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# MIXED USE DEVELOPMENT CAR PARK VENTS

36 Warry Street, Fortitude Valley

Air Quality Assessment

LFL Projects



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Report  
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# 1. INTRODUCTION

## 1.1 Overview

Trinity Consultants Australia was commissioned by LFL Projects to complete an air quality assessment for proposed car park exhaust vents at the multiple dwelling development located at 36 Warry Street, Fortitude Valley.

The proposed development comprises two (2) car park exhaust vents located within 15 metres of the nearest on- and off-site 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.

## 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 car park 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 36 Warry Street, Fortitude Valley, on Lot 2 on RP221701, currently occupied by multiple commercial buildings. The subject site is situated within a Mixed use (Inner city) zone under the Brisbane City Plan 2014 Zoning Overlay and within the Priority Infrastructure Area.

The site is bounded by the following land uses:

- North: Warry Street, with commercial uses on the opposite side of the road.
- East: Approved mixed use, multiple dwelling development sharing the eastern site boundary. Beyond, St Pauls Terrace and Principal centre (City centre) zoning.
- South: Commercial uses, Kennigo Street and various commercial and accommodation uses on the opposite side of the road.
- West: Commercial and residential land uses.

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

The proposed development is located in the northeast corner of the lot, the existing heritage buildings to the northwest and south will not be disturbed. The location of the proposed development on the lot is shown in Figure 2.2.

Figure 2.1: Site Location and Zoning

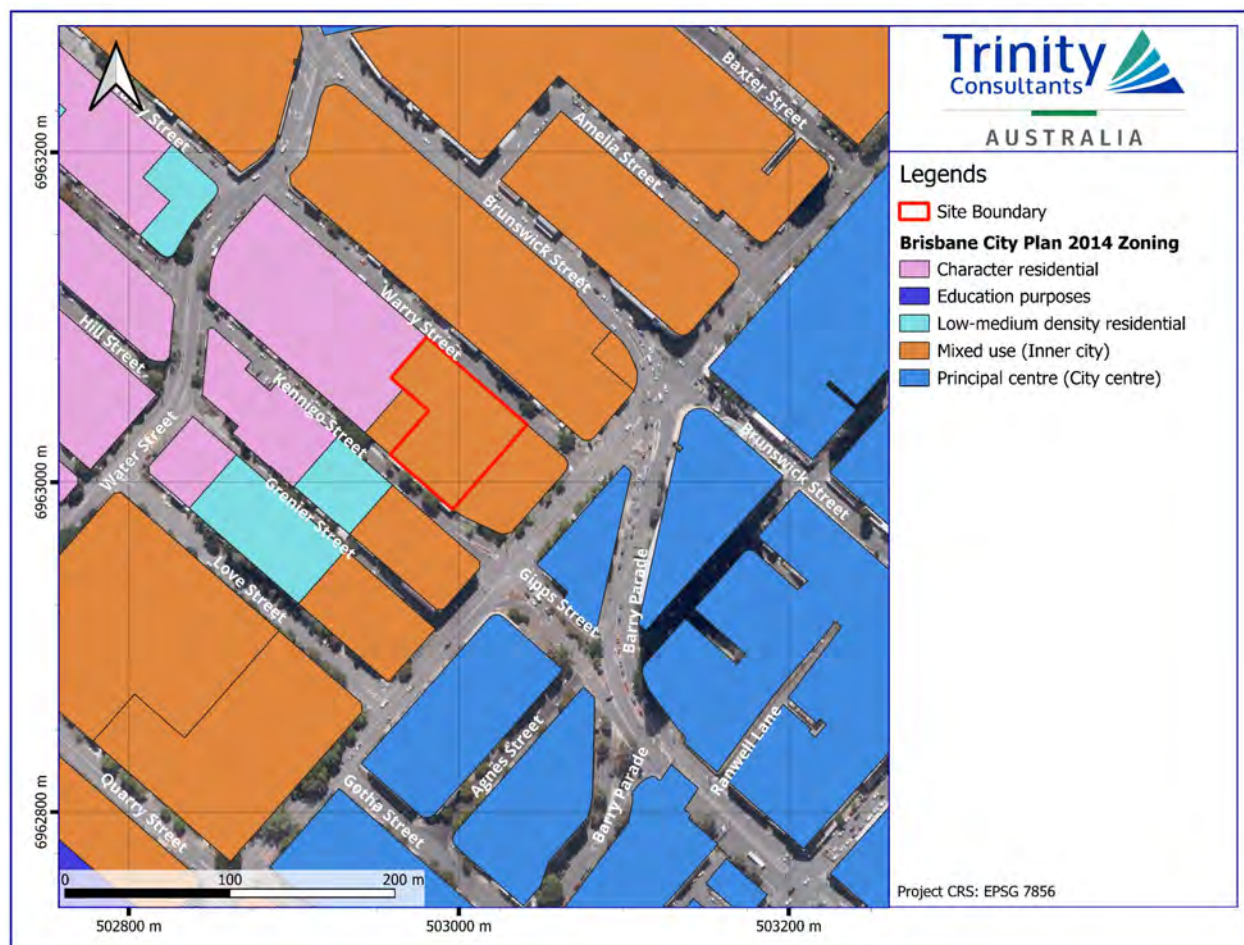
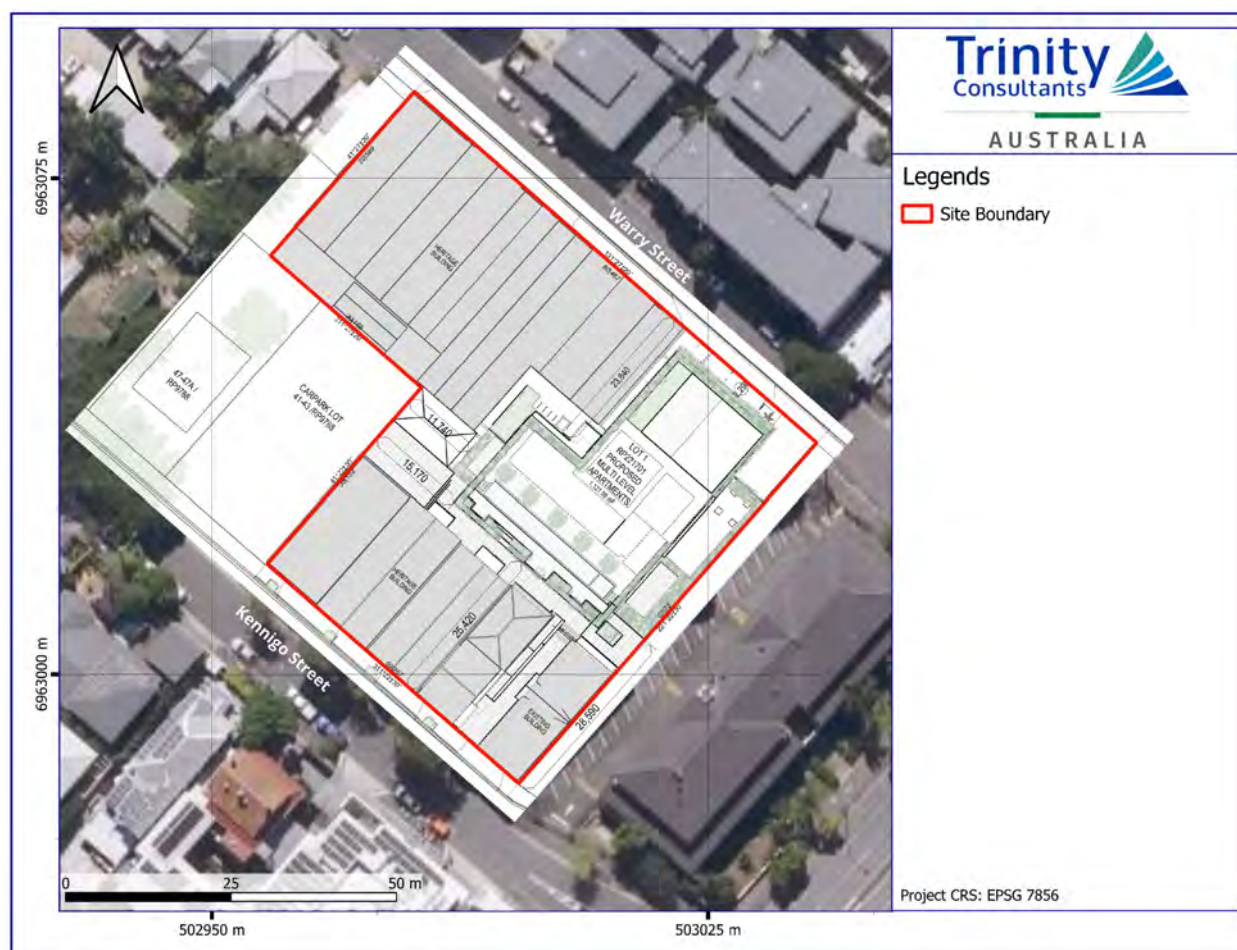


Figure 2.2: Location of Proposed Development on Lot



## 2.2 Project Description

The proposed development comprises a high-density 17-storey residential apartment complex with associated basement car parking and building services. In total, the development will accommodate 100 residential apartments across a mix of 2- and 3-bedroom dwellings and 970 m<sup>2</sup> of commercial tenancies.

Car parking for residents and visitors is provided across 3 basement levels and the lower ground level. Residential and commercial visitor parking is confined to the lower ground level.

The Level 1, Level 2-16 and Level 17 plans are provided in **Figure 2.3** to **Figure 2.5**. Building elevation is provided in **Figure 2.6**.

