the same temporal pattern observed in the TMR census data has been assumed, with traffic volumes returning to levels comparable to those observed in 2019 by 2023. A conservative annual growth rate of 1.9% has been applied and projected to the assessment years 2026 and 2036, consistent with a 10-year assessment horizon in accordance with the Air Quality Planning Scheme Policy. A conservative traffic volume of 91,438 AADT has been estimated for year 2036.

Hourly data from the TMR census has been used to derive the traffic profile. The following traffic profile has been derived for the assessed road source (**Table 5.1**):

Table 5.1: Traffic Profiles Derived from TMR 2024 Data

Hour of Day	% Profile (Both Directions)	% Profile (Northbound)	% Profile (Southbound)
0 – 1	0.7%	0.6%	0.9%
1 – 2	0.5%	0.4%	0.6%
2 – 3	0.4%	0.3%	0.5%
3 – 4	0.5%	0.5%	0.5%
4 – 5	1.1%	1.4%	0.9%
5 – 6	3.8%	5.1%	2.4%
6 – 7	5.4%	6.4%	4.4%
7 – 8	6.5%	7.5%	5.5%
8 – 9	6.1%	7.0%	5.2%
9 – 10	5.9%	6.5%	5.3%
10 – 11	5.4%	5.7%	5.1%
11 – 12	5.5%	5.6%	5.4%
12 – 13	5.6%	5.5%	5.8%
13 – 14	5.8%	5.5%	6.1%
14 – 15	6.4%	5.5%	7.2%
15 – 16	6.2%	5.7%	6.8%
16 – 17	6.4%	5.8%	7.1%
17 – 18	6.5%	5.6%	7.4%
18 – 19	5.8%	5.2%	6.4%
19 – 20	4.2%	4.0%	4.4%
20 – 21	3.6%	3.4%	3.7%
21 – 22	3.5%	3.2%	3.8%
22 – 23	2.6%	2.3%	2.9%
23 – 24	1.6%	1.4%	1.8%

[3] https://www.data.qld.gov.au/dataset/queensland-traffic-data-averaged-by-hour-of-day-and-day-of-week

Table 5.2 presents the derived traffic hourly profile for the assessed road.

Table 5.2: Derived Traffic Hourly Profile for Coronation Drive

Hour of Day	Veh/h (Both Directions)	Veh/h (Northbound)	Veh/h (Southbound)
0 – 1	676	275	400
1 – 2	445	175	270
2 – 3	375	161	214
3 – 4	454	239	215
4 – 5	1053	652	401
5 – 6	3505	2372	1133
6 – 7	5036	2968	2068
7 – 8	6064	3492	2572
8 – 9	5676	3271	2405
9 – 10	5477	3018	2459
10 – 11	5015	2648	2367
11 – 12	5087	2584	2502
12 – 13	5226	2543	2682
13 – 14	5407	2578	2830
14 – 15	5930	2578	3353
15 – 16	5812	2646	3165
16 – 17	5990	2688	3302
17 – 18	6047	2595	3452
18 – 19	5409	2418	2990
19 – 20	3926	1867	2059
20 – 21	3310	1570	1740
21 – 22	3251	1478	1773
22 – 23	2421	1071	1350
23 – 24	1451	632	819

Vehicle emission factors have been adopted from COPERT Australia vehicle emission model (DSITI, 2019).

The following inputs have been considered:

- Road gradient: 0
- Season: winter
- Traffic situation: urban/congested depending on traffic volume to capacity ratio
- Heavy vehicles: 10%
- Year of traffic fleet: 2025 [4]

Coronation Drive is identified as an arterial road in the Brisbane City Plan 2014 Road Hierarchy Overlay. Accordingly, and in accordance with the Air Quality Planning Scheme Policy (AQPSP), the Urban traffic setting may be adopted where traffic conditions are not congested. Road capacity information has been sourced from the Ipswich City Plan 2025 Local Government Infrastructure Plan and is summarised in **Table 5.3**. Based on

[4] COPERT Australia vehicle emission model (Department of Science, Information Technology and Innovation, August 2016)

these values, the estimated northbound road capacity is 3,240 vehicles per hour, conservatively calculated by applying the single-lane capacity across three lanes, while the southbound carriageway, comprising two lanes, has an estimated capacity of 2,340 vehicles per hour. All hours with traffic volumes exceeding 80% of the lane capacity have been modelled as congested. For the northbound carriageway, only two hours exceeded this threshold; however, the four hours with the highest traffic volumes were conservatively modelled as congested.

Table 5.3: Ipswich City Plan 2025 – Road Network Key Performance Indicators

Link Function	Carriageway Configuration	Single Lane (VPH)	Dual Lane (VPH)
Arterial	Divided	1,080	2,340
	Undivided	900	1,980
Sub-Arterial	Divided	900	1,980
	Undivided	810	1,710

Since COPERT does not provide emission factors for carbon monoxide, PIARC 2012 has been used to derive a CO/NO_x and $CO/PM_{2.5}$ ratio [5]. Then the higher CO predicting ratio has been applied in order to be conservative. The following inputs have been considered:

- Speed: 60 km/h
- Gradient: 0%
- 25% Diesel / 75% Petrol fleet
- Year of traffic fleet: 2020 [6]

Table 5.4 presents PIARC emission factors.

Table 5.4: PIARC Emission Factors

Pollutant	Emission Factor (g/vehicle/hour)	
	Passenger (Petrol)	Passenger (Diesel)
Year 2010		
CO	132.8	11.2
NO_x	20.3	31.9
$PM_{2.5}$	-	17.0
Year 2020		
CO	55.8	4.8
NO_x	6.3	19.5
$PM_{2.5}$	-	1.3
Ratios		
CO/NO_x	4.5	
$CO/PM_{2.5}$	128.6	

Table 5.5 presents the emission rates for Coronation Drive (Northbound) and **Table 5.6** for Coronation Drive (Southbound).

[5] PIARC, Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, Reference 2012R05EN.
[6] PIARC 2012 only provides emission factors up to the year 2020. The more recent PIARC 2019 has not been adopted due to complexities (requirement of emission technology breakdown) associated with accurately representing emissions from the Australian fleet.

Table 5.5: Emission Rates for Coronation Drive (Northbound)

Hour of Day	Hourly Traffic	Traffic situation	CO g/s/m	NO_x g/s/m	PM_{10} g/s/m	$PM_{2.5}$ g/s/m	Benzene g/s/m	Benzo(a)pyrene g/s/m
0 – 1	275	Urban	3.05E-04	3.54E-05	4.09E-06	2.37E-06	4.37E-07	1.02E-10
1 – 2	175	Urban	1.94E-04	2.25E-05	2.60E-06	1.51E-06	2.78E-07	6.47E-11
2 – 3	161	Urban	1.79E-04	2.08E-05	2.40E-06	1.39E-06	2.56E-07	5.96E-11
3 – 4	239	Urban	2.66E-04	3.08E-05	3.56E-06	2.06E-06	3.80E-07	8.85E-11
4 – 5	652	Urban	7.23E-04	8.40E-05	9.70E-06	5.62E-06	1.04E-06	2.41E-10
5 – 6	2372	Urban	2.63E-03	3.05E-04	3.53E-05	2.05E-05	3.77E-06	8.77E-10
6 – 7	2968	Congested	3.72E-03	6.90E-04	4.75E-05	2.89E-05	7.29E-06	1.79E-09
7 – 8	3492	Congested	4.38E-03	8.12E-04	5.58E-05	3.40E-05	8.57E-06	2.10E-09
8 – 9	3271	Congested	4.10E-03	7.61E-04	5.23E-05	3.19E-05	8.03E-06	1.97E-09
9 – 10	3018	Congested	3.78E-03	7.02E-04	4.83E-05	2.94E-05	7.41E-06	1.82E-09
10 – 11	2648	Urban	2.94E-03	3.41E-04	3.94E-05	2.28E-05	4.21E-06	9.79E-10
11 – 12	2584	Urban	2.87E-03	3.33E-04	3.84E-05	2.23E-05	4.10E-06	9.56E-10
12 – 13	2543	Urban	2.82E-03	3.27E-04	3.78E-05	2.19E-05	4.04E-06	9.40E-10
13 – 14	2578	Urban	2.86E-03	3.32E-04	3.83E-05	2.22E-05	4.09E-06	9.53E-10
14 – 15	2578	Urban	2.86E-03	3.32E-04	3.83E-05	2.22E-05	4.09E-06	9.53E-10
15 – 16	2646	Urban	2.94E-03	3.41E-04	3.93E-05	2.28E-05	4.20E-06	9.79E-10
16 – 17	2688	Urban	2.98E-03	3.46E-04	4.00E-05	2.32E-05	4.27E-06	9.94E-10
17 – 18	2595	Urban	2.88E-03	3.34E-04	3.86E-05	2.24E-05	4.12E-06	9.60E-10
18 – 19	2418	Urban	2.68E-03	3.11E-04	3.60E-05	2.09E-05	3.84E-06	8.94E-10
19 – 20	1867	Urban	2.07E-03	2.40E-04	2.78E-05	1.61E-05	2.97E-06	6.90E-10
20 – 21	1570	Urban	1.74E-03	2.02E-04	2.33E-05	1.35E-05	2.49E-06	5.80E-10
21 – 22	1478	Urban	1.64E-03	1.90E-04	2.20E-05	1.27E-05	2.35E-06	5.47E-10
22 – 23	1071	Urban	1.19E-03	1.38E-04	1.59E-05	9.23E-06	1.70E-06	3.96E-10
23 – 24	632	Urban	7.01E-04	8.14E-05	9.40E-06	5.45E-06	1.00E-06	2.34E-10

Table 5.6: Emission Rates for Coronation Drive (Southbound)

Hour of Day	Hourly Traffic	Traffic situation	CO g/s/m	NO_x g/s/m	PM_{10} g/s/m	$PM_{2.5}$ g/s/m	Benzene g/s/m	Benzo(a)pyrene g/s/m
0 – 1	400	Urban	4.44E-04	5.15E-05	5.95E-06	3.45E-06	6.36E-07	1.48E-10
1 – 2	270	Urban	3.00E-04	3.48E-05	4.02E-06	2.33E-06	4.29E-07	9.99E-11
2 – 3	214	Urban	2.37E-04	2.75E-05	3.18E-06	1.84E-06	3.40E-07	7.91E-11
3 – 4	215	Urban	2.38E-04	2.76E-05	3.19E-06	1.85E-06	3.41E-07	7.94E-11
4 – 5	401	Urban	4.45E-04	5.16E-05	5.96E-06	3.46E-06	6.37E-07	1.48E-10
5 – 6	1133	Urban	1.26E-03	1.46E-04	1.68E-05	9.77E-06	1.80E-06	4.19E-10
6 – 7	2068	Urban	2.29E-03	2.66E-04	3.07E-05	1.78E-05	3.29E-06	7.65E-10
7 – 8	2572	Congested	3.22E-03	5.98E-04	4.11E-05	2.51E-05	6.31E-06	1.55E-09
8 – 9	2405	Congested	3.02E-03	5.59E-04	3.85E-05	2.34E-05	5.90E-06	1.45E-09
9 – 10	2459	Congested	3.08E-03	5.72E-04	3.93E-05	2.40E-05	6.03E-06	1.48E-09
10 – 11	2367	Congested	2.97E-03	5.50E-04	3.79E-05	2.31E-05	5.81E-06	1.42E-09
11 – 12	2502	Congested	3.14E-03	5.82E-04	4.00E-05	2.44E-05	6.14E-06	1.51E-09
12 – 13	2682	Congested	3.36E-03	6.24E-04	4.29E-05	2.61E-05	6.58E-06	1.61E-09
13 – 14	2830	Congested	3.55E-03	6.58E-04	4.53E-05	2.76E-05	6.94E-06	1.70E-09
14 – 15	3353	Congested	4.20E-03	7.79E-04	5.36E-05	3.27E-05	8.23E-06	2.02E-09
15 – 16	3165	Congested	3.97E-03	7.36E-04	5.06E-05	3.09E-05	7.77E-06	1.90E-09
16 – 17	3302	Congested	4.14E-03	7.68E-04	5.28E-05	3.22E-05	8.10E-06	1.99E-09
17 – 18	3452	Congested	4.33E-03	8.02E-04	5.52E-05	3.36E-05	8.47E-06	2.08E-09
18 – 19	2990	Congested	3.75E-03	6.95E-04	4.78E-05	2.91E-05	7.34E-06	1.80E-09
19 – 20	2059	Urban	2.28E-03	2.65E-04	3.06E-05	1.77E-05	3.27E-06	7.61E-10
20 – 21	1740	Urban	1.93E-03	2.24E-04	2.59E-05	1.50E-05	2.76E-06	6.44E-10
21 – 22	1773	Urban	1.97E-03	2.28E-04	2.64E-05	1.53E-05	2.82E-06	6.56E-10
22 – 23	1350	Urban	1.50E-03	1.74E-04	2.01E-05	1.16E-05	2.15E-06	4.99E-10
23 – 24	819	Urban	9.08E-04	1.05E-04	1.22E-05	7.06E-06	1.30E-06	3.03E-10

