Aspect Industrial Estate, Kemps Creek Warehouse 4

Air Quality Impact Assessment

Mirvac Projects Pty Ltd

Level 28, 200 George Street
Sydney NSW 2000

Prepared by:

SLR Consulting Australia

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Revision Record

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V1.0	11 December 2025	F Jafarigol	M Pickett	M Pickett
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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Mirvac Projects Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) was engaged by Mirvac Projects Pty Ltd to prepare an Air Quality Impact Assessment (AQIA) for the proposed construction and operation of Warehouse 4 (WH4), at Mirvac's Aspect Industrial Estate (AIE) (the Project).

This AQIA report is prepared in accordance with the NSW Government Planning Secretary's Environmental Assessment Requirements (SEARs). The SEARs for the proposal outline key issues to be addressed as part of the EIS and include emissions to air associated with construction and operation (SSD-98407710 2025).

Table 1 lists the SEARS requirements and the sections where they are addressed within this report.

Table 1 SEARS Requirements (SSD-98407710)

Item	Requirements	Where Addressed
SEARs key issues– Air Quality	• An assessment of the potential air quality, dust and odour impacts of the development (construction and operation) on surrounding landowners, businesses and sensitive receptors, and details of proposed mitigation measures, in accordance with relevant Environment Protection Authority guidelines.	This report is a quantitative assessment of potential air quality impacts. Modelling of construction impacts – **Section 5.0**. Modelling of operation impacts - **Section 6.0**. Construction mitigation measures **Section 5.4**.

1.1 Approach to Assessment

This assessment has been prepared with consideration of the following policies and guidelines:

- "*Protection of the Environment Operations (Clean Air) Regulation 2022"* (NSW Parliament 2022)
- "*Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*" (NSW EPA 2022b)
- "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (NSW EPA 2022)(the Approved Methods)

1.1.1 Construction Impact Assessment Methodology

The key potential air quality issue identified for the construction phase of the Site is particulate matter (dust) emissions associated with bulk earthworks.

To assess potential peak impacts associated with construction stage emissions from the Site, a quantitative assessment in general accordance with the NSW EPA's *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* publication (NSW EPA 2022), (hereafter referred to as the Approved Methods), has been prepared.

Section 2.1 of the Approved Methods outlines a two-tiered approach to Air Quality Impact Assessments (AQIA):

- Level 1, which is a basic screening using worst-case assumptions, and
- Level 2, a more detailed assessment with refined techniques and site-specific data.

If a Level 1 assessment shows that adverse impacts are unlikely, there is no need to proceed to Level 2. For this assessment, considering the type of emissions associated with bulk earth works, a Level 2 assessment using the TAPM/CALMET/CALPUFF modelling systems has been completed.

1.1.2 Operational Impact Assessment Methodology

The key potential air quality issue identified for the operational phase of the Site is emissions of combustion products associated with vehicle movements generated by the Site.

To estimate potential peak impacts associated with operational stage emissions from the Site, a quantitative assessment in general accordance with the Approved Methods, has been prepared.

For this assessment, the Roadside Air Quality Screening Tool (RAQST) is employed. RAQST, developed by Transport for NSW (TfNSW), is a simplified version of a road vehicle emission model used for initial air quality impact screening. It employs worst-case scenarios to determine if a detailed Level 2 assessment is necessary, providing conservative predictions of incremental impacts. TfNSW recommends its use as a Level 1 equivalent for near-field ground-level pollutant concentration prediction from traffic.

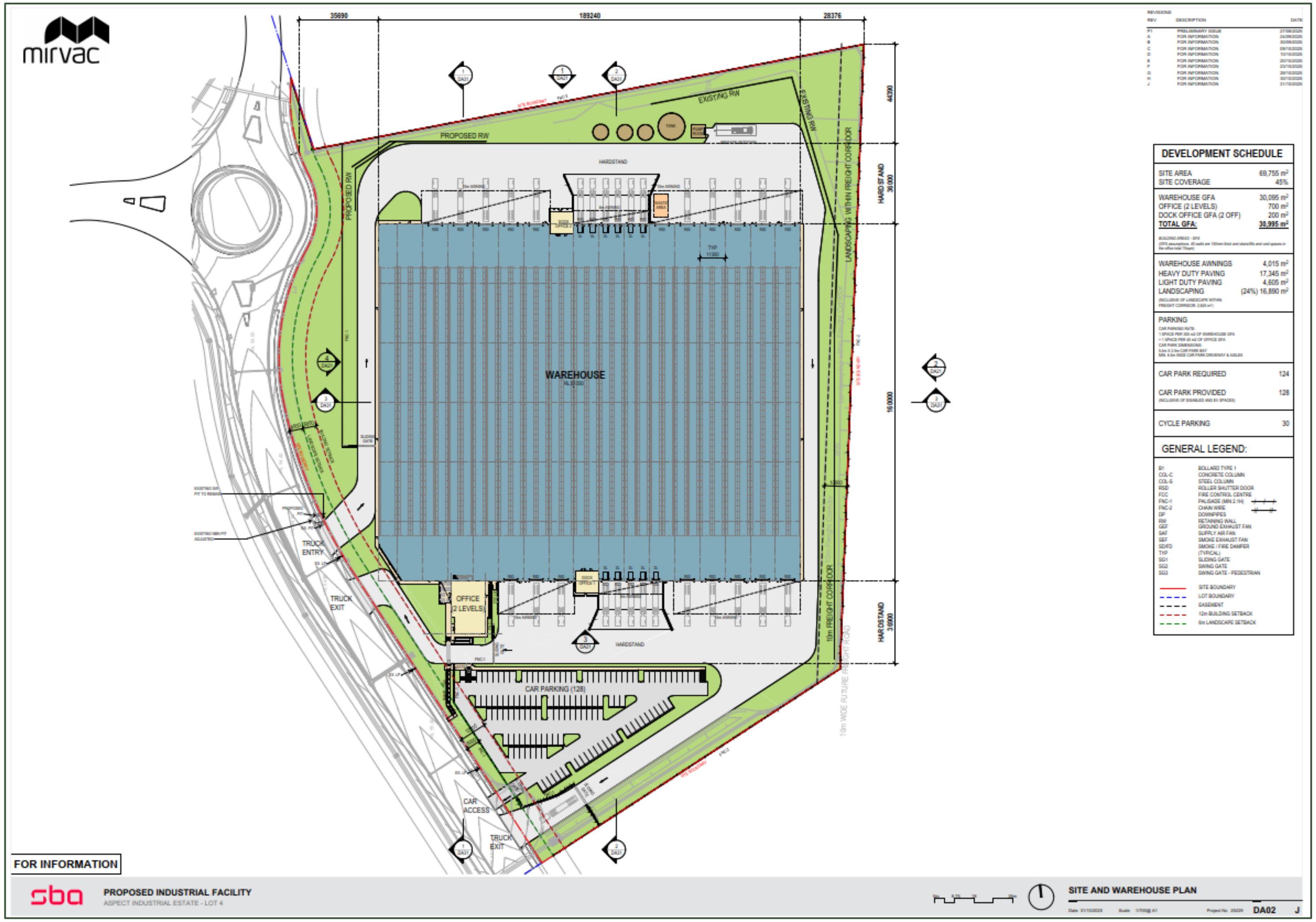
2.0 Project Overview

2.1 Site Location

The Site is located at Mamre Road, Kemps Creek (Lot 4,5). The location of Warehouse 4 (WH4) at Mirvac's Aspect Industrial Estate (AIE), 'the Site', is shown in **Figure 1**, and the layout is shown in **Figure 2**.

Figure 1 Site Location

Figure 2 Site Layout



2.2 Proposed Development

A change to the warehouse footprint and on-lot configuration of Lot 4 and Lot 5 will be sought under SSD-10448 MOD 12 intended to be lodged concurrently with the Warehouse 4 SSDA. The modification will seek to consolidate the warehouse built form from two buildings, as currently approved, into a single building identified as Warehouse 4.

This modification will also seek to amend the alignment of the Automated Guided Vehicle network at the eastern boundary of Lots 4 & 5 to be consistent with the approved AGV alignment within the GPT approvals to the north and Barings approvals to the South

Warehouse 4 on AIE Lot 4 will comprise one warehouse building. It is proposed to be used for warehouse and distribution premises 24 hours a day, 7 days a week. The proposed development will comprise (see **Figure 2**):

- Construction and fitout of a warehouse building, comprising 30,095 m^2 of Gross Floor Area (GFA)
- Ancillary two level office space, comprising 700 m^2 of GFA
- Ancillary dock office space, comprising 200 m^2 of GFA
- Hardstand comprising of 21,950 m^2
- Landscaped Area of 16,890 m^2, comprising 24% of site area
- Car parking area, including 128 spaces on the southern side of the proposed warehouse.

The construction phase of the Site includes site preparatory works, including bulk earthworks to create flat development platforms for the proposed buildings, topsoiling, grassing, and site stabilisation works.

An indicative plan of how material would be moved around the Site for the bulk earthworks required is presented in **Figure 3**, and summarised in **Table 2**.

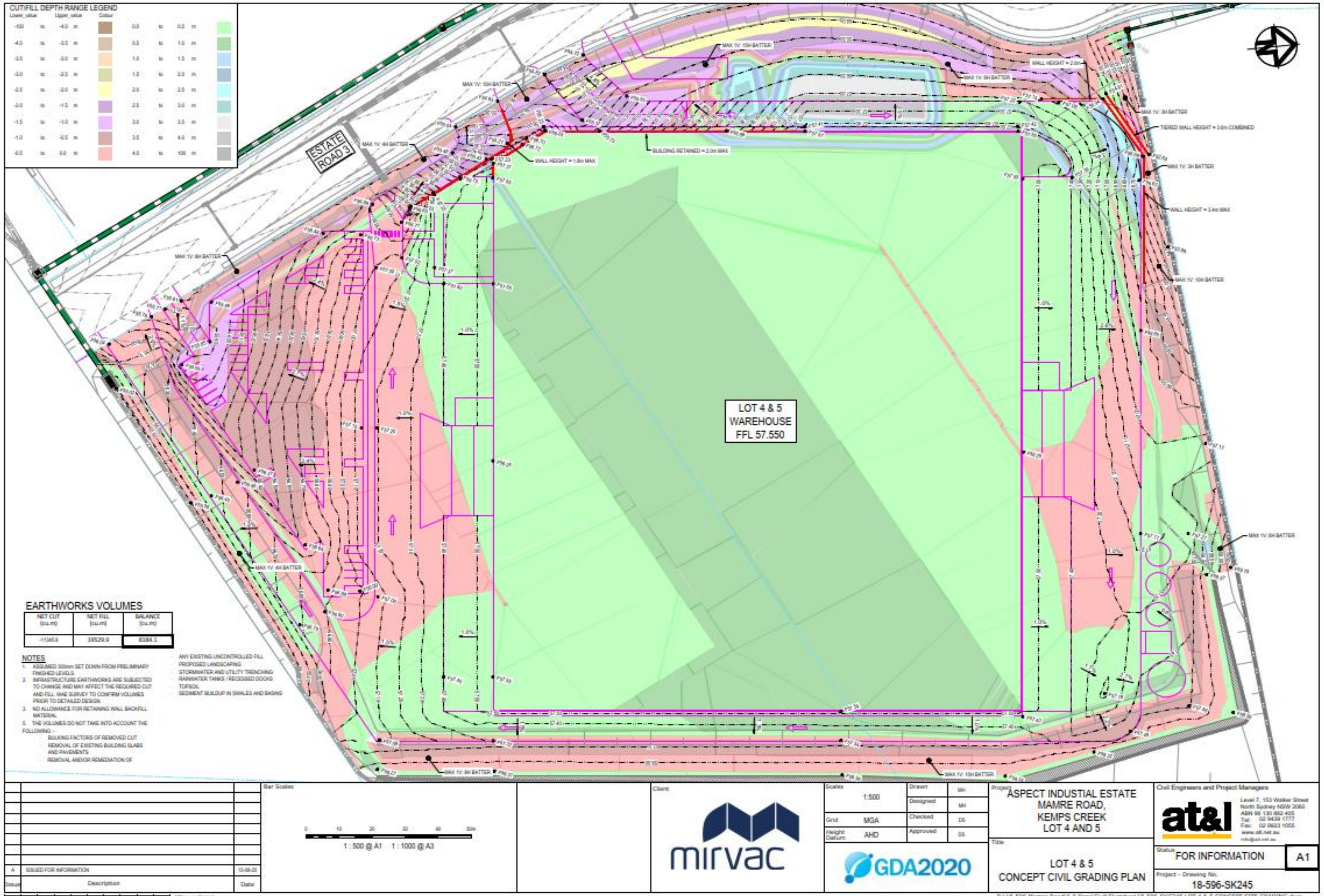
Table 2 Earthworks Volume

Net Cut (cu.m)	Net Fill (cu.m)	Balance (cu.m)
11,345.8	19,529.9	8,184.1

2.2.1 Traffic data

Traffic data provided by the client suggests that the operation of WH4 is expected to generate up to 200 vehicles per day, consisting of 140 light vehicles and 60 heavy vehicles. This corresponds to approximately 400 vehicle movements per day: inbound and outbound combined. Of these, around 45 vehicle movements are anticipated during the AM peak hour (35 light and 10 heavy vehicles), and 35 vehicle movements during the PM peak hour (30 light and 5 heavy vehicles).

Figure 3 Indicative Material Movements During the Site Bulk Earthworks



2.3 Potential Sources of Emissions to Air

2.3.1 Construction Phase

The main air quality issues associated with construction works relate to emissions of fugitive dust. Generally, the activities that are most likely to lead to dust emissions include:

- Loading and unloading of materials;
- Crushing of materials;
- Wheel-generated dust from construction equipment, e.g. haul trucks;
- Wind erosion of exposed surfaces;
- Combustion emissions from construction equipment.

Temporary elevations in local dust levels are most likely to occur when construction activities are undertaken during periods of low rainfall and/or windy conditions. The impact of elevated dust emissions is dependent upon the potential for particulates to become and remain airborne before being deposited as dust or experienced as an ambient particulate concentration.

A number of environmental factors may affect the generation and dispersion of dust emissions, including:

- Wind direction - determines whether dust and suspended particles are transported in the direction of the sensitive receptors;
- Wind speed - determines the potential suspension and drift resistance of particles;
- Surface type - more erodible surface material types have an increased soil or dust erosion potential;
- Surface material moisture - increased surface material moisture reduces soil or dust erosion potential;
- Rainfall or dew - rainfall or heavy dew that wets the surface of the soil reduces the risk of dust generation.

Where diesel-powered mobile machinery and vehicles are used, localised increases in ambient concentrations of combustion-related pollutants will occur. However, there is a low risk of these relatively small emissions causing exceedances of air quality impact assessment criteria.

2.3.2 Operational Phase

During the operational phase, the main source of air emissions are emissions of products of fuel combustion, particulate emissions from brake and tyre wear, and the re-entrainment of road dust associated with trucks and other vehicles entering and leaving or idling at the Site during loading/unloading operations.

It is assumed that no refuelling or power generation will occur on site.

Emissions associated with the combustion of diesel and petrol etc. in road vehicles include the air pollutants: carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (measured as PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and volatile organic compounds (VOCs). The rate and composition of air pollutant emissions from road vehicles is a function of several factors, including the type, size and age of the vehicles, the type of fuel combusted, the number and speed of vehicles and the road gradient.

2.4 Pollutants of Interest

From a review of the air emissions expected from the Project, the key air pollutants of interest are: particulate matter from construction works, and wheel-generated dust and products of fuel combustion from operations.

The following sections outline the potential health and amenity issues associated with particulate matter and products of fuel combustion, while **Section 3.4** identifies the relevant air quality assessment criteria.

2.4.1 Particulate Matter

Airborne contaminants that can be inhaled directly into the lungs can be classified based on their physical properties as gases, vapours or particulate matter. In common usage, the terms "dust" and "particulates" are often used interchangeably. The health effects of particulate matter are strongly influenced by the size of the airborne particles. Smaller particles can penetrate further into the respiratory tract, with the smallest particles having a greater impact on human health as they penetrate the gas exchange areas of the lungs. Larger particles primarily cause nuisance associated with coarse particles settling on surfaces.

The term "particulate matter" refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm and is called total suspended particulate (TSP). Particulate matter with an aerodynamic diameter of 10 microns or less is referred to as PM_{10}. The PM_{10} size fraction is sufficiently small to penetrate the large airways of the lungs, while $PM_{2.5}$ (2.5 microns or less) particulates are generally small enough to be drawn in and deposited into the deepest portions of the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children.

2.4.2 Nuisance Dust

In addition, nuisance impacts need also to be considered, mainly in relation to deposited dust. Dust can cause nuisance by settling on surfaces and possessions, affecting visibility and contaminating tank water supplies. High rates of dust deposition can also adversely affect vegetation by blanketing leaf surfaces.

2.4.3 Products of Combustion

The air pollutant emissions important for assessment, associated with road traffic and the combustion of diesel and petrol etc., are CO, NO_x, PM_{10}, $PM_{2.5}$, SO_2 and VOCs.

CO is an odourless, colourless gas formed from the incomplete burning of fuels in motor vehicles. It can be a common pollutant at the roadside and the highest concentrations are found at the kerbside with concentrations decreasing rapidly with increasing distance from the road. CO in urban areas results almost entirely from vehicle emissions and its spatial distribution follows that of traffic flow. The incomplete combustion of fuel in diesel powered vehicles can generate particulate in the form of black soot.

NO_x is a general term used to describe any mixture of nitrogen oxides formed during combustion. For air quality assessments, in general NO_x refers to the total concentration of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a colourless and odourless gas that does not significantly affect human health. However, in the presence of ozone, NO can be oxidised to NO_2, which can have significant health effects, including damage to the respiratory tract and increased susceptibility to respiratory infections and asthma. NO will be converted to NO_2 soon after leaving the engine exhaust, assuming typical background ozone levels.

Engine exhausts can contain emissions of SO_2 due to impurities in the fuel. The sulfur content in diesel fuel has significantly reduced over the years ambient SO_2 concentrations in Australian cities are typically well below regulatory criteria.

Volatile organic compounds (VOCs) may be emitted as a result of the incomplete combustion of fuel. VOCs emissions are reducing significantly due to the improved combustion processes of modern engine technology.

3.0 Relevant Legislation, Policy and Guidance

The following Air Quality Policy and Guidance documents have been referenced within this assessment and have been used to identify the relevant air quality criteria.

3.1 Protection of the Environment Operations (POEO) Act 1997 & Amendment Act 2011

The POEO Act (and Amendment Act 2011) is a key piece of environment protection legislation administered by the EPA group which enables and establishes instruments for setting environmental standards, goals, protocols and guidelines.

The following sections of the POEO Act are of general relevance to the Site:

- Section 126 of the POEO Act requires that materials (e.g. raw ingredients and waste storage/disposal at the Site) are managed in a proper and efficient manner to prevent air pollution (e.g. odour).
- Section 128 of the POEO Act states:

1 The occupier of premises must not carry out any activity or operate any plant in or on the premises in such a manner to cause or permit the emission at any point specified in or determined in accordance with the regulation of air impurities in excess of [the standard of concentration and/or the rate] prescribed by the regulations in respect of any such activity or any such plant.

2 Where neither such a standard nor rate has been so prescribed, the occupier of any premises must carry on activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution.

3.2 Protection of the Environment Operations (Clean Air) Regulation 2022

The POEO (Clean Air) Regulation 2022 (the Regulation) is the core regulatory instrument for air quality issues in NSW. In relation to industry, the Regulation:

- sets maximum limits on emissions from activities and plants for a number of substances; and
- restricts the use of high sulphur liquid fuel.

3.3 NSW Environment Protection Authority Air Quality Policy and Guidance

The NSW Environmental Protection Agency (EPA) is the NSW regulatory authority responsible for air quality regulation and associated activities.

The NSW EPA document, Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (hereafter 'the Approved Methods') (NSW EPA 2022), lists the statutory methods for modelling and assessing air pollutants from stationary sources and specifies criteria that reflect the environmental outcomes adopted by the EPA. The Approved Methods are referred to in the POEO (Clean Air) Regulation 2022 for assessment of impacts of air pollutants. The air quality criteria set out in the Approved Methods have been reproduced and discussed in **Section 3.4.**

3.4 Ambient Air Quality Criteria

State air quality guidelines specified by the NSW EPA for the pollutants identified in **Section 2.4** are published in the Approved Methods. The air quality impact assessment criteria listed in **Section 3.4** of the Approved Methods have been established by NSW EPA to achieve appropriate environmental outcomes and to minimise risks to human health. They have been derived from a range of sources and are the defining ambient air quality criteria for NSW, considered appropriate for use in this assessment.

The impact assessment criteria listed in the Approved Methods for relevant pollutants are shown in **Table 3**.