Figure 2.3: Level 1 Plan



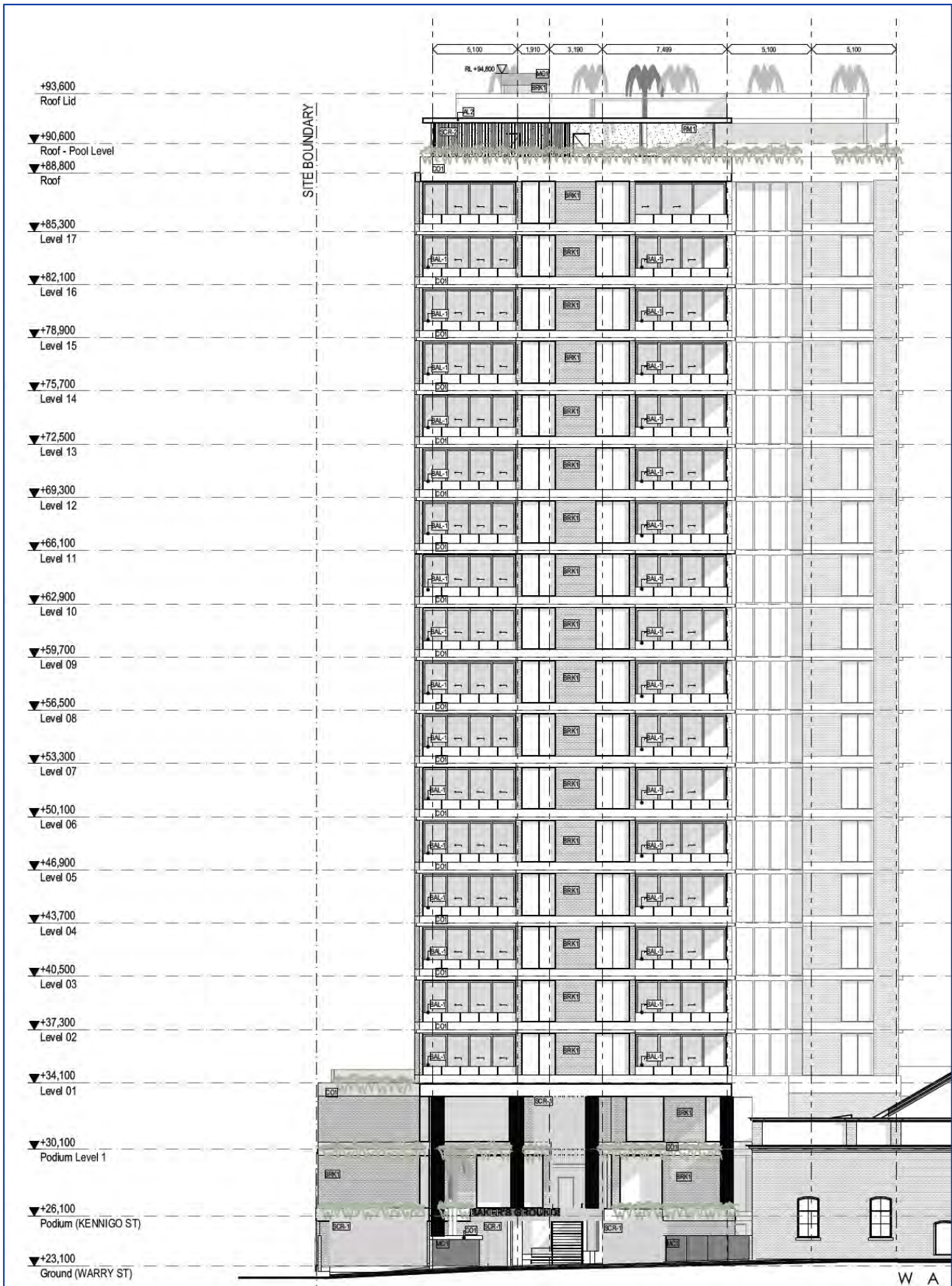
Figure 2.4: Level 2-16 Plan



Figure 2.5: Level 17 Plan



Figure 2.6: Building North Elevation

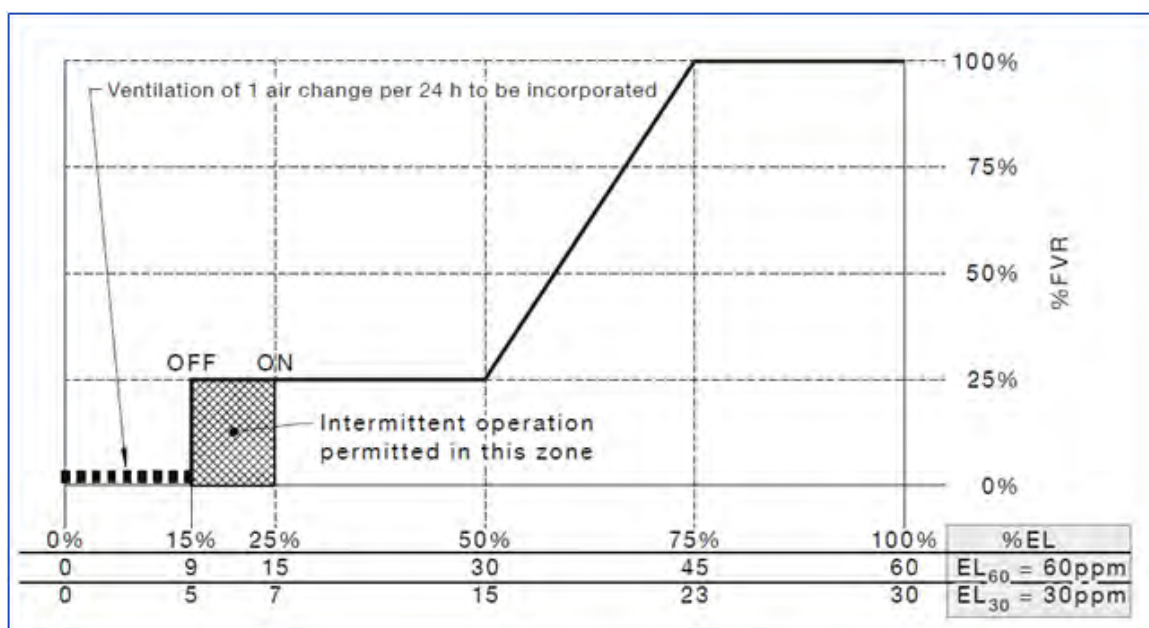


### 3. CAR PARK VENTILATION SYSTEM

Two (2) car park exhaust vents will be installed across the completed development. Vent 1, servicing Basement Levels 1 to 3, is located on the northeast side of the building at ground height and will discharge horizontally towards the eastern boundary (Warry St), at an approximate distance of 7 metres from the site boundary. Lower Ground Level emissions rise through a masonry shaft and are exhausted at roof lid height through Vent 2, discharges east towards the eastern boundary, at an approximate distance of 8.5 metres from the 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<sup>1</sup> (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**

Vent	Level	Area (m <sup>2</sup> )	Max Flow Rate (m <sup>3</sup> /s)	Modelled Exit Velocity <sup>a</sup> (m/s)
1	Basement 1 – 3	6.02	9.85	0.41
2	Lower Ground	0.5	3.2	1.6

<sup>a</sup> Based on louvre dimensions and 25% of the maximum flow rate.

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

<sup>1</sup> 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)

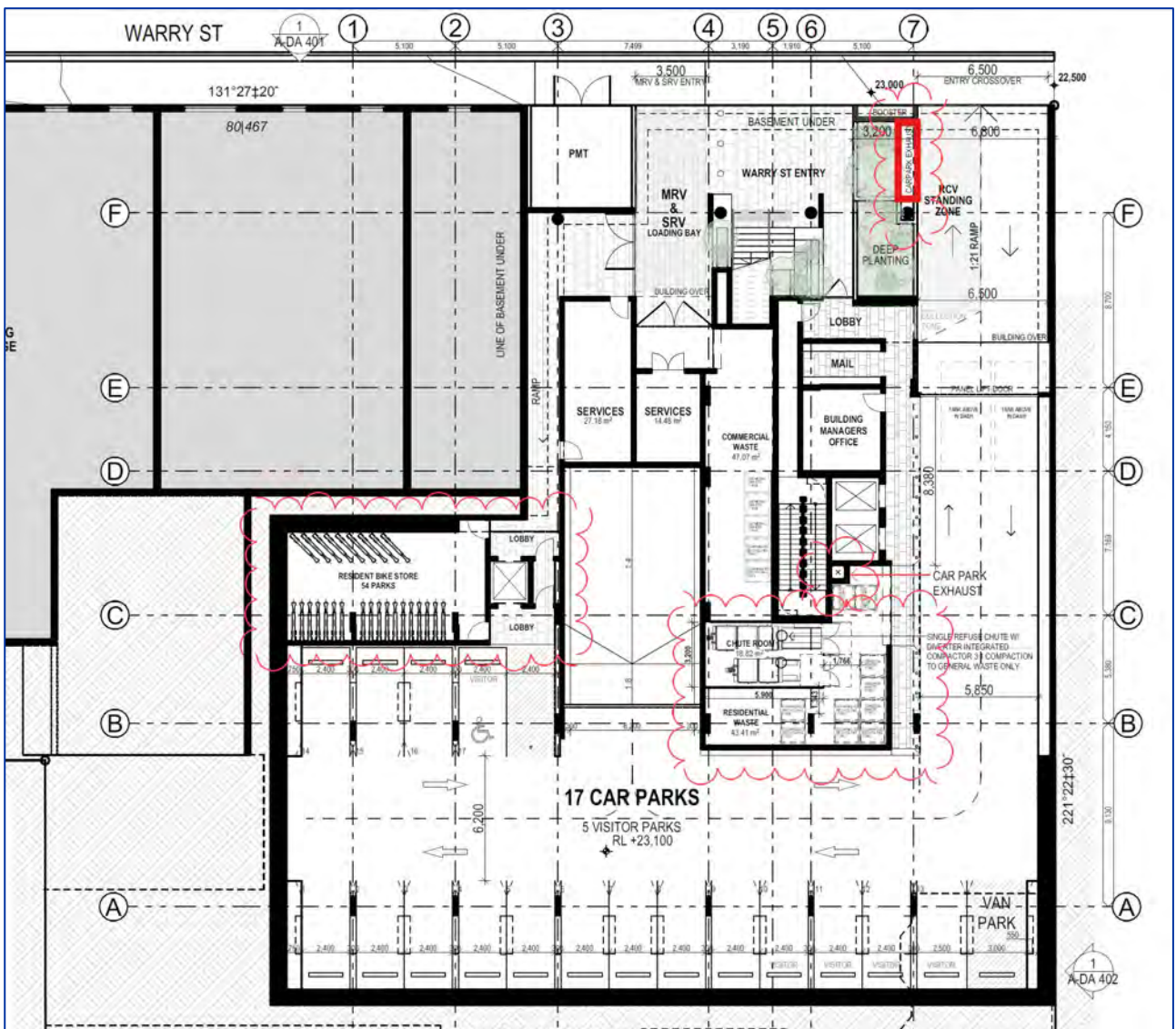
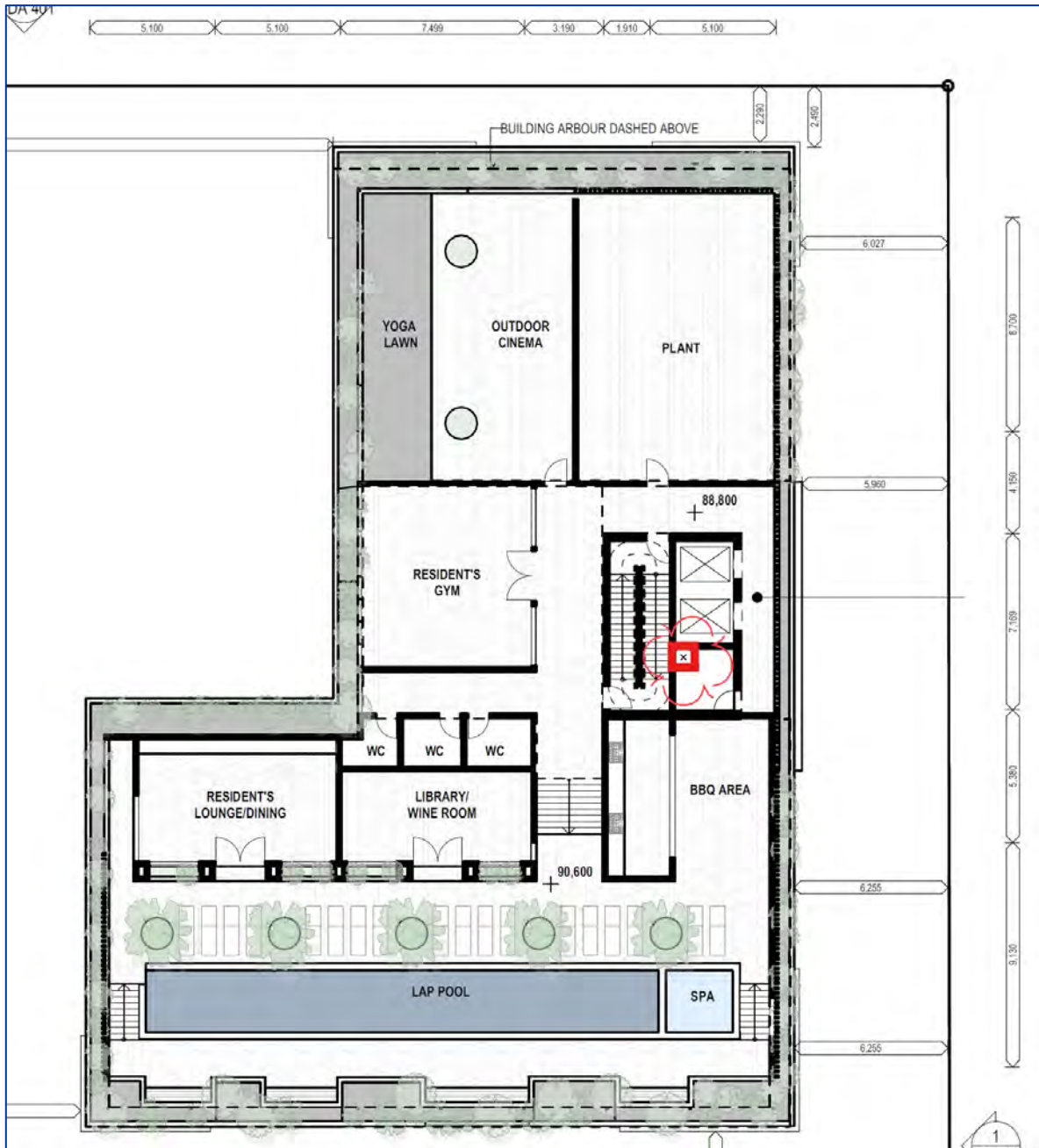


Figure 3.3: Lower Ground Exhaust Vent Location at Rooftop (Vent 2)

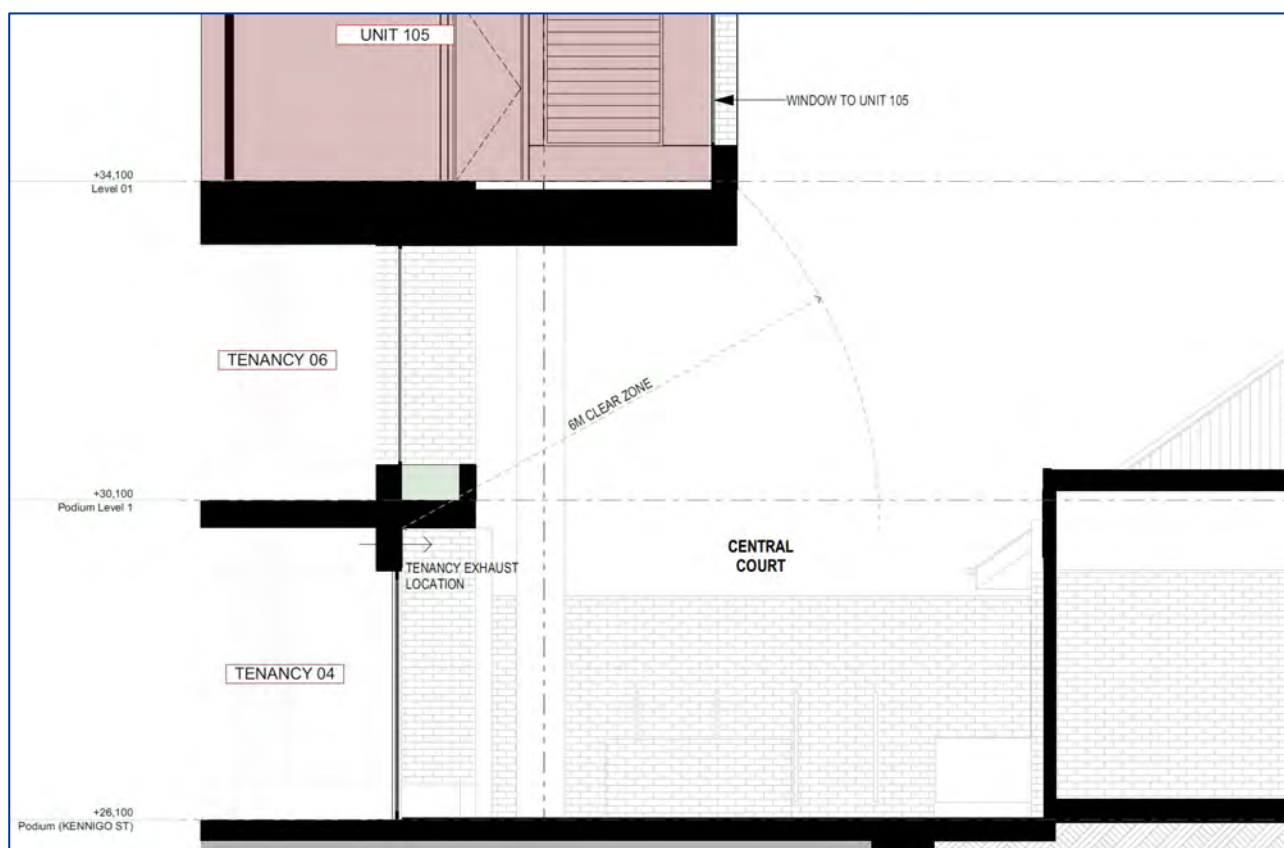


## 4. AIR QUALITY VALUES AND CRITERIA

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 zones or 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.