5.3 Representative Monitoring Data

Air quality data from the Queensland Government air quality monitoring network have been used to develop representative background levels for the assessment.

As the main road emission source near the subject site has been included in the air dispersion model, background air quality data has been used from a station not immediately exposed to traffic emissions. The Department of Environment, Science, Tourism and Innovation (DETSI) operates air monitoring stations in Queensland. Existing background air quality concentrations have been obtained according to the AQPSP with 70th percentile concentrations of short-term averaging period concentrations and highest annual average concentrations for pollutants with annual averaging periods. The annual average $PM_{2.5}$ background concentration has been calculated using the 2020 to 2024 period average as outlines in Section 5.3.1 of the AQPSP. Historical reports of DETSI data do not provide 70% percentile, so it is necessary to analyse raw data.

Background data for NO_2, PM_{10} and $PM_{2.5}$ were obtained from the Rocklea monitoring station for the years 2021 to 2025, accessed via the Queensland Government Data Portal. This data has been used to account for background concentrations associated with regional sources and no major traffic impacts.

As CO is not monitored at the Rocklea station, data was sourced from the Woolloongabba monitoring station. Data for the period 2020 to 2024 was used for the analysis.

For benzene, formaldehyde, toluene and xylenes, data was sourced from the Springwood monitoring station, which is the only site in Southeast Queensland with monitoring for these VOC species. Data was available up to 2020, and therefore, the period 2016 to 2020 was used for the analysis.

The adopted background concentrations are presented in **Table 5.7**, with the highest 70th percentile used for the 1-hour, 24-hour and 8-hour averaging periods.

Table 5.7: Ambient Pollutant Concentrations

Pollutant	Ambient Pollutant Concentration	Averaging Period	Monitoring Station
CO	285.5	8-hour (2021)	Woolloongabba
NO_2	22.6	1-hour (2023)	Rocklea
	18.5	Annual (2023)	
PM_{10}	18.5	24-hour (2023)	
	16.5	Annual (2023)	
$PM_{2.5}$	9.1	24-hour (2023)	
	6.2	Annual (2023)	
Benzene	6.6	1-hour (2017)	Springwood
	5.5	Annual (2017)	
Formaldehyde	10.9	1-hour (2016)	
	11.2	24-hour (2016)	
Toluene	23	1-hour (2016)	
	22.4	24-hour (2016)	
	17.8	Annual (2016)	
Xylenes	41.7	24-hour (2020)	
	41.4	Annual (2020)	

6. EMISSIONS INVENTORY

6.1 Carpark Exhausts

6.1.1 PIARC

To estimate emission rates, reference has been made to pollutant emission rates for the Australian vehicle fleet defined in PIARC [7]. Emission factors depend on fleet composition, road gradient, season, and traffic scenario. The follow inputs have been considered:

- Road gradient: depending on each car park section
- Vehicle speed: 10 km/h
- Heavy vehicles: 0%
- Year of traffic fleet: 2025 [8]

PIARCs maximum gradient available is 6%, so, for the car park sections where gradient was higher than 6%, e.g., ramps, this value was used to calculate the emission factors.

Table 6.1 presents the adopted emission factors for vehicle movements within the car park.

Table 6.1: PIARC Emission Factors (0% gradient)

Pollutant	Emission Factor (g/vehicle/hour)		
	Passenger (Petrol)	Passenger (Diesel)	Total
	Year 2010		
CO	56.3	10.3	44.8
NO_x	8.5	13.8	9.8
PM_{10} [b]	-	5.7 m^2/hr/veh	1.4 m^2/hr/veh
$PM_{2.5}$ [a]	-	5.1 m^2/hr/veh	1.3 m^2/hr/veh
	Year 2020		
CO	23.6	4.4	18.8
NO_x	2.6	8.4	4.1
PM_{10}	-	2.1 m^2/hr/veh	0.52 m^2/hr/veh
$PM_{2.5}$	-	1.9 m^2/hr/veh	0.47 m^2/hr/veh

[a] $PM_{2.5}$ based on opacity, which is converted to g/veh/hr emission factor by dividing by a factor of 4.7 (as per PIARC).
[b] PM_{10} emissions calculated by assuming $PM_{2.5}$ is 90% of PM_{10}.

To derive emission rates (g/s) for each hour of the day, assumptions have been made regarding potential vehicle movements and distance travelled through the car park. For the purpose of the assessment, the following assumptions have been made:

- 25% of vehicles are diesel, 75% are petrol.
- PIARC emissions primarily account for hot running emissions associated with on-road traffic. Vehicles leaving the car park operate in a 'cold start' phase, which is associated with higher pollutant emissions as engines and catalysts are not operating at optimum conditions. To estimate emissions for vehicles the methodology outlines in the EMEP [9] guidebook has been adopted. Specifically, the emission factors presented in Table 3-40 of the guidebook were adopted, with the extracted data provided in **Table 6.2**.

[7] PIARC, Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, Reference 2012R05EN.
[8] PIARC 2012 only provides emission factors up to the year 2020. The more recent PIARC 2019 has not been adopted due to complexities (requirement of emission technology breakdown) associated with accurately representing emissions from the Australian fleet.
[9] European Monitoring and Evaluation Programme – Air Pollutant Emission Inventory Guidebook 2023 – Updated 2024.

the calculated cold/hot ratios are provided in **Table 6.3**. these were calculated based on a vehicle speed of 10 km/h and worst-case temperature (minimum annual temperature for CO and VOCs and maximum temperature for NO_x). The guidebook does not provide a factor for particulate matter; therefore, a conservative factor of 7.8 has been adopted based on guidance provided in Australian Standard 1668.2-2012 [10].

Table 6.2: Cold Start Calculation Methodology

Table 3-40: Over-emission ratios e^{COLD} / e^{HOT} for Euro 1 to Euro 5 petrol vehicles (*V*: speed in km/h, t_a: temperature in °C)

Case	Category	Speed [km/h]	Temp [°C]	$e^{COLD}/e^{HOT} = A \times V + B \times t_a + C$		
				A	B	C
CO	Mini, Small	5– 33	-20 : 15	0.156	-0.155	3.519
		34–45	-20 : 15	0.538	-0.373	-6.24
		5–45	> 15	8.032E-02	-0.444	9.826
	Medium	5–33	-20 : 15	0.121	-0.146	3.766
		34–45	-20 : 15	0.299	-0.286	-0.58
		5–45	> 15	5.03E-02	-0.363	8.604
	Large-SUV-Executive	5–33	-20 : 15	7.82E-02	-0.105	3.116
		34–45	-20 : 15	0.193	-0.194	0.305
		5–45	> 15	3.21E-02	-0.252	6.332
NOx	Mini, Small	5–25	> -20	4.61E-02	7.38E-03	0.755
		26–45	> -20	5.13E-02	2.34E-02	0.616
	Medium	5–25	> -20	4.58E-02	7.47E-03	0.764
		26–45	> -20	4.84E-02	2.28E-02	0.685
	Large-SUV-Executive	5–25	> -20	3.43E-02	5.66E-03	0.827
		26–45	> -20	3.75E-02	1.72E-02	0.728
VOC	Mini, Small	5–35	-20 : 15	0.154	-0.134	4.937
		36–45	-20 : 15	0.323	-0.240	0.301
		5–45	> 15	9.92E-02	-0.355	8.967
	Medium	5–35	-20 : 15	0.157	-0.207	7.009
		36–45	-20 : 15	0.282	-0.338	4.098
		5–45	> 15	4.76E-02	-0.477	13.44
	Large-SUV-Executive	5–35	-20 : 15	8.14E-02	-0.165	6.464
		36–45	-20 : 15	0.116	-0.229	5.739
		5–45	> 15	1.75E-02	-0.346	10.462
EC	All classes	-	-10 : 30	0	-0.009	1.47

Note: If the calculated value of e^{COLD} /e^{HOT} is less than 1, a value of 1 should be used.

Table 6.3: Calculated Cold Start Factors

Pollutant	Category	Speed (km/h)	Temperature (ºC)	A	B	C	Cold/Hot Emissions Ratio	Max.
CO	Mini, Small	10	10.5	0.156	-0.155	3.519	3.45	3.45
	Medium	10	10.5	0.121	-0.146	3.766	3.44	
	Large SUV	10	10.5	7.82E-02	-0.105	3.116	2.80	

[10] AS 1668.2-2012 The Use of Ventilation and Air Conditioning in Buildings – Mechanical Ventilation in Buildings

Pollutant	Category	Speed (km/h)	Temperature (ºC)	A	B	C	Cold/Hot Emissions Ratio	Max.
NO_x	Mini, Small	10	30.4	0.0461	0.00738	0.755	1.44	1.45
	Medium	10	30.4	0.0458	0.00747	0.764	1.45	
	Large SUV	10	30.4	0.0343	0.00566	0.827	1.34	
VOCs	Mini, Small	10	10.5	0.154	-0.134	4.937	5.07	6.41
	Medium	10	10.5	0.157	-0.207	7.009	6.41	
	Large SUV	10	10.5	0.0814	-0.165	6.464	5.55	

6.1.2 VOCs

6.1.2.1 Vehicle Running Emissions

To estimate vehicle VOC emissions have been adopted from COPERT Australia vehicle emission model (Department of Science, Information Technology and Innovation, August 2016). COPERT estimates vehicle emissions based on various influencing factors including gradient, heavy vehicle percentage and season.

The following inputs have been considered:

- Road gradient: depending on each carpark section;
- Season: winter;
- Heavy vehicles: 0%; and
- Year of traffic fleet: 2025.

As a conservative approach, winter emissions have been considered. Using the above assumptions and inputs, emissions data for 2025 have been calculated as outlined in **Table 6.4**.

Table 6.4: COPERT Emission factors (0% gradient)

Year	Benzene mg/VKT	Benzo(a)pyrene µg/VKT
2025	6.3	1.3

COPERT only provides emission rates for benzene and benzo(a)pyrene, so for estimating emission factors for 1,3-butadiene, formaldehyde, toluene and xylenes, emissions ratios based on benzene have been derived from the Air Emissions Inventory for the Greater Metropolitan Region in New South Wales (NSW EPA, 2008).