Table 3 NSW EPA Impact Assessment Criteria for Air Quality Assessment

Pollutant	Averaging Period	Ambient Air Quality Criterion	
		µg/m³	ppm
Total suspended particulate (TSP)	Annual	90	-
Particulate matter less than 10 microns (PM_{10})	24-Hour	50	-
	Annual	25	-
Particulate matter less than 2.5 microns ($PM_{2.5}$)	24-Hour	25	-
	Annual	8	-
Nitrogen dioxide (NO_2)	1-hour	164	8
	Annual	31	1.5
Carbon monoxide (CO)	15-minutes	100,000	8,700
	1-hour	30,000	2,500
	8-hour	10,000	900
Sulfur dioxide (SO_2)	1-hour	215	10
	24-hour	57	2
Benzene	1-hour	29	0.9
Toluene	1-hour	360	9
Ethylbenzene	1-hour	8,000	180
Xylenes	1-hour	190	4

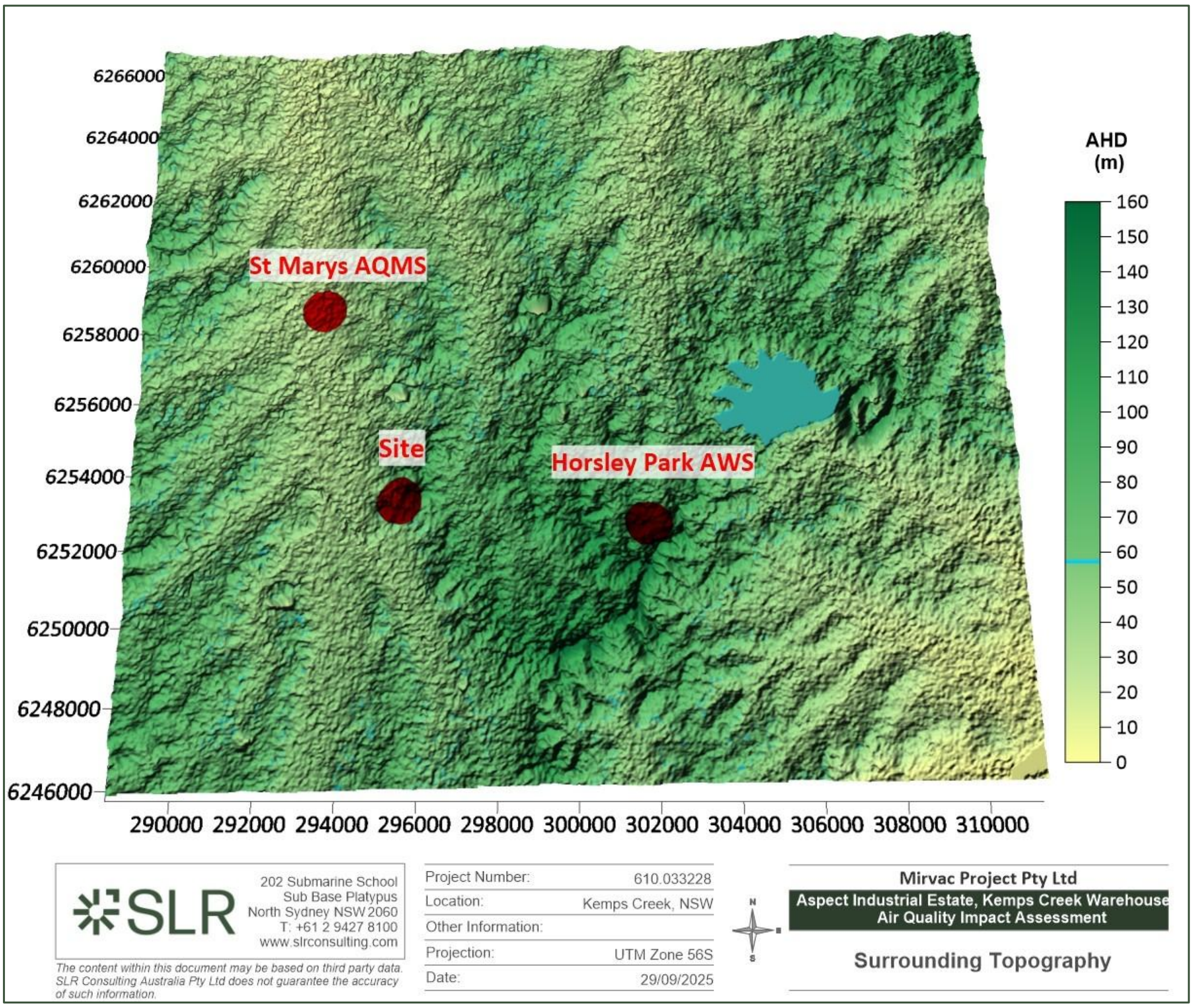
4.0 Existing Environment

4.1 Surrounding Topography

Local topography is important in air quality studies as local atmospheric dispersion can be influenced by night-time katabatic (downhill) drainage flows from elevated terrain or channelling effects in valleys or gullies.

The topography of the Site and its surrounding area is undulating, with elevations ranging from approximately 25 m to 160 m Australian Height Datum (AHD). The Site is situated at a moderate elevation, with higher terrain generally located to the north and northeast, and lower-lying areas extending to the south and west. A three-dimensional representation of the region is shown in **Figure 4**. The locations of the St Marys air quality monitoring station (AQMS; refer to **Section 4.4**), and the Horsley Park automatic weather station (AWS; refer to **Section 4.4**), are indicated.

Figure 4 Regional Topography



4.2 Surrounding Land Uses and Sensitive Receptors

As shown in **Figure 5**, the Site is located within the IN1, General Industrial zone, which supports industrial and business activities. Land adjoining the Site includes areas zoned Environmental Conservation/Management (C2) to the northwest, and Infrastructure (SP2), to the west and southeast.

There are several sensitive receptors located around the Site. The closest sensitive receptor is located approximately 130 m to the west of the Site boundary. **Table 4** outlines the location of the identified receptors included in the assessment and their approximate distances to the nearest Site boundary. The location of the receptors relative to the Site is illustrated in **Figure 6**.

Figure 5 Surrounding Land Zoning

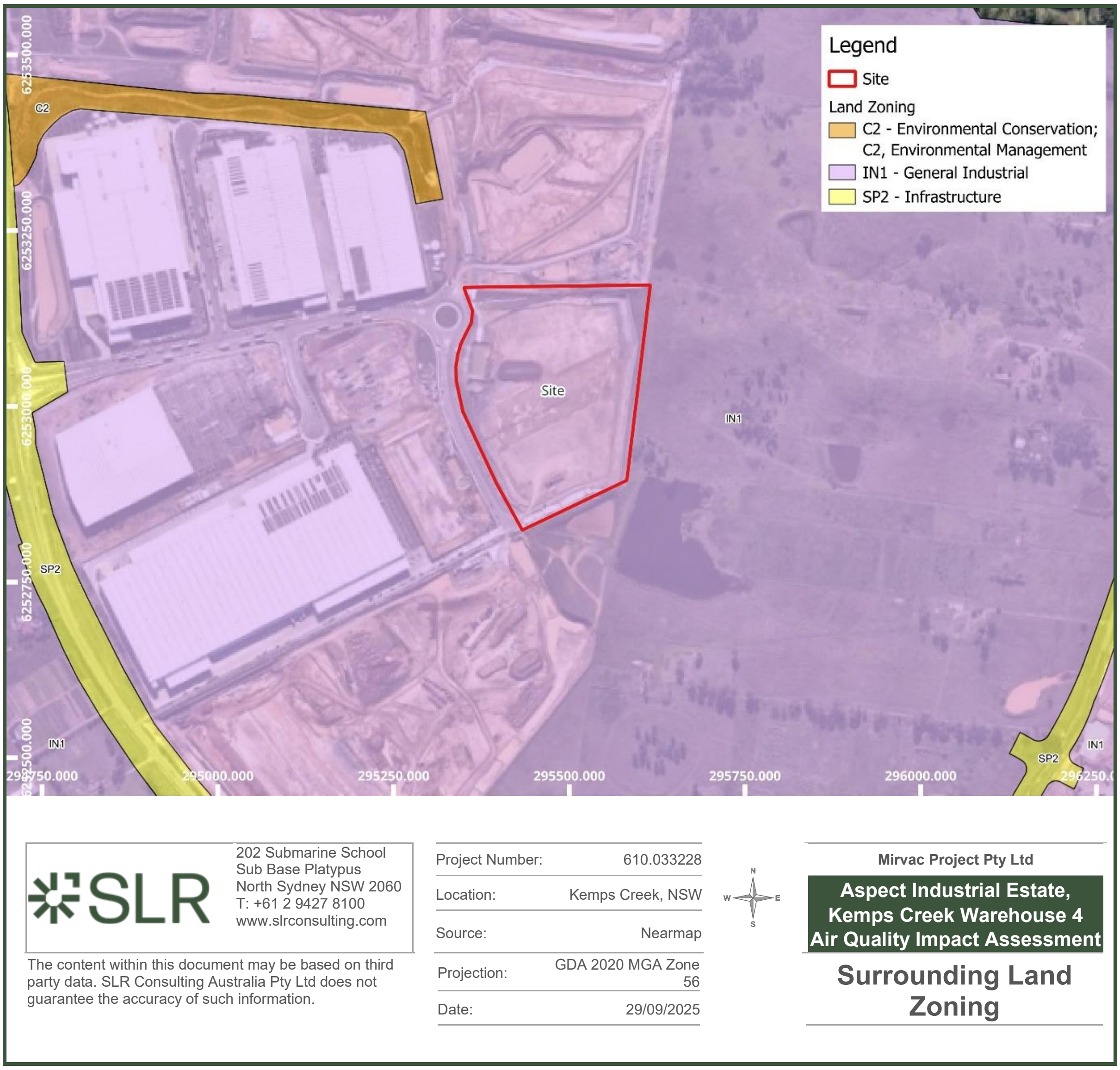


Figure 6 Surrounding Receptors

SLR
202 Submarine School
Sub Base Platypus
North Sydney NSW 2060
T: +61 2 9427 8100
www.slrconsulting.com

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Project Number:	610.033228
Location:	Kemps Creek, NSW
Source:	Nearmap
Projection:	GDA 2020 MGA Zone 56
Date:	01/10/2025

Mirvac Project Pty Ltd

Aspect Industrial Estate, Kemps Creek Warehouse 4
Air Quality Impact Assessment

Surrounding Receptors

Table 4 Sensitive Receptor Locations

Map ID	Easting (m)	Northing (m)	Approximate Distance from Closest Site Boundary (km)
R_1	296,227	6,252,256	0.9
R_2	295,567	6,254,307	1.1
R_3	295,368	6,254,499	1.3
R_4	295,149	6,254,271	1.2
R_5	297,449	6,252,037	2.0
R_6	292,761	6,253,753	2.6
R_7	295,251	6,254,354	1.2
R_8	295,744	6,254,616	1.4
R_9	296,019	6,251,919	1.1
R_10	296,108	6,251,749	1.3
R_11	295,402	6,251,777	1.1
R_12	295,348	6,251,904	0.9
R_13	295,401	6,252,385	0.5
R_14	296,137	6,252,947	0.6
R_15	295,425	6,252,134	0.7
R_16	294,734	6,252,687	0.7
R_17	294,673	6,252,874	0.7
R_18	294,636	6,252,983	0.7
R_19	296,188	6,253,600	0.7
R_20	296,177	6,254,014	1.0
R_21	294,619	6,253,088	0.7
R_22	295,960	6,254,579	1.5
R_23	295,878	6,254,173	1.0
R_24	297,112	6,253,507	1.5
R_25	296,271	6,251,739	1.4
R_26	294,793	6,252,207	0.9
R_27	294,593	6,253,773	1.0
R_28	295,243	6,253,241	0.2
R_29	295,186	6,252,826	0.2

4.3 Local Meteorological Conditions

Local wind speed and direction influence the dispersion of air pollutants. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of 'plume' stretching. Wind direction, and the variability in wind direction, determines the general path pollutants will follow and the extent of crosswind spreading.

The Bureau of Meteorology (BoM) maintains and publishes data from weather stations across Australia. The closest such station to the Site is Horsley Park Equestrian Centre Automatic Weather Station (AWS) (Station no. 67119), which is located approximately 5 km to the east of the Site. Considering the distance, terrain and land cover between the Site and Horsley Park Equestrian Centre AWS, wind conditions at the AWS are likely to be a reasonable representation of those at the Site.

The Horsley Park Equestrian Centre AWS was commissioned in 1997, sits at an elevation of 100 m and has data available for the following parameters:

- wind speed (m/s) and wind direction (degrees)
- temperature (°C)
- rainfall (mm)
- relative humidity (%).

A review of the long-term climate data collected at this station is provided in the following sections.

4.3.1 Rainfall

Rainfall statistics for Horsley Park Equestrian Centre AWS are summarised in **Figure 7**. The average monthly rainfall is distributed evenly throughout the year. The lowest mean monthly rainfall of 37.6 mm/month was recorded during September. The highest average monthly rainfall of 122.3 mm/month occurred in February. The maximum mean number of rain days occurs in December, with an average of 12.2 rain days recorded in this month. Maximum rainfall of 461.8 mm and minimum rainfall of 0 mm have been recorded.

4.3.2 Relative Humidity

Available humidity statistics (9 am and 3 pm monthly averages) for Horsley Park Equestrian Centre AWS are summarised in **Figure 8**. Morning humidity levels range from an average of around 61% in mid spring to around 81% in early autumn. Afternoon humidity levels are lower at around 42% in early spring, and around 55% in mid-winter.

4.3.3 Temperature

Available temperature statistics for Horsley Park Equestrian Centre AWS are summarised in **Figure 9**. Mean maximum temperatures range from 17.6°C in winter to 29.9°C in summer, while mean minimum temperatures range from 5.9°C in winter to around 18.0°C in summer. Maximum temperatures of 47°C and minimum temperatures of -2.3°C have been recorded.

Figure 7 Monthly Rainfall Data for Horsley Park Equestrian Centre AWS

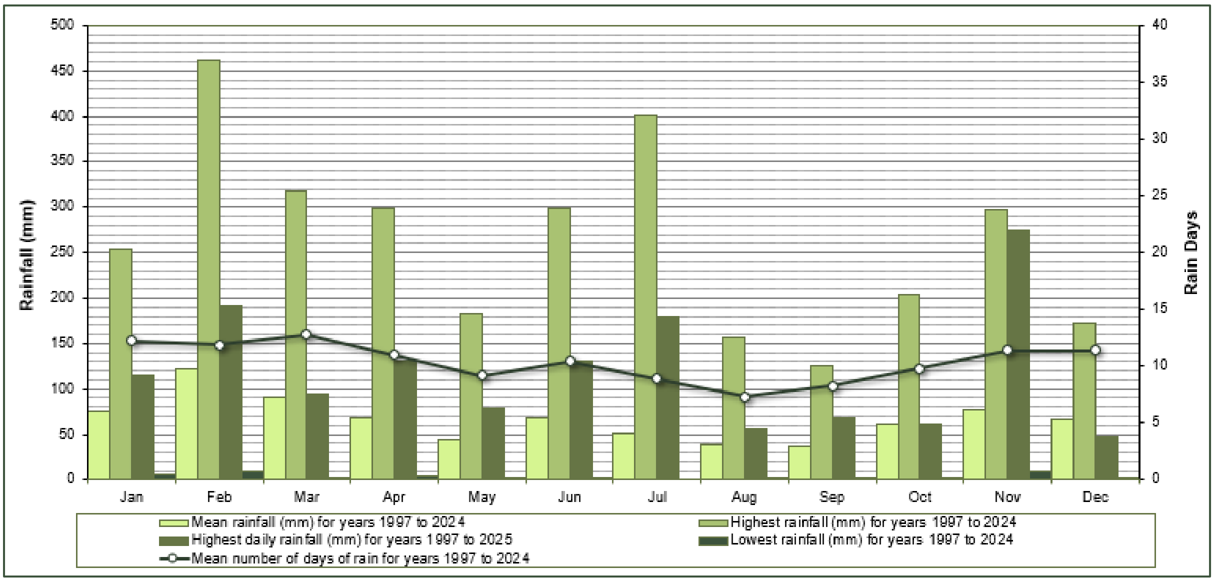


Figure 8 Humidity Data for Horsley Park Equestrian Centre AWS

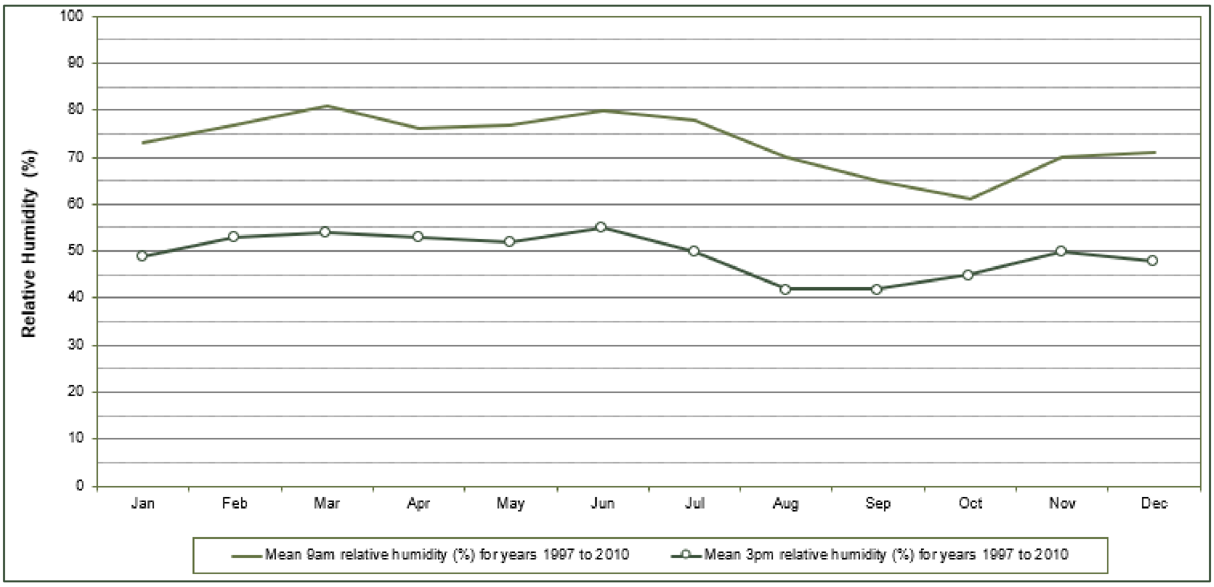
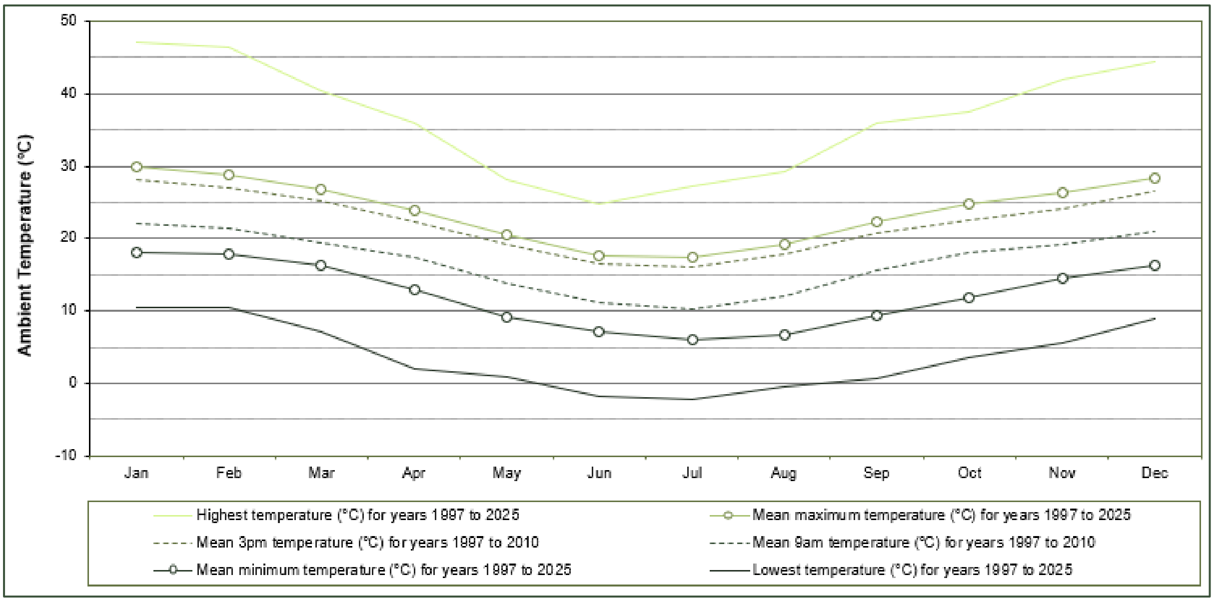


Figure 9 Temperature Data for Horsley Park Equestrian Centre AWS



4.3.4 Wind Speed and Wind Direction

Local wind speed and direction influence the dispersion of air pollutants. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of 'plume' stretching. Wind direction, and the variability in wind direction, determine the general path pollutants will follow and the extent of crosswind spreading.