Additionally, commercial Tenancy 4 and 5, located at Podium Level, have proposed kitchen exhaust vent outlets. The location of these vents, shown in **Figure 4.1** and **Figure 4.2**, allows for separation distances of greater than 6 metres from outdoor air intakes. Therefore, the development complies with Acceptable Outcome AO20.1(a) of the Multiple dwelling code and Acceptable Outcome AO3.2(a) of the Centre or Mixed Use code. To mitigate potential odour impacts, carbon filtration is proposed. Compliance with AO3.2(b) is therefore achieved through both the provision of adequate separation distances and the minimisation of impacts via filtration.

**Figure 4.1: Tenancy 4 Kitchen Exhaust Vent Location**



**Figure 4.2: Tenancy 5 Kitchen Exhaust Vent Location**

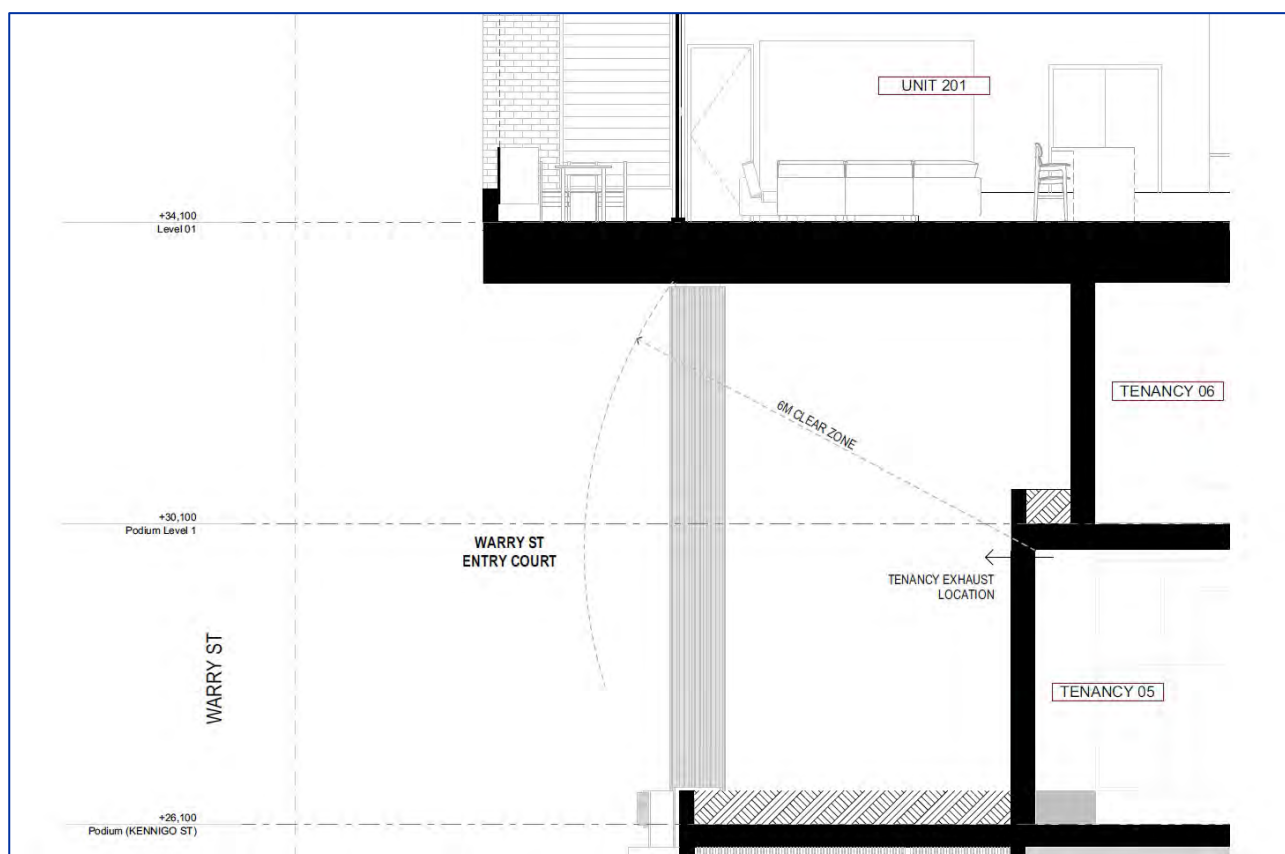


Table 4.1 and Table 4.2 present a copy of the air quality performance outcomes detailed in both applicable codes.

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

Performance Outcomes	Acceptable Outcomes
<p><b>PO3</b> Development:</p> <ul style="list-style-type: none"> <li>a. Avoids or minimises air emissions;</li> <li>b. complies with the air quality (planning) criteria in Table 9.3.3.3.1 in a sensitive zone or sensitive use.</li> </ul> <p>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.</p>	<p><b>AO3.2</b> Development ensures that if food and cooking odour is released, exhaust vent outlets are discharged vertically and directed away from any sensitive use with the following constraints:</p> <ul style="list-style-type: none"> <li>a. separated by a minimum of 6m from a sensitive use, including any outdoor air intake of a sensitive use;</li> <li>b. does not cause an odour or air emission which is detectable and disturbing at a sensitive use.</li> </ul> <hr/> <p><b>AO3.3</b> Development ensures that exhaust vents from any car park or bus station are separated from any sensitive use by a minimum of 15 m</p>

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

Performance Outcomes	Acceptable Outcomes
<p><b>PO20</b> Development is located, designed and constructed to achieve the:</p> <ul style="list-style-type: none"> <li>a. air quality (planning) criteria in Table 9.3.14.3.G;</li> </ul>	<p><b>AO20.1</b> 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:</p>

Performance Outcomes	Acceptable Outcomes
... 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.	a. exhaust vent outlets of premises where food or cooking odour is released, by a minimum of 6m; b. Exhaust vent outlets from car parks or bus stations, by a minimum of 15 m.

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<sub>10</sub> and PM<sub>2.5</sub>), nitrogen dioxide (NO<sub>2</sub>), volatile organic compounds (benzene, toluene, xylenes, 1,3-butadiene), formaldehyde and benzo(a)pyrene.

**Table 4.3: Adopted Air Quality Criteria**

Pollutant	Criteria (µg/m <sup>3</sup> )	Averaging Time	Environmental Value
CO	11,000	8-hour	Health and wellbeing
PM <sub>10</sub>	50	24-hour	
	25	Annual	
PM <sub>2.5</sub>	25	24-hour	
	8	Annual	
NO <sub>2</sub>	250	1-hour	
	62	Annual	
1,3-Butadiene	2.4	Annual	
Benzene	29	1-hour	
	10	Annual	
Benzo(a)pyrene	0.0003	Annual	
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	
Xylenes	1,200	24-hour	Health and wellbeing
	950	Annual	

## 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. Average annual daily traffic on St Pauls Terrace is currently 20,000 vehicles per day, with projected 2046 volume of 24,000 vehicles per day. Therefore, St Pauls Terrace has not been included in the model, however, to conservatively assess cumulative impacts, ambient monitoring data from monitoring stations located in high traffic areas have been added to the predicted results.

### 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 discussed in **Section 5.2**, background air quality data has conservatively been used from stations exposed to higher traffic emissions. The Department of Environment, Tourism, Science and Innovation (DETSI) operates air monitoring stations in Queensland. Existing background air quality concentrations have been obtained according to the Air Quality Planning Scheme Policy (AQPSP) with 70<sup>th</sup> percentile short-term averaging period concentrations and highest annual average concentrations for pollutants with annual averaging periods. Historical reports of DETSI data do not provide 70<sup>th</sup> percentile concentrations, so it is necessary to analyse raw data.

The nearest location to the site with publicly available data considered representative of the proposed development is the Woolloongabba monitoring station. This monitoring station is located 4.5 kilometres south of the site and in an area of similar land use. This monitoring station has been selected to develop conservative background levels as it is located in a high traffic area, being immediately adjacent to Ipswich Road and nearby the Pacific Motorway.

For VOCs (benzene, toluene and xylenes) and formaldehyde, 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 analysis.

The adopted background concentrations obtained from DETSI monitoring stations are presented in **Table 5.1**.

**Table 5.1: Ambient Pollutant Concentrations**

Pollutant	Ambient Pollutant Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Monitoring Station
CO	285.5	8-hour (2021)	Woolloongabba
PM <sub>10</sub>	22.9	24-hour (2023)	
	20.7	Annual (2023)	
PM <sub>2.5</sub>	7.3	24-hour (2023)	
	6.9	Annual (2023)	
NO <sub>2</sub>	36.9	1-hour (2021)	
	29.4	Annual (2021)	

Pollutant	Ambient Pollutant Concentration ( $\mu\text{g}/\text{m}^3$ )	Averaging Period	Monitoring Station
1,3-Butadiene	-	Annual	-
Benzene	6.6	1-hour (2017)	Springwood
	5.5	Annual (2017)	
Benzo(a)pyrene	-	Annual	-
Formaldehyde	10.9	1-hour (2016)	Springwood
	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 Car Park 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 <sup>2</sup>. Emission factors depend on fleet composition, road gradient, season, and traffic scenario. The following inputs have been considered:

- Road gradient: depending on each car park section
- Vehicle speed: 10 km/h
- Heavy vehicles: 0%
- Year of traffic fleet: 2020 <sup>3</sup>

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 movement within the car park.

**Table 6.1: PIARC Emission Factor (0% gradient)**

Pollutant	Emission Factor (g/vehicle/hour)		
	Passenger (Petrol)	Passenger (Diesel)	Total
<b>Year 2010</b>			
CO	56.3	10.3	44.8
NO <sub>x</sub>	8.5	13.8	9.8
PM <sub>10</sub> <sup>b</sup>	-	5.7 m <sup>2</sup> /hr/veh	1.4 m <sup>2</sup> /hr/veh
PM <sub>2.5</sub> <sup>a</sup>	-	5.1 m <sup>2</sup> /hr/veh	1.3 m <sup>2</sup> /hr/veh
<b>Year 2020</b>			
CO	23.6	4.4	18.8
NO <sub>x</sub>	2.6	8.4	4.1
PM <sub>10</sub>	-	2.1 m <sup>2</sup> /hr/veh	0.52 m <sup>2</sup> /hr/veh
PM <sub>2.5</sub>	-	1.9 m <sup>2</sup> /hr/veh	0.47 m <sup>2</sup> /hr/veh

<sup>a</sup> PM<sub>2.5</sub> based on opacity, which is converted to g/veh/hr emission factor by dividing by a factor of 4.7 (as per PIARC).

<sup>b</sup> PM<sub>10</sub> emissions calculated by assuming PM<sub>2.5</sub> is 90% of PM<sub>10</sub>.

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 operated at optimum conditions. To estimate emissions for vehicles the

<sup>2</sup> PIARC, Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, Reference 2012R05EN.

<sup>3</sup> 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.

methodology outlined in the EMEP<sup>4</sup> 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**. The calculated hot/cold ratios are provided in **Table 6.3**. These were calculate 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<sub>x</sub>). 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<sup>5</sup>.

**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 (°C)	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	

<sup>4</sup> European Monitoring and Evaluation Programme – Air Pollutant Emission Inventory Guidebook 2023 – Updated 2024.