Table 6.5 presents the ratios used in the calculations and emissions factors for the VOCs considered.

Table 6.5: Emission factors derived from NSW EPA Air Emissions Inventory

Pollutant	Emission ratio (target compound/Benzene)	Emission factor (mg/VKT)
1,3-Butadiene	0.2553	1.6
Formaldehyde	0.3059	1.9
Toulene	1.8586	11.8
Xylenes (total)	1.5380	9.7

6.1.2.2 Vehicle Evaporative Emissions

To estimate evaporative emissions from cars parked inside the car parks two reference sources have been used. Huan Liu studied emissions factors for the different evaporative processes that occur when cars are parked with the engine not running for Tier 2 and Euro 4 vehicles (Liu et al., 2015) [11]. The evaporative processes include:

- Hoat soak: hydrocarbon emissions arising from the fuel system of a stationary vehicle after a period of driving.
- 24-h diurnal: evaporative emissions resulting from the daily cycling of ambient temperatures.

The study also addresses refuelling emissions which are irrelevant to this study and permeation emissions which are already included in the 24-h diurnal emission rate and, therefore, are not considered in this assessment.

To be conservative, the VOC emission factors for Euro 4 vehicles have been adopted since they are higher than the Tier 2 results. **Table 6.6** presents the emission factors considered.

Table 6.6: VOC emission Factors for Evaporative Processes Considered

Process	Tier 2	Euro 4
Hoat Soak (g/h/veh)	0.065	0.066
24-h Diurnal (g/day/veh)	0.297	0.834

The hot soak process has been assumed to be 1-hour long.

To derive an emission factor for each speciated VOC, a second source has been referenced. Hanyang Man studied the species characteristics involved in each emission process (Man et al., 2019) [12].

In this study, weight percentages of different VOC species from different evaporative processes are provided for Tier 2 and Euro 4 vehicles. Due to the absence of available data for 1,3-Butadiene, Benzo(a)pyrene and Formaldehyde, the vehicle evaporative emissions for these compounds were not assessed.

Table 6.7 presents the values adopted.

Table 6.7: VOC weight fraction for evaporative processes

Compound	Hot Soak (%)	24-h Diurnal (%)
Benzene	1.05	0.65
Toulene	8.91	4.82
Xylenes	5.12	1.08

6.1.3 Hourly Profile

The following inputs have been considered in the modelling of emissions:

- Maximum travelled distances as per **Table 6.8**. These travel distances are considered conservative as they are assuming that all cars are travelling to the furthest away car park on each level.
- A 20% in / 80% out split has been assumed for cars entering and leaving the car park during the morning peak, 80% in / 20% out during the evening peak, and 50% / 50% split for the rest of the day.

[11] VOC emissions from the vehicle evaporation process: status and control strategy. Huan Liu et al. (2015).
[12] VOCs evaporative emissions from vehicles in China: Species characteristics of different emission processes. Hanyang Man et al. (2019).

- Peak hour traffic movement of 36 vehicles per hour (VPH) for the morning peak and 29 VPH for the evening peak (extracted from traffic impact assessment prepared by Colliers for the proposed development).
- Assumed diurnal traffic profile as per **Table 6.9**.

Table 6.8: Maximum Travelled Distances (m)

Car Park	Max. Distance Staying in Car Park (0% gradient)	Max. Distance Staying in Car Park (>6% gradient)	Max. Distance Passing Through Car Park (0% gradient)	Max. Distance Passing Through Car Park (>6% gradient)
Podium 3	96	16	-	-
Podium 2	76	23	78	23
Podium 1	107	47	112	33
Ground Floor	-	-	-	-
Basement 1	106	19	85	23
Basement 2	86	17	80	24
Basement 3	98	17	-	-

Table 6.9: Assumed Traffic Generation Profile

Hour	Podium 3 (VPH)	Podium 2 (VPH)	Podium 1 (VPH)	Ground Floor (VPH)	Basement 1 (VPH)	Basement 2 (VPH)	Basement 3 (VPH)	Total
0 – 1	1	1	1	0	1	1	1	3
1 – 2	0	0	0	0	0	0	0	2
2 – 3	0	0	0	0	0	0	0	2
3 – 4	0	0	0	0	0	0	0	1
4 – 5	0	0	0	0	0	0	0	2
5 – 6	1	1	1	0	1	1	1	4
6 – 7	6	6	6	1	6	6	6	36
7 – 8	6	6	6	1	6	6	6	36
8 – 9	6	6	6	1	6	6	6	36
9 – 10	2	2	2	0	2	2	2	13
10 – 11	2	2	2	0	2	2	2	15
11 – 12	2	2	2	0	2	2	3	15
12 – 13	3	3	3	0	3	3	3	17
13 – 14	3	3	3	0	3	3	3	16
14 – 15	3	3	3	0	3	3	3	16
15 – 16	5	5	5	0	5	5	5	29
16 – 17	5	5	5	0	5	5	5	29
17 – 18	5	5	5	0	5	5	5	29
18 – 19	4	4	4	0	4	4	4	25
19 – 20	3	3	3	0	3	3	4	21
20 – 21	3	3	3	0	3	3	3	17

Hour	Podium 3 (VPH)	Podium 2 (VPH)	Podium 1 (VPH)	Ground Floor (VPH)	Basement 1 (VPH)	Basement 2 (VPH)	Basement 3 (VPH)	Total
21 – 22	3	3	3	0	2	2	3	15
22 – 23	2	2	2	0	2	2	2	12
23 – 24	1	1	1	0	1	1	1	6

6.1.4 Emission Rates

Table 6.10 and **Table 6.11** present the modelled combined emission rates for the car park vent emission assessment.

Table 6.10: Basement Car Park Exhaust – Modelled Emission Rates (g/s)

Hour	CO	NOc	PM10	PM2.5	1,3-Butadiene	Benzene	Benzo(a)pyrene	Formaldehyde	Toluene	Xylenes
0 – 1	4.22E-04	5.02E-05	5.29E-06	4.76E-06	6.41E-07	1.16E-05	5.20E-10	7.69E-07	7.25E-05	2.41E-05
1 – 2	2.53E-04	3.01E-05	3.17E-06	2.85E-06	3.85E-07	1.06E-05	3.12E-10	4.61E-07	7.01E-05	2.22E-05
2 – 3	2.53E-04	3.01E-05	3.17E-06	2.85E-06	3.85E-07	1.06E-05	3.12E-10	4.61E-07	7.01E-05	2.22E-05
3 – 4	1.69E-04	2.01E-05	2.11E-06	1.90E-06	2.57E-07	1.00E-05	2.08E-10	3.07E-07	6.89E-05	2.13E-05
4 – 5	2.11E-04	2.51E-05	2.64E-06	2.38E-06	3.21E-07	1.03E-05	2.60E-10	3.84E-07	6.95E-05	2.18E-05
5 – 6	5.06E-04	6.02E-05	6.34E-06	5.71E-06	7.70E-07	1.22E-05	6.24E-10	9.22E-07	7.37E-05	2.50E-05
6 – 7	6.54E-03	6.53E-04	9.66E-05	8.70E-05	1.15E-05	5.41E-05	9.34E-09	1.38E-05	1.51E-04	9.08E-05
7 – 8	6.54E-03	6.53E-04	9.66E-05	8.70E-05	1.15E-05	5.34E-05	9.34E-09	1.38E-05	1.46E-04	8.93E-05
8 – 9	6.54E-03	6.53E-04	9.66E-05	8.70E-05	1.15E-05	5.28E-05	9.34E-09	1.38E-05	1.41E-04	8.78E-05
9 – 10	1.69E-03	2.01E-04	2.11E-05	1.90E-05	2.57E-06	1.76E-05	2.08E-09	3.07E-06	7.54E-05	3.35E-05
10 – 11	1.90E-03	2.26E-04	2.38E-05	2.14E-05	2.89E-06	1.89E-05	2.34E-09	3.46E-06	7.84E-05	3.58E-05
11 – 12	1.94E-03	2.31E-04	2.43E-05	2.19E-05	2.95E-06	1.92E-05	2.39E-09	3.54E-06	7.90E-05	3.63E-05
12 – 13	2.19E-03	2.61E-04	2.75E-05	2.47E-05	3.34E-06	2.08E-05	2.70E-09	4.00E-06	8.26E-05	3.90E-05
13 – 14	2.11E-03	2.51E-04	2.64E-05	2.38E-05	3.21E-06	2.03E-05	2.60E-09	3.84E-06	8.14E-05	3.81E-05
14 – 15	2.11E-03	2.51E-04	2.64E-05	2.38E-05	3.21E-06	2.03E-05	2.60E-09	3.84E-06	8.14E-05	3.81E-05
15 – 16	2.43E-03	3.82E-04	2.25E-05	2.03E-05	2.86E-06	2.09E-05	2.32E-09	3.43E-06	9.48E-05	4.41E-05
16 – 17	2.43E-03	3.82E-04	2.25E-05	2.03E-05	2.86E-06	2.14E-05	2.32E-09	3.43E-06	9.88E-05	4.53E-05
17 – 18	2.43E-03	3.82E-04	2.25E-05	2.03E-05	2.86E-06	2.19E-05	2.32E-09	3.43E-06	1.03E-04	4.64E-05
18 – 19	3.29E-03	3.91E-04	4.12E-05	3.71E-05	5.00E-06	2.93E-05	4.06E-09	6.00E-06	1.10E-04	5.45E-05
19 – 20	2.74E-03	3.26E-04	3.44E-05	3.09E-05	4.17E-06	2.59E-05	3.38E-09	5.00E-06	1.02E-04	4.85E-05
20 – 21	2.28E-03	2.71E-04	2.85E-05	2.57E-05	3.46E-06	2.29E-05	2.81E-09	4.15E-06	9.56E-05	4.34E-05
21 – 22	1.98E-03	2.36E-04	2.48E-05	2.24E-05	3.01E-06	2.11E-05	2.44E-09	3.61E-06	9.14E-05	4.02E-05
22 – 23	1.52E-03	1.81E-04	1.90E-05	1.71E-05	2.31E-06	1.81E-05	1.87E-09	2.77E-06	8.49E-05	3.51E-05
23 – 24	7.60E-04	9.03E-05	9.51E-06	8.56E-06	1.15E-06	1.33E-05	9.36E-10	1.38E-06	7.41E-05	2.68E-05

Table 6.11: Podium Car Park Exhaust – Modelled Emission Rates (g/s)