The Bureau of Meteorology (BoM) maintains and publishes data from weather stations across Australia. The closest station recording wind speed and wind direction data is the Horsley Park Equestrian Centre AWS (Station ID 67119), located approximately 6 km east of the Site. It is assumed that the wind conditions recorded at the Horsley Park Equestrian Centre AWS are representative of the wind conditions experienced at the Site.

Annual and seasonal wind roses for the years 2020 to 2024 compiled from data recorded by the Horsley Park Equestrian Centre AWS are presented in **Figure 10**.

Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from North). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus, it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

The annual wind rose indicates that winds blow from all directions, with the least frequent winds coming from the northeastern quadrant and the most frequent winds coming from the southwestern quadrant. Calm wind conditions (wind speed less than 0.5 m/s) were recorded to occur 18.5% of the time throughout the investigated period. The average seasonal wind roses for the year 2020-2024 indicate that:

- In summer, winds blow from all directions except the northwestern quadrant, where winds occur infrequently. Calms were recorded approximately 16% of the time during the summer months.

- In autumn, winds predominantly blow from the southwestern quadrant, with the least frequent winds originating from the northeastern quadrant. Calms were recorded approximately 20% of the time during the autumn months.
- In winter, winds predominantly blow from the southwestern and northwestern quadrant, with the least frequent winds originating from the northeastern and southeastern quadrants. Calms were recorded 21% of the time.
- In spring, winds blow almost evenly from all directions. Calms were recorded approximately 16% of the time during spring.

Wind erosion of dust from exposed surfaces is usually initiated when wind speeds exceed the threshold friction velocity for a given surface or material. In general, wind erosion can be expected to occur for wind speeds greater than approximately 5.5 m/s. The frequency of wind speeds for the period of 2020-2024 is presented in **Figure 11**. The plot shows that the frequency of wind speeds exceeding 5.5 m/s for the period 2020-2024 at Horsley Park Equestrian Centre AWS was approximately 2% of the time.

Figure 10 Annual and Seasonal Wind Roses for Horsley Park Equestrian Centre AWS (2020 to 2024)

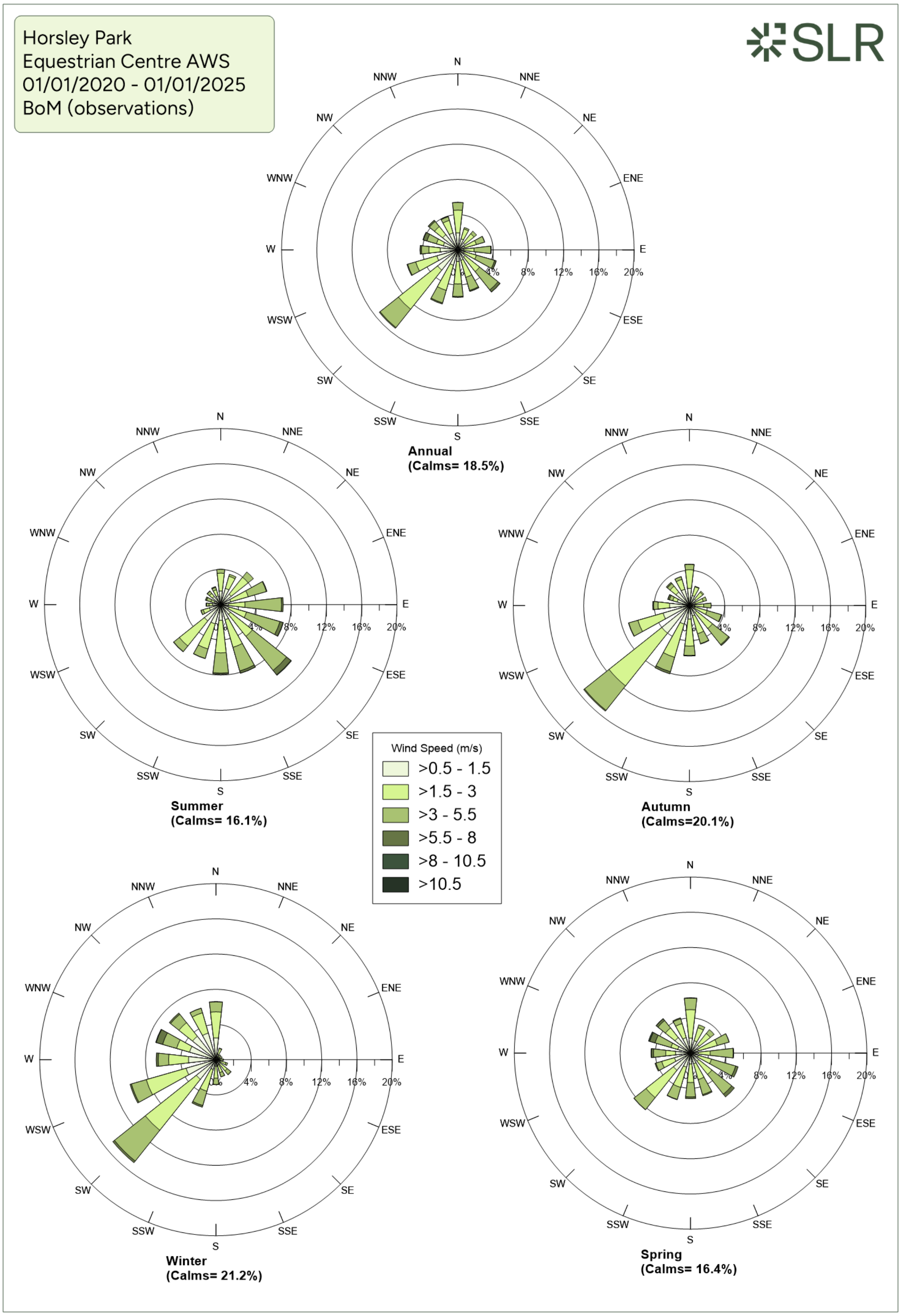
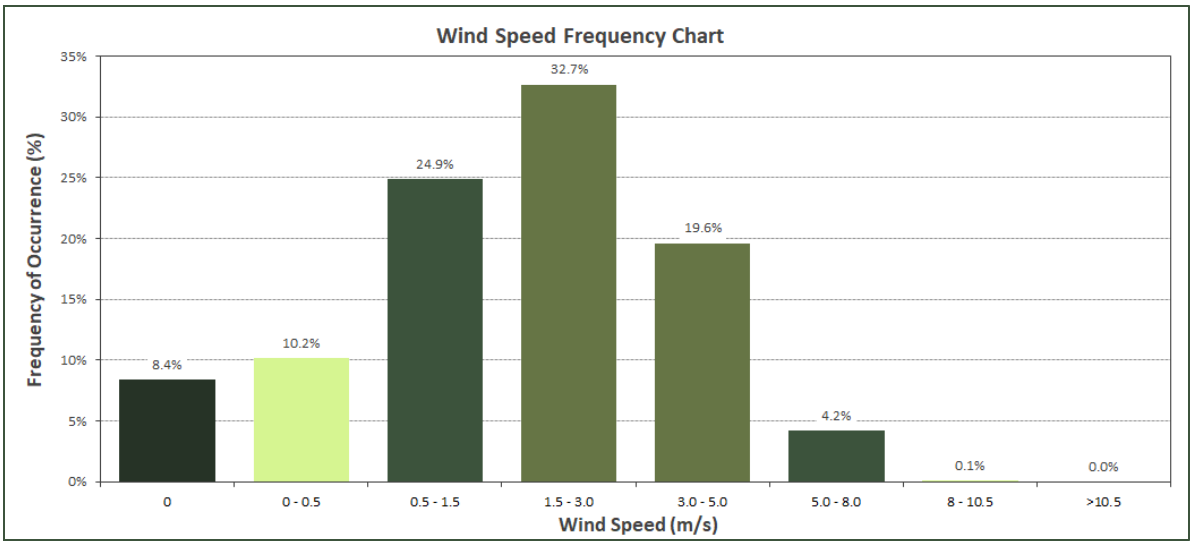


Figure 11 Wind Speed Frequency Chart for Horsley Park Equestrian Centre AWS – 2020-2024



4.4 Review of Ambient Air Quality Monitoring Data

Air quality monitoring is performed by the NSW OEH at a number of monitoring stations across NSW. The nearest such station is located at St Marys, approximately 5.5 km northwest of the Site. The St Marys AQMS was commissioned in 1992 and is located on a residential property off Mamre Road, St Marys. It is situated in the centre of the Hawkesbury Basin, at an elevation of 29 m. The St Marys AQMS monitors the concentration levels of the following air pollutants:

- Oxides of nitrogen (NO, NO_2 and NO_X); and
- Fine particles ($PM_{2.5}$ and PM_{10}).

A summary of the monitored pollutant concentrations for the last five years (2020-2024) is presented in **Table 5** and the data are presented graphically in **Figure 12** to **Figure 14**.

Table 5 Summary of Air Quality Monitoring Data at St Marys AQMS (2020 - 2024)

Pollutant	NO_2		PM_{10}		$PM_{2.5}$	
	Maximum 1-hour	Annual	Maximum 24-hour	Annual	Maximum 24-hour	Annual
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
2020	69.7	7.9	260.3	18.9	82.5	7.6
2021	67.7	8.1	54.9	16.2	40.3	5.8
2022	61.5	8.7	29.7	12.0	12.6	3.9
2023	73.8	11.6	42.5	16.1	36.8	5.8
2024	61.5	10.5	43.2	17.0	17.5	5.6
Criterion	**164**	**31**	**50**	**25**	**25**	**8**

Figure 12 Measured Daily Maximum 1-Hour Average NO_2 Concentrations at St Marys AQMS (2020 - 2024)

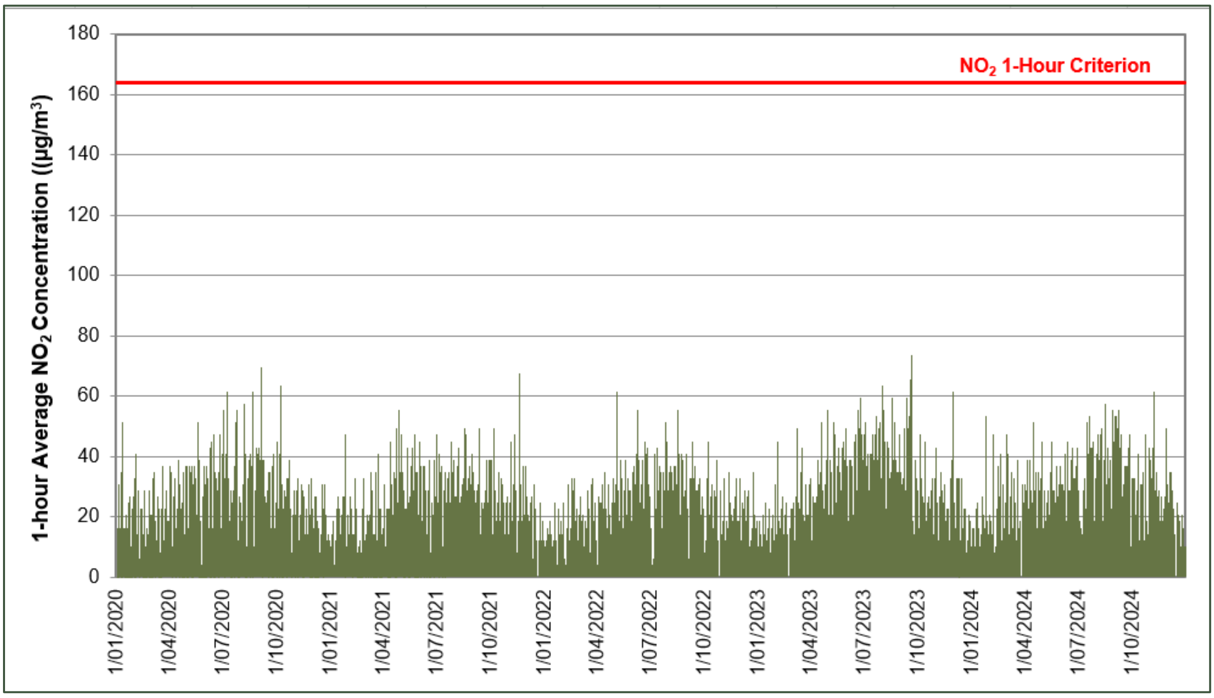


Figure 13 Measured 24-Hour Average PM_{10} Concentrations at St Marys AQMS (2020 - 2024)

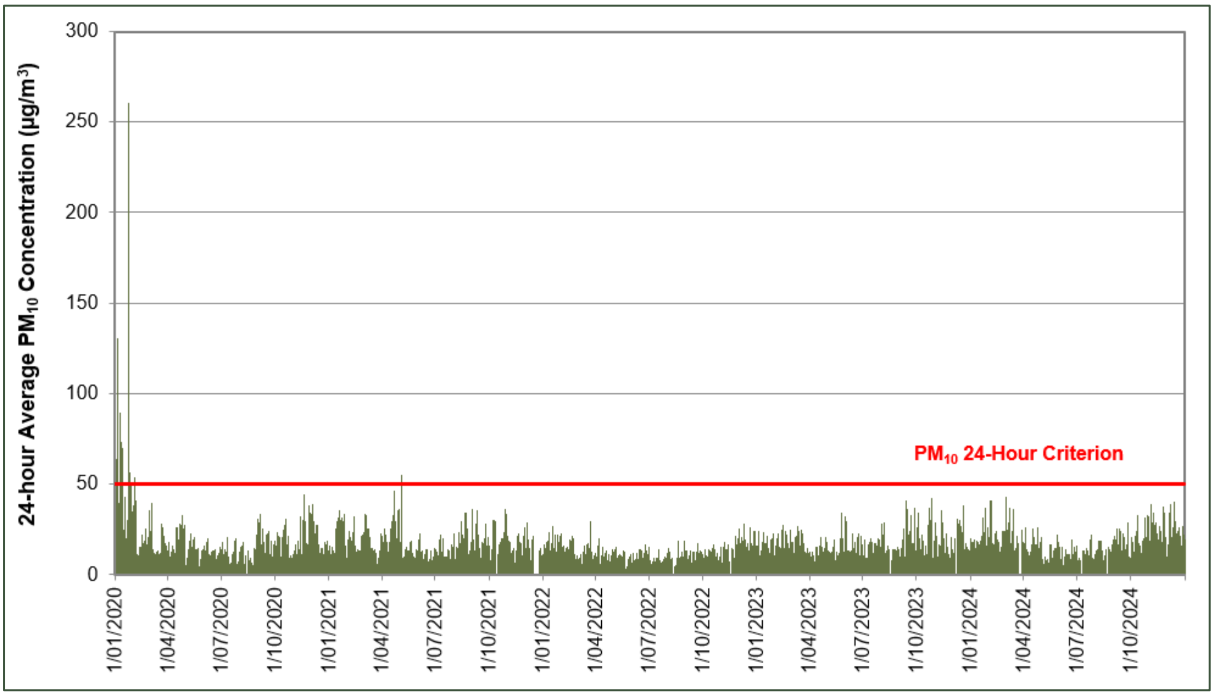
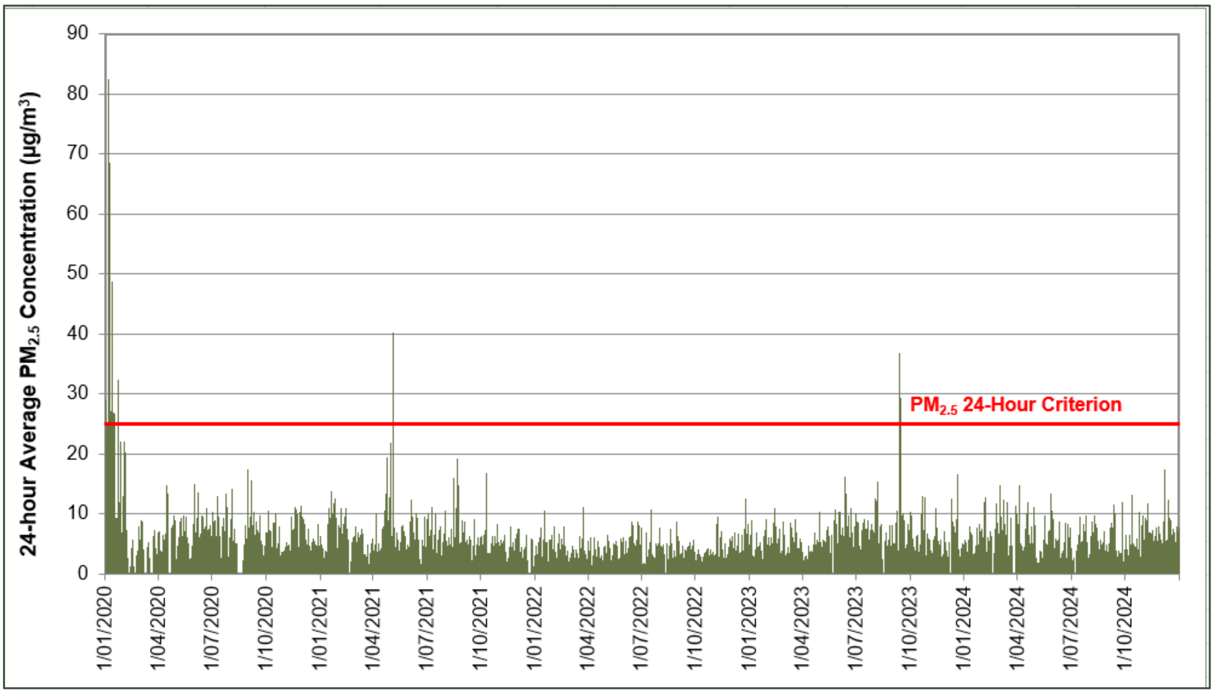


Figure 14 Measured 24-Hour Average $PM_{2.5}$ Concentrations at St Marys AQMS (2020-2024)



A review of the ambient air quality data presented in the following tables and graphs shows:

- Maximum 24-hour PM_{10} concentrations show exceedances including in 2020 (260.3 µg/m³) and 2021 (54.9 µg/m³), above the 50 µg/m³ criterion. The five-year average (96.9 µg/m³) is affected by bushfires in 2020. Annual averages range from 12 µg/m³ to 18.9 µg/m³ with a five-year average of 15.4 µg/m³.

- Maximum 24-hour $PM_{2.5}$ concentrations exceed the 25 µg/m³ criterion in 2020 (82.5 µg/m³), 2021 (40.3 µg/m³), and 2023 (36.8 µg/m³), with a five-year average of 43.2 µg/m³. Annual averages range from 3.9 µg/m³ to 7.6 µg/m³, all less than the annual average criterion (8 µg/m³).

- Maximum 1-hour NO_2 Concentrations remain well within the 164 µg/m³ criterion, peaking at 73.8 µg/m³ (2023) with a five-year average of 69.7 µg/m³. Annual averages (7.9–11.6 µg/m³) are consistently below the 31 µg/m³ criterion and showing higher concentrations around winter.

5.0 Construction Air Quality Assessment

5.1 Assessment Methodology

The assessment of air emissions from the proposed construction Project has been performed quantitatively using dispersion modelling techniques.

The dispersion modelling was performed using the CALPUFF dispersion model (Version 6). The CALPUFF dispersion model is approved by NSW EPA for the assessment of air quality impacts in NSW. CALPUFF has been used for many air quality impact assessments in NSW and across Australia.

CALPUFF is a transport and dispersion model that simulates “puffs” of material emitted from modelled sources, and the time evolution of dispersion. In doing so, typically CALPUFF uses the fields generated by a meteorological pre-processor CALMET. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period.

The primary output files from CALPUFF contain hourly concentrations or deposition values evaluated at selected receptor locations. The CALPOST post-processor is used to process CALPUFF’s outputs, producing summaries of results for user-selected averaging periods.

5.1.1 Meteorological Modelling

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth’s boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume ‘stretching’. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction determine the general path that pollutants will follow and the extent of crosswind spreading.

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke 1988).

To adequately characterise the dispersion meteorology of the Site, information is needed on the prevailing wind regime, mixing height and atmospheric stability and other parameters such as ambient temperature, rainfall and relative humidity.

In order to determine a representative meteorological year for use in dispersion modelling, five years of meteorological data (2019-2023) from the closest meteorological monitoring station, the BoM Horsley Park Equestrian Centre AWS, were compared with five-year average meteorological conditions. The following parameters were analysed:

- frequency and distribution of the predominant wind directions
- monthly average wind speeds observed
- monthly average temperatures.