<sup>5</sup> AS 1668.2-2012 The Use of Ventilation and Air Conditioning in Buildings – Mechanical Ventilation in Buildings

Pollutant	Category	Speed (km/h)	Temperature (°C)	A	B	C	Cold/Hot Emissions Ratio	Max.
NO <sub>x</sub>	Large SUV	10	10.5	7.82E-02	-0.105	3.116	2.80	1.45
	Mini, Small	10	30.4	0.0461	0.00738	0.755	1.44	
	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, emission factors 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 car park 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
2026	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

Pollutant	Emission ratio (target compound/Benzene)	Emission factor (mg/VKT)
Toluene	1.8586	11.8
Xylenes (total)	1.5380	9.7

### 6.1.2.2 Vehicle Evaporative Emissions

Two reference sources have been used to estimate evaporative emissions from cars parked inside the car parks. Huan Liu (2015) 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<sup>6</sup>. The evaporative processes include:

- Hot soak: hydrocarbon emissions arising from the fuel system of a stationary vehicle after a period of driving.
- 25-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
Hot 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 references, Hanyang Man (2019) studied the species characteristics involved in each emission process<sup>7</sup>.

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
Toluene	8.91	4.82
Xylenes	1.12	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.

<sup>6</sup> VOC emissions from the vehicle evaporation process: status and control strategy. Huan Liu et al. (2015).

<sup>7</sup> VOCs evaporative emissions from vehicles in China: Species characteristics of different emission processes. Hanyang Man et al. (2019).

- A 20% in / 80% split has been assumed for cars entering and leaving the basement car parks during the morning peak, 80% in / 20% out during the evening peak, and 50% / 50% split for the rest of the day.
- A 50% / 50% split has been assumed for cars entering and leaving the Lower Ground car park during operational hours assumed as 6am to 10 pm.
- Peak residential hourly traffic movement of 24 vehicles per hour (VPH) and of 19 VPH for commercial traffic movement for the morning and evening peaks (extracted from traffic impact assessment prepared by PTT 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)
Lower Ground	64	-	51	-
Basement 1	103	17	83	17
Basement 2	103	17	83	17
Basement 3	103	17	-	-

**Table 6.9: Assumed Traffic Generation Profile**

Hour	Lower Ground (VPH)	Basement 1 (VPH)	Basement 2 (VPH)	Basement 3 (VPH)	Total
0 – 1	0	1	1	1	3
1 – 2	0	1	1	1	2
2 – 3	0	1	1	1	2
3 – 4	0	0	0	0	1
4- 5	0	0	0	0	1
5 – 6	0	1	1	1	3
6 – 7	20	8	8	8	43
7 – 8	20	8	8	8	43
8 – 9	20	8	8	8	43
9 – 10	20	3	3	4	30
10 – 11	20	4	4	4	32
11 – 12	20	4	4	4	32
12 – 13	20	4	4	5	33
13 – 14	20	4	4	5	33
14 – 15	20	4	4	5	33
15 – 16	20	8	8	8	43
16 – 17	20	8	8	8	43
17 – 18	20	8	8	8	43
18 – 19	20	7	7	7	40
19 – 20	20	5	5	6	37
20 – 21	20	5	5	5	34

Hour	Lower Ground (VPH)	Basement 1 (VPH)	Basement 2 (VPH)	Basement 3 (VPH)	Total
21 – 22	20	4	4	4	32
22 – 23	20	3	3	3	29
23 – 24	0	2	2	2	5

### 6.1.4 Emission Rate

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

**Table 6.10: Vent 1 (Basement Car Park) Exhaust – Modelled Emission Rates (g/s)**

Hour	CO	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	1,3-Butadiene	Benzene	Benzo(a)pyrene	Formaldehyde	Toluene	Xylenes
0 – 1	6.83E-04	8.12E-05	8.46E-06	7.61E-06	1.03E-06	1.20E-05	8.32E-10	1.23E-06	6.68E-05	2.41E-05
1 – 2	4.10E-04	4.87E-05	5.07E-06	4.57E-06	6.16E-07	1.03E-05	4.99E-10	7.38E-07	6.30E-05	2.12E-05
2 – 3	4.10E-04	4.87E-05	5.07E-06	4.57E-06	6.16E-07	1.03E-05	4.99E-10	7.38E-07	6.30E-05	2.12E-05
3 - 4	2.73E-04	3.25E-05	3.38E-06	3.04E-06	4.10E-07	9.43E-06	3.33E-10	4.92E-07	6.11E-05	1.97E-05
4 – 5	3.41E-04	4.06E-05	4.23E-06	3.81E-06	5.13E-07	9.85E-06	4.16E-10	6.15E-07	6.20E-05	2.04E-05
5 – 6	8.19E-04	9.75E-05	1.01E-05	9.13E-06	1.23E-06	1.28E-05	9.98E-10	1.48E-06	6.87E-05	2.56E-05
6 – 7	8.31E-03	8.29E-04	1.20E-04	1.08E-04	1.43E-05	6.39E-05	1.16E-08	1.72E-05	1.63E-04	1.05E-04
7 – 8	8.31E-03	8.29E-04	1.20E-04	1.08E-04	1.43E-05	6.30E-05	1.16E-08	1.72E-05	1.56E-04	1.04E-04
8 – 9	8.31E-03	8.29E-04	1.20E-04	1.08E-04	1.43E-05	6.21E-05	1.16E-08	1.72E-05	1.50E-04	1.02E-04
9 – 10	2.73E-03	3.25E-04	3.38E-05	3.04E-05	4.10E-06	2.22E-05	3.33E-09	4.92E-06	7.63E-05	4.07E-05
10 – 11	3.07E-03	3.65E-04	3.81E-05	3.42E-05	4.62E-06	2.43E-05	3.74E-09	5.53E-06	8.11E-05	4.44E-05
11 – 12	3.14E-03	3.74E-04	3.89E-05	3.50E-05	4.72E-06	2.48E-05	3.83E-09	5.66E-06	8.20E-05	4.51E-05
12 – 13	3.55E-03	4.22E-04	4.40E-05	3.96E-05	5.34E-06	2.73E-05	4.33E-09	6.39E-06	8.78E-05	4.96E-05
13 – 14	3.41E-03	4.06E-04	4.23E-05	3.81E-05	5.13E-06	2.65E-05	4.16E-09	6.15E-06	8.59E-05	4.81E-05
14 – 15	3.41E-03	4.06E-04	4.23E-05	3.81E-05	5.13E-06	2.65E-05	4.16E-09	6.15E-06	8.59E-05	4.81E-05
15 – 16	3.95E-03	6.22E-04	3.67E-05	3.30E-05	4.67E-06	2.78E-05	3.78E-09	5.59E-06	1.08E-04	5.84E-05
16 – 17	3.95E-03	6.22E-04	3.67E-05	3.30E-05	4.67E-06	2.87E-05	3.78E-09	5.59E-06	1.15E-04	6.03E-05
17 – 18	3.95E-03	6.22E-04	3.67E-05	3.30E-05	4.67E-06	2.95E-05	3.78E-09	5.59E-06	1.21E-04	6.22E-05
18 – 19	5.32E-03	6.33E-04	6.60E-05	5.94E-05	8.00E-06	4.10E-05	6.49E-09	9.59E-06	1.32E-04	7.45E-05
19 – 20	4.44E-03	5.28E-04	5.50E-05	4.95E-05	6.67E-06	3.55E-05	5.41E-09	7.99E-06	1.20E-04	6.48E-05
20 – 21	3.69E-03	4.39E-04	4.57E-05	4.11E-05	5.54E-06	3.08E-05	4.49E-09	6.64E-06	1.09E-04	5.67E-05
21 - 22	3.21E-03	3.82E-04	3.97E-05	3.58E-05	4.82E-06	2.78E-05	3.91E-09	5.78E-06	1.02E-04	5.15E-05
22 – 23	2.46E-03	2.92E-04	3.04E-05	2.74E-05	3.69E-06	2.31E-05	2.99E-09	4.43E-06	9.17E-05	4.34E-05
23 - 24	1.23E-03	1.46E-04	1.52E-05	1.37E-05	1.85E-06	1.54E-05	1.50E-09	2.21E-06	7.45E-05	3.01E-05

**Table 6.11: Vent 2 (Lower Ground Car Park) Exhaust – Modelled Emission Rates (g/s)**

Hour	CO	NO <sub>x</sub>	PM10	PM2.5	1,3-Butadiene	Benzene	Benzo(a)pyrene	Formaldehyde	Toluene	Xylenes
0 – 1	1.61E-04	1.92E-05	1.89E-06	1.70E-06	2.29E-07	1.97E-06	1.86E-10	2.74E-07	9.66E-06	3.74E-06
1 – 2	9.67E-05	1.15E-05	1.13E-06	1.02E-06	1.37E-07	1.61E-06	1.11E-10	1.65E-07	8.96E-06	3.17E-06
2 – 3	9.67E-05	1.15E-05	1.13E-06	1.02E-06	1.37E-07	1.61E-06	1.11E-10	1.65E-07	8.96E-06	3.17E-06
3 - 4	6.45E-05	7.68E-06	7.55E-07	6.79E-07	9.16E-08	1.43E-06	7.42E-11	1.10E-07	8.61E-06	2.89E-06
4 – 5	8.06E-05	9.61E-06	9.43E-07	8.49E-07	1.14E-07	1.52E-06	9.28E-11	1.37E-07	8.79E-06	3.03E-06
5 – 6	1.93E-04	2.31E-05	2.26E-06	2.04E-06	2.75E-07	2.15E-06	2.23E-10	3.29E-07	1.00E-05	4.03E-06
6 – 7	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
7 – 8	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
8 – 9	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
9 – 10	2.09E-03	2.49E-04	2.45E-05	2.20E-05	2.97E-06	1.46E-05	2.41E-09	3.56E-06	4.57E-05	2.95E-05
10 – 11	2.17E-03	2.59E-04	2.54E-05	2.29E-05	3.09E-06	1.51E-05	2.50E-09	3.70E-06	4.66E-05	3.02E-05
11 – 12	2.19E-03	2.61E-04	2.56E-05	2.31E-05	3.11E-06	1.52E-05	2.52E-09	3.73E-06	4.68E-05	3.04E-05
12 – 13	2.29E-03	2.72E-04	2.68E-05	2.41E-05	3.25E-06	1.57E-05	2.63E-09	3.89E-06	4.78E-05	3.12E-05
13 – 14	2.25E-03	2.69E-04	2.64E-05	2.37E-05	3.20E-06	1.55E-05	2.60E-09	3.84E-06	4.75E-05	3.10E-05
14 – 15	2.25E-03	2.69E-04	2.64E-05	2.37E-05	3.20E-06	1.55E-05	2.60E-09	3.84E-06	4.75E-05	3.10E-05
15 – 16	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
16 – 17	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
17 – 18	2.88E-03	3.44E-04	3.37E-05	3.04E-05	4.09E-06	1.91E-05	3.32E-09	4.91E-06	5.43E-05	3.65E-05
18 – 19	2.71E-03	3.22E-04	3.17E-05	2.85E-05	3.84E-06	1.81E-05	3.12E-09	4.60E-06	5.24E-05	3.50E-05
19 – 20	2.50E-03	2.97E-04	2.92E-05	2.63E-05	3.54E-06	1.69E-05	2.87E-09	4.25E-06	5.01E-05	3.31E-05
20 – 21	2.32E-03	2.76E-04	2.71E-05	2.44E-05	3.29E-06	1.59E-05	2.67E-09	3.95E-06	4.82E-05	3.15E-05
21 - 22	2.21E-03	2.63E-04	2.58E-05	2.32E-05	3.13E-06	1.53E-05	2.54E-09	3.75E-06	4.70E-05	3.05E-05
22 – 23	2.03E-03	2.42E-04	2.37E-05	2.14E-05	2.88E-06	1.43E-05	2.34E-09	3.45E-06	4.50E-05	2.90E-05
23 - 24	2.90E-04	3.46E-05	3.40E-06	3.06E-06	4.12E-07	2.70E-06	3.34E-10	4.94E-07	1.11E-05	4.89E-06

## 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 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 2.8 kilometres south-southeast of the subject site. Data for the years 2021 to 2025 were available for analysis, model year selection, and assimilation into the model run. **Table 7.1** summarises the relevant wind conditions from 2021 to 2025 at the Brisbane BoM weather station. **Figure 7.1** presents the wind roses for each year and the 2021 – 2025 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 between 11.4% to 16.6% of the time.