Hour	CO	NOc	PM10	PM2.5	1,3-Butadiene	Benzene	Benzo(a)pyrene	Formaldehyde	Toluene	Xylenes
0 – 1	4.83E-04	5.74E-05	6.14E-06	5.53E-06	7.45E-07	1.21E-05	6.04E-10	8.93E-07	7.37E-05	2.48E-05
1 – 2	2.90E-04	3.44E-05	3.69E-06	3.32E-06	4.47E-07	1.09E-05	3.63E-10	5.36E-07	7.10E-05	2.27E-05
2 – 3	2.90E-04	3.44E-05	3.69E-06	3.32E-06	4.47E-07	1.09E-05	3.63E-10	5.36E-07	7.10E-05	2.27E-05
3 – 4	1.93E-04	2.30E-05	2.46E-06	2.21E-06	2.98E-07	1.03E-05	2.42E-10	3.57E-07	6.97E-05	2.17E-05
4 – 5	2.41E-04	2.87E-05	3.07E-06	2.76E-06	3.73E-07	1.06E-05	3.02E-10	4.47E-07	7.04E-05	2.22E-05
5 – 6	5.79E-04	6.89E-05	7.37E-06	6.63E-06	8.94E-07	1.27E-05	7.25E-10	1.07E-06	7.51E-05	2.59E-05
6 – 7	6.94E-03	6.83E-04	8.81E-05	7.93E-05	1.05E-05	5.02E-05	8.51E-09	1.26E-05	1.44E-04	8.48E-05
7 – 8	6.94E-03	6.83E-04	8.81E-05	7.93E-05	1.05E-05	4.95E-05	8.51E-09	1.26E-05	1.39E-04	8.33E-05
8 – 9	6.94E-03	6.83E-04	8.81E-05	7.93E-05	1.05E-05	4.88E-05	8.51E-09	1.26E-05	1.34E-04	8.18E-05
9 – 10	1.93E-03	2.30E-04	2.46E-05	2.21E-05	2.98E-06	1.93E-05	2.42E-09	3.57E-06	7.88E-05	3.61E-05
10 – 11	2.17E-03	2.58E-04	2.76E-05	2.49E-05	3.35E-06	2.08E-05	2.72E-09	4.02E-06	8.22E-05	3.88E-05
11 – 12	2.22E-03	2.64E-04	2.83E-05	2.54E-05	3.43E-06	2.11E-05	2.78E-09	4.11E-06	8.29E-05	3.93E-05
12 – 13	2.51E-03	2.99E-04	3.19E-05	2.87E-05	3.88E-06	2.30E-05	3.14E-09	4.64E-06	8.69E-05	4.24E-05
13 – 14	2.41E-03	2.87E-04	3.07E-05	2.76E-05	3.73E-06	2.24E-05	3.02E-09	4.47E-06	8.56E-05	4.14E-05
14 – 15	2.41E-03	2.87E-04	3.07E-05	2.76E-05	3.73E-06	2.24E-05	3.02E-09	4.47E-06	8.56E-05	4.14E-05
15 – 16	3.00E-03	4.77E-04	3.32E-05	2.98E-05	4.22E-06	2.62E-05	3.42E-09	5.05E-06	1.05E-04	5.25E-05
16 – 17	3.00E-03	4.77E-04	3.32E-05	2.98E-05	4.22E-06	2.68E-05	3.42E-09	5.05E-06	1.09E-04	5.36E-05
17 – 18	3.00E-03	4.77E-04	3.32E-05	2.98E-05	4.22E-06	2.73E-05	3.42E-09	5.05E-06	1.13E-04	5.48E-05
18 – 19	3.77E-03	4.48E-04	4.79E-05	4.31E-05	5.81E-06	3.26E-05	4.71E-09	6.97E-06	1.16E-04	5.96E-05
19 – 20	3.14E-03	3.73E-04	3.99E-05	3.59E-05	4.85E-06	2.86E-05	3.93E-09	5.81E-06	1.08E-04	5.27E-05
20 – 21	2.61E-03	3.10E-04	3.32E-05	2.99E-05	4.03E-06	2.52E-05	3.26E-09	4.82E-06	1.00E-04	4.70E-05
21 – 22	2.27E-03	2.70E-04	2.89E-05	2.60E-05	3.50E-06	2.31E-05	2.84E-09	4.20E-06	9.55E-05	4.33E-05
22 – 23	1.74E-03	2.07E-04	2.21E-05	1.99E-05	2.68E-06	1.97E-05	2.18E-09	3.22E-06	8.81E-05	3.75E-05
23 – 24	8.69E-04	1.03E-04	1.11E-05	9.95E-06	1.34E-06	1.41E-05	1.09E-09	1.61E-06	7.59E-05	2.81E-05

7. MODELLING METHODOLOGY

7.1 Overview

Atmospheric dispersion modelling involves the mathematical simulation of the dispersion of air contaminants in the environment. The modelling utilises a range of information to estimate the dispersion of pollutants released from a source including:

- Meteorological data including wind conditions, temperature and pressure profiles, as well as humidity, rainfall, cloud cover and ceiling height information
- Emission parameters including source location and height, source dimensions and physical parameters (e.g., exit velocity and temperature) along with pollutant mass emission rates
- Terrain elevations and land use both at the source and throughout the surrounding region
- The location, height and width of any obstructions (such as buildings or other structures) that could significantly impact on the dispersion of the plume
- Sensitive receptor locations and heights.

For the purpose of the assessment, meteorological modelling has been undertaken using GRAMM to predict localised meteorological conditions. The meteorological data derived from these models has been used as an input for the GRAL dispersion modelling. GRAL was chosen for this modelling due to the presence of structures around the exhaust vents. Air flows over and around these structures cannot be modelled using the traditional air dispersion models such as CALPUFF or AERMOD, and therefore GRAL is a more suitable model for this site. Furthermore, GRAL allows for the modelling of a vertical area source with a horizontal velocity.

7.2 Model Year

The nearest available weather station, Brisbane BoM station, is approximately 3.5 kilometres east of the subject site. Data for the years 2020 to 2024 were available for analysis, model year selection, and assimilation into the model run. **Table 7.1** summarises the relevant wind conditions from 2020 to 2024 at the Brisbane BoM weather station. **Figure 7.1** presents wind roses for each year and the 2020 – 2024 average.

The average wind speed at the BoM station shows minimal inter-annual variability, ranging from 1.5 to 1.6 m/s. Low wind speed conditions account for approximately 38.8% to 41.9% of the year, while calm conditions occur for between 11.4% and 17.0% of the time.

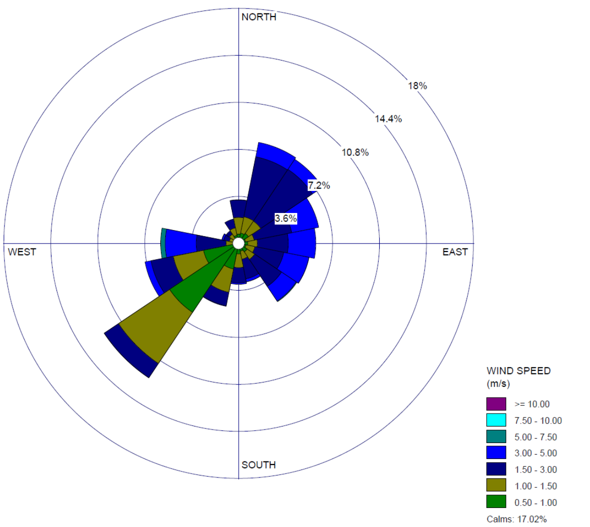
Calm and low wind speed conditions are associated with reduced atmospheric dispersion, allowing pollutants to travel for longer periods with limited dilution, and therefore represent worst-case conditions for assessment of near ground and wake affected sources. The 2021 dataset exhibits a higher-than-average frequency of calm conditions relative to other years analysed, while remaining broadly representative of the long-term occurrence of light wind conditions at the site. On this basis, 2021 is considered a conservative and appropriate year for dispersion modelling and has therefore been adopted for the purpose of the assessment.

Table 7.1: BoM Brisbane Station Meteorological Data Comparison

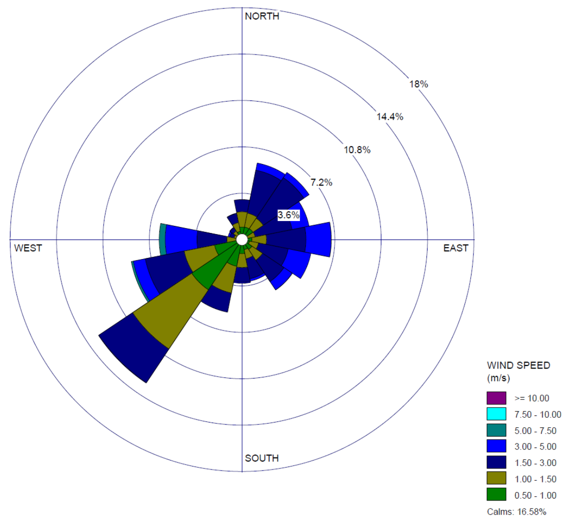
Year	AVG WS (m/s)	Calms (%)	0.5 - 1.5 m/s (%)	1.5 – 5.0 m/s (%)	> 5.0 m/s (%)
2020	1.5	17.0	38.3	44.3	0.5
2021	**1.5**	**16.6**	**39.0**	**43.4**	**0.7**
2022	1.6	11.4	38.8	49.4	0.3
2023	1.5	12.8	41.7	45.3	0.2
2024	1.5	12.7	41.9	45.2	0.1

Year	AVG WS (m/s)	Calms (%)	0.5 - 1.5 m/s (%)	1.5 – 5.0 m/s (%)	> 5.0 m/s (%)
Average	1.5	14.1	40.0	45.5	0.3

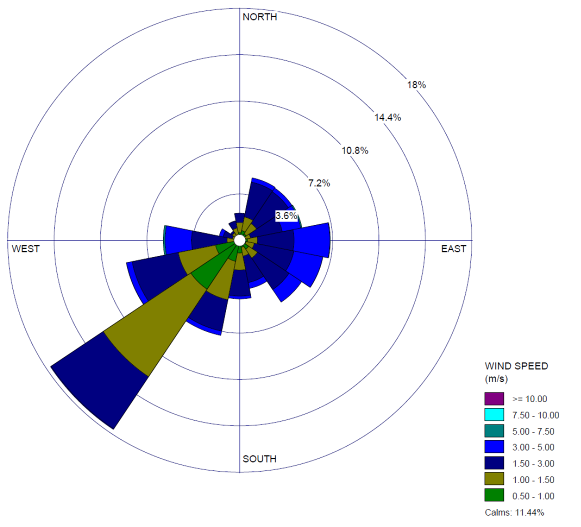
Figure 7.1: 2020-2024 Annual Wind Roses for the Brisbane BoM Station