Based on this analysis, it was concluded that the year 2021 was representative of average conditions experienced at the Site and hence, the 2021 calendar year was adopted for use in this assessment. A summary of the analysis is presented in **Appendix A**.

Details of the completed meteorological modelling are provided below. A summary of the meteorological model domain details is provided in **Table 6.** Evaluation of the processed meteorological data is provided **Appendix B**.

- **TAPM**

In order to calculate all required meteorological parameters required by the dispersion modelling process, meteorological modelling was performed using The Air Pollution Model (TAPM, v 4.0.4). TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations.

TAPM predicts and provides outputs for wind speed and direction, temperature, pressure, water vapour, cloud, rainwater and turbulence. The program generates synthetic observations using databases covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses, which are used to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere. A full description of TAPM is available in the model user manual (CSIRO, 2008).

TAPM may assimilate actual local wind observations so that they can optionally be included in a model solution. However, given that TAPM is known to under-predict calm wind conditions, the wind speed and direction observations obtained from the nearest BoM and stations have also been used in the subsequent CALMET component of the modelling as described in **Section 5.1.2.**

The dispersion modelling requires twelve months of hourly timestep meteorological data. The Air Pollution Model (TAPM) was used to generate site-representative data for input into CALMET for further processing of the fine scale three-dimensional wind field data required for the CALPUFF dispersion model.

- **CALMET**

CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain required as inputs to the CALPUFF dispersion model. Two dimensional fields such as mixing height, surface characteristics and dispersion properties are included in the CALMET outputs. The interpolated wind field is modified within the model to account for the influences of topography, local winds such as sea breezes, and differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

A full description of the CALMET/CALPUFF model is available in the CALPUFF manual (SRC 2011).

The CALMET domain was modelled with a resolution of 50 metres. The TAPM-generated 3-dimensional, 1 km resolution meteorological data was used as the ‘initial guess’ wind field, and local topography and local weather observations were used to refine the wind fields by TAPM.

Table 6 TAPM and CALMET Modelling Domain Details

Model and Domain Settings	Details	Model and Domain Settings	Details
TAPM		**CALMET**	
5 nested grids	25 x 25 x 35 grid points	Domain size	4 km x 4 km

Model and Domain Settings	Details	Model and Domain Settings	Details
Grid point resolutions	30 km, 10 km, 3 km, 1 km, 300 m	Receptor grid	50 m resolution
Domain origin centre point	E: 295,164 N: 6,253,975 Zone: 56H	Domain origin southwest corner	E: 291,500 N: 6,247,500 Zone: 56H
Period	31/12/2020 to 01/01/2022	Period	31/12/2020 to 01/01/2022
Further details on model settings can be provided as required.		Initial guess field	3D output from TAPM

5.1.2 Dispersion Modelling

The air dispersion model CALPUFF is used widely in Australia, and is suitable for a range of applications and conditions including dust dispersion modelling assessments. CALPUFF requires three major types of inputs:

- emission rates and source details
- meteorology
- terrain and surface details, as well as specification of specific receptor locations.

A summary of the model details is provided in **Table 7**.

Table 7 CALPUFF Domain Details and Model Settings

Item	Details
Domain details	50 m resolution for 4 km by 4 km domain
Receptor details	50 m resolution gridded receptors and 29 discrete receptors
Emissions data	Varys by emission source. Refer to **Section 5.2** for details.
Further details on model settings can be provided as required.	

5.1.2.1 Model Configuration

Dust emissions from the earthworks activities at the Site were represented by a series of volume sources, while wind erosion from exposed areas was represented by area sources.

The estimated particulate emissions were modelled as, with particle sizes indicated:

- Fine Particulates (FP < 2.5 µm);
- Course Matter (2.5 µm<CM<10 µm); and
- Remaining larger dust particles (RE>10 µm).

These parameters were then grouped using CALPOST to predict $PM_{2.5}$, PM_{10} and TSP concentrations at surrounding receptor locations. This approach allows for the lighter, finer particulate matter being dispersed further than more massive particles that settle out of the air more rapidly.

Based on the sensitivity of each activity to wind speed, an hourly varying emission file representing hourly FP, CM and RE emissions for each source was generated using the annual average emission rate estimated for each activity. Details of the algorithm used to generate the variable emission files are presented in **Appendix D**.

5.1.3 Adopted Background Air Quality for this Assessment

The purpose of assessing background air quality is to determine the concentrations of air pollutants currently experienced at surrounding receptors. Model-predicted concentrations from the Site are added to these background concentrations as a part of the cumulative air quality impact assessment.

In accordance with the Approved Methods, the background data used in this AQIA were from the same year as the meteorological year used in the modelling (2021).

The representative background ambient air quality concentrations adopted for use in this assessment are summarised in **Table 8**.

Table 8 Adopted Background Data

Pollutant	Averaging Period	Regional Background	Notes
TSP	Annual	22 µg/ m^3	Calculated from PM_{10} concentrations at St Marys AQMS during 2021, with a PM_{10}/TSP ratio of 0.4
PM_{10}	24-hour	Daily varying	As monitored at St Marys AQMS during 2021
	Annual	16.2 µg/ m^3	As monitored at St Marys AQMS during 2021
$PM_{2.5}$	24-hour	Daily varying	As monitored at St Marys AQMS during 2021
	Annual	5.8 µg/ m^3	As monitored at St Marys AQMS during 2021
Deposited dust	Annual	2 g/m^2/month	Assumed, not monitored at St Marys AQMS The estimate for background is typical based on experience with measurements of the insoluble fractions of deposited dust.

5.1.4 Accuracy of Modelling

All atmospheric dispersion models, including CALPUFF, represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results, it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below:

- Oversimplification of physics: This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Uncertainties are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally varying meteorology).
- Uncertainties in emission rates: Ground level concentrations are proportional to the pollutant emission rate. In addition, most modelling studies assume constant worst-case emission levels or are based on the results of a small number of stack tests, however, operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.

- Uncertainties in wind direction and wind speed: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of the plume. Uncertainties in these parameters can result in errors in the predicted distance from the source of the plume impact and the magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- Uncertainties in mixing height: If the plume elevation reaches 80% or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.
- Uncertainties in temperature: Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and the magnitude of that impact.
- Uncertainties in stability estimates: Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, uncertainties in these parameters can cause either under-prediction or over-prediction of ground level concentrations. For example, if an error is made in one stability class, then the computed concentrations can be off by 50% or more.

The US EPA makes the following statement in its Modelling Guideline (US EPA 2005) on the relative accuracy of models:

"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in the highest estimated concentrations of ±10 to 40% are found to be typical, i.e., certainly well within the often-quoted factor-of-two accuracy that has long been recognised for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."

5.2 Emission Estimation

To effectively estimate the worst-case impacts due to the proposed bulk earthworks for the Site, a maximum day operating scenario was assessed and assumed to occur every day. This ensures that the peak 24-hour impacts are captured.

The maximum cut/fill/transfer activity rates were derived by scaling up the indicative bulk material volumes over the anticipated 2-month bulk earthworks period (refer to **Table 2**). In reality, bulk earthwork activities will only occur 5.5 days per week between the hours of 7:00 am and 6:00 pm and 8:00 am to 1:00 pm on Saturday, no work on Sundays, and are anticipated to last 2 months. The equipment is anticipated to include the following:

- Scrapers
- Dozers
- Material delivery trucks
- Water trucks

It is important to note that as the emission inventory is based on quantity (and type) of material moved, and/or distance travelled, the precise numbers and types of equipment would not change the extent or shape of the predicted dust dispersion. In addition, as the precise location of the equipment will vary on a day-to-day basis, the emissions estimation conservatively assumes that multiple equipment will be operating concurrently during the Site. Thus, the predicted contributions are also considered to be conservative, particularly with respect to travel on unsealed roads.

The estimated emissions for each activity are presented in **Table 9**. A detailed breakdown of the emissions factors and assumptions used to determine the Site emissions is provided in **Appendix C.**

Table 9 Estimated Emissions

Activity	TSP emission (kg/y)	PM_{10} emission (kg/y)	$PM_{2.5}$ emission (kg/y)	Total (kg/y)
Scrapers stripping clay and shales	1,810	518	52	2,380
Scraper travel moving clay and shales to fill	2,658	761	76	3,495
Scraper unloading clay and shales to fill the area	55	26	4	85
FEL- rehandling material at fill area	55	26	4	85
Imported material haulage to fill the area	1721	493	49	2,263
Unloading at the fill area (from imported material)	41	19	3	63
Dozer (x1) - ripping, pushing and compacting materials (topsoil/clay/shales)	13,079	2,822	1,373	17,275
Wind erosion (active)	5,475	2,738	274	8,486
Diesel combustion	234	234	224	692
Total emissions (kg/yr)	**25,129**	**7,638**	**2,059**	**34,825**

5.3 Predicted Air Quality Impacts

The sections below present a summary of the air quality impacts predicted by the modelling at the sensitive receptors identified in **Section 4.2.**

Isopleth plots showing the incremental impact predicted due to the Site emissions; i.e., excluding background levels, for each pollutant are presented in **Appendix E**. These plots do not represent the dispersion pattern for any individual time period but rather illustrate the maximum concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2021 modelling period.

5.3.1 Particles as $PM_{2.5}$

5.3.1.1 Maximum 24-Hour Average $PM_{2.5}$ Concentrations

Table 10 presents a summary of the predicted maximum incremental and maximum cumulative impacts 24-hour average $PM_{2.5}$ impacts at the sensitive receptors.

Table 10 Summary of 24-Hour $PM_{2.5}$ Cumulative Impact Analysis

Receptor ID	Maximum 24-Hour Average $PM_{2.5}$ Concentrations (µg/m^3)		Additional Exceedances
	Incremental Impact	Cumulative Impact	
R_1	0.8	82.5	0
R_2	0.4	82.5	0
R_3	0.3	82.5	0
R_4	0.3	82.5	0
R_5	0.2	82.5	0
R_6	0.1	82.5	0
R_7	0.3	82.5	0
R_8	0.3	82.5	0
R_9	0.5	82.5	0
R_10	0.5	82.5	0
R_11	0.4	82.5	0
R_12	0.5	82.5	0
R_13	1.5	82.5	0
R_14	1.4	82.6	0
R_15	0.8	82.5	0
R_16	0.9	82.5	0
R_17	0.8	82.5	0
R_18	0.8	82.5	0
R_19	1.2	82.6	0
R_20	0.6	82.5	0
R_21	0.7	82.5	0

Receptor ID	Maximum 24-Hour Average $PM_{2.5}$ Concentrations (µg/m³)		Additional Exceedances
	Incremental Impact	Cumulative Impact	
R_22	0.3	82.5	0
R_23	0.4	82.5	0
R_24	0.5	82.5	0
R_25	0.5	82.5	0
R_26	0.8	82.5	0
R_27	0.3	82.5	0
R_28	2.3	82.8	0
R_29	3.5	82.5	0
Criterion		**25**	**-**

Table 10 shows that there are predicted exceedances of the criterion; however, impacts are dominated by the background $PM_{2.5}$. There are no additional exceedances due to the Site.

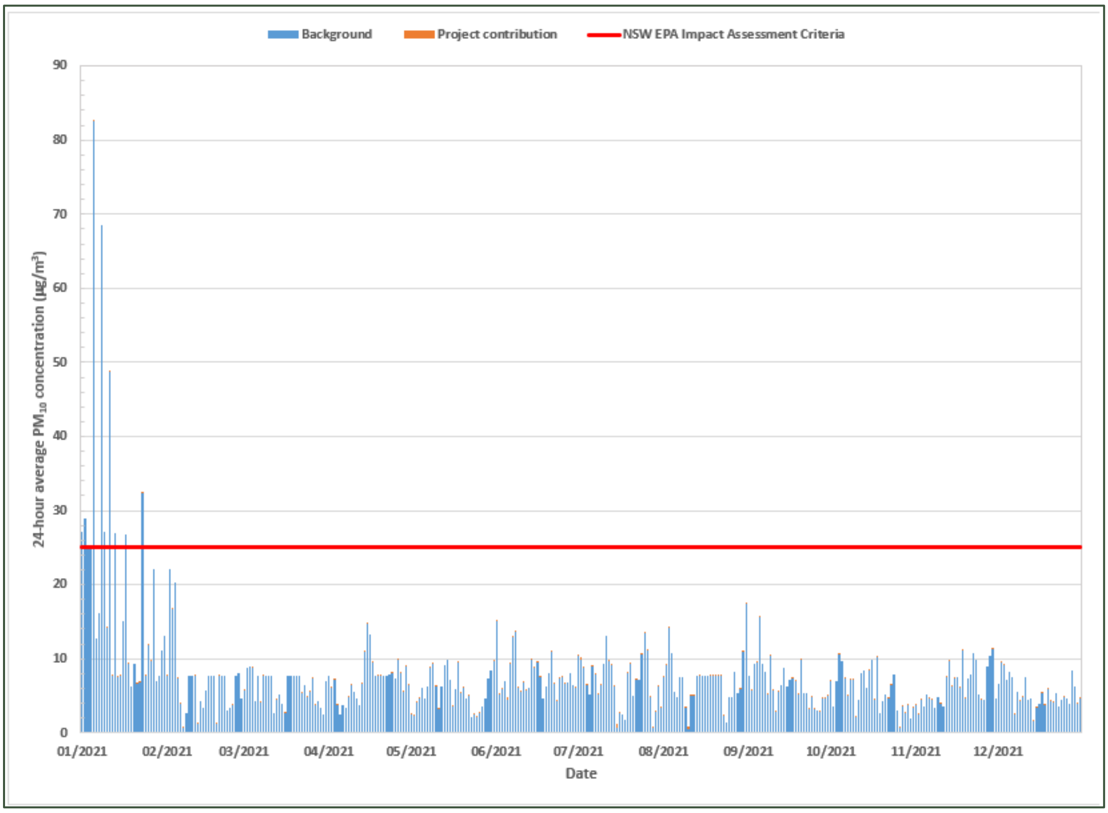
As discussed in **Section 5.1.3**, daily varying background concentrations were adopted from the St Mary AQMS for contemporaneous analysis of the cumulative assessment. In accordance with the Approved Methods, a contemporaneous analysis of the maximum predicted concentrations at the worst impacted receptor (R29) was performed and is presented in **Table 11**. This analysis shows that the contribution of the Project Site towards the maximum cumulative 24-hour average $PM_{2.5}$ concentrations does not result in additional exceedances of the criterion. **Figure 15** shows the daily cumulative impact predicted at R29.

Table 11 24-hour Average $PM_{2.5}$ Contemporaneous Analysis Summary (Receptor R29)

Date	$PM_{2.5}$ 24-Hour Average (µg/³)			Date	$PM_{2.5}$ 24-Hour Average (µg/m³)		
	Highest Background	Project Site Increment	Total		Background	Highest Project Site Increment	Total
5/01/2021	82.5	0.01	82.5	30/07/2021	6.2	3.5	9.7
8/01/2021	68.5	<0.01	68.5	3/06/2021	5.9	3.3	9.2
11/01/2021	48.8	0.56	49.4	22/06/2021	6.6	2.9	9.5
23/01/2021	32.4	0.59	33.0	1/06/2021	15.0	2.8	17.8
2/01/2021	28.9	0.12	29.0	8/07/2021	5.1	2.6	7.7
9/01/2021	27.2	0.09	27.3	25/05/2021	2.2	2.2	4.4
1/01/2021	27.1	<0.01	27.1	2/06/2021	5.1	2.2	7.3
13/01/2021	27.0	0.77	27.8	10/06/2021	5.6	2.1	7.7
17/01/2021	26.8	0.03	26.8	1/07/2021	10.4	2.1	12.5
3/01/2021	25.0	0.83	25.8	16/06/2021	9.5	1.9	11.4
4/01/2021	24.8	0.27	25.1	19/05/2021	5.3	1.8	7.1

Date	$PM_{2.5}$ 24-Hour Average (µg/³)			Date	$PM_{2.5}$ 24-Hour Average (µg/m³)		
	Highest Background	Project Site Increment	Total		Background	Highest Project Site Increment	Total
2/02/2021	22.1	0.01	22.1	31/05/2021	9.7	1.7	11.4

Figure 15 Daily Contemporaneous $PM_{2.5}$ Analysis - Receptor R-29



5.3.1.2 Annual Average $PM_{2.5}$ Concentrations

Table 12 presents the incremental and cumulative annual average $PM_{2.5}$ concentrations predicted at each of the identified receptors.

Table 12 Predicted Incremental and Cumulative Annual Average $PM_{2.5}$ Concentrations

Receptor ID	Annual Average $PM_{2.5}$ Concentrations (µg/m³)	
	Incremental Impact	Cumulative Impact
R_1	0.03	7.7
R_2	0.03	7.7
R_3	0.02	7.7
R_4	0.03	7.7
R_5	0.01	7.6

Receptor ID	Annual Average $PM_{2.5}$ Concentrations (µg/m^3)	
	Incremental Impact	Cumulative Impact
R_6	0.00	7.6
R_7	0.03	7.7
R_8	0.02	7.7
R_9	0.02	7.6
R_10	0.01	7.6
R_11	0.03	7.7
R_12	0.04	7.7
R_13	0.11	7.7
R_14	0.10	7.7
R_15	0.06	7.7
R_16	0.06	7.7
R_17	0.05	7.7
R_18	0.05	7.7
R_19	0.09	7.7
R_20	0.05	7.7
R_21	0.05	7.7
R_22	0.02	7.7
R_23	0.04	7.7
R_24	0.02	7.7
R_25	0.01	7.6
R_26	0.06	7.7
R_27	0.03	7.7
R_28	0.33	8.0
R_29	0.33	8.0
Criterion		**8**

Table 12 shows that the cumulative annual average $PM_{2.5}$ concentrations are predicted to equal the annual average $PM_{2.5}$ criterion of 8 µg/m^3 at two of the 29 receptors modelled. The emission estimations adopted conservative assumptions to ensure short term impacts are not underestimated. For example, while the bulk earthworks are expected to be completed in 2 months, all activities were scaled up by approximately 75% to allow for the assessment of emissions under varying meteorological conditions. These assumptions result in an overestimation of annual predictions by potentially up to 75%.

5.3.2 Particles as PM_{10}

5.3.2.1 Maximum 24-Hour Average PM_{10} Concentrations

Table 13 presents a summary of the predicted maximum incremental and maximum cumulative impacts, 24-hour average PM_{10} impacts at the sensitive receptors.

Table 13 Summary of 24-Hour PM_{10} Cumulative Impact Analysis

Receptor ID	Maximum 24-Hour Average PM_{10} Concentrations (µg/m³)		Additional Exceedances
	Incremental Impact	Cumulative Impact	
R_1	2.0	262.3	1
R_2	1.1	261.4	1
R_3	0.8	261.1	1
R_4	0.9	261.2	1
R_5	0.4	260.7	1
R_6	0.3	260.6	1
R_7	0.8	261.1	1
R_8	0.7	261.0	1
R_9	1.4	261.7	1
R_10	1.2	261.5	1
R_11	1.1	261.4	1
R_12	1.4	261.7	1
R_13	4.1	264.4	1
R_14	3.8	264.1	1
R_15	2.0	262.3	1
R_16	2.2	262.5	1
R_17	2.1	262.4	1
R_18	2.2	262.5	1
R_19	3.4	263.7	1
R_20	1.7	262.0	1
R_21	1.8	262.1	1
R_22	0.7	261.0	1
R_23	1.0	261.3	1
R_24	1.1	261.4	1
R_25	1.4	261.7	1
R_26	2.0	262.3	1
R_27	0.9	261.2	1
R_28	6.0	266.3	2
R_29	9.4	269.7	1

Receptor ID	Maximum 24-Hour Average PM_{10} Concentrations (µg/m³)		Additional Exceedances
	Incremental Impact	Cumulative Impact	
Criterion		**50**	**-**

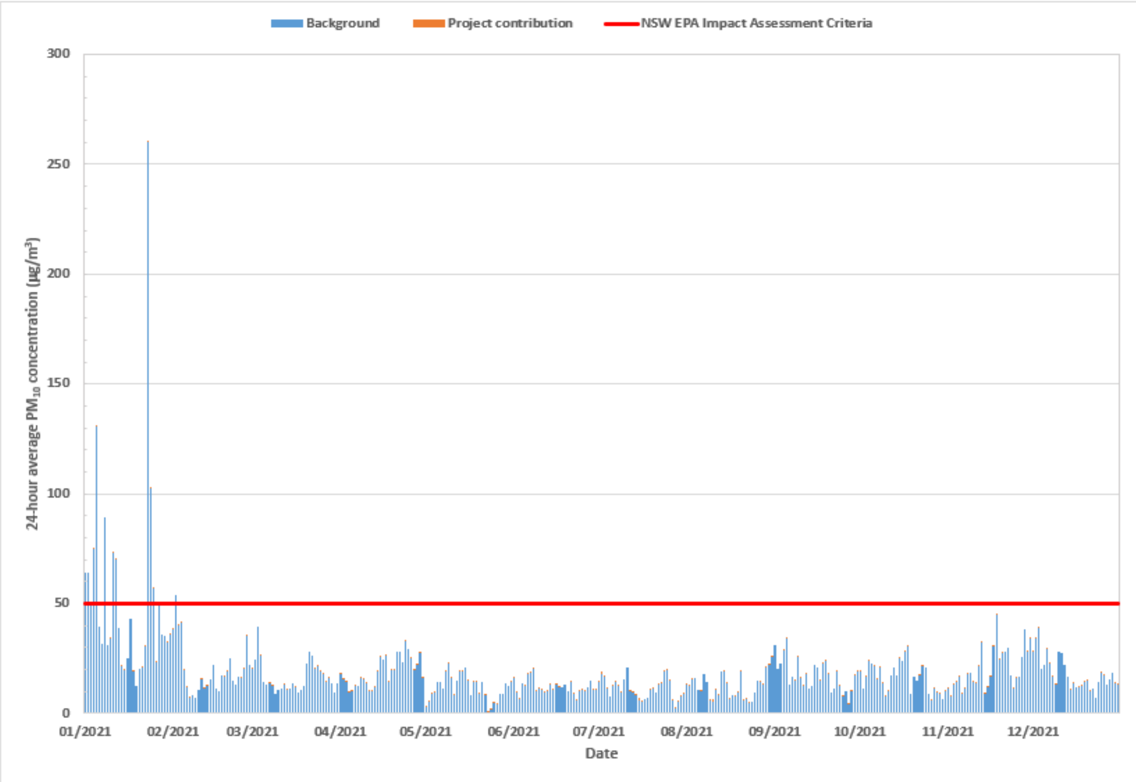
Table 13 shows that there are predicted exceedances of the criterion at some receptors. As discussed in **Section 5.1.3**, daily varying background concentrations were adopted from the St Marys AQMS for contemporaneous analysis of the cumulative assessment. In accordance with the Approved Methods, a contemporaneous analysis of the maximum predicted concentrations at the worst-impacted receptor (R-29) was performed and is presented in **Table 14.** The highest 24-hour average PM_{10} increment (Project only) was predicted at R-29, and this receptor has the highest number of predicted additional exceedances. **Figure 16** shows the daily cumulative impact predicted at R-29.