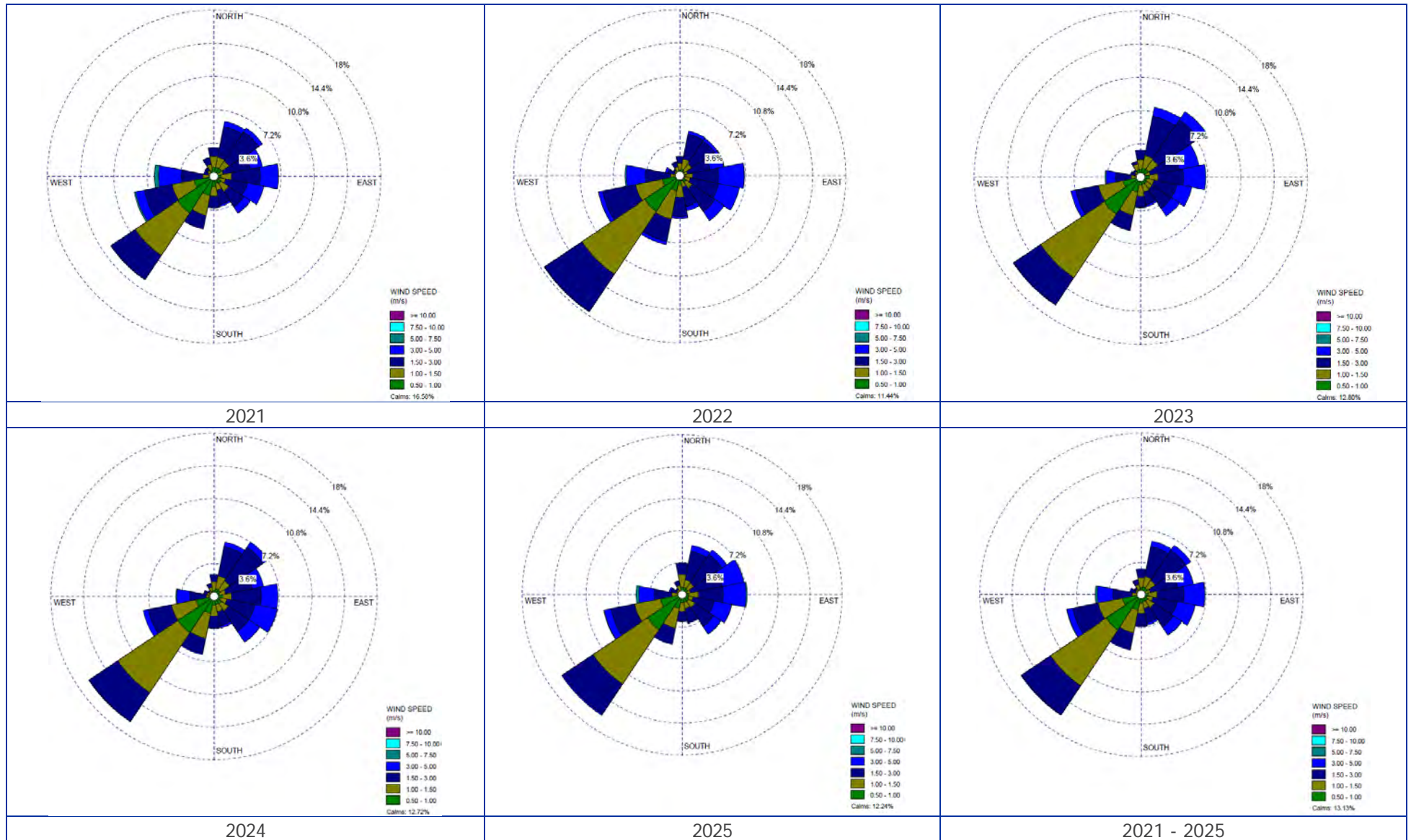
Calm and low wind speed conditions are associated with reduced atmospheric dispersion, allowing pollutants to travel for longer periods with limited dilution, and therefore represent worst-case conditions for assessment of near ground and wake affected sources. The 2023 dataset exhibits a higher-than-average frequency of low wind conditions and lower-than-average frequency of high wind conditions, while remaining broadly representative of the long-term occurrence of calm wind conditions at the site. On this basis, 2023 is considered a representative and appropriate year for dispersion modelling and has therefore been adopted for use in the assessment.

**Table 7.1: BoM Brisbane Station Wind Condition Data Comparison**

Year	AVG WS (m/s)	Calms (%)	0.5 – 1.5 m/s (%)	1.5 – 5.0 m/s (%)	> 5.0 m/s (%)
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
2025	1.6	12.5	39.5	46.8	0.6

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	13.2	40.2	46.0	0.4

Figure 7.1: 2021 – 2025 Annual Wind Roses for the Brisbane BoM Station



## 7.3 GRAMM Setup

### 7.3.1 Overview

GRAMM has been modelled for the year 2023 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 meteorological conditions. GRAMM is run in the first instance to fit the 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. Meteorological data from the nearby Brisbane BoM station has subsequently been incorporated into the GRAMM modelling. Gaps occurring in the Brisbane BoM dataset have been filled using either linear interpolation for 1-hour gaps, or from observational data measured at the South Brisbane DETSI station located approximately 3.2 km south-southeast from the subject site. 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.

When the “all situations” meteorological file wind fields were matched to the observed data from the Brisbane BoM station dataset and at the station location, however, the resulting wind conditions at the site were considered unrealistic. The matched-to-observation wind rose at the site showed unrealistically high wind speeds and wind directions that do not represent the typical wind patterns in the area. Therefore, the Brisbane BoM station observations were matched at the site.

Several weighting 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 0.8 and a direction factor of 1 were considered based on an iterative process to ensure that predicted wind conditions and stability classes were reasonably accurate. In addition to this, the “vectorial” optimisation setting was adopted which results in improved wind speed and direction 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)	501,500 m, 6,959,600 m
GRAMM Domain (NE Corner)	506,400 m, 6,964,500 m
Horizontal grid resolution	100 m
Vertical thickness of first layer	10 m
Number of vertical layers	15
Vertical stretching factor	1.10
Height of top layer	328 m
Max time step	5 s
Modelling time	3600 s
Relaxation velocity	0.10

GRAMM Parameter	Adopted Value
Relaxation scalars	0.10
Match-to-observation factors	Weighting factor = 0.8 Direction factor = 1.0

### 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 national 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 raster 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

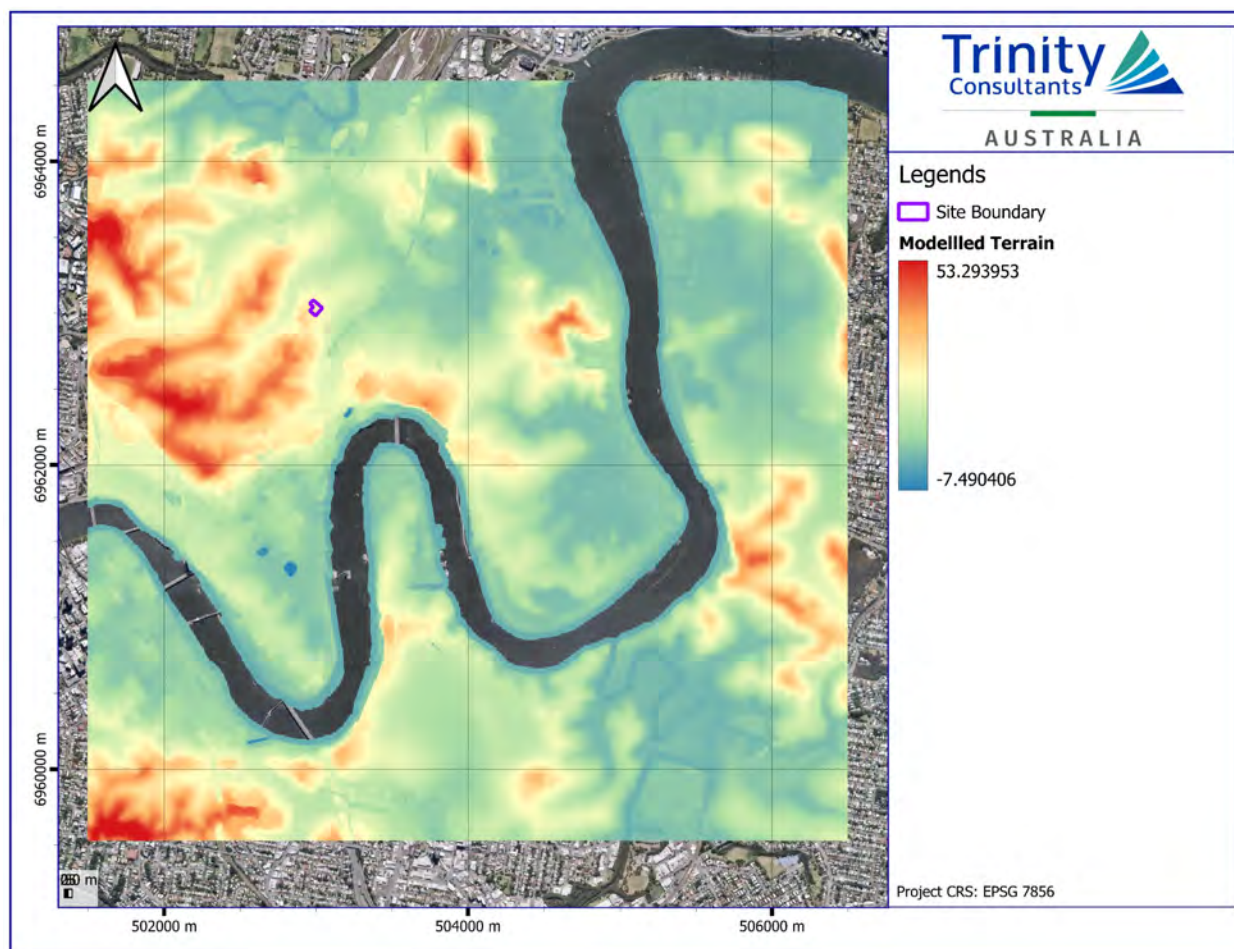
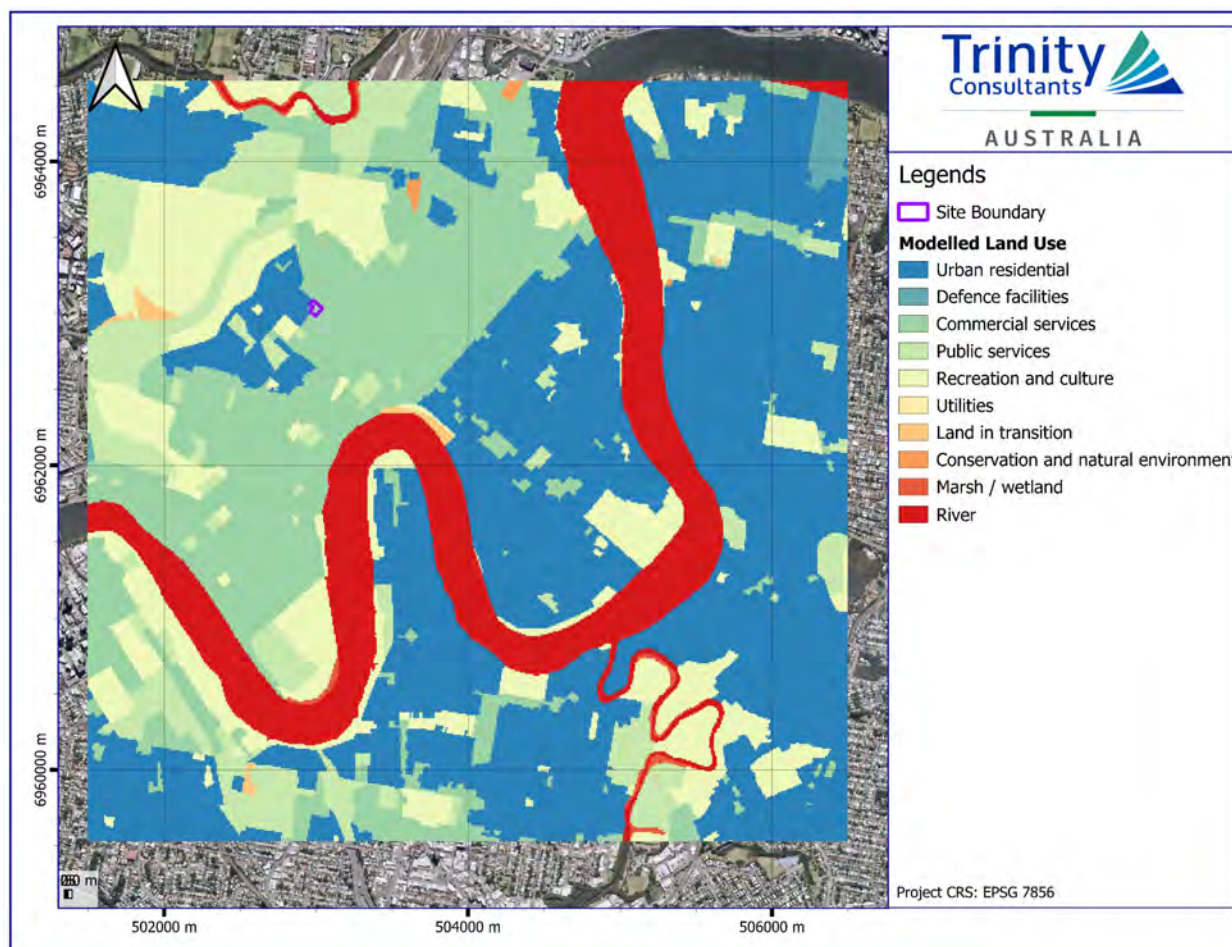


