AIR QUALITY ASSESSMENT

FIRST BUILDING BRADFIELD

Western Parkland City Authority

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Job Number 20101198

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Air Quality Assessment
First Building Bradfield

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for the Western Parkland City Authority. The report presents an air quality assessment for the proposed development of the Bradfield City Centre First Building at Bradfield, New South Wales (NSW) (hereafter referred to as the Project).

The purpose of the First Building within the Bradfield City Centre will be an advanced manufacturing research, development and training facility to support early industry engagement, investment attraction, employment and skills-development in the advanced manufacturing sector. This air quality assessment investigates the potential for air quality impacts to arise due to the construction and operation of the First Building in the surrounding environment.

This air quality assessment has been prepared in general accordance with the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

To assess the potential air quality impacts associated with the Project, this report incorporates the following aspects:

- A background to the Project and description of the proposed site and operations;
- A review of the existing meteorology surrounding the site;
- A description of the dispersion modelling approach and emission estimation used to assess potential air quality impacts;
- Presentation of the predicted results and discussion of the potential air quality impacts; and,
- Recommendations for consideration to incorporate in the development to mitigate any potential air quality impacts.

2 PROJECT BACKGROUND

2.1 Project setting

The Project site is located approximately 19.5 kilometres (km) south-southwest of Penrith and approximately 17km west of Liverpool. The local land use surrounding the site is currently comprised of rural properties and open paddock land. Most of the Project site is cleared with clusters of trees in parts.

Figure 2-1 presents the location of the Project site and selected residential receptors assessed as discrete receptors in this assessment. **Table 2-1** presents the approximate address of each of the residential receptors assessed.

Table 2-1: Residential receptor address

Receptor ID	Address	Receptor ID	Address
R1	162 Badgerys Creek Road, Bringelly	R10	175A Badgerys Creek Road, Bringelly
R2	158 Badgerys Creek Road, Bringelly	R11	155 Badgerys Creek Road, Bringelly
R3	142 Badgerys Creek Road, Bringelly	R12	145 Badgerys Creek Road, Bringelly
R4	140 Badgerys Creek Road, Bringelly	R13	100 Badgerys Creek Road, Bringelly
R5	205 Badgerys Creek Road, Bringelly	R14	125 Badgerys Creek Road, Bringelly
R6	195A Badgerys Creek Road, Bringelly	R15	5 Medich Place, Bringelly
R7	195 Badgerys Creek Road, Bringelly	R16	22 Kelvin Park Drive, Bringelly
R8	130 Badgerys Creek Road, Bringelly	R17	30 Kelvin Park Drive, Bringelly
R9	175 Badgerys Creek Road, Bringelly		