This analysis shows that the contribution of the Site towards the maximum cumulative PM_{10} 24-hour average concentrations results in a number of additional exceedances of the criterion, however all the results are dominated by high background levels.

Table 14 24-hour Average PM_{10} Contemporaneous Analysis Summary (Receptor R29)

Date	PM_{10} 24-Hour Average (µg/m³)			Date	PM_{10} 24-Hour Average (µg/m³)		
	Highest Background	Project Increment	Total		Background	Highest Project Increment	Total
23/01/2021	260.3	2.04	262.3	30/07/2021	7.6	9.4	17.0
5/01/2021	130.4	0.05	130.4	3/06/2021	6.7	8.9	15.6
24/01/2021	102.7	1.33	104.0	22/06/2021	8.7	7.7	16.4
8/01/2021	89.2	<0.01	89.2	1/06/2021	15.8	7.6	23.4
4/01/2021	74.6	0.80	75.4	8/07/2021	12.6	7.2	19.8
11/01/2021	73.1	2.24	75.3	25/05/2021	4.6	6.3	10.9
12/01/2021	69.9	1.54	71.4	2/06/2021	9.6	6.0	15.6
2/01/2021	64.0	0.39	64.4	10/06/2021	11.1	5.9	17.0
1/01/2021	63.8	<0.01	63.8	1/07/2021	14.3	5.8	20.1
25/01/2021	56.7	2.41	59.1	16/06/2021	13.2	5.2	18.4
2/02/2021	53.7	0.04	53.7	19/05/2021	14.3	4.8	19.1
3/01/2021	50.0	2.39	52.4	31/05/2021	14.4	4.7	19.1

Figure 16 Daily Contemporaneous PM_{10} Analysis - Receptor R29



5.3.2.2 Annual Average PM_{10} Concentrations

Table 15 presents the incremental and cumulative annual average PM_{10} concentrations predicted at each of the identified receptors.

Table 15 Predicted Incremental and Cumulative Annual Average PM_{10} Concentrations

Receptor ID	Annual Average PM_{10} Concentrations (µg/m³)	
	Incremental Impact	Cumulative Impact
R_1	0.10	19.0
R_2	0.12	19.0
R_3	0.08	19.0
R_4	0.10	19.0
R_5	0.02	19.0
R_6	0.02	18.9
R_7	0.09	19.0
R_8	0.08	19.0
R_9	0.05	19.0
R_10	0.04	19.0
R_11	0.09	19.0
R_12	0.12	19.0

Receptor ID	Annual Average PM_{10} Concentrations (µg/m^3)	
	Incremental Impact	Cumulative Impact
R_13	0.34	19.3
R_14	0.33	19.3
R_15	0.17	19.1
R_16	0.20	19.1
R_17	0.17	19.1
R_18	0.16	19.1
R_19	0.33	19.3
R_20	0.20	19.1
R_21	0.15	19.1
R_22	0.08	19.0
R_23	0.15	19.1
R_24	0.08	19.0
R_25	0.04	19.0
R_26	0.20	19.1
R_27	0.11	19.0
R_28	1.09	20.0
R_29	1.05	20.0
Criterion		**25**

Table 15 shows that the cumulative annual average PM_{10} concentrations at the receptor are below the annual average PM_{10} criterion of 25 µg/ m^3 at all receptors. As noted in **Section 5.3.1.1**, the assumptions made for the emission estimation are expected to have resulted in an overestimation of annual predictions by potentially up to 75%.

5.3.3 Particles as TSP

5.3.3.1 Annual Average TSP Concentrations

Table 16 presents the incremental and cumulative annual average TSP concentrations predicted at each of the identified receptors. **Table 16** indicate that the predicted cumulative concentrations at all receptors are below the annual average TSP criterion of 90 µg/ m^3. As noted in **Section 5.3.1.1**, the assumptions made for the emission estimation are expected to have resulted in an overestimation of annual predictions by potentially over 75%.

Table 16 Predicted Incremental and Cumulative Annual Average TSP Concentrations

Receptor ID	Annual Average TSP Concentrations (µg/m3)		
	Regional Background	Incremental Impact	Cumulative Impact
R_1	22.0	0.2	22.2
R_2	22.0	0.3	22.3
R_3	22.0	0.2	22.2
R_4	22.0	0.2	22.2
R_5	22.0	0.0	22.0
R_6	22.0	0.0	22.0
R_7	22.0	0.2	22.2
R_8	22.0	0.2	22.2
R_9	22.0	0.1	22.1
R_10	22.0	0.1	22.1
R_11	22.0	0.2	22.2
R_12	22.0	0.3	22.3
R_13	22.0	0.9	22.9
R_14	22.0	0.8	22.8
R_15	22.0	0.4	22.4
R_16	22.0	0.5	22.5
R_17	22.0	0.4	22.4
R_18	22.0	0.4	22.4
R_19	22.0	0.8	22.8
R_20	22.0	0.5	22.5
R_21	22.0	0.4	22.4
R_22	22.0	0.2	22.2
R_23	22.0	0.4	22.4
R_24	22.0	0.2	22.2
R_25	22.0	0.1	22.1
R_26	22.0	0.5	22.5
R_27	22.0	0.3	22.3

Receptor ID	Annual Average TSP Concentrations (µg/m3)		
	Regional Background	Incremental Impact	Cumulative Impact
R_28	22.0	3.1	25.1
R_29	22.0	3.0	25.0
Criterion			**90**

5.3.4 Dust Deposition

Table 17 shows the annual average dust deposition rates predicted at each of the identified receptors. **Table 17** indicates that the predicted incremental and cumulative annual average dust deposition rates at all receptors are below the criterion of 4 g/m^2/month (incremental increase in dust deposition) and below 4 g/m^2/month (cumulative dust deposition). At all receptors modelled, the incremental impacts predicted due to the estimated emissions from the Site are very low (<0.5 g/m^2/month) and represent a negligible contribution to the total cumulative concentrations. As noted in **Section 5.3.1.1**, the assumptions made for the emission estimation are expected to have resulted in an overestimation of annual predictions by potentially over 75%.

Table 17 Predicted Annual Average Dust Deposition Rates

Receptor ID	Annual Average Dust Deposition Rate (g/m^2/month)		
	Regional Background	Incremental Impact	Cumulative Impact
R_1	2.0	0.01	2.01
R_2	2.0	0.01	2.01
R_3	2.0	0.01	2.01
R_4	2.0	0.01	2.01
R_5	2.0	<0.01	2.00
R_6	2.0	<0.01	2.00
R_7	2.0	0.01	2.01
R_8	2.0	0.01	2.01
R_9	2.0	<0.01	2.00
R_10	2.0	<0.01	2.00
R_11	2.0	0.01	2.01
R_12	2.0	0.01	2.01
R_13	2.0	0.03	2.03
R_14	2.0	0.04	2.04
R_15	2.0	0.02	2.02
R_16	2.0	0.02	2.02
R_17	2.0	0.02	2.02
R_18	2.0	0.02	2.02
R_19	2.0	0.03	2.03
R_20	2.0	0.02	2.02

Receptor ID	Annual Average Dust Deposition Rate (g/m^2/month)		
	Regional Background	Incremental Impact	Cumulative Impact
R_21	2.0	0.02	2.02
R_22	2.0	0.01	2.01
R_23	2.0	0.01	2.01
R_24	2.0	0.01	2.01
R_25	2.0	<0.01	2.00
R_26	2.0	0.02	2.02
R_27	2.0	0.01	2.01
R_28	2.0	0.19	2.19
R_29	2.0	0.13	2.13
Criterion			**4**

5.4 Construction Stage Mitigation Measures

The results of the dispersion modelling indicate potential exceedances of both short-term (24-hour) and long term (annual average) particulate averages criteria for PM_{10} and exceedances of the long-term particulate averages criterion for $PM_{2.5}$. It is noted that conservative assumptions made to ensure short term impacts are not underpredicted are expected to have resulted in potentially significant overestimation of long-term impacts. Therefore, if appropriate measures are put in place to ensure compliance with the relevant short-term criteria, exceedances of long-term criteria are unlikely (assuming background levels are typical).

Control measures quantified for the purpose of this AQIA and proposed to be adopted for the Site are listed in **Appendix C**.

5.4.1 Mitigation Measures for Adoption by an AQMP

Additional dust mitigation and management measures recommended are listed in **Table 18** to **Table 21**.

These mitigation measures may be adopted in a site-specific Air Quality Management Plan (AQMP). AQMPs cover all sources of emissions, such as those identified in **Section 5.2** of this AQIA, including wind erosion, wheel generated dust, extraction, material handling and processing of extracted material.

In addition, it is recommended that the Site utilises a Trigger Action Response Plan (TARP) supported by PM_{10} real-time air quality monitors to manage impacts at receptors.

Table 18 Recommended Dust Mitigation Measures for the Site

	Activity
1	Display the name and contact details of person(s) account-able for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.
2	Display the head or regional office contact information.
3	Develop and implement a Dust Management Plan (DMP), which may include measures to control other emissions, approved by the Local Authority. The level of detail will depend on the risk and should include as a minimum the highly recommended measures in this document. The desirable measures should be included as appropriate for the site.
Site Management	
4	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.
5	Make the complaints log available to the local authority when asked.
6	Record any exceptional incidents that cause dust and/or air emissions, either on- or off-site, and the action taken to resolve the situation in the logbook.
Monitoring	

	Activity
7	Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the local authority when asked.
8	Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.
Preparing and Maintaining the Site	
9	Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.
10	Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site.
11	Fully enclose site or specific operations where there is a high potential for dust production and the site is actives for an extensive period
12	Avoid site runoff of water or mud.
13	Keep site fencing, barriers and scaffolding clean using wet methods.
14	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below.
15	Cover, seed, or fence stockpiles to prevent wind whipping.
Operating Vehicle/Machinery and Sustainable Travel	
16	Ensure all vehicles switch off engines when stationary - no idling vehicles.
17	Avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment where practicable.
18	Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on un-surfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate).
Operations	
19	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.
20	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.

	Activity
21	Use enclosed chutes and conveyors, and covered skips.
22	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and using fine water sprays on such equipment wherever appropriate.
23	Ensure equipment is readily available on site to clean any dry spillages and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.
Waste Management	
24	Avoid bonfires and burning of waste materials.

Table 19 Mitigation Measures Specific to Earthworks

Activity
Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.
Use Hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.
Only remove the cover in small areas during work and not all at once.

Table 20 Mitigation Measures Specific to Construction

Activity
Avoid scabbling (roughening of concrete surfaces) if possible.
Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.
Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.
For smaller supplies of fine power materials, ensure bags are sealed after use and stored appropriately to prevent dust.

Table 21 Mitigation Measures Specific to Trackout

Activity
Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use.
Avoid dry sweeping of large areas.
Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.
Record all inspections of haul routes and any subsequent action in a site log book.
Install hard-surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.
Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).
Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permit.
Access gates to be located at least 10 m from receptors where possible.

5.4.2 Recommended Trigger Action Response Plan

Trigger action response plans (TARPs) define the minimum set of actions required by workers in response to a deviation from normal working conditions.

A 1-hour average time period has been selected as a practical time-step for identifying sustained elevated dust concentrations that could potentially result in an exceedance of the NSW EPA 24-hour average PM_{10} criterion, while providing sufficient time for additional mitigation measures to be implemented at the Site to reduce dust emissions before such an exceedance occurs.

Table 22 presents recommended 1-hour average PM_{10} concentrations and actions. In the absence of local guidance, these values are adapted from the recommendation in the UK Institute of Air Quality Management (IAQM) Guidance on Monitoring in the Vicinity of Demolition and Construction Sites (IAQM 2018) that was developed based on extensive monitoring in the vicinity of construction sites and recommended a 1-hour average PM_{10} concentration of 190 mg/m^3 as the trigger upon which action must immediately be taken to minimise dust emissions. The upper trigger has been conservatively lowered to 150 mg/ m^3.

Table 22 TARP PM_{10} Trigger Levels and Responses

Level	1-hour Average PM_{10} Trigger Level	Action
Alert	≥100 mg/ m3 but < 125 mg/ m^3	• Review operations via a visual inspection of dust emissions from current activities to ensure

Level	1-hour Average PM_{10} Trigger Level	Action
	Or Wind speed < 2m/s Or Visible dust leaving the Site	all standard dust mitigation measures are being appropriately implemented. Where appropriate, implement additional remedial measures, such as: • Deployment of additional water sprays, water trucks etc • Determine if background concentrations may be the key contributor to high concentrations being recorded (e.g., based on wind direction, information on regional events such as bush fires or dust storms, etc). • Continue to closely monitor PM_{10} concentrations being recorded.
Action I	≥125 mg/ m^3 but < 150 mg/ m^3 AND Wind speed < 2m/s Or Visible dust leaving the Site	• Increase watering rates on haul roads where appropriate. • Reduce speed of equipment / vehicles. • Continue to closely monitor PM_{10} concentrations being recorded. • Undertake an investigation of the dust generating activities, and if necessary, temporarily halt the dust generating activities
Action II	≥ 150 mg/ m^3 AND Wind speed < 2m/s AND Or Visible dust leaving the Site	• Review planned operations considering exposed areas. • Cease any non-critical dust-producing activities or relocate relevant activities where possible away from sensitive receptors, or to less exposed locations. • Continue to closely monitor PM_{10} concentrations being recorded.

6.0 Operational Air Quality Assessment

6.1 Pollutants Assessed

RAQST provides predictions of NO_2, PM_{10} and $PM_{2.5}$ concentrations at various distances from the road kerb. It does not provide predictions of the other traffic-related pollutants identified in **Section 2.3.2**, namely CO, SO_2 and VOCs. Given the relatively low levels of CO and SO_2 emissions from vehicles and the low ambient concentrations recorded in the region (see **Section 4.4**), CO and SO_2 emissions from road traffic are unlikely to result in significant air quality impacts. Also, SLR's experience in modelling VOC emissions from roads has shown that the kerbside concentration of VOCs is typically well below relevant air quality criteria.

Given the above, the lower risk air pollutants CO, SO_2 and VOCs have not been considered further in this assessment.

6.2 Dispersion Model Configuration

RAQST requires a number of inputs to describe the Site environment and emissions to air, including:

- Background pollutant concentrations
- Daily or peak hour traffic volumes and vehicle speeds
- Traffic mix (heavy vehicle percentage)
- Road type, number of lanes and gradient
- Year of assessment (vehicle fleet).

The sources of the required data and assumptions made for this assessment are summarised in **Table 23**.

Table 23 RAQST Input Data

Parameter	Value	Description
Assessment Year	2027	Assumed project completion
Electric vehicle projections	Included	-
Number of Lanes	1 in each direction	-
Road type	Commercial Arterial	Based on the land use of the area
Road gradient	3.0%	Average road gradient calculated based on terrain elevations.
Lane width (m)	3.5 m	Assumed
Level for traffic composition	Level 2	No detailed information on traffic composition is available.
Traffic speed	10 km/hr	Conservative assumption representative of emissions during high congestion periods
Traffic volume	400 vpd (200 vpd per lane)	Peak incremental change
Peak hour traffic as a percentage of AADT	10%	Calculated based on data presented in Section 2.2.1.
Heavy vehicle percentage	30%	Calculated average daily based on data presented in Section 2.2.1.
Background Concentrations		
Background site	St Mary AQMS	Nearest air quality monitoring station
Background year	2021	-
1-hour metric for NO_x	Maximum	Per the Approved Methods, if the existing ambient air pollutant concentrations exceed the impact assessment criteria, the assessment demonstrates that no additional exceedances of the impact assessment criteria will occur.
24-hour metric for PM_{10} and $PM_{2.5}$	Maximum below the criterion	

6.3 Modelling Results

The nearest receptors to the Mamre Road kerbside, which is the main access point for the Site are located approximately 30 m from the kerb. Therefore, predicted air pollutant concentrations at 30 m from the kerbside have been quantified.

As shown in **Table 24**, the incremental predicted concentrations due to Site generated traffic on Mamre Road are insignificant, and none of the predicted concentrations are predicted to contribute significantly to the potential for exceedances of the relevant criteria.

Furthermore, all cumulative concentrations comply with the relevant criteria at the nearest sensitive receptor location (approximately 30 m from the Mamre Road kerb), therefore the potential impact of the development is considered negligible. It is noted that for the receptors located further away from the Site and unlikely to be impacted by the peak traffic generation rates, given vehicles will be using a variety of routes to access the Site, the incremental impact would be less than those presented in **Table 24**.

Table 24 RAQST Model Results – Peak Hour

Pollutant and Averaging Period	Background Concentration (µg/m^3)	Incremental Impact (µg/m^3)	Cumulative Impact (µg/m^3)	Criteria
Maximum 1-hour NO_2 concentrations	Not Applicable	Not applicable	139.6	**164**
Annual NO_2 concentrations	10.7	0.3	10.9	**31**
Maximum 24-hour PM_{10} concentrations	46.2	0.1	46.3	**50**
Annual PM_{10} concentrations	16.2	0.0	16.2	**25**
Maximum 24-hour $PM_{2.5}$ concentrations	21.8	0.1	21.9	**25**
Annual $PM_{2.5}$ concentrations	5.8	0.0	5.8	**8**

7.0 Conclusion

SLR was commissioned by Mirvac Projects Pty Ltd to prepare an air quality impact assessment report for the construction and operation of WH4 at Mirvac's Aspect Industrial Estate (AIE). The report was prepared in accordance with the NSW Government Planning SEARs, which outline key issues to be addressed as part of the EIS – these included emissions to air associated with the construction and operation of the Project.

The main potential sources of air emissions were identified as earthworks during the construction phase and road vehicle traffic during the operational phase of the Site.

The potential for off-site dust impacts during the construction phase was assessed using modelling methods in general accordance with the Approved Methods. The results of this assessment, based on a conservative scenario assuming all activities occur concurrently, indicate that exceedances of short term and long term PM_{10} criteria could occur if sufficient dust mitigation measures are not adopted by the Site. Overestimation of predicted concentrations by the model is likely due to the following factors:

- Inability to quantify benefits gained from some of the proposed mitigation measures; e.g., speed reduction, reducing the intensity of dust generating activities on days with elevated background pollutant concentrations, weather conditions conducive to dust impacts, etc.
- Assessment of all activities operating simultaneously.
- Limitation of the CALPUFF model in predicting near-field pollutant concentrations.
- Overestimation of dust impacts due to model limitations related to the effects of rainfall.

The key recommendations of this study are:

- Real-time monitoring of ambient air quality be performed throughout the construction period to assist with effective site management and minimising the potential for adverse air quality impacts at sensitive receptors.
- A TARP based on 1-hour average PM_{10} concentrations and wind directions with a range of actions to minimise the potential for adverse effects at the sensitive receptors should be adopted.