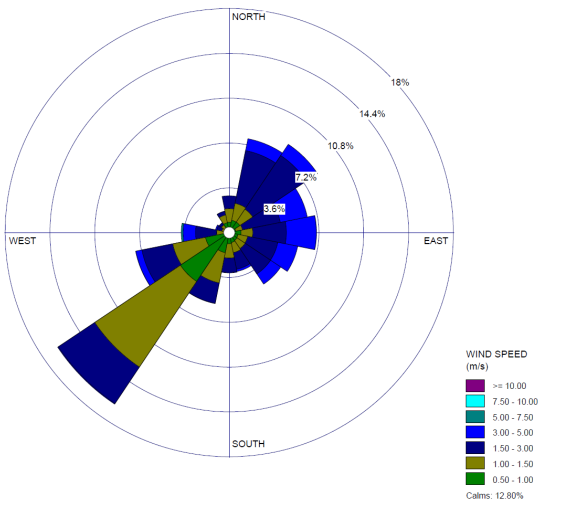
Year 2020



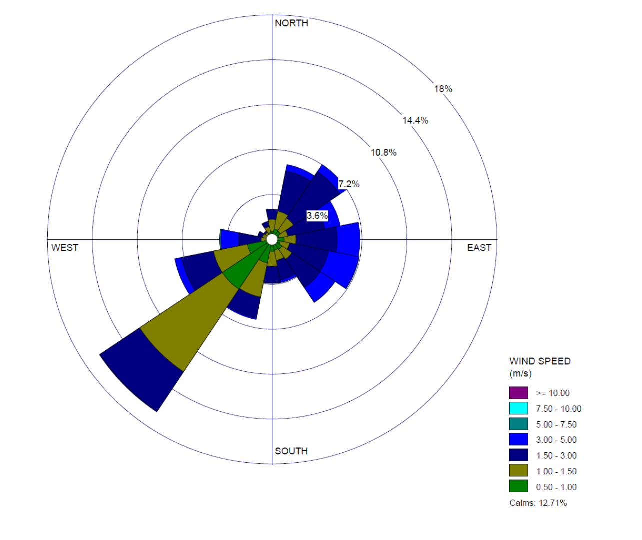
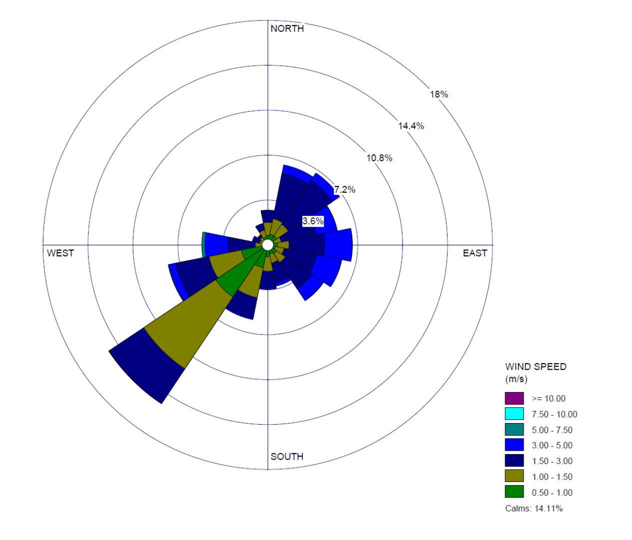
Year 2021



Year 2022



Year 2023

Year 2024	2020 - 2024
	

7.3 GRAMM Setup

7.3.1 Overview

GRAMM has been modelled for the year 2021 to predict site-specific meteorological conditions. GRAMM is a prognostic non-hydrostatic mesoscale model which predicts flow fields. The GRAMM modelling system interprets land use and terrain data to predict 3D flow fields.

It is noted that there are different approaches to deriving meteorology using GRAMM. One approach is to use a synthetic meteorological file covering a range of metrological conditions. GRAMM is run in the first instance to fit these conditions to the modelled terrain, and then the match-to-observations function is utilised with local observational data to match the modelled conditions to the measured data. Metrological data from the nearby Brisbane BoM station has been subsequently incorporated into the GRAMM modelling. More specifically, after initialising GRAMM with an "all situations" meteorological file, the wind fields were then matched to the observed data from the Brisbane BoM station. Linear interpolation has been used to fill gaps occurring in the Brisbane dataset. Hourly atmospheric stability classes were derived from measured data using the Sigma Theta method, which is an accepted approach under the Brisbane City Plan 2014 Air Quality Planning Scheme Policy. As sigma theta data are not reported at BoM stations, measurements from South Brisbane DETSI station were used as a surrogate. This station is located less than 800 metres from the BoM station and is therefore considered representative due to its close proximity and comparable surrounding land use and topographic conditions.

Several weighing factors were considered when incorporating the measured data through the match-to-observations function. A higher weighting factor lowers the influence of the stability class and increases the weighting of the wind speed and direction. Therefore, a high weight results in wind speeds and direction being very similar to the measured data. However, the stability classes are poorly reflected. A weighting factor of 1.25 and a direction factor of 4.25 were considered based on an iterative process to ensure that predicted wind conditions and stability classes were reasonably accurate. In addition to this the "Components" optimisation setting was adopted which results in improved stability class outputs.

Table 7.2 presents the GRAMM input parameters adopted in the modelling.

Table 7.2: Adopted GRAMM Parameters

GRAMM Parameter	Adopted Value
GRAMM Domain (SW Corner)	499444 m, 6958629 m
GRAMM Domain (NE Corner)	504444 m, 6963629 m
Horizontal grid resolution	100 m
Vertical thickness of first layer	10 m
Number of vertical layers	15
Vertical stretching factor	1.20 m
Height of top layer	730 m
Max time step	5 sec
Modelling time	3600 sec
Relaxation velocity	0.1
Relaxation scalars	0.1
Match to observation factors	Weighing factor = 1.25 Direction factor = 4.25

7.3.2 Terrain and Land Use Data

Terrain data for the area surrounding the development site was obtained from the LiDAR Derived 5-metre Digital Elevation Model (DEM), which represents a nation 5-metre (bare earth) DEM derived from some 236 individual LiDAR surveys between 2001 and 2015. Data for a 5 kilometre x 5 kilometre area surrounding the site has been extracted in an ASCII rater format for use in the modelling.

Land use data was also created based on the 2018 Queensland Government Queensland Land Use Mapping Program dataset (QLUMP). Land use data for a 5 kilometre x 5 kilometre area surrounding the site was converted from a vector shapefile to an ASCII raster file using the CORINE land use categories for inclusion in the modelling.

Figure 7.2 and **Figure 7.3** present the modelled terrain and land use included in the GRAMM modelling.

Figure 7.2: Modelled Terrain

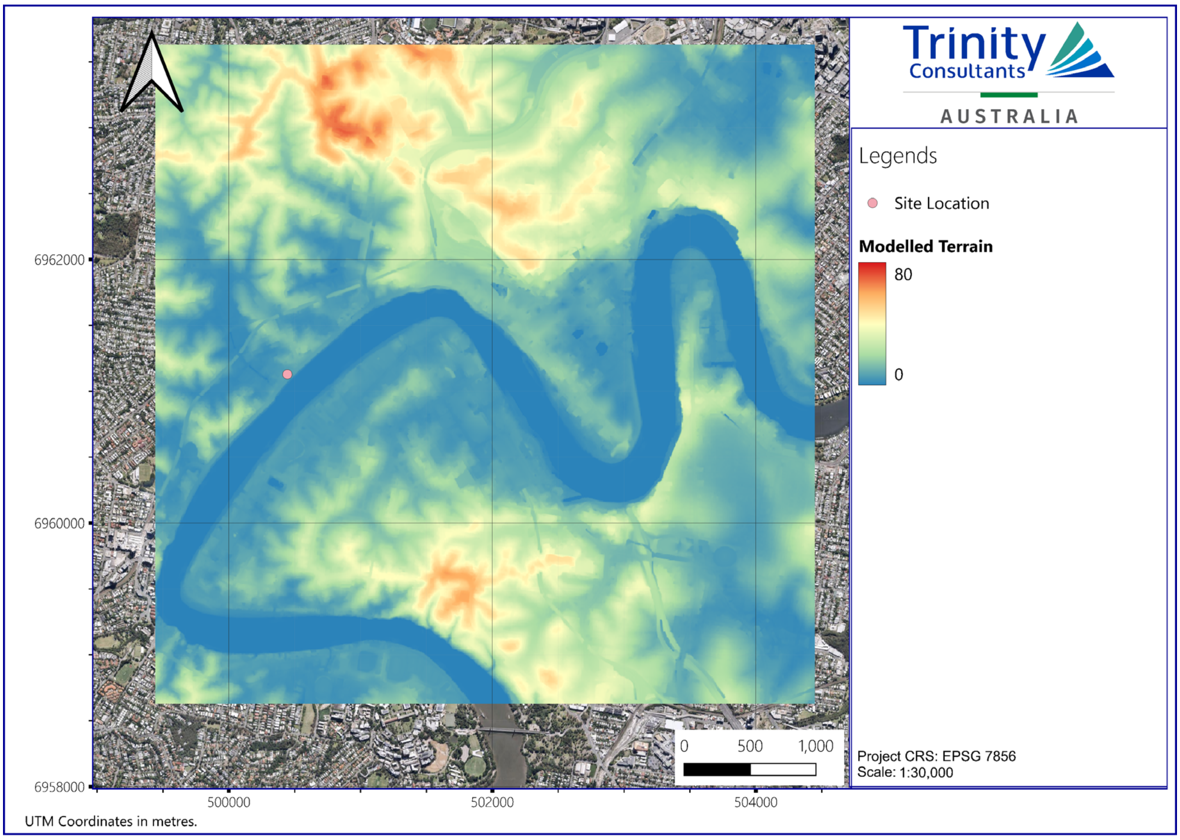
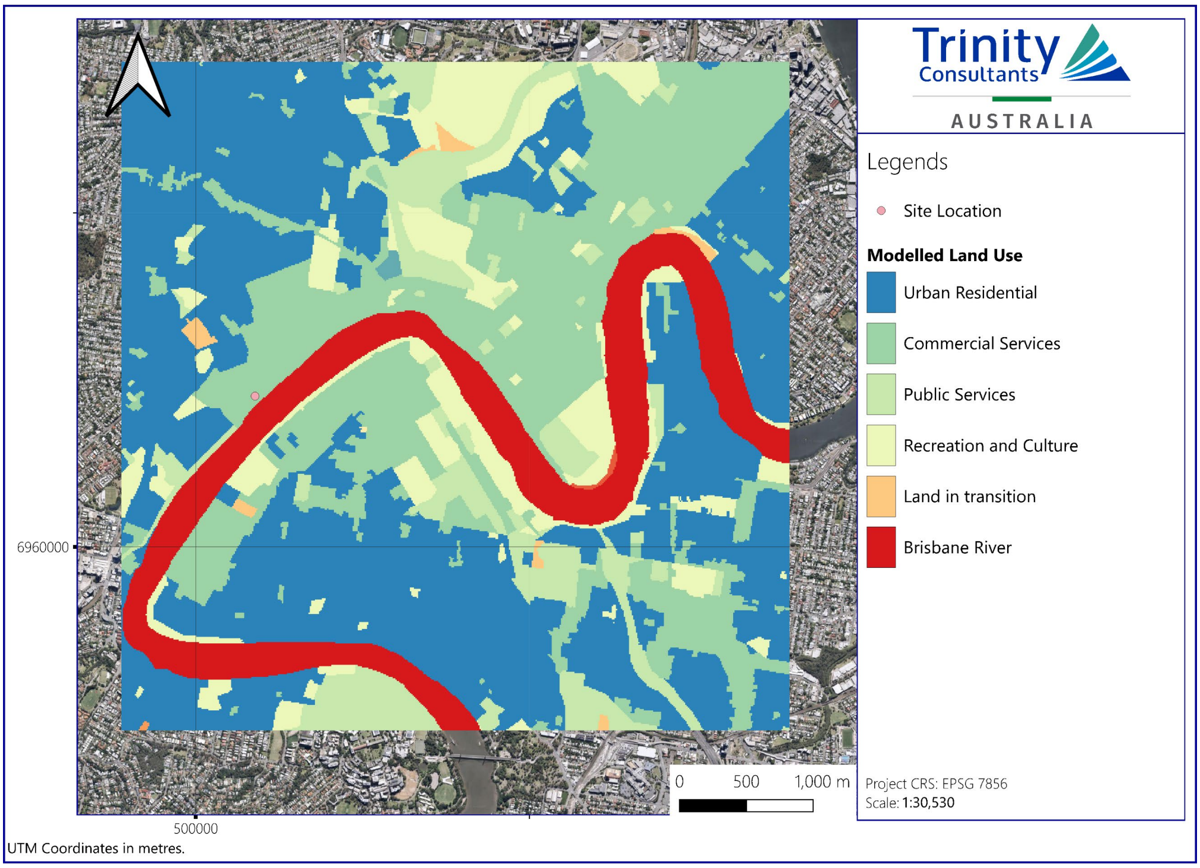


Figure 7.3: Modelled Land Use



7.4 GRAMM Results

7.4.1 Wind Conditions

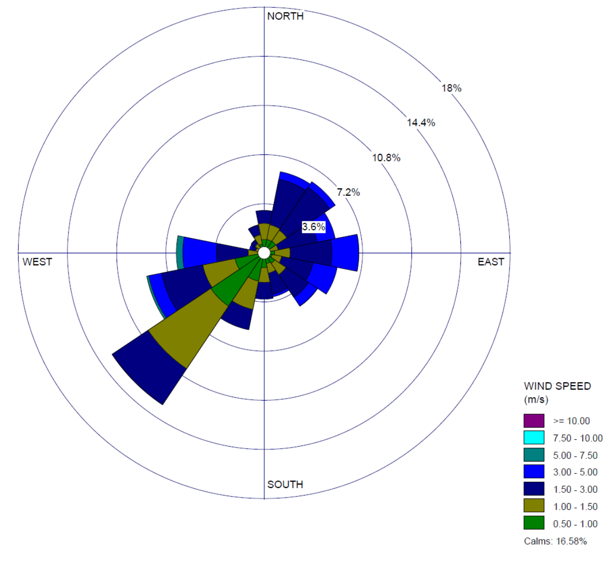
The observed 2021 Brisbane BoM station wind conditions and the GRAMM-predicted wind conditions at both the BoM station and the subject site are presented in **Figure 7.4**. At the BoM station, the predicted wind rose shows good agreement with the observational data, with predominant winds from the southwest and comparable calm conditions of 16.58% (measured) and 15.25% (predicted).