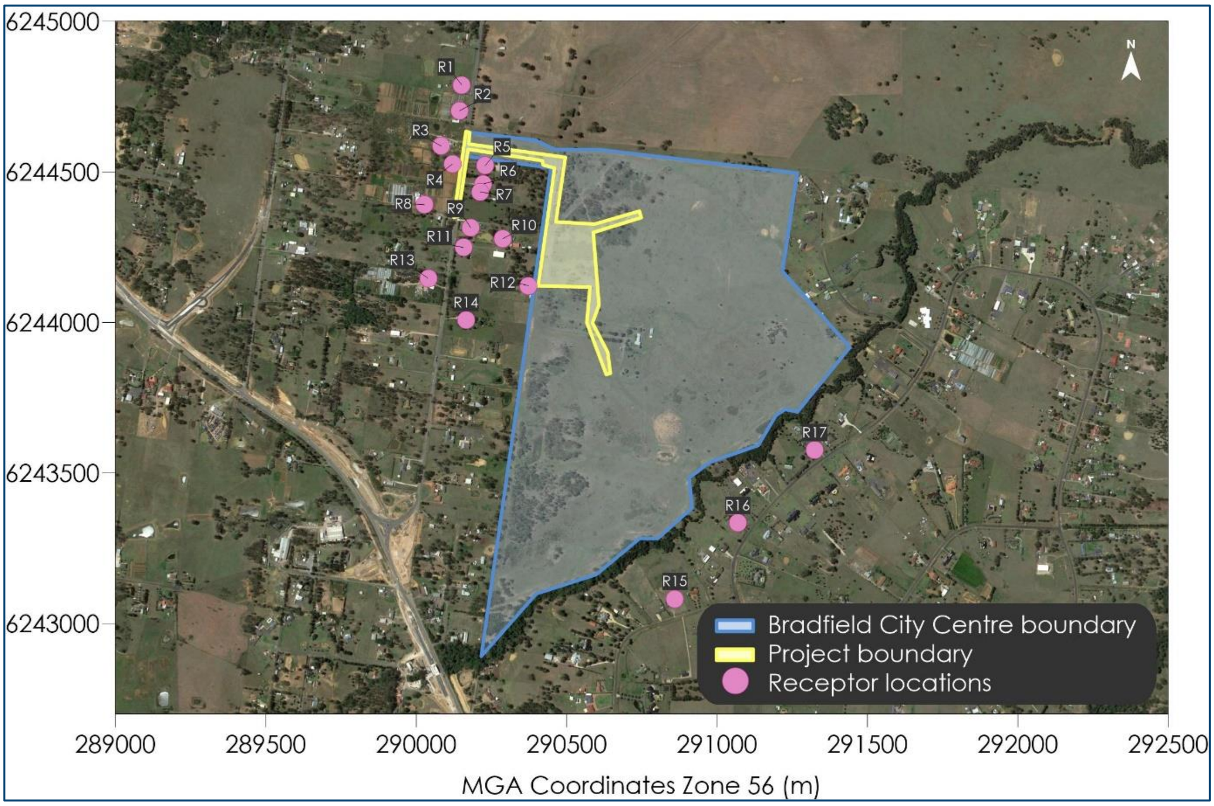

Figure 2-1: Project setting

Figure 2-2 presents a pseudo three-dimensional visualisation of the topography in the general vicinity of the Project. The Project area is located on a ridgeline with the topography increasing to the west and flattens to the east of the site.

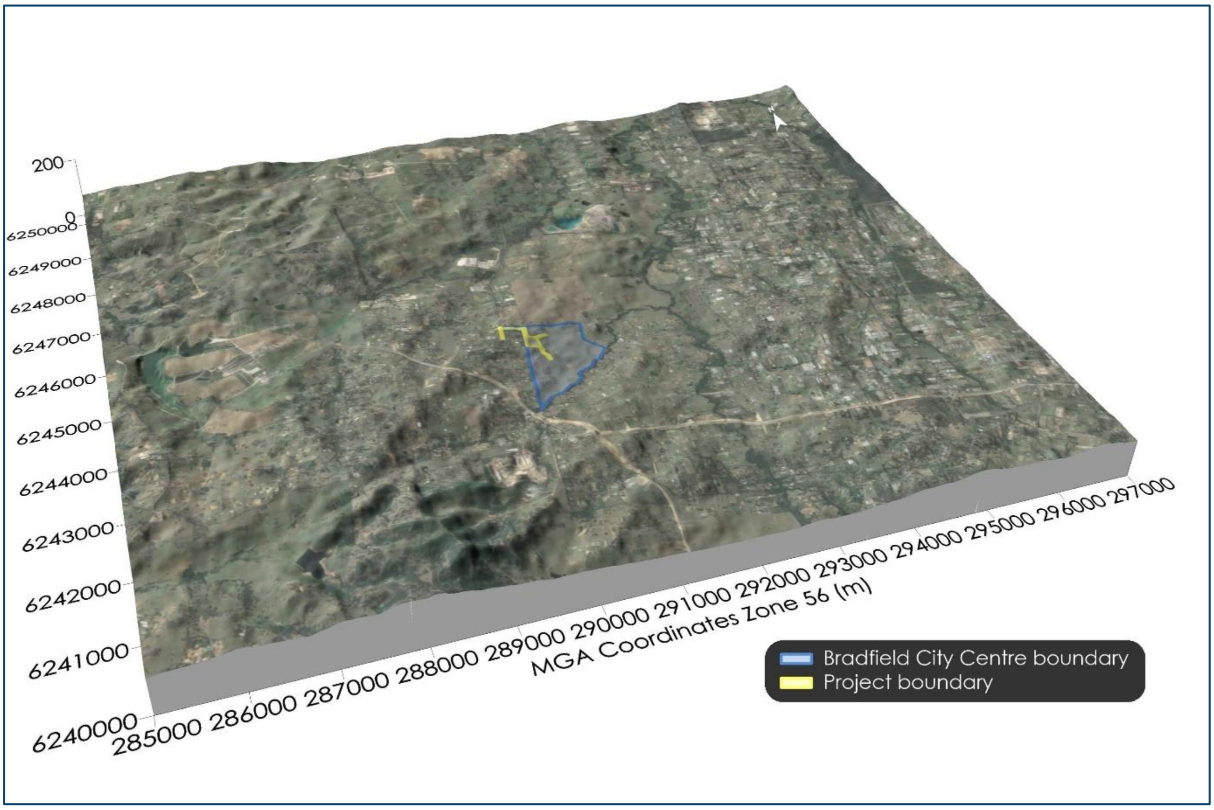

Figure 2-2: Representative visualisation of topography in the area surrounding the Project

2.2 Project description

The First Building is intended to be a significant resource that attracts industry and researchers to the Bradfield City Centre through the provision of manufacturing research and administrative workspaces. It will be used as a space for applied research, proof of concept, prototype manufacturing and testing with specialised equipment and machinery not normally accessible to individual enterprises and made available to a broad range of users to fast-track innovation and business development. A range of work settings shall be provided that address the need for environments to support collaborative and individual work.