It is concluded that with an appropriate AQMP and TARP in place the proposed construction activities can be completed without any significant impact on the surrounding receptors.

The screening-level assessment of operational stage emissions found that the incremental impacts associated with vehicle traffic on surrounding roads was negligible at the closest receptors. This means that Project vehicles are unlikely to result in a significant worsening of air quality impacts at these locations. Air quality is not a constraint for Project operations, and a detailed assessment is not required.

8.0 References

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Appendix A Selection of Representative Meteorological Data

Aspect Industrial Estate, Kemps Creek Warehouse 4

Air Quality Impact Assessment

Mirvac Projects Pty Ltd

SLR Project No.: 610.033228.00001

11 December 2025

Meteorological Year Selection

Once emitted to atmosphere, the emissions will:

- Rise according to the momentum and buoyancy of the emission at the discharge point relative to the prevailing atmospheric conditions.
- Be advected from the source according to the strength and direction of the wind at the height which the plume has risen in the atmosphere.
- Be diluted due to mixing with the ambient air, according to the intensity of turbulence.
- (Potentially) be chemically transformed and/or depleted by deposition processes.

Dispersion is the combined effect of these processes. Dispersion modelling is used as a tool to simulate the air quality effects of specific emission sources, given the meteorology typical for a local area together with the expected emissions. Selection of a year when the meteorological data is atypical means that the resultant predictions may not appropriately represent the most likely air quality impacts. Therefore, in dispersion modelling, one of the key considerations is the representative nature of the meteorological data used.

The year of meteorological data used for the dispersion modelling was selected by reviewing the most recent five years of historical surface observations at (2019 to 2023 inclusive) to determine the year that is most representative of average conditions. Wind direction and wind speed were compared to averages for the region to determine the most representative year.

It is noted that comparison of meteorological data was conducted prior to SLR obtaining 2024 BoM data, therefore 2024 has not been included in the comparison.

Data collected from 2019 to 2023 is summarised in **Figures A-1** to **A-2**. Examination of the data indicates the following:

Figure A-1 indicates relatively similar wind roses for all years analysed.

Figure A-2 indicates that 2021 exhibit wind speeds that are lower than the 5-year average which will result in a conservative assessment due to reduced dispersion.

Given the above, the year 2021 was selected as the representative year of meteorology.

Figure A-1 Frequency of Winds at Horsley Park Equestrian Centre AWS for 2019 – 2023

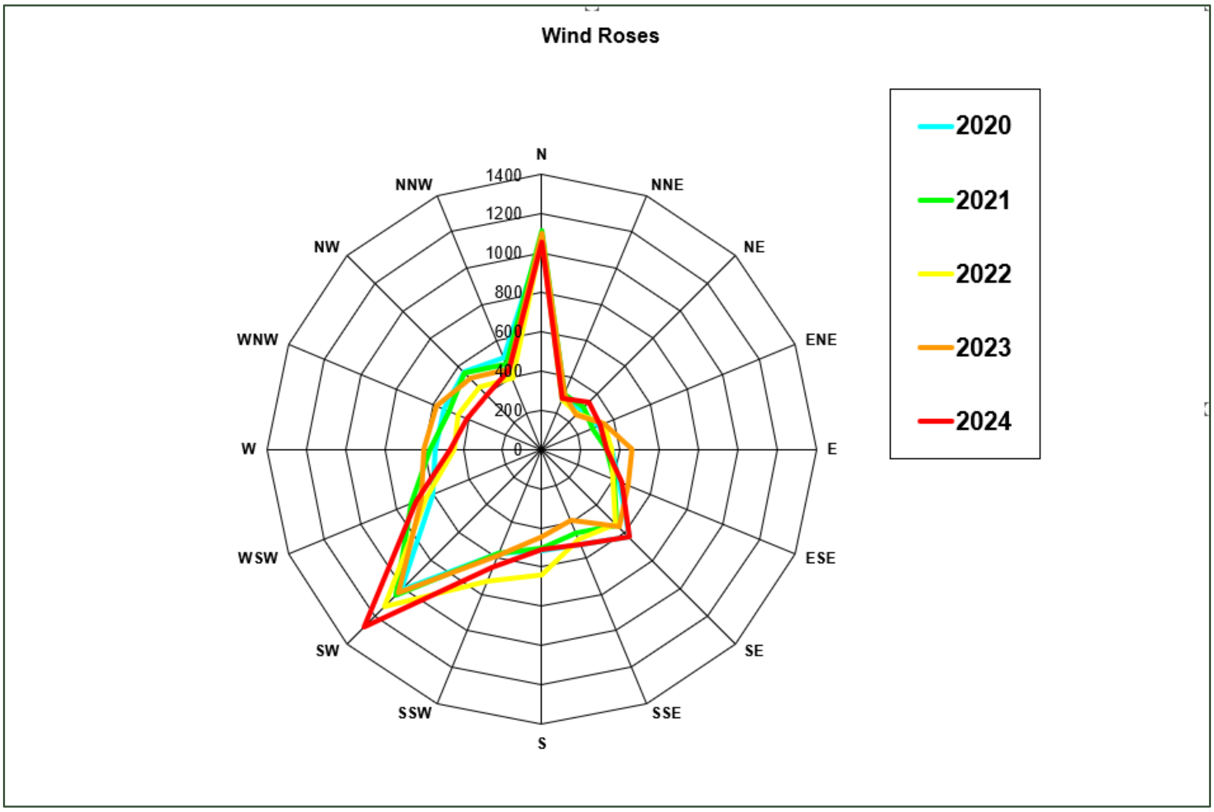
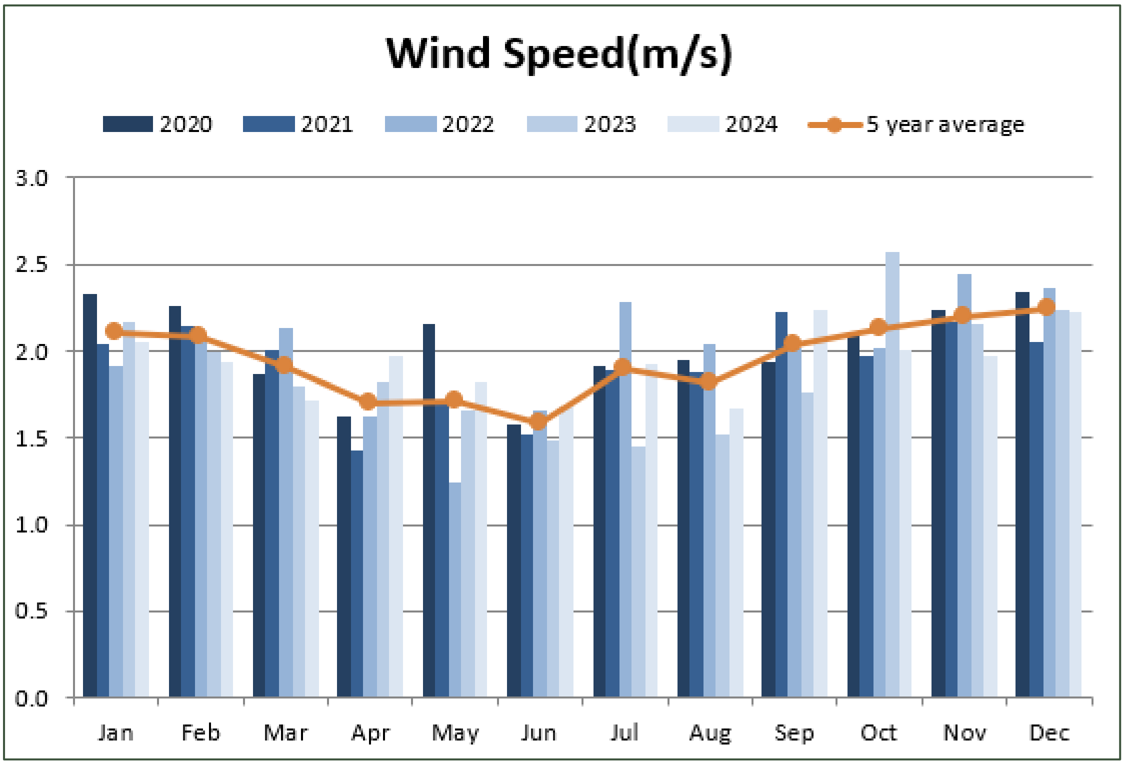


Figure A-2 Monthly Average Wind Speed at Horsley Park Equestrian Centre AWS for 2019 – 2023



Appendix B Evaluation of Meteorological Data

Aspect Industrial Estate, Kemps Creek Warehouse 4

Air Quality Impact Assessment

Mirvac Projects Pty Ltd

SLR Project No.: 610.033228.00001

11 December 2025

The primary meteorological data parameters relevant for dispersion modelling are typically:

- wind (wind speed and direction)
- turbulence (atmospheric stability)
- mixing height (depth of turbulent layer)

A review of the meteorological data used in the dispersion modelling for the above parameters is provided below.

Wind Speed and Wind Direction

A summary of the annual wind behaviour predicted by CALMET for 2021 (extracted at the Site) is presented as wind roses in **Figure B-1** and as a wind speed distribution plot in **Figure B-2**. These plots show that winds in the study area were predicted to be predominantly light to moderate during 2021. Calm wind conditions were predicted to occur approximately 10.3% of the time throughout the modelling period. Generally, higher wind speeds and a low percentage of calm wind conditions will assist pollutant dispersion, resulting in lower pollution concentrations at the surrounding receptors.

The seasonal wind roses indicate that typically:

- In summer, winds blow from all directions except the northwestern quadrant, where winds occur infrequently. Calms were recorded approximately 6.5% of the time during the summer months.
- In autumn, winds predominantly blow from the southwestern quadrant, with the least frequent winds originating from the northeastern quadrant. Calms were recorded approximately 12.9% of the time during the autumn months.
- In winter, winds predominantly blow from the southwestern and northwestern quadrants, with the least frequent winds originating from the northeastern and southeastern quadrants. Calms were recorded 14.7% of the time.
- In spring, winds blow almost evenly from all directions. Calms were recorded approximately 7.0% of the time during spring.

A comparison of the wind roses presented in **Figure B-1** with the Horsley Park Equestrian Centre AWS wind roses presented in **Figure 10** shows that the frequency distribution of wind speed and direction for both is very similar throughout the year, with the CALMET predictions having slightly lower calm frequency.

Figure B-1 CALMET-Predicted Seasonal Wind Roses for the Site – 2021

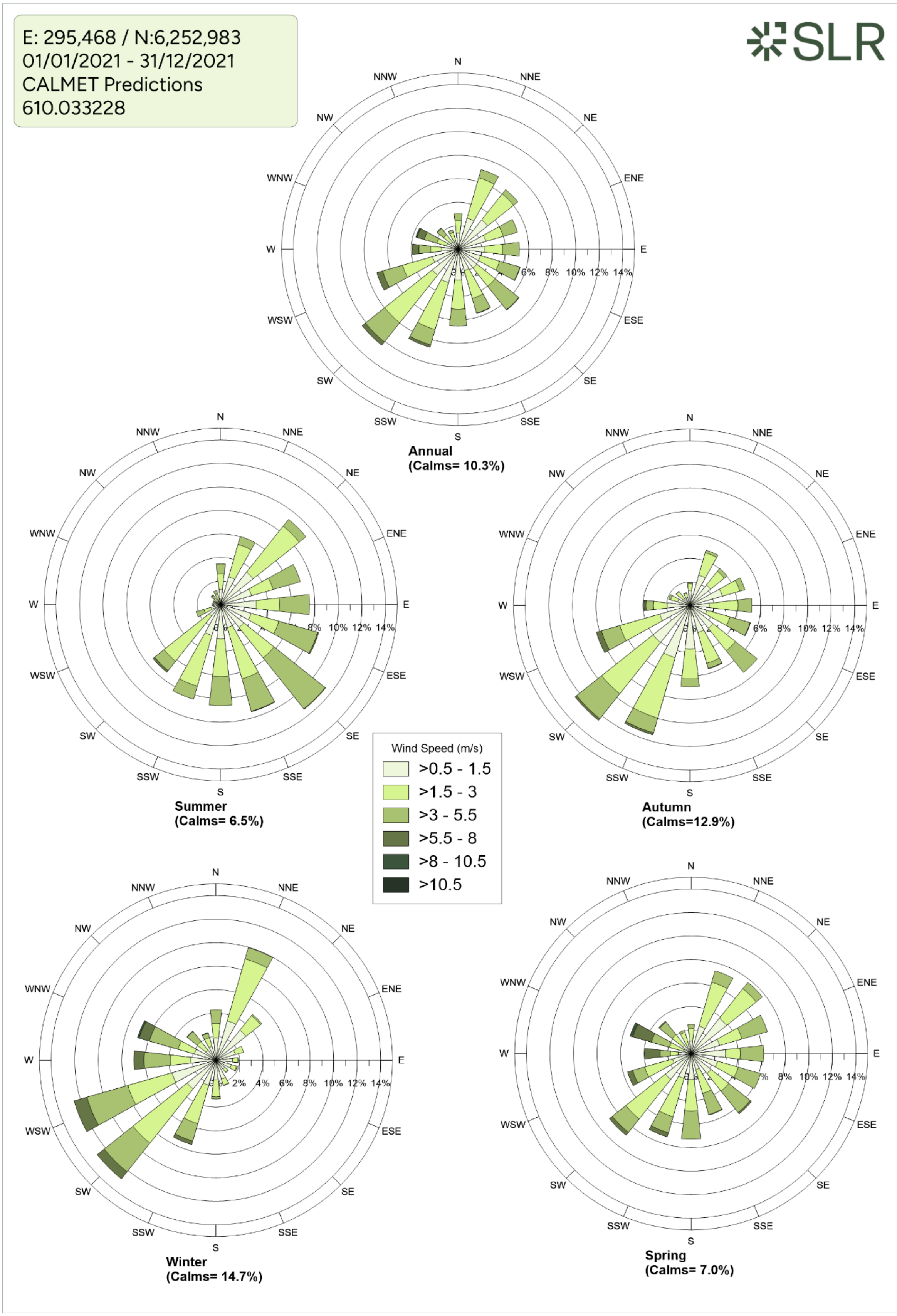
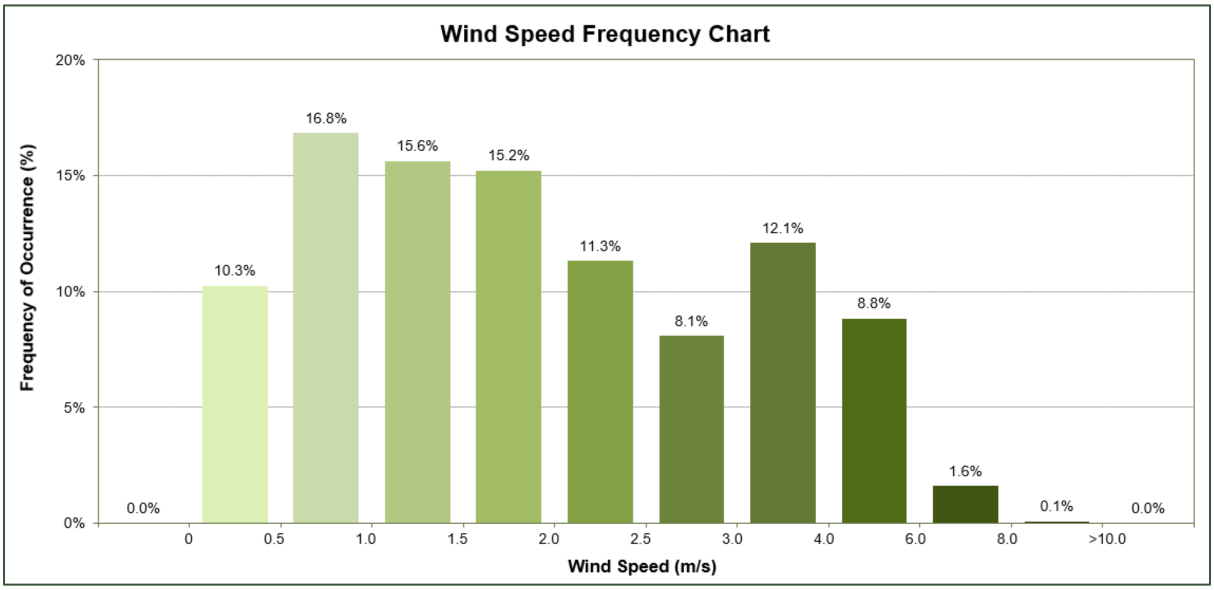


Figure B-2 Annual Wind Speed Frequencies at the Site (CALMET Predictions, 2021)



Atmospheric Stability

Atmospheric stability refers to atmospheric turbulence and the tendency of the atmosphere to resist or enhance vertical motion. Depending on conditions the atmospheric stability can either inhibit or promote pollutant dispersion. The Pasquill-Gifford scheme provides six stability classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in **Table B-1**.

Unstable conditions are favourable for dispersion, while stable conditions are unfavourable for dispersion.

The dispersion modelling in CALPUFF used a more advanced atmospheric stability scheme (based on micro meteorology). Stability class data were extracted from the meteorological dispersion modelling data set for the meteorological data evaluation.

Table B-1 Meteorological Conditions Defining PGT Stability Classes

Surface Wind Speed (m/s)	Daytime Insolation			Night-Time Conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

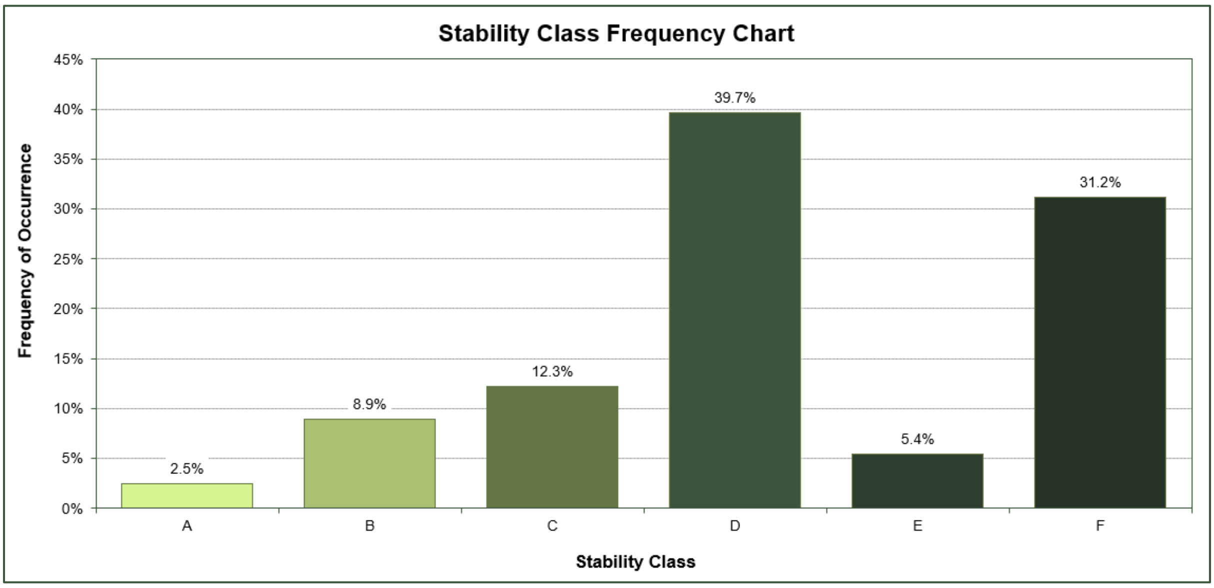
Source: (NOAA 2018)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England, slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The frequency of each stability class predicted by CALMET at the Site during the modelling period is presented in **Figure B-3**. The results indicate a high frequency of conditions typical to Stability Class D and F. Stability Class D is indicative of neutral conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing. Stability Class F is indicative of calm conditions, which typically indicates poorer dispersion of pollutants.