A higher occurrence of lower wind speeds are predicted at the study site, with 60.2% of winds below 1.5 m/s compared to 38.7% measured at the BoM station. These lower wind speeds reduce dispersion and lead to higher predicted pollutant concentrations, increasing conservatism. The predicted proportion of calm conditions is 22.8%. This is broadly comparable to the BoM observations, although slightly higher, resulting in a more conservative assessment.

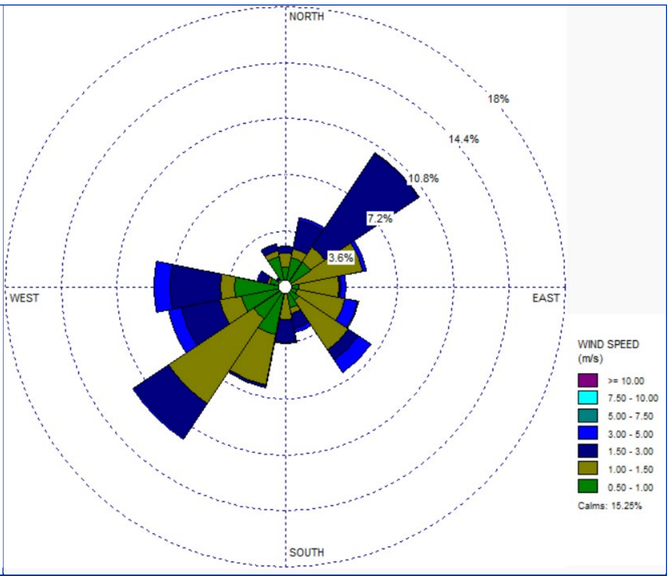
The site is located approximately 3.6 km from the Brisbane BoM station, and surrounding land use differs, particularly due to the Brisbane River immediately to the southeast. Some variation is therefore expected.

Overall, the GRAMM predictions are considered consistent with the observed data and are assessed to be conservative for the purposes of this assessment.

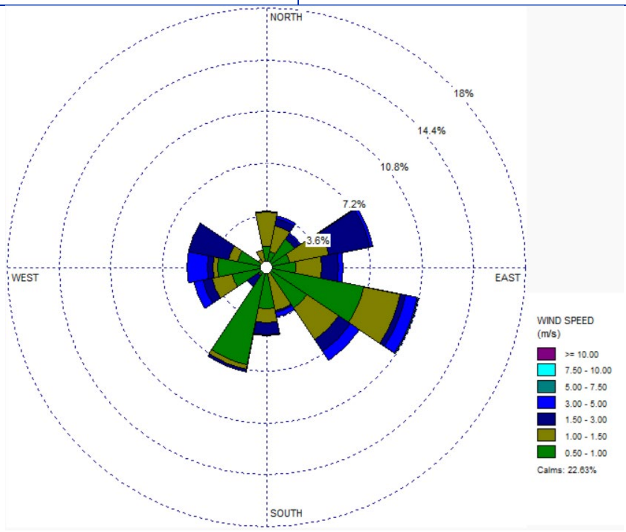
Figure 7.4: GRAMM Predicted Wind Roses (2021)



BoM Brisbane observations



BoM Brisbane GRAMM predicted



Site GRAMM Predicted

7.4.2 Predicted Atmospheric Stability

The amount of turbulence in the ambient air has a major effect on the rise and dispersion of emissions. The amount of turbulence in the atmosphere is often described using a series of six Pasquill stability classes A, B, C, D, E, F and G. Of these, Class A denotes the most unstable or most turbulent conditions and Class G denotes the most stable or least turbulent conditions. The larger proportion of stable conditions is likely to result in poorer dispersion conditions and higher pollutant concentrations in the air dispersion modelling.

Figure 7.5 to **Figure 7.7** present the calculated and GRAMM-predicted atmospheric stability classes at the BoM stations and the subject site. At the BoM station, the predicted stability classes show good agreement with those calculated using the Sigma Theta method based on measured data from the South Brisbane DETSI station.

GRAMM predicts a higher proportion of very stable atmospheric conditions, which represent worst-case dispersion scenarios, and a lower proportion of very unstable conditions. Overall, these predictions are considered conservative.

At the subject site, a similar pattern is observed; however, the results lean further toward the conservative side due to an increased frequency of very stable conditions and a reduced occurrence of very unstable conditions.

Figure 7.5: Summary of Calculated Stability Classes at the DETSI South Brisbane Station (based on Measured Data)

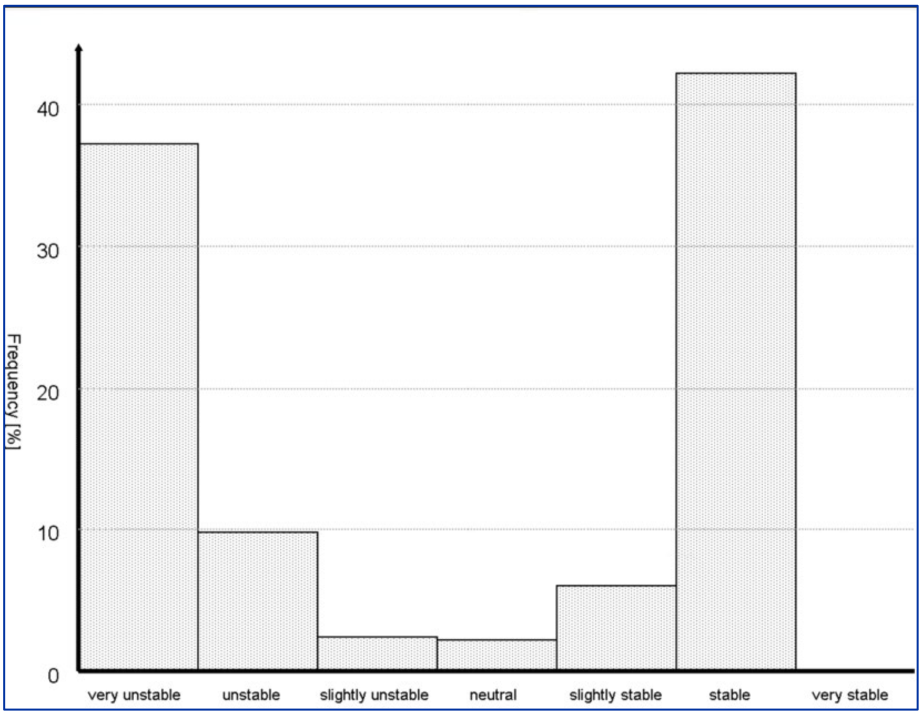


Figure 7.6: Summary of GRAMM Predicted Stability Classes at BoM Brisbane Station

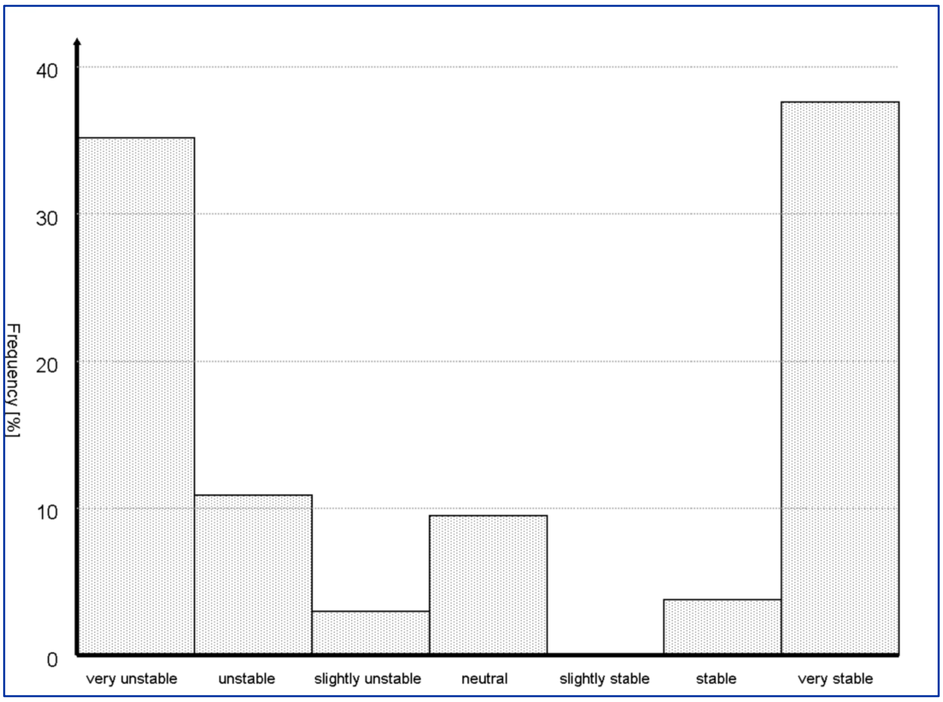
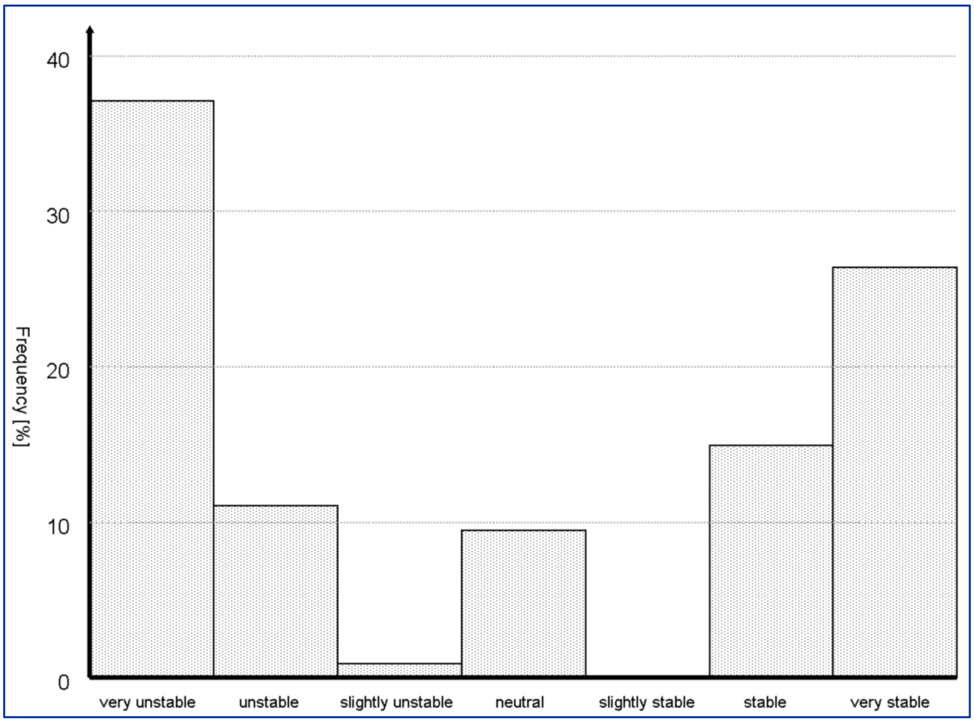


Figure 7.7: Summary of Predicted Stability Classes at Subject Site



7.5 GRAL

GRAL was run in transient and prognostic model to allow for modelling of a full year of meteorological and to consider the on-site and off-site building structures that will affect air flow and pollutant dispersion across the site. To reduce run times, GRAL was run without discrete receptors to compute the gridded concentrations for each modelled height above ground. Finally, the concentration time series for each discrete receptor was extracted using the GRAL GUI post-processing tool.