Figure 7.3: Modelled Land Use



## 7.4 GRAMM Results

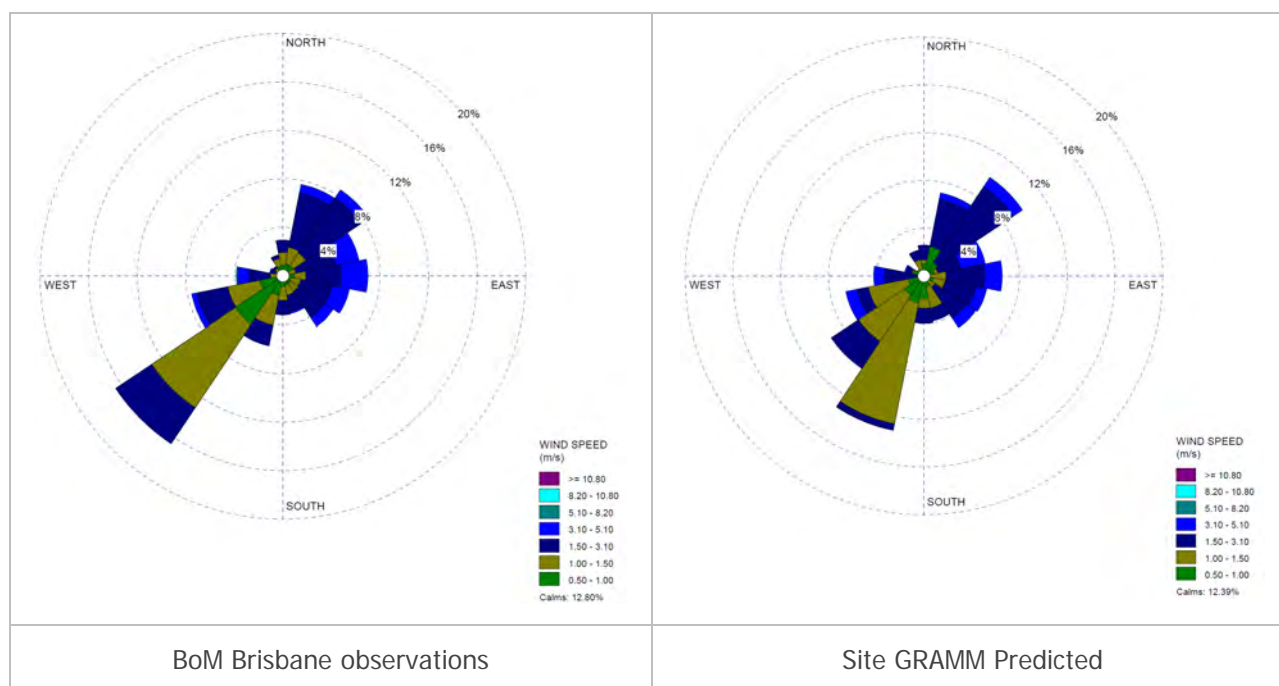
### 7.4.1 Wind Conditions

The observed 2023 Brisbane BoM station and GRAMM-predicted wind conditions at the subject site are presented in **Figure 7.4**. The predicted wind rose shows good agreement with the observational data, with predominant winds from the southwest and comparable calm conditions of 12.8% (measured) and 12.4% (predicted).

A higher occurrence of lower wind speeds is predicted at the study site, with 44.1% of winds below 1.5 m/s compared to 41.7% measured at the BoM site. These lower wind speeds reduce dispersion and lead to higher predicted pollutant concentrations, increasing conservatism. The predicted proportion of high (>3.1 m/s) wind speeds is 0.01%, broadly comparable to the BoM observation, although slightly lower, resulting in a more conservative assessment.

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



## 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 more stable or least turbulent conditions. A 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** and **Figure 7.6** present the calculated and GRAMM-predicted atmospheric stability classes at the subject site. As described in **Section 7.3.1**, the measured data from the South Brisbane DETSI station was forced at the subject site. At the site, 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 for the purpose of the assessment.

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

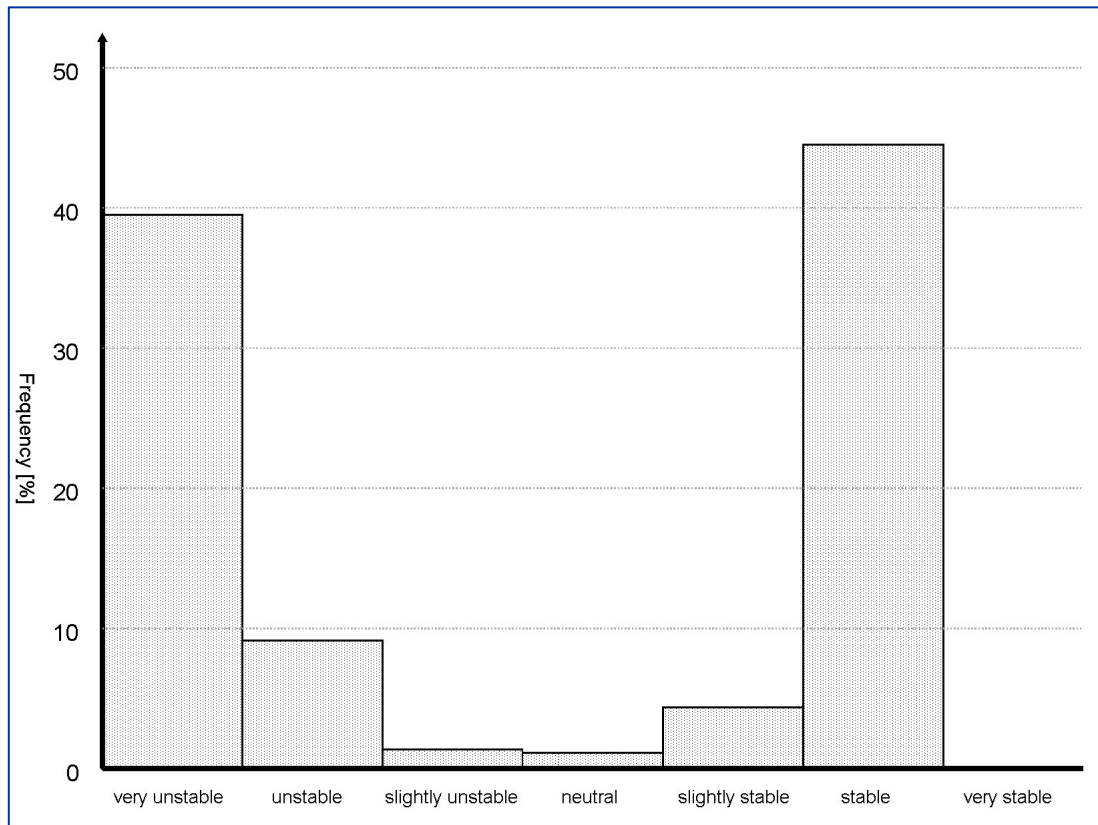
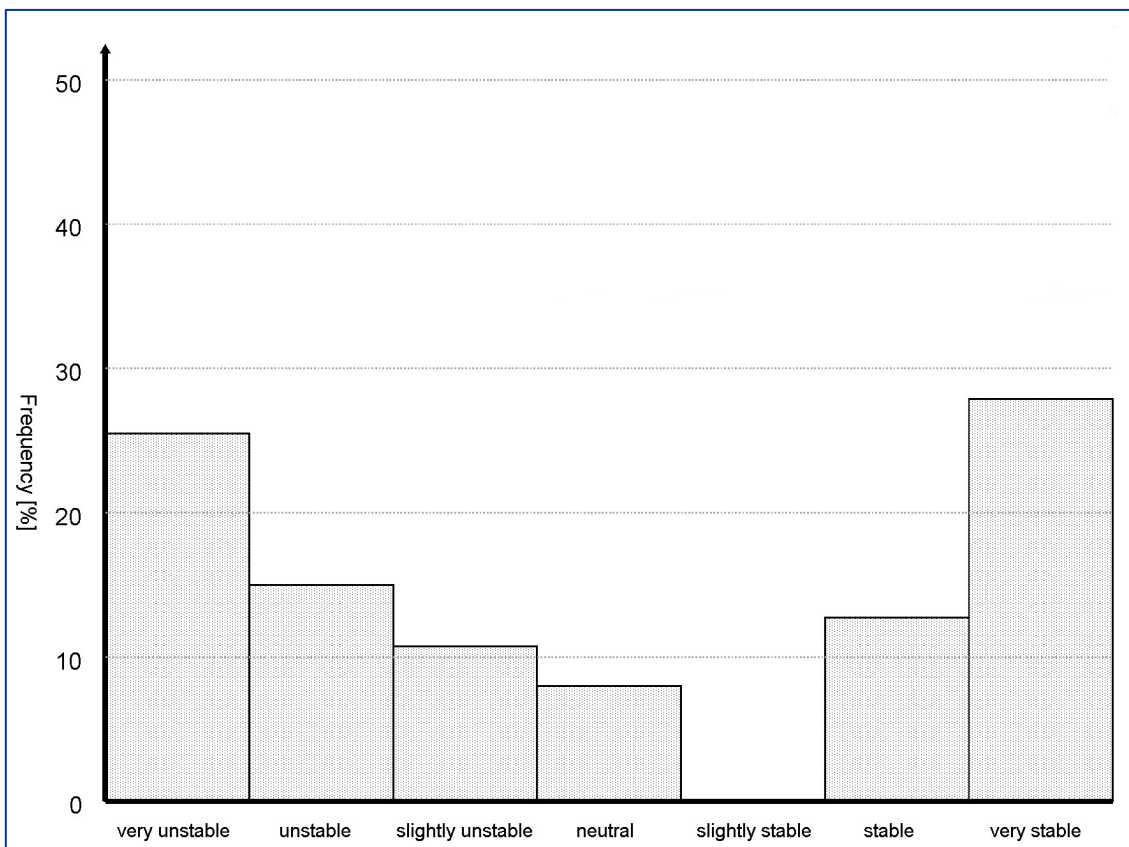


Figure 7.6: Summary of Predicted Stability Classes at Subject Site



## 7.5 GRAL

GRAL was run in transient and prognostic mode to allow for modelling of a full year of meteorology 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 model 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
<b>General</b>	
Dispersion time	3600 seconds
Particles per second	100
Surface roughness	Local land use file included
Latitude	-27.46 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.
<b>Concentration Grid</b>	
Horizontal grid resolution	2.0 metres
Vertical dimension of concentration layers	1.0 metres
Number of horizontal slices	18 divided into 3 model runs (2.0, 4.5, 7.5, 11.0, 14.2, 17.4, 55.8, 59.0, 62.2, 65.7, 67.7, 68.9, 70.9, 72.1, 75.3, 78.5, 81.7 and 82.9 metres above ground)
<b>Internal Flow Field Grid</b>	
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 7.7** presents the modelled building footprints and heights considered in the assessment. Off-site building footprint and heights were estimated using Google Earth. All buildings are represented using relative heights above ground level.

Figure 7.7: Modelled Building Heights (m)



### 7.5.1 Car Park Exhaust Vents Locations and Parameters

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 source parameters for the car park exhaust.

The locations of the modelled sources are presented in Figure 7.8.

Table 7.4: Car Park Exhaust Parameters

Vent	Car Park	Exhaust Location	Absolute Base Height (m)	Dimensions (m)	Horizontal Exit Velocity (m/s)	Exit Temperature (K)
1	Basement 1 – 3	Lower Ground	23.1	3.8 x 1.6	0.4	Ambient
2	Lower Ground	Rooftop	93.6	0.7 x 0.7	1.6	Ambient

Figure 7.8: Modelled Sources



## 7.5.2 Discrete Receptors

Receptors have been selected to represent worst-case sensitive use locations nearest to the car park exhausts. A total of 45 receptors were considered in the modelling and selected from Level 01, Level 02, Levels 14 to 17, the rooftop and along the site's eastern boundary.

Receptors have been modelled at the finished floor levels for Levels 1 and 2. This approach is conservative, as it assumes that air-conditioning intakes are located closest to the car park exhaust vent at ground level. **Figure 7.9** illustrates the locations of modelled on- and off-site discrete receptors for Levels 1 and 2 and **Figure 7.10** illustrates the locations of Level 14 to 17 on- and off-site discrete receptors. Intermediate levels are more than 15 metres away and comply with the minimum separation distance from the vent as specified in the BCC City Plan 2014. **Figure 7.11** shows the modelled receptors at the rooftop.