Figure B-3 Predicted Stability Class Frequencies at the Site (CALMET predictions, 2021)



Mixing Heights

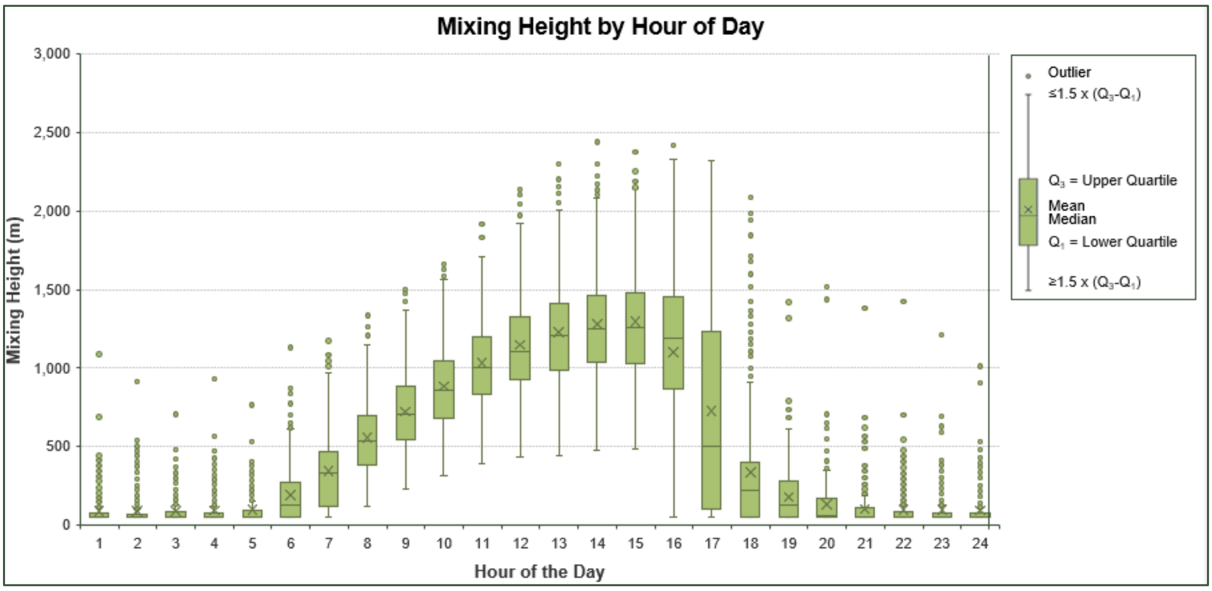
The mixing height is the depth of the atmospheric mixing layer between ground level and an elevated temperature inversion. Depending on conditions, vertical dispersion is typically limited by the mixing height. This is an important parameter in dispersion modelling since the mixing height largely sets the vertical profile the dispersion can take place in.

Mixing heights have a diurnal variation in response to mixing from convection due to insolation and grow from sunrise to around midday. Followed by a decline until sunset when there typically is a rapid decline. If a plume penetrates through, or is released above, the mixing height the pollutants will be trapped aloft with no mixing to ground level (unless in specific conditions such as fumigation). Similarly, if a plume is trapped below a low mixing height (inversion layer) the vertical dispersion will be limited, and higher ground-level concentrations are likely to occur.

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Site during the 2021 modelling period are illustrated in **Figure B-4**.

As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and growth of the convective mixing layer.

Figure B-4 Predicted Mixing Heights at the Site (CALMET predictions, 2021)



Appendix C Emission Factors and Assumptions for Emissions Estimation

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Particulate matter emissions from the Site have been estimated using published emission factors for the relevant emission sources. Emission factors were sourced from the following documents:

- National Pollutant Inventory Emissions Estimation Technique Manual (NPI EETM) for Mining Version 3.1 (DSEWPC 2012)
- US EPA AP42 Section 11.9 Western Surface Coal Mining (US EPA 1998)
- US EPA AP42 Section 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing (US EPA 2004)
- US EPA AP42 Section 13.2.2 Unpaved Roads (US EPA 2006a)
- US EPA AP42 Section 13.2.4 Aggregate Handling and Storage Piles (US EPA 2006b)
- US EPA AP42 Section 13.2.5 Industrial Wind Erosion (US EPA 2006)
- Proposed Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors (Cowherd, Donaldson and Hegarty 2010)
- National Pollutant Inventory Emissions Estimation Technique Manual (NPI EETM) for Combustion engines Version 3.0 June 2008 (DEWHA 2008)

A summary of the emission factor equations used to estimate emissions from each activity at the Site are presented in **Table C-1**.

The assumptions applied to the relevant equations are provided as follows:

- Material properties refer to **Table C-2.**
- Vehicle properties and exposed areas refer to **Table C-3**.

Dust control measures are presented in **Table C-5**.

Estimated emission rates are presented in **Table C-6**.

Table C-1 Summary of Emission Factor/ Equations Used to Estimate Emissions

Activity	Emission Factor			Units	Source	Notes
	TSP	PM_{10}	$PM_{2.5}$			
Scraper stripping topsoil and cut material	$EF_{TSP} = 0.029$	$EFPM_{10} = 0.0073$	$EFPM_{2.5} = 0.0015$	kg/t	EFTSP: (US EPA 1998) $EFPM_{10}$: (DSEWPC 2012) $EFPM_{2.5}$: (Cowherd, Donaldson and Hegarty 2010)	As detailed in Section 1.1.13 of the NPI EETM for Mining (DSEWPC 2012), the PM_{10} emission factor was derived from the application of PM_{10}/TSP ratio for the scraper in travel mode (i.e. 25%).
Unloading and unloading (material transfer)	$EF_{TSP} = \frac{0.74 \times 0.0016 \times \frac{U}{2.2}^{1.3}}{\frac{M}{2}^{1.4}}$	$EF_{PM10} = \frac{0.35 \times 0.0016 \times \frac{U}{2.2}^{1.3}}{\frac{M}{2}^{1.4}}$	$EF_{PM2.5} = \frac{0.053 \times 0.0016 \times \frac{U}{2.2}^{1.3}}{\frac{M}{2}^{1.4}}$	kg/t	EFTSP & $EFPM_{10}$: (DSEWPC 2012) $EFPM_{2.5}$: (US EPA 2006b)	U1.3/2.2 = wind speed factor = 1.0 Refer to **Table C-2** for moisture (M) assumptions

Activity	Emission Factor			Units	Source	Notes
	TSP	PM_{10}	$PM_{2.5}$			
Dozer	$EF_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}}$	$EF_{PM10} = 0.34 \times \frac{s^{1.5}}{M^{1.4}}$	$EFPM_{2.5} = 0.105 \times EFPM_{10}$	kg/h	EFTSP & $EFPM_{10}$: (DSEWPC 2012) $EFPM_{2.5}$: (Cowherd, Donaldson and Hegarty 2010)	Refer to **Table C-2** for silt (s) and moisture (M) assumptions
Crushing	EFTSP = 0.0027	$EFPM_{10}$ = 0.0012	$EFPM_{2.5}$ = 0.148 × TSP	kg/t	(US EPA 2004)	The $PM_{2.5}$ emission factor was derived from the application of $PM_{2.5}/PM_{10}$ ratio of tertiary crushing (controlled) emission factors
Vehicle Movements on Unpaved Roads	$EF_{TSP} = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM10} = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM2.5} = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	kg/VKT	(US EPA 2006a)	Refer to **Table C-2** for surface silt (s) and vehicle weight (W) assumptions
Diesel Combustion	EFTSP = 1.17	$EFPM_{10}$ = 1.17	$EFPM_{2.5}$ = 1.12	kg/ m^3	(DEWHA 2008)	All TSP is assumed to be PM_{10}

Activity	Emission Factor			Units	Source	Notes
	TSP	PM_{10}	$PM_{2.5}$			
Wind Erosion of Exposed Areas	EFTSP = 0.4	$EFPM_{10}$ = 0.5 × EFTSP	$EFPM_{2.5}$ = 0.075 × EFTSP	kg/ha/hr	EFTSP & $EFPM_{10}$: (DSEWPC 2012) $EFPM_{2.5}$: (US EPA 2006)	Refer to **Table C-4** for assumptions.

Where:

M = material moisture content (%)

s = material silt content (or surface silt content in unpaved roads) (%)

U = wind speed (m/s)

W = mean vehicle weight (tonnes)

S = mean vehicle speed (km/h)

Table C-2 Emission Factor Assumptions - Material Properties

Parameter	Value	Units	
Silt content	8.5	%	Double the average silt content value in AP42 Section 11.9 Table 11.9-3 (Overburden mean) (US EPA 1998)
Moisture content	4	%	Conservatively half of the average moisture content value in AP42 Section 11.9 Table 11.9-3 (Overburden mean) (US EPA 1998)
Topsoil density	1.7	t/m^3	Provided by client based on geotechnical report findings
Clay density	1.7	t/m^3	
Hard rock density	3.0	t/m^3	

Table C-3 Emission Factor Assumptions – Vehicles

Variable	Value	Units	Source
Scrapers – Cut			
Empty weight	75	tonnes	https://www.cat.com/en_US/products/new/equipment/wheel-tractor-scrapers/open-bowl-scrapers/111020.html
Capacity	45	tonnes per load	
Gross weight	120	tonnes	
Average empty/gross weight	97.5	tonnes	
Dozers - Hard Rock - Extraction(a)(b)			
Number of units	2	-	Client information
Utilisation	75	%	
Operating hours	5,148	Hours per year	Client information

Variable	Value	Units	Source
Import/Export Trucks			
Empty weight	33	tonnes	Client information
Capacity	41	tonnes per load	
Gross weight	74	tonnes	
Average empty/gross weight	53.5	tonnes	

Table C-4 Material Movements and Travel Distances

Parameter	Annual/Max Unit	Unit
Earthworks quantities		
Topsoil total	-	m^3 / 3 months
	-	tonnes / 3 months
	-	tonnes / year
	-	m^3 / year
Cut - Clay	9,076	m^3/2months
	15,429	tonnes/2months
	92,575	tonnes/annual
	54,456	m^3/annum
Cut - Hard Rock	-	m^3 / 3 months
	-	tonnes / 3 months
	-	tonnes / year
	-	m^3 / year

Parameter	Annual/Max Unit	Unit
Cut (excluding topsoil)	20,807	tonnes / 3 months
	124,840	tonnes / year
	68,070	m^3 / year
Import	8,185	m^3 / 3 months
	15,011	tonnes / 3 months
	90,068	tonnes / year
Fill	19,530	m^3 / 3 months
	35,818	tonnes / 3 months
	214,908	tonnes / year
Wind Erosion		
Site area	14.0	ha
Actively disturbed area	2.8	ha
Scrapers (Total)		
Scrapers removal topsoil %	100%	% of topsoil material moved using scraper
Scrapers removal % clay	100%	% of all material moved using scraper
Scrapers removal % hard rock	0%	% of hard rock moved using scraper
Topsoil		
Scrapers removal - topsoil	-	tonnes / year
Scraper empty weight	75.0	tonnes
Scraper capacity - for inventory	45.0	tonnes per load
Scraper gross weight	120.0	tonnes
Scraper - average empty/gross - for inventory	97.5	tonnes
Scraper travel distance	0.6	km/trip

Parameter	Annual/Max Unit	Unit
Scraper trips	2,774.2	trips/year
Scraper - travel	1,942.0	VKT/year
Cut material		
Scrapers removal - clay	92,575	tonnes / year
Scrapers removal - hard rock	-	tonnes / year
Scrapers removal - total	124,840.4	tonnes / year
651 Scraper empty weight	210,038.4	tonnes
651 Scraper capacity - for inventory	75.0	tonnes per load
651 Scraper gross weight	45.0	tonnes
651 Scraper - average empty/gross	120	tonnes
Scraper travel distance	98	km/trip
Scraper trips	0.6	trips/year
Scraper - travel	1,942.0	VKT/year
Excavator / FEL		
Road length to crusher	0.5	km/return trip
Quantity of material moved - clay	-	tonnes / year
Quantity of material moved - hard rock	-	tonnes / year
Quantity of material moved - total	-	tonnes / year
Dozer		
Total no.	2.0	
Utilisation	75%	%
Hours per year (total)	4,538	hours per year
Crushing		

Parameter	Annual/Max Unit	Unit
Crushing	-	tonnes / year
Onsite material transfer		
Haul road silt content	8.6	%
Haul road length	0.5	km/return trip
Import / Export		
Haul truck empty weight	33.0	tonnes
Haul truck capacity - for inventory	41.0	tonnes per load
Haul truck gross weight	74.0	tonnes
Haul truck - average empty/gross - for inventory	53.5	tonnes
Number of return trips across pit	2,196.8	trips/annum
Haul road silt content	8.6	%
Haul road length	0.8	km/return trip
Truck unloading at fill area	90,067.7	tonnes / year
Fuel usage		
Diesel combustion -Stage 2	200,000.0	L/year

Table C-5 Control Measures

Control Measure	Control Efficiency
Water carts used while scrapers stripping	50%
Water carts used while scraper travels	75%
Water carts used on haulage routes (Level 2 watering (>2 L/m^2/h)	75%
Water carts used with dozer activities*	50%
Water carts used on exposed area	50%
Source: (DSEWPC 2012) *Assumed to be similar to scrapers stripping.	

Haul Road Watering to Supress Wheel Generated Dust

The NPI EETM for Mining indicates emission control of wheel generated dust as follows:

- Level 1 watering (2 L/m^2/h): 50% control
- Level 2 watering (>2 L/m^2/h): 75% control

Site specific watering emission control C expressed as a percentage can be estimated from typical evaporation rates for the area and haul road traffic rate using the following equation (Air & Waste Management Association 2000):

$$C = 100 - \frac{0.8pdt}{i}$$

where p is the average hourly daytime evaporation rate, d is the average hourly daytime traffic rate, t is the time (hours) between water application and i is the application intensity (L/m2).

BoM[1] publish total evaporation maps for Australia showing the amount of water which evaporates from an open pan. Annual average and seasonal average evaporation rates for the area in which the Site is situated are calculated from these maps which indicate the following:

- approximate total annual average evaporation rate: 1600 mm, or 0.18 mm/h
- approximate total summer average evaporation rate: 600 mm, or 0.28 mm/h

Using water carts and water sprays to supress dust emissions will achieve less control in areas with greater evaporation than areas with less evaporation. Greater rates of watering are likely to be required in summer when evaporation rates are increased to achieve adequate dust control.

From the evaporation rates above, if a conservative traffic rate of 40 movements per hour and 1 hour between water applications, a control of greater than 90% is calculated for the Site haul roads (including for the summer months) with a watering rate of less than 1 L/m^2/h. This control rate would increase with more frequent water application, likely lower traffic rates, and the anticipated watering rate of less than 2 L/m^2/h. However, for modelling

[1] Australian Climate Averages - Evaporation (Climatology 1975-2005), , http://www.bom.gov.au/jsp/ncc/climate_averages/evaporation/index.jsp?period=sum#maps, accessed February 2025

purposes, a 75% control factor was conservatively applied to the unpaved haul road wheel generated dust estimates.

Table C-6 Emission Factors

Activity	TSP Emission Factor	PM_{10} Emission Factor	PM2.5 Emission Factor	Units
Scrapers stripping clay and shales	0.0290	0.0083	0.00083	kg/t
Scraper travel moving clay and shales to fill	0.0852	0.0244	0.0024	kg/t
Scraper unloading clay and shales to fill area	0.0004	0.0002	0.0000	kg/t
FEL- rehandling material at fill area	0.0004	0.0002	0.0000	kg/t
Imported material haulage to fill area	0.0764	0.0219	0.0022	kg/t
Unloading at fill area (from imported material)	0.0005	0.0002	0.0000	kg/t
Dozer (x1) - ripping, pushing and compacting materials (topsoil/clay/shales)	5.76	1.24	0.61	kg/h
Wind erosion (active)	0.4000	0.2000	0.0200	kg/ha/hour
Diesel combustion	1.1700	1.1700	1.1200	kg/m3

Appendix D Variable Emission file

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Variable Emission File – Calculation Steps

A brief summary of the steps used in calculating the hourly varying emission rates for each source are presented below.

Step 1: Calculate annual average emission rate (kg/year) for FP, CM and RE

FPannual = $PM_{2.5}$, annual	(FP) Fine Particulate – particulate of size less than 2.5 μm
CMannual = PM_{10}, annual – $PM_{2.5}$, annual	(CM) Coarse Particulate – particulate of size between 10 μm and 2.5 μm
REannual = TSPannual - PM10, annual	(RE) Rest Particulate – particulate of size greater than 10 μm

Step 2: Identify the operating hours for each activity

Step 3: Classify the sensitivity of each type of activity to wind speed

Wind insensitive: activities with emission factor that is independent of wind speed (e.g. blasting)

Wind sensitive: activities with emission factor that is a function of (wind speed/2.2)1.3 (e.g. loading)

Wind erosion: emission from exposed areas/stockpiles

Step 4: Identify the number of sources associated with each activity

Note that each wind erosion source is modelled as an independent source.

Step 5: Calculate the hourly average emission rate for each activity per source

$$FP_{AC,i,h} = \frac{FP_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i} \times WSFactor_{i,h}}$$ $$CM_{AC,i,h} = \frac{CM_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i} \times WSFactor_{i,h}}$$ $$RE_{AC,i,h} = \frac{RE_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$ **FOR WIND INSENSITIVE ACTIVITIES** $$WSFactor_{i,h} = 1$$ **FOR WIND SENSITIVE ACTIVITIES** $$WSFactor_{i,h} = \frac{\left(\frac{WS_h}{2.2}\right)^{1.3}}{\frac{\sum_{j=1}^{n}\left(\frac{WS_j}{2.2}\right)^{1.3}}{n}}$$ **FOR WIND EROSION ACTIVITIES** $$WSFactor_{i,h} = \frac{(WS_h)^3}{\frac{\sum_{j=1}^{n}(WS_j)^3}{n}}$$	WHERE: FPAC,I,H- FINE PARTICULATES EMISSION RATE FOR ACTIVITY I (G/S) AT HOUR H CMAC,I,H- FINE PARTICULATES EMISSION RATE FOR ACTIVITY I (G/S) AT HOUR H CMAC,I,H- FINE PARTICULATES EMISSION RATE FOR ACTIVITY I (G/S) AT HOUR H OHI-DAILY OPERATING HOURS (1- 24) FOR ACTIVITY I NDAYS -NUMBER OF DAYS IN THE METEOROLOGICAL DATA FILE NS,I -NUMBER OF SOURCES ASSOCIATED WITH ACTIVITY I WSH-WIND SPEED AT THE HOUR N -NUMBER OF HOURS IN THE METEOROLOGICAL DATA FILE

Note: If the activity was modelled as area source, the equation on the left column of the table needs to be divided by the area of that activity.

Step 6: Calculate hourly average emission rate for each source

To calculate the emission rate for a particular source for a particular hour, add up the calculated emission rate for each activity associated with source.