Table 7.3 presents a summary of the modelled GRAL parameters.

Table 7.3: Adopted GRAL Parameters

GRAL Parameter	Adopted Value
General	
Dispersion time	3600 seconds
Particles per second	100
Surface roughness	Local land use file included
Latitude	-27.47 degrees
Buildings	Prognostic GRAL
Topography	Original GRAL topography option adopted to allow modelling of buildings with absolute heights for the subject site. The rest of the buildings were modelled with relative heights.
Concentration Grid	
Horizontal grid resolution	2
Vertical dimension of concentration layers	1.0 metres
Number of horizontal slices	6 (15.8, 19, 22.3, 25.5, 28.8 and 32 metres above ground)

GRAL Parameter	Adopted Value
Internal Flow Field Grid	
Horizontal grid resolution	2.0 metres
Vertical thickness of first layer	2.0 metres
Vertical stretching factor	Flexible: 1.00 (height < 20 metres) 1.02 (20 < height < 50 metres) 1.05 (50 < height < 150 metres) 1.10 (150 < height < 250 metres) 1.20 (height > 250 metres)
Number of prognostic cells in z-direction	40
Minimum iterations	100
Maximum iterations	500

Figure 7.8 presents the modelled building footprints and heights considered in the assessment. Off-site building footprints and heights were estimated using Google Earth. All buildings are represented using relative heights above ground level.

Figure 7.8: Modelled Building Heights (m)

7.5.1 Carpark Exhaust Vents Locations and Parameters

The locations of the modelled sources are presented in **Figure 7.9**.

Car park emissions will be released via rectangular ventilation louvres. GRAL provides the option of modelling various types of sources, including point sources, horizontal area sources, tunnel portals and line sources. Given the configuration of the car park exhaust outlets, the use of the tunnel portal option has been adopted.

Table 7.4 presents the modelled emission parameters for the car park exhausts.

Table 7.4: Car Park Exhaust Parameters

Source	Relative Base Height (m)	Dimensions (m)	Horizontal Exit Velocity (m/s)	Exit Temperature (K)
Basement 1 – 3 Vent	0	5.2 x 1.2	0.54	Ambient
Podium 1 – 3 Vent	5	2.5 x 2.5	0.53	Ambient

Figure 7.9: Modelled Sources

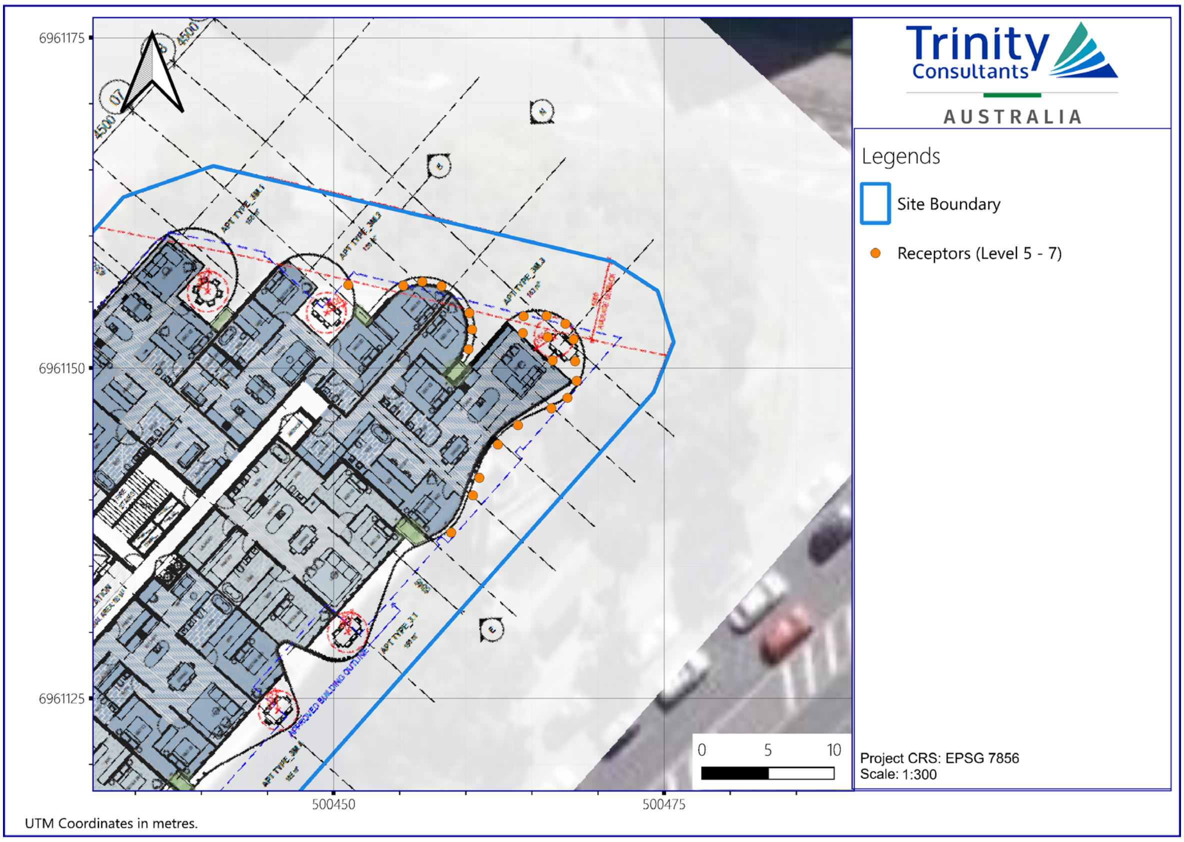
7.5.2 Discrete Receptors

Receptors have been selected to represent worst-case sensitive use locations nearest to the car par exhausts. A total of 48 receptors were considered in the modelling and selected from level 4 to 7 of the proposed on-site building.

Receptors have been modelled at the finished floor levels for Levels 4 to 7. This approach is conservative, as it assumes that air-conditioning intakes are located closest to the car park exhaust vents. **Figure 7.10** illustrates the locations of the modelled discrete receptors for Level 4 and **Figure 7.11** illustrates the locations of Level 5 to 7 discrete receptors. Level 8 is more than 15 metres away and complies with the minimum separation distance from the vent specified in the BCC City Plan 2014.

Figure 7.10: Modelled Receptors (Level 4)

Figure 7.11: Modelled Receptors (Level 5 – 7)



7.6 NO_x Conversion to NO_2

For conversion of NO_x to NO_2, the US EPA Ozone Limiting Method (OLM) has been adopted. This method assumes all ozone in the atmosphere reacts with NO_x to form NO_2 (regardless of distance and atmospheric conditions).

The NO_2 predictions for each hour have been converted to NO_2 using the OLM method, based on the hourly ambient ozone concentrations at the Cannon Hill station for the year 2021. A 0.27 initial NO_2/NO_x ratio was assumed for the calculations based on COPERT Australia vehicle emission model.

8. MODELLING RESULTS

The results of the modelling are presented in the following tables:

- **Table 8.1**: Predicted Results – Source Only
- **Table 8.2**: Predicted Results – Source Plus Background
- **Table 8.3**: Predicted VOCs Results – Source Only
- **Table 8.4**: Predicted VOCs Results – Source Plus Background

The predicted results of the car park exhaust modelling show compliance with the air quality criteria for all assessed pollutants at all receptor locations. Accordingly, the proposed development achieves compliance with Performance Outcome PO3(b) of the Centre or Mixed Use code and PO20(a) of the Multiple Dwelling code.

Given the significant compliance margins and low cumulative concentrations predicted for all other pollutants and averaging periods, concentration plots have been provided only for the worst-case pollutant for both a long- and short-term averaging period. The concentration plot for incremental and cumulative annual $PM_{2.5}$ are presented for the most affected receptor heights in **Figure 8.1** and **Figure 8.2** respectively.

PO3(a) of the Centre or Mixed Use Code requires that development avoids or minimises air emissions. Both vents are noted to be outward facing towards the road, away from any nearby buildings and off-site sensitive receptors. The basement exhaust is at a maximum distance from on-site receptors, being at ground level. The podium exhaust is positioned beneath the Level 2 slab, maximising separation from the nearest balconies on Level 4. Based on this, compliance with PO3(a) is achieved.

Table 8.1: Predicted Results – Source Only

Receptor ID	CO	NO_2		PM_{10}		$PM_{2.5}$	
Averaging Time	8-hr	1-hr, 99^{th} Perc.	Annual	24-hr	Annual	24-hr	Annual
Maximum	83.3	15.1	0.3	0.4	0.04	0.4	0.03
Criteria	11,000	250	62	50	25	25	8
L4	83.3	15.1	0.3	0.4	0.04	0.4	0.03
L5	26.1	5.6	0.2	0.1	0.02	0.1	0.02
L6	24.8	4.4	0.2	0.1	0.02	0.1	0.02
L7	28.1	3.9	0.1	0.1	0.01	0.1	0.01

Table 8.2: Predicted Results – Source Plus Background

Receptor ID	CO	NO_2		PM_{10}		$PM_{2.5}$	
Averaging Time	8-hr	1-hr, 99^{th} Perc.	Annual	24-hr	Annual	24-hr	Annual
Maximum	1260.2	154.2	40.1	26.7	19.1	14.0	7.8
Background	285.5	22.6	18.5	18.5	16.5	9.1	6.2
Criteria	11,000	250	62	50	25	25	8
L4	1260.2	154.3	40.1	26.8	19.1	14.0	7.8
L5	719.1	99.7	34.0	22.4	17.9	11.4	7.1
L6	635.3	93.8	31.3	21.6	17.6	10.9	6.9
L7	578.4	88.5	29.2	21.2	17.4	10.7	6.8

Table 8.3: Predicted VOCs Results – Source Only

Receptor ID	1,3 - Butadiene	Benzene		Benzo(a)pyren e	Formaldehyde		Toluene			Xylenes	
Averaging Time	Annual	1-hr, 99.9^{th} Perc.	Annual	Annual	1-hr, 99.9^{th} Perc.	24-hr	1-hr, 99.9^{th} Perc.	24-hr	Annual	24-hr	Annual
Maximum	4.56E-03	1.3	0.03	3.70E-06	0.3	0.06	4.3	0.7	0.1	0.4	0.05