Figure 7.9: Modelled Receptors (Level 1 - 2)

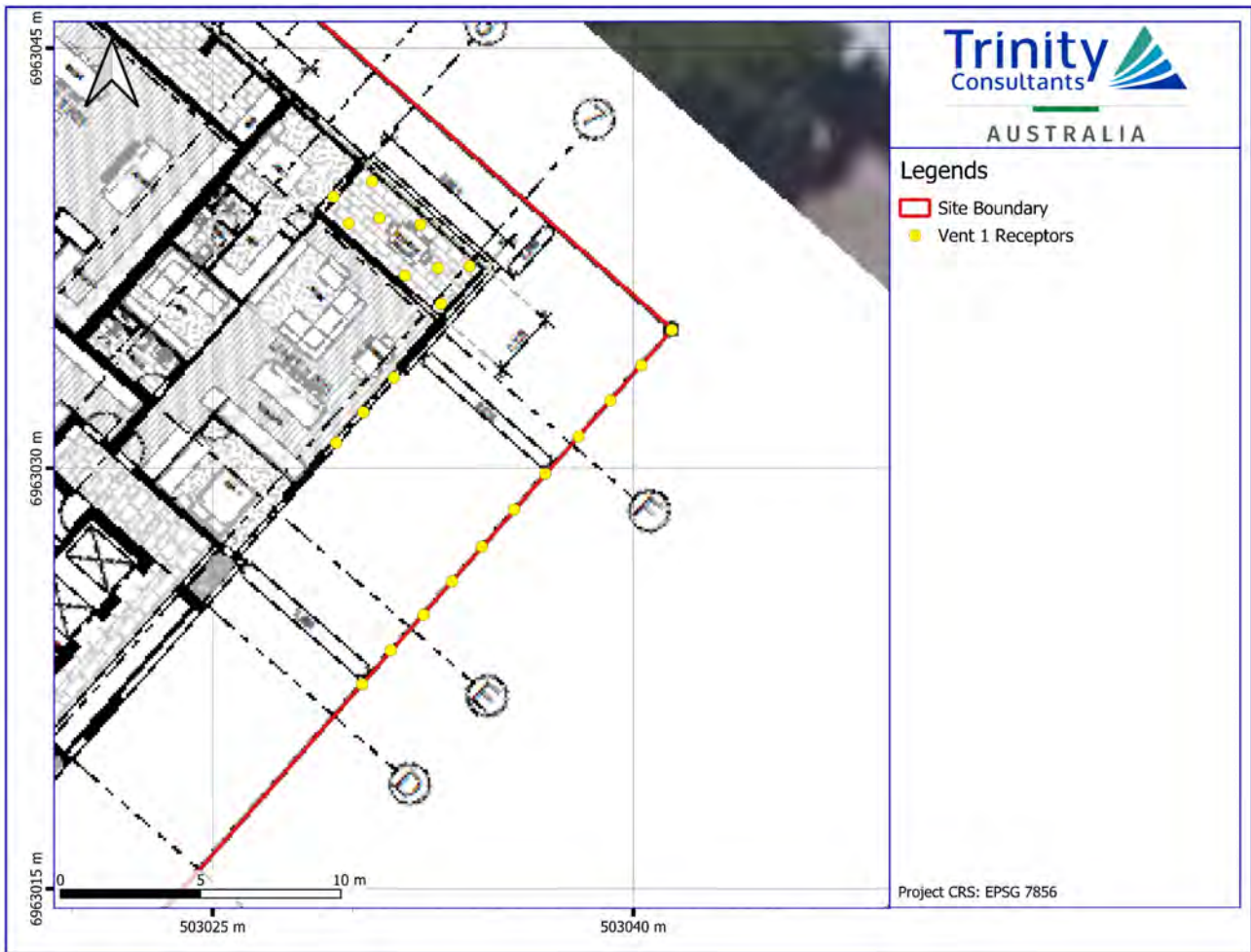


Figure 7.10: Modelled Receptors (Level 14 to 17)

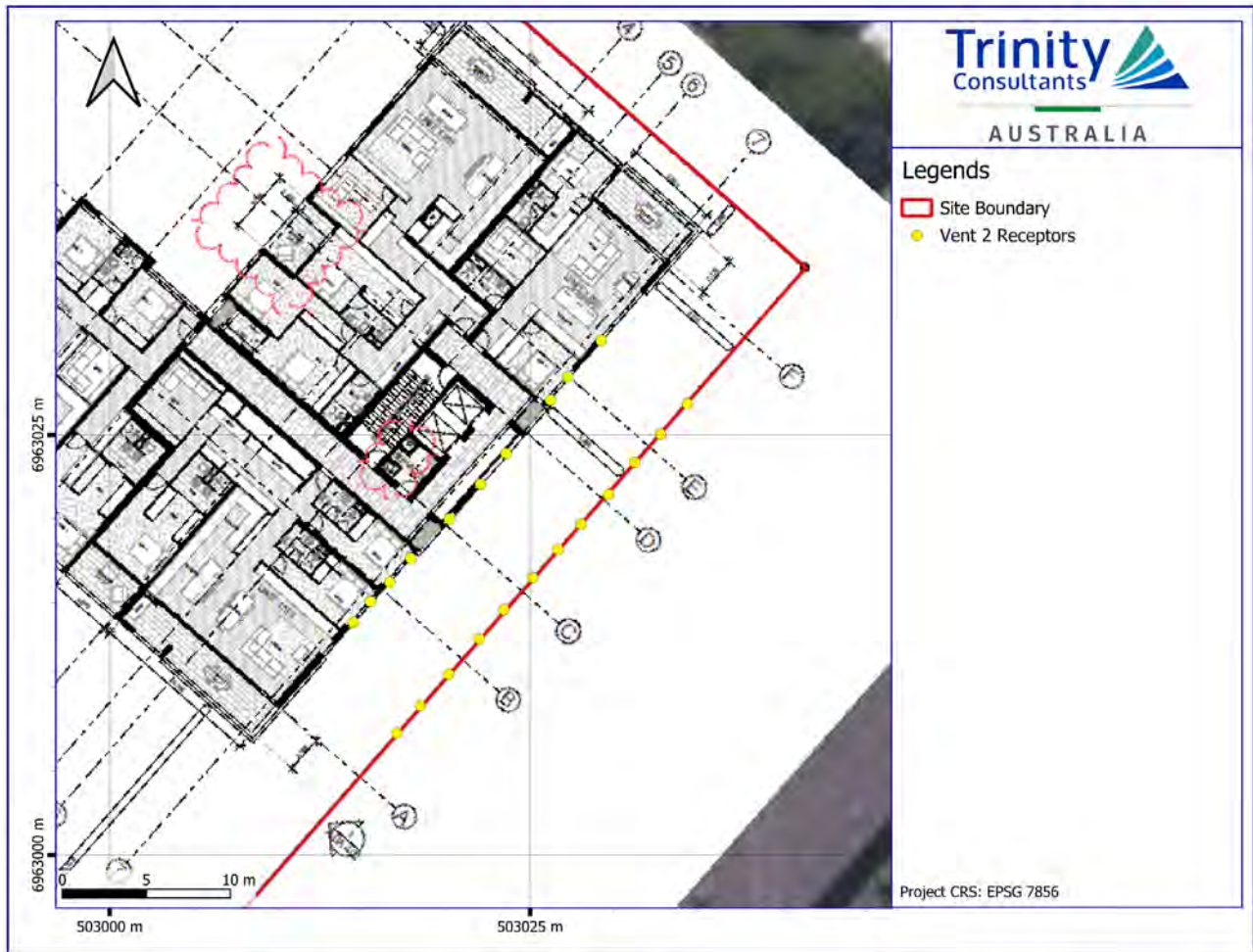
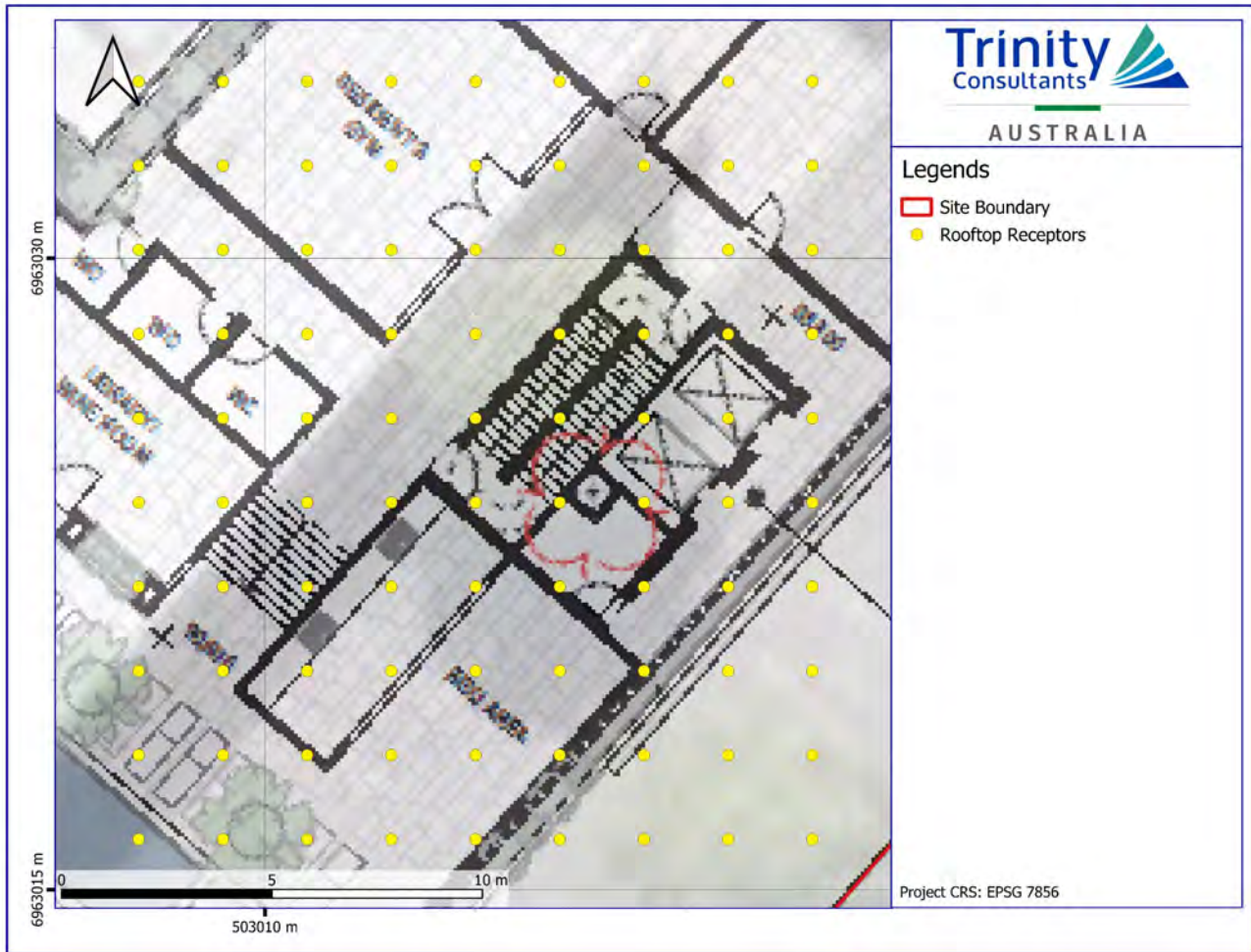


Figure 7.11: Modelled Receptors (Rooftop)



## 7.6 NO<sub>x</sub> Conversion to NO<sub>2</sub>

For conversion of NO<sub>x</sub> to NO<sub>2</sub> the US EPA Ozone Limiting Method (OLM) has been adopted. This method assumes all ozone in the atmosphere reacts with NO<sub>x</sub> to form NO<sub>2</sub> (regardless of distance and atmospheric conditions).

The NO<sub>2</sub> predictions for each hour have been converted to NO<sub>2</sub> using the OLM method, based on the hourly ambient ozone concentrations at the Cannon Hill station for the year 2023. A 0.27 initial NO<sub>2</sub>/NO<sub>x</sub> ratio was assumed for the calculations based on the COPERT Australia vehicle emission model.

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## 8. MODELLING RESULTS

The results for 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 across 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 worst-case receptor is located at the site's eastern boundary with the neighbouring sensitive use. Concentration plots for cumulative 24-hour PM<sub>10</sub> and annual PM<sub>2.5</sub> concentrations are presented for the most affected off-site receptor heights in the following figures:

- **Figure 8.1:** Predicted Cumulative PM<sub>10</sub> 24-hour Concentrations at 2 metres
- **Figure 8.2:** Predicted Cumulative PM<sub>2.5</sub> Annual Concentrations at 2 metres

PO3(a) of the Centre or Mixed Use Code requires that development avoids or minimises air emissions. The proposed vent locations have been selected to maximise separation distances to sensitive receptors, having regard to practical design constraints. On this basis, the development is considered to comply with PO3(a).

**Table 8.1: Predicted Results – Source Only**

Receptor ID	CO			NO <sub>2</sub>			PM <sub>10</sub>		PM <sub>2.5</sub>	
	Averaging Time	8-hr	1-hr, 99 <sup>th</sup> Perc.	Annual	24-hr	Annual	24-hr	Annual		
Maximum	60.8	15.2	2.2	0.6	0.2	0.5	0.2			
Criteria	11,000	250	62	50	25	25	8			
L1	14.5	3.8	0.7	0.1	0.1	0.1	0.1			
L2	9.0	2.7	0.4	0.1	<0.1	0.1	<0.1			
L14	0.7	0.2	<0.1	<0.1	<0.1	<0.1	<0.1			
L15	0.9	0.2	<0.1	<0.1	<0.1	<0.1	<0.1			
L16	1.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1			
L17	2.6	0.8	0.1	<0.1	<0.1	<0.1	<0.1			
Rooftop	7.2	1.5	0.2	<0.1	<0.1	<0.1	<0.1			
Off-site	60.8	15.2	2.2	0.6	0.2	0.5	0.2			

**Table 8.2: Predicted Results – Source Plus Background**

Receptor ID	CO			NO <sub>2</sub>			PM <sub>10</sub>		PM <sub>2.5</sub>	
	Averaging Time	8-hr	1-hr, 99 <sup>th</sup> Perc.	Annual	24-hr	Annual	24-hr	Annual		
Maximum	346.3	52.1	31.5	23.5	21.0	7.8	7.1			
Background	285.5	36.9	29.4	22.9	20.7	7.3	6.9			
Criteria	11,000	250	62	50	25	25	8			
L1	300.0	40.7	30.1	23.0	20.8	7.4	7.0			
L2	294.5	39.6	29.8	22.9	20.8	7.4	6.9			
L14	286.2	37.1	29.4	22.9	20.7	7.3	6.9			
L15	286.4	37.1	29.4	22.9	20.7	7.3	6.9			
L16	286.7	37.2	29.4	22.9	20.7	7.3	6.9			
L17	288.1	37.7	29.4	22.9	20.7	7.3	6.9			
Rooftop	292.7	38.4	29.6	22.9	20.7	7.3	6.9			