For example, if Source 1 is associated with Activity 1, Activity 2 and Activity 3, then:

ERS1,h,FP = FPAC,1,h+ FPAC,2,h+ FPAC,3,h

ERS1,h,CM = CMAC,1,h+ CMAC,2,h+ CMAC,3,h

ERS1,h,RE = REAC,1,h+ REAC,2,h+ REAC,3,h

Appendix E Isopleths

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Figure E-1 24-hour Average Incremental Impacts of $PM_{2.5}$

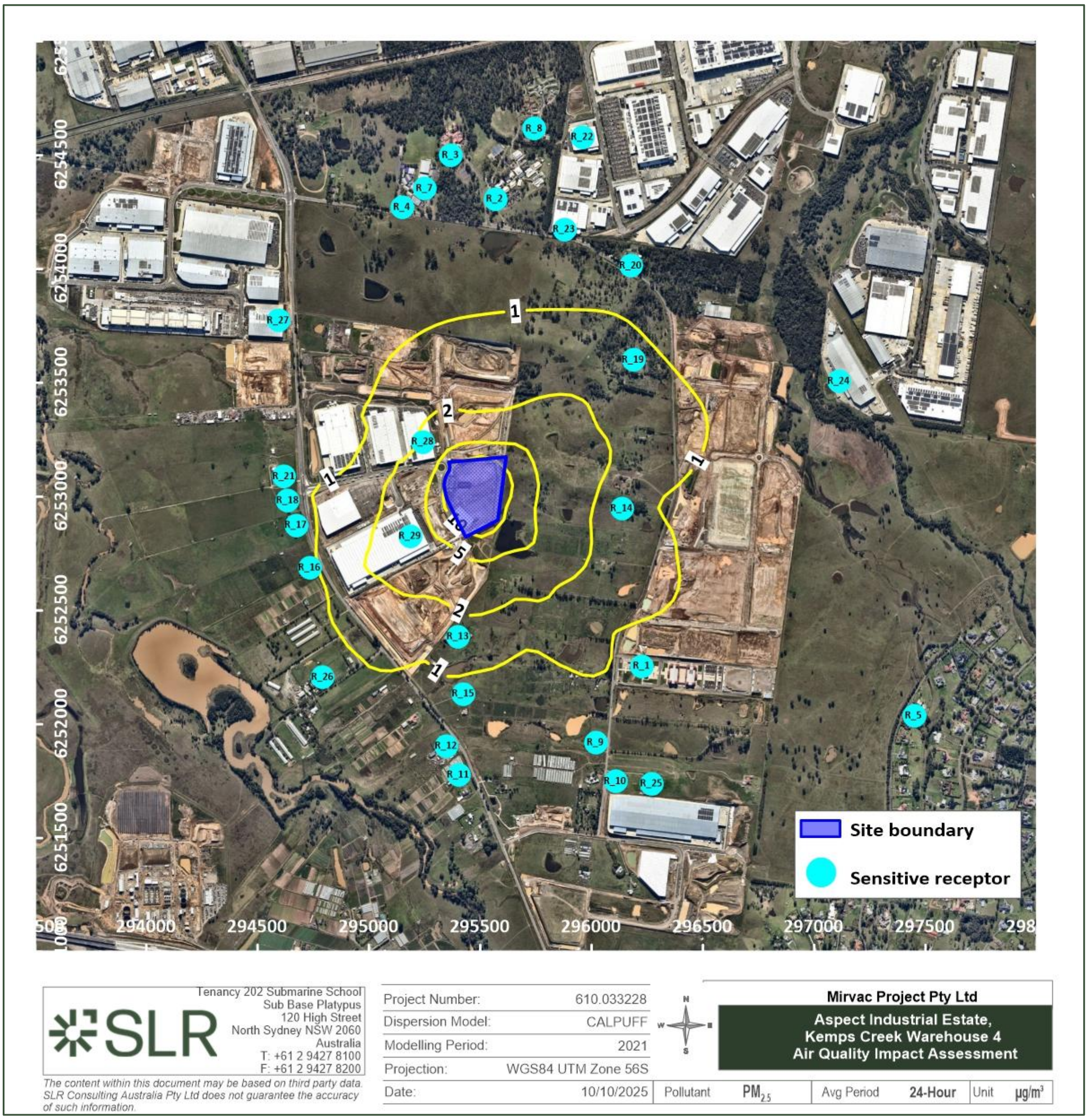


Figure E-2 Annual Average Incremental Impacts of $PM_{2.5}$

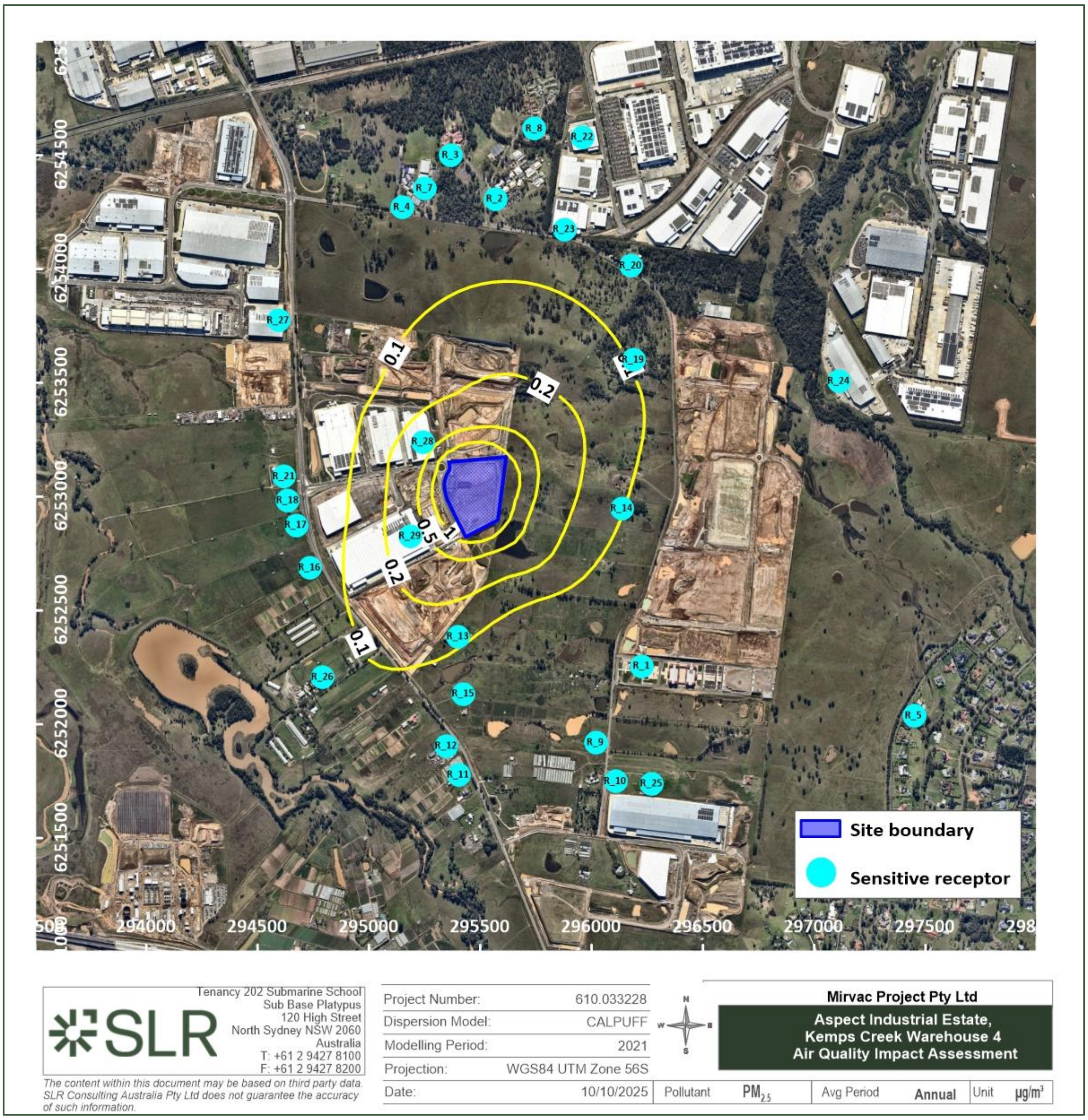


Figure E-3 24-hour Average Incremental Impacts of PM_{10}

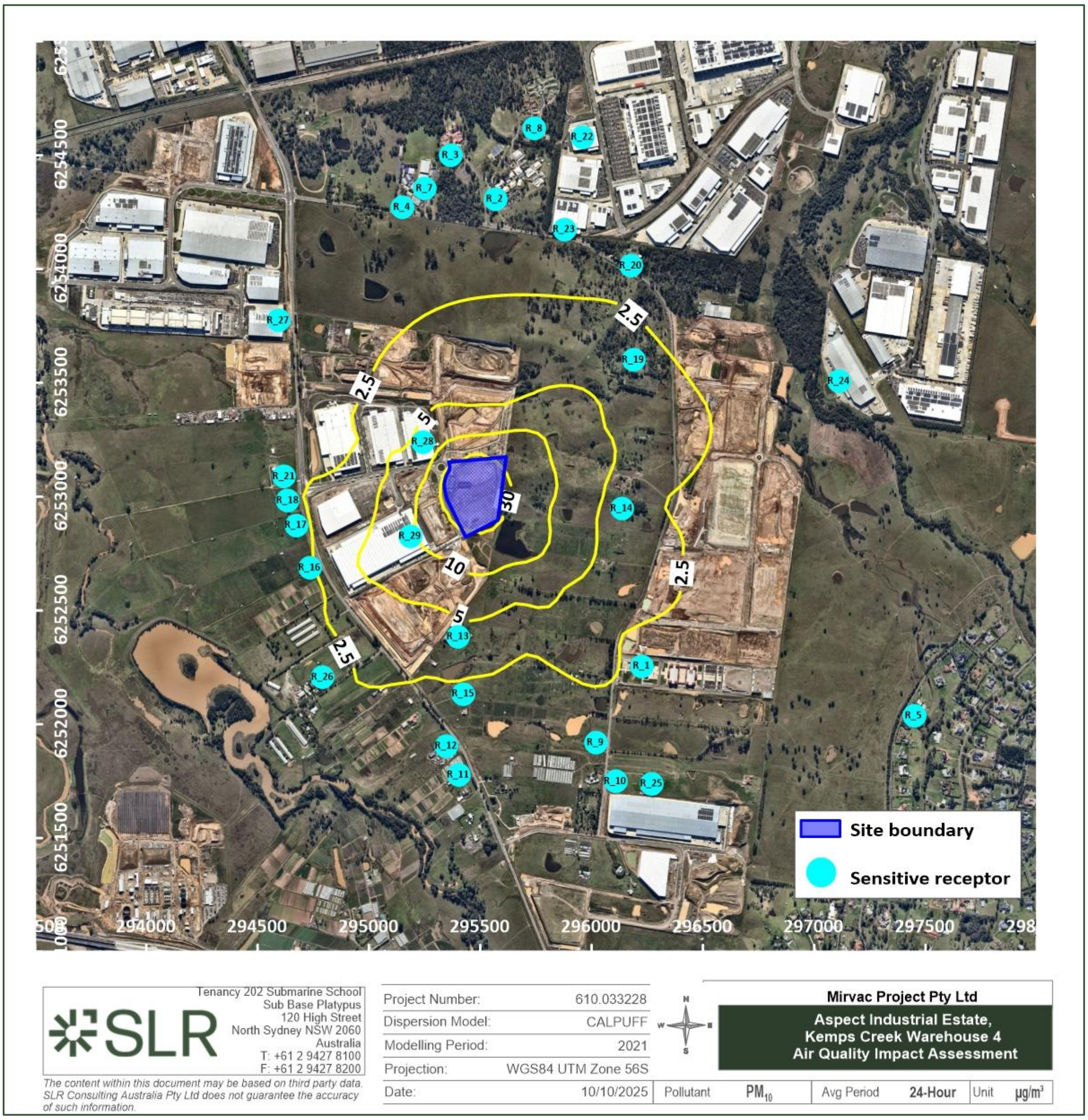


Figure E-4 Annual Average Incremental Impacts of PM_{10}

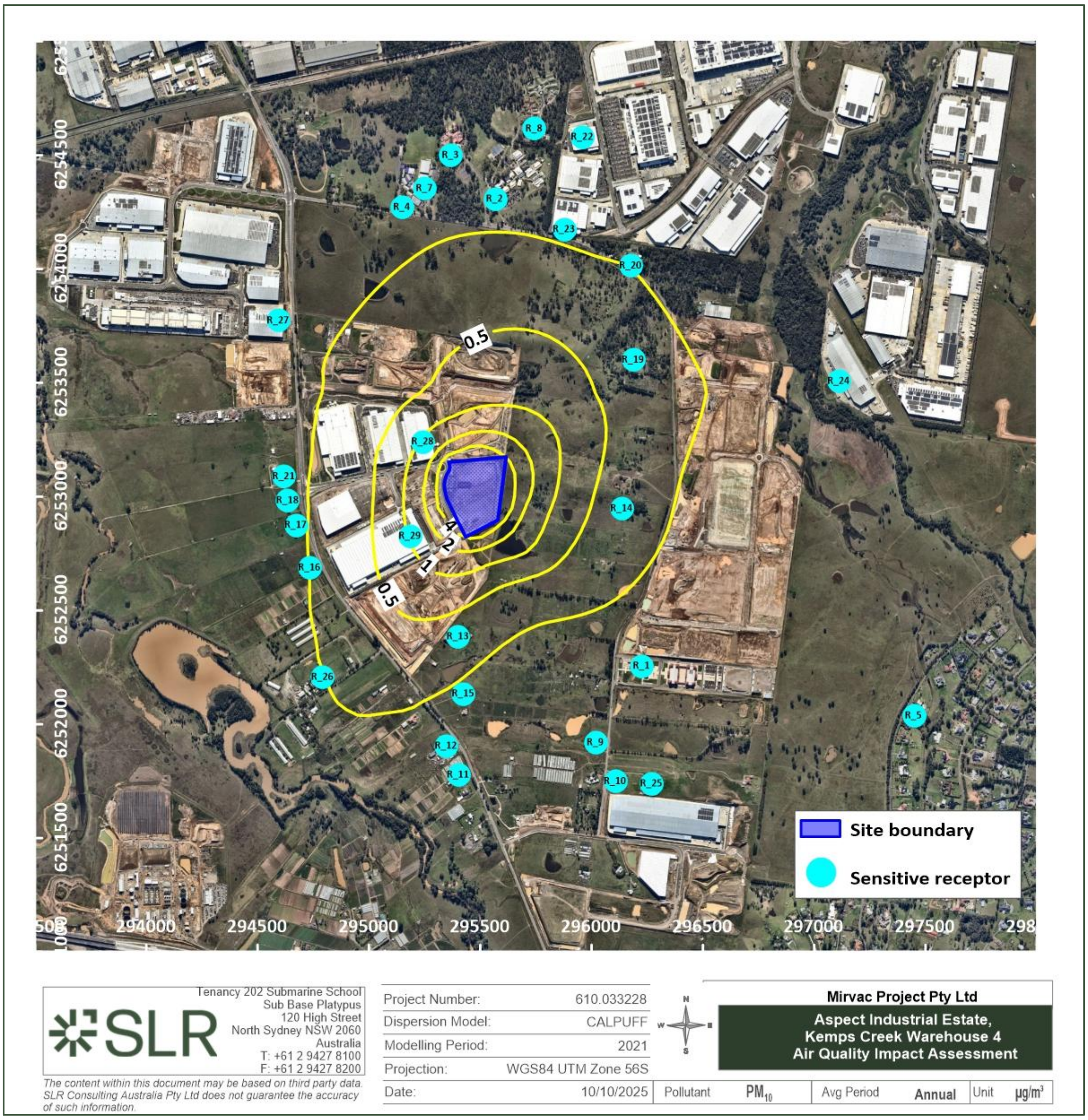


Figure E-5 Annual Average Incremental Impacts of TSP

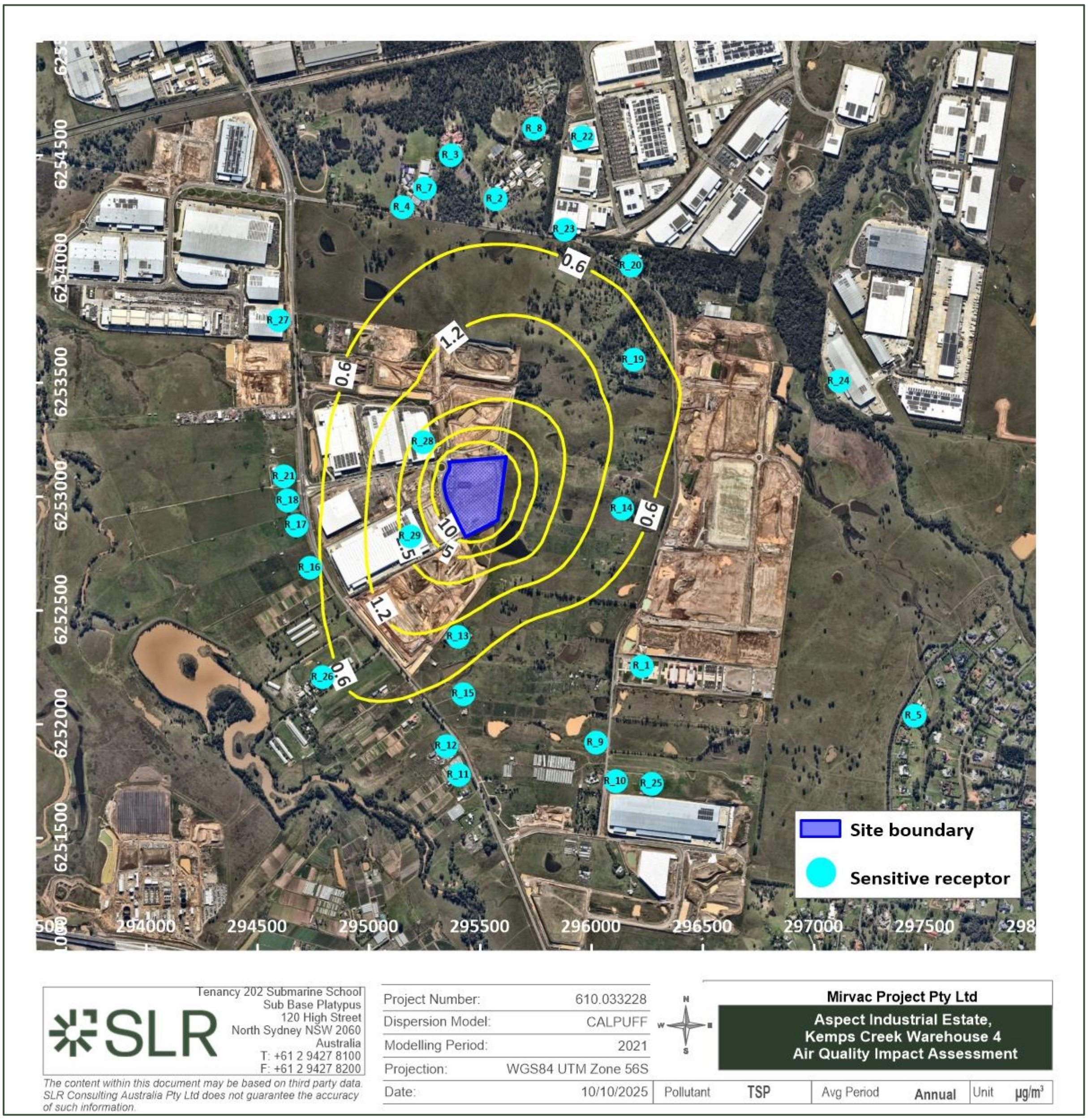
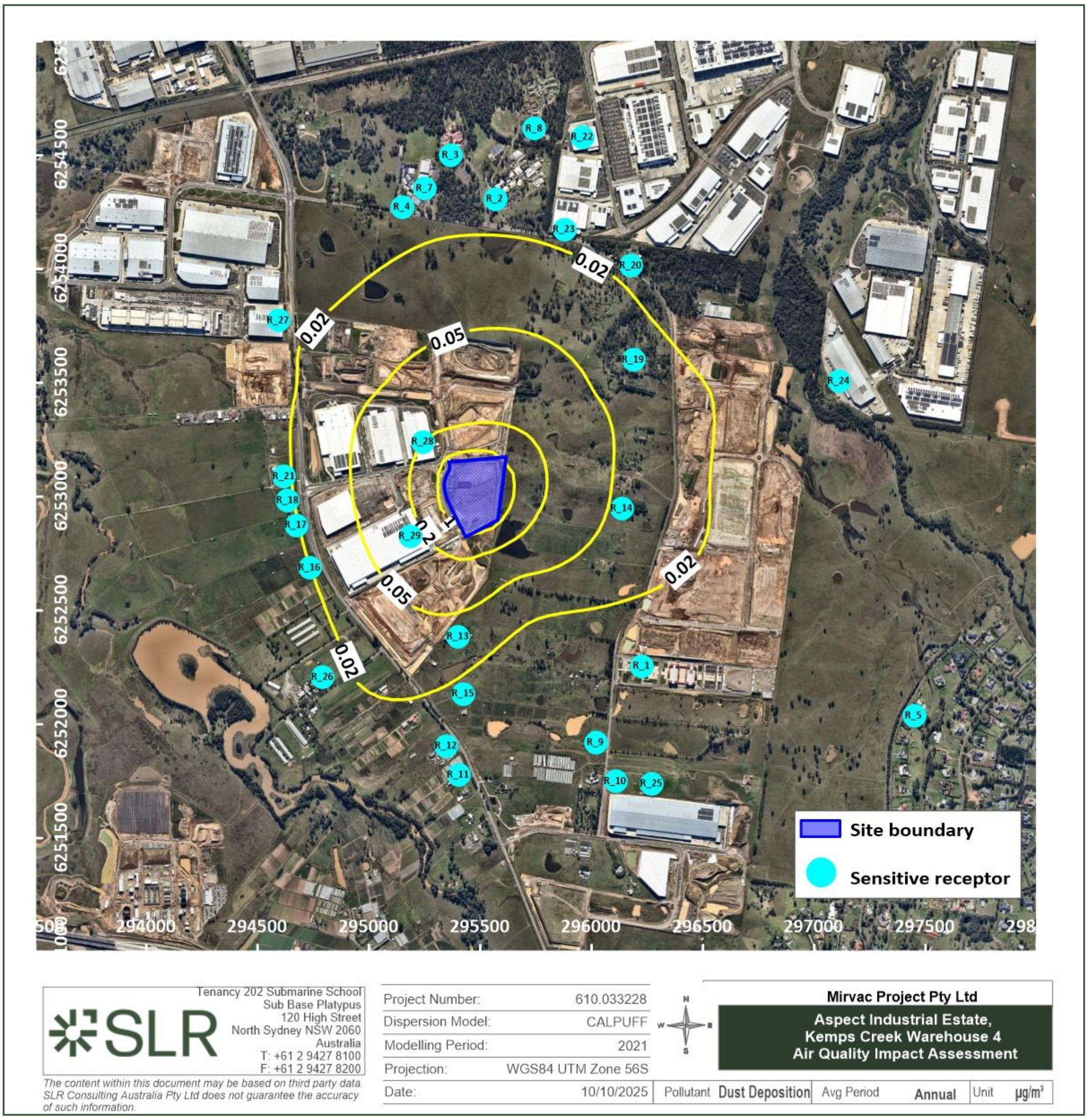


Figure E-5 Annual Average Incremental Impacts of Dust Deposition



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