Receptor ID	1,3 - Butadiene	Benzene		Benzo(a)pyrene	Formaldehyde		Toluene			Xylenes	
Criteria	2.4	29	10	3.00E-04	96	54	958	4100	410	1200	950
L4	4.6E-03	1.3	0.03	3.7E-06	0.3	0.06	4.3	0.7	0.1	0.4	0.05
L5	2.8E-3	0.4	0.02	2.3E-06	0.09	0.02	1.6	0.3	0.07	0.1	0.03
L6	2.3E-03	0.3	0.01	1.8E-06	0.08	0.02	1.2	0.2	0.05	0.1	0.03
L7	1.8E-03	0.3	0.01	1.4E-06	0.07	0.02	1.0	0.2	0.04	0.1	0.02

Table 8.4: Predicted VOCs Results – Source Plus Background

Receptor ID	1,3 - Butadiene	Benzene		Benzo(a)pyrene	Formaldehyde		Toluene			Xylenes	
Averaging Time	Annual	1-hr, 99.9th Perc.	Annual	Annual	1-hr, 99.9th Perc.	24-hr	1-hr, 99.9th Perc.	24-hr	Annual	24-hr	Annual
Maximum	4.56E-03	10.6	5.9	8.34E-05	11.2	11.3	27.3	23.1	17.9	42.1	41.5
Background	-	6.6	5.5	-	10.90	11.20	23	22.4	17.8	41.70	41.40
Criteria	2.4	29	10	3.00E-04	96	54	958	4100	410	1200	950
L4	4.6E0-3	10.6	5.9	8.3E-05	11.2	11.3	27.3	23.1	17.9	42.1	41.5
L5	2.8E-03	8.4	5.7	4.8E-05	11.0	11.2	24.3	22.7	17.9	41.8	41.4
L6	2.2E-03	8.1	5.7	3.9E-05	11.0	11.2	24.4	22.6	17.9	41.8	41.4
L7	1.8E-03	7.9	5.6	3.2E-05	11.0	11.2	24.0	22.6	17.8	41.8	41.4

Figure 8.1: Predicted Level 4 Source-Only $PM_{2.5}$ Annual Concentrations

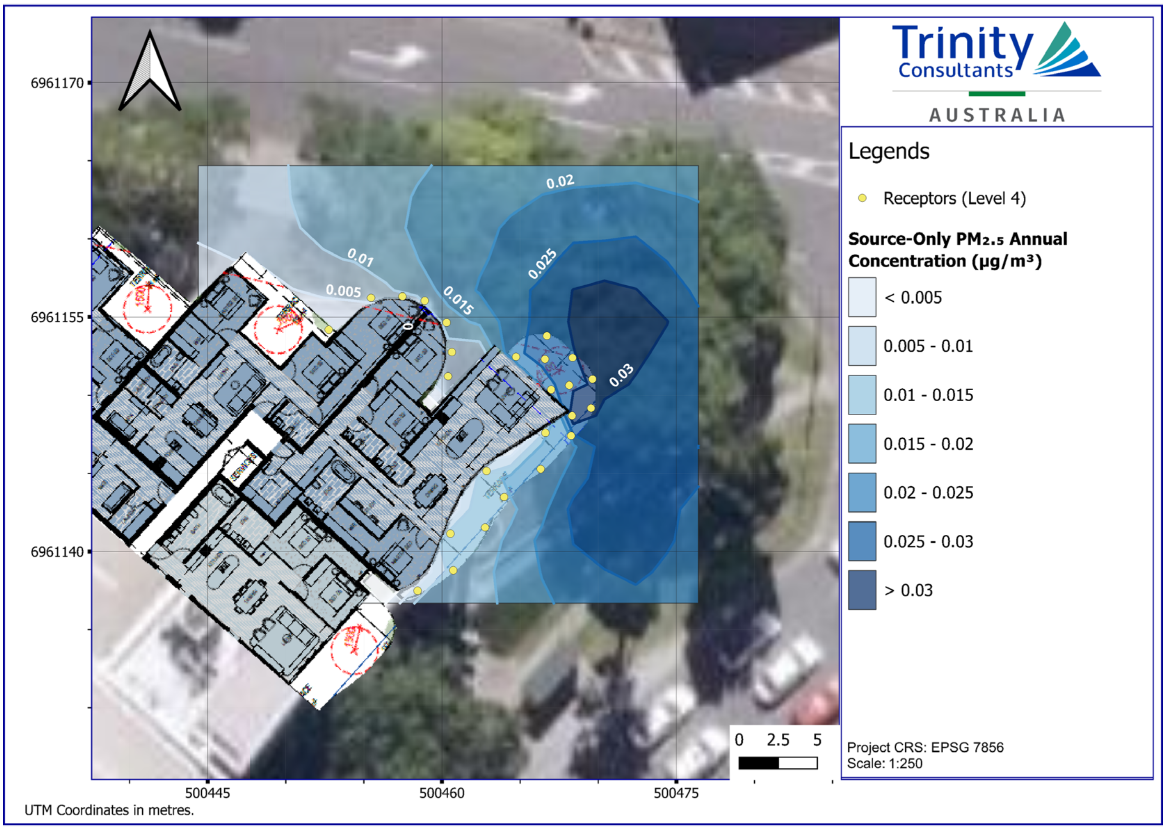
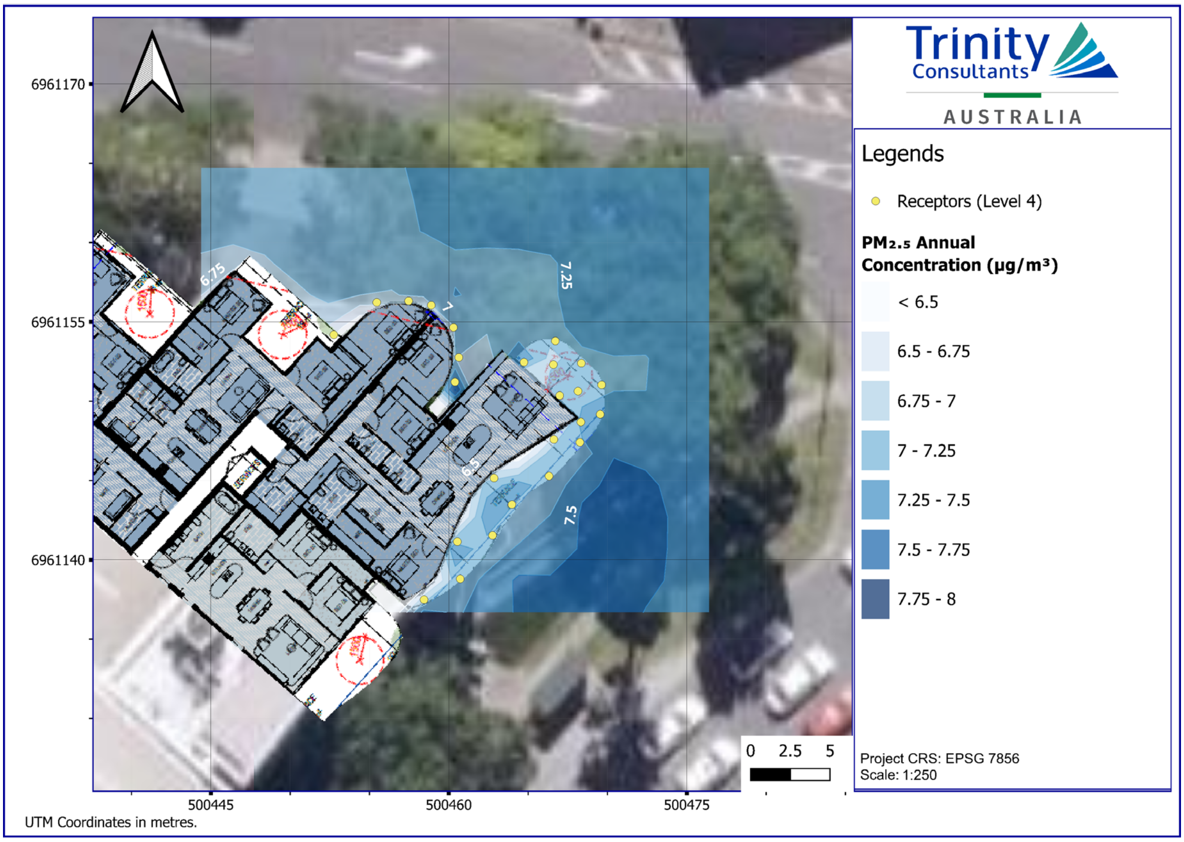


Figure 8.2: Predicted Level 4 Cumulative $PM_{2.5}$ Annual Concentrations



9. CONCLUSION

An air quality assessment for the proposed residential development at 299 Coronation Drive, Milton has been completed. The outcomes for the assessment are summarised as follows:

- Key air emission sources for the site include:
  - One car park exhaust serving three basement car parks located at ground floor level facing Coronation Drive on the eastern side of the building, further than 15 metres from the nearest sensitive receptor, and;
  - One car park exhaust servicing three podium car parks located below the Level 2 slab facing Graham Street on the northeastern corner of the building, withing 15 metres from the nearest unit balcony on-site.
- Air dispersion modelling has been undertaken for the car park exhaust emissions to assess potential air quality impacts on proposed on-site sensitive uses, in accordance with the Brisbane City Plan 2014 Air Quality Planning Scheme Policy.
- The modelling results demonstrate compliance with the applicable air quality criteria for all assessed pollutants at all on-site receptor locations. Accordingly, the proposed development achieves compliance with Performance Outcome PO3(b) of the Centre and Mixed Use Code and PO20(a) of the Multiple Dwelling Use Code, and no additional mitigation or control measures are required.
- Regarding PO3(a) of the Centre or Mixed Use Code, the development minimises air emissions through the location of the exhaust vents. Both vents are noted to be outward facing towards the road, away from any nearby buildings and off-site sensitive receptors.

Based on the assessment undertaken, the proposed car park exhaust vent locations are considered appropriate and achieve predicted compliance with the relevant air quality criteria.

APPENDIX A GLOSSARY

Parameter or Term	Description
Conversion of ppm to mg/m^3	Where R is the ideal gas constant; T, the temperature in Kelvin (273.16 + T°C); and P, the pressure in mm Hg, the conversion is as follows: mg/m^{-3} = (P/RT) x Molecular weight x (concentration in ppm) $= \dfrac{\text{P x Molecular weight x (concentration in ppm)}}{62.4 \text{ x } (273.2 + \text{T°C})}$
g/s	Grams per second
mg/m^3	Milligrams per cubic metre
$\mu g/m^3$	Micrograms per cubic metre
ppb	Parts per billion
ppm	Parts per million
PM_{10}, $PM_{2.5}$, PM_1	Fine particulate matter with an equivalent aerodynamic diameter of less than 10, 2.5 or 1 micrometres respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
99.5^{th} Percentile	The value exceeded 99.5% of the time
CO	Carbon monoxide.
NO_x	Oxides of nitrogen – a suite of gaseous contaminants that are emitted from road vehicles and other sources. Some of the compounds can react in the atmosphere and, in the presence of other contaminants, convert to different compounds (eg, NO to NO_2).
NO_2	Nitrogen dioxide.
VOC	Volatile Organic Compound/s. These compounds can be both toxic and odorous.

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