Receptor ID	CO	NO <sub>2</sub>		PM <sub>10</sub>		PM <sub>2.5</sub>	
Off-site	346.3	52.1	31.5	23.5	21.0	7.8	7.1

**Table 8.3: Predicted VOCs Results – Source Only**

Receptor ID	1,3 - Butadiene	Benzene		Benzo(a)pyrene	Formaldehyde		Toluene		Xylenes		
Averaging Time	Annual	1-hr, 99.9 <sup>th</sup> Perc.	Annual	Annual	1-hr, 99.9 <sup>th</sup> Perc.	24-hr	1-hr, 99.9 <sup>th</sup> Perc.	24-hr	Annual	24-hr	Annual
Maximum	2.9E-02	1.2	0.2	2.4E-05	0.3	<0.1	3.1	1.5	0.6	0.8	0.3
Criteria	2.4	29	10	3.0E-04	96	54	958	4,100	410	1,200	950
L1	9.7E-03	0.3	<0.1	7.4E-06	<0.1	<0.1	0.8	0.3	0.2	0.1	0.1
L2	5.5E-03	0.2	<0.1	4.5E-06	<0.1	<0.1	0.5	0.2	0.1	0.1	0.1
L14	1.8E-04	<0.1	<0.1	1.5E-07	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
L15	2.1E-04	<0.1	<0.1	1.7E-07	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
L16	2.8E-04	<0.1	<0.1	2.2E-07	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
L17	7.1E-04	<0.1	<0.1	5.8E-07	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Rooftop	1.8E-03	0.1	<0.1	1.5E-06	<0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1
Off-site	2.9E-02	1.2	0.2	2.4E-05	0.3	<0.1	3.1	1.5	0.6	0.8	0.3

**Table 8.4: Predicted VOCs Results – Source Plus Background**

Receptor ID	1,3 - Butadiene	Benzene		Benzo(a)pyrene	Formaldehyde		Toluene		Xylenes		
	Annual	1-hr, 99.9 <sup>th</sup> Perc.	Annual	Annual	1-hr, 99.9 <sup>th</sup> Perc.	24-hr	1-hr, 99.9 <sup>th</sup> Perc.	24-hr	Annual	24-hr	Annual
Maximum	2.9E-02	7.8	5.7	2.4E-05	11.2	11.3	26.1	23.9	18.4	42.5	41.7
Background	-	6.6	5.5	-	10.9	11.2	23	22.4	17.8	41.7	41.1
Criteria	2.4	29	10	3.0E-04	96	54	958	4,100	410	1,200	950
L1	9.1E-03	6.9	5.5	7.4E-06	11.0	11.2	23.8	22.7	18.0	41.8	41.5
L2	5.5E-03	6.8	5.5	4.5E-06	11.0	11.2	23.5	22.6	17.9	41.8	41.5
L14	1.8E-04	6.6	5.5	1.5E-07	10.9	11.2	23.0	22.4	17.8	41.7	41.4
L15	2.1E-04	6.6	5.5	1.7E-07	10.9	11.2	23.0	22.4	17.8	41.7	41.4
L16	2.8E-04	6.6	5.5	2.2E-07	10.9	11.2	23.0	22.4	17.8	41.7	41.4
L17	7.1E-04	6.6	5.5	5.8E-07	10.9	11.2	23.1	22.4	17.8	41.7	41.4
Rooftop	1.8E-03	6.7	5.5	1.5E-06	10.9	11.2	23.2	22.5	17.8	41.7	41.4
Off-site	2.9E-02	7.8	5.7	2.4E-05	11.2	11.3	26.1	23.9	18.4	42.5	41.7

Figure 8.1: Predicted Off-Site Cumulative PM<sub>10</sub> 24-hour Concentrations (2m Above Ground)

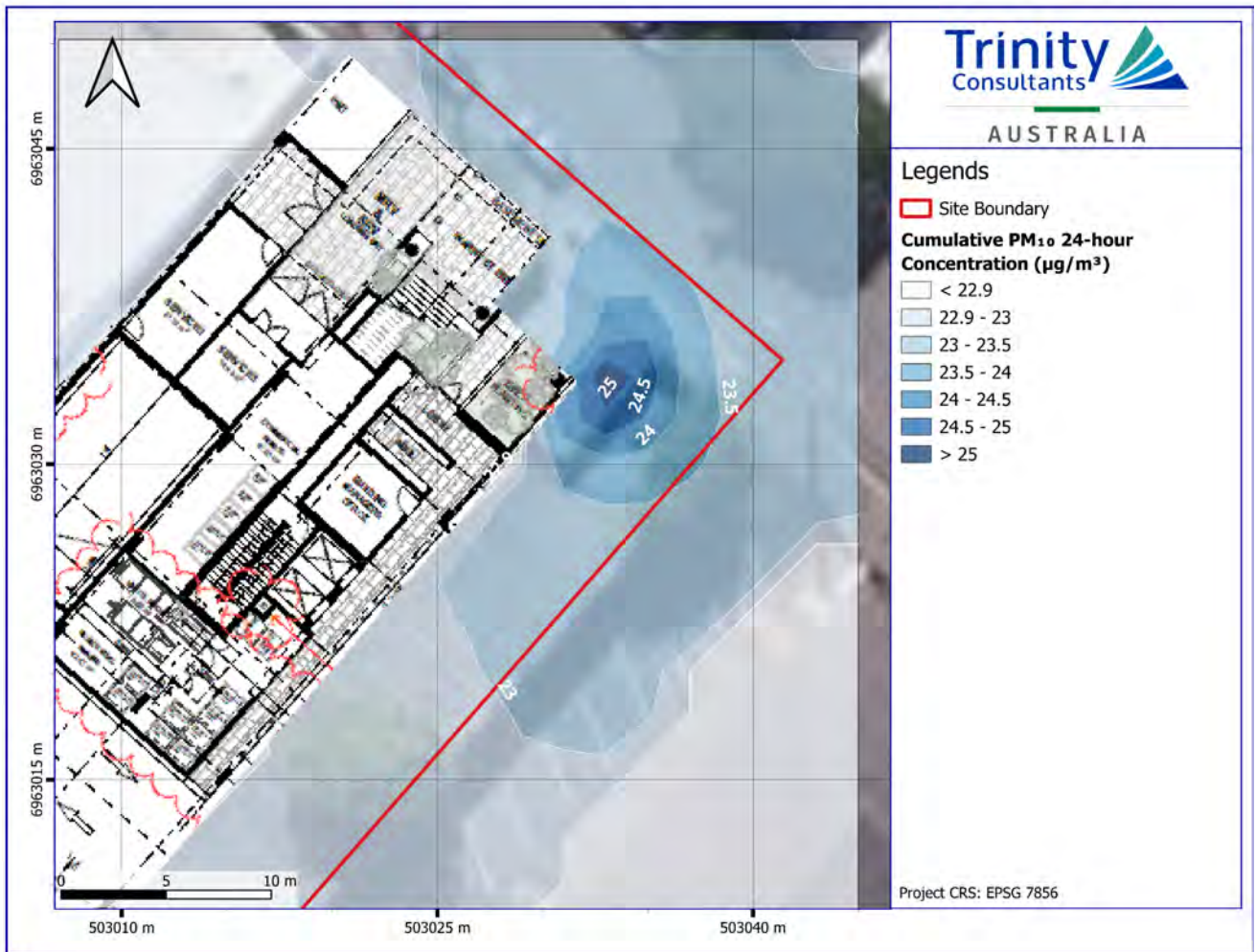
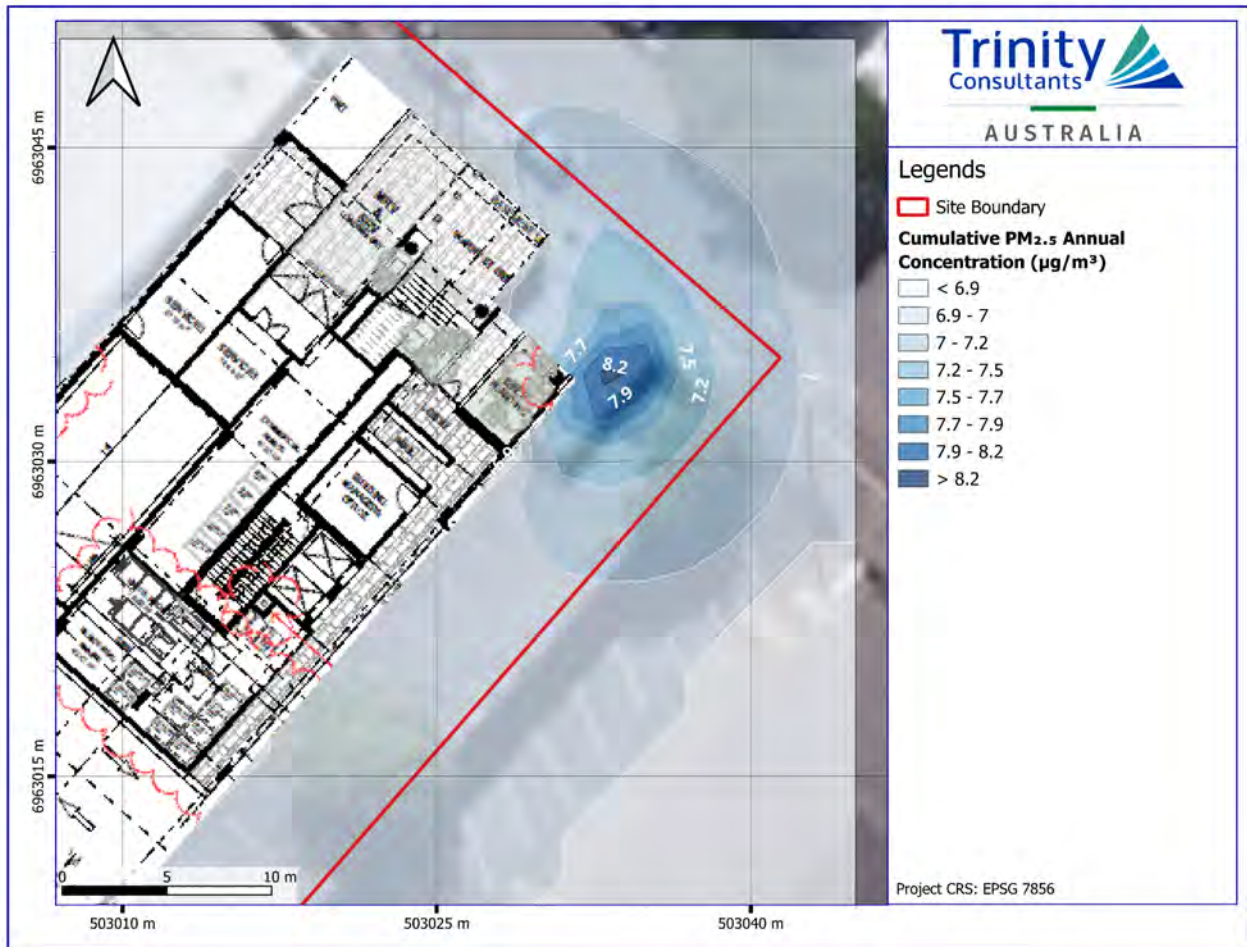


Figure 8.2: Predicted Off-Site Cumulative PM<sub>2.5</sub> Annual Concentrations (2m Above Ground)



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## 9. CONCLUSION

An air quality assessment for the proposed residential development at 36 Warry Street, Fortitude Valley 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 lower ground floor on the northeastern side of the building, facing east, within 15 metres from the nearest on-site sensitive receptor and off-site sensitive zone,
  - One car park exhaust servicing the lower ground level located on the eastern side of the rooftop facing east, within 15 meters from the nearest on-site sensitive receptor and off-site sensitive zone, and;
  - Two kitchen exhausts, servicing Tenancy 4 and 5, located underneath the Podium Level 1 slab, greater than 6 metres from the nearest sensitive receptor.
- Air dispersion modelling has been undertaken for the car park exhaust emissions to assess potential air quality impacts on proposed on-site sensitive uses and off-site sensitive zones, 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- and off-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 vent locations maximise separation distance from air intakes when considering the design constraints.

Based on the assessment undertaken, the proposed car park exhaust vents and kitchen exhaust 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 <sup>3</sup>	<p>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:</p> $\text{mg/m}^{-3} = (P/RT) \times \text{Molecular weight} \times (\text{concentration in ppm})$ $= \frac{P \times \text{Molecular weight} \times (\text{concentration in ppm})}{62.4 \times (273.2 + T^{\circ}\text{C})}$
g/s	Grams per second
mg/m <sup>3</sup>	Milligrams per cubic metre
µg/m <sup>3</sup>	Micrograms per cubic metre
ppb	Parts per billion
ppm	Parts per million
PM <sub>10</sub> , PM <sub>2.5</sub> , PM <sub>1</sub>	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 <sup>th</sup> Percentile	The value exceeded 99.5% of the time
CO	Carbon monoxide.
NO <sub>x</sub>	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 <sub>2</sub> ).
NO <sub>2</sub>	Nitrogen dioxide.
VOC	Volatile Organic Compound/s. These compounds can be both toxic and odorous.



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