The type of specialised equipment and machinery provided in the First Building may include:

- Industrial robot/ collaborative robot/ conveyor and continuous automation;
- Virtual Reality/ Augmented Reality suites;
- Microscopes, metrology and measuring; and,
- Digital technology (CAD/ DM/ PLM/ MES).

An indicative site layout for the Project is show in **Figure 2-3**.

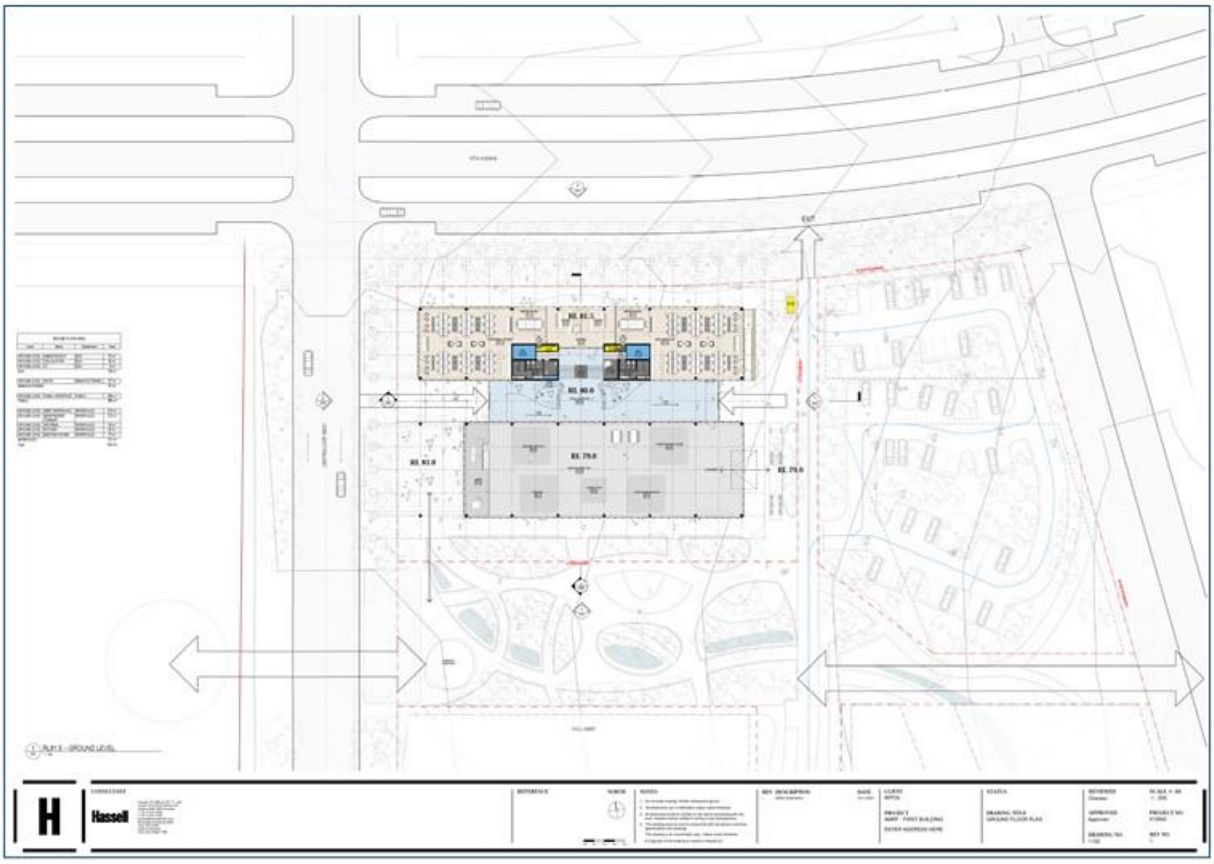

Figure 2-3: Indicative site layout

3 STUDY REQUIREMENTS

The purpose of this report is to provide an assessment of the likely effects on air quality which may arise from the Project. The assessment presented in this report addresses planning and regulatory agency requirements, as set out below.

3.1 Secretary's Environmental Assessment Requirements

In preparing this Air Quality Impact Assessment, the Secretary's Environmental Assessment Requirements (SEARs) issued for the Project in September 2021 have been addressed and the key matters raised for consideration in the Air Quality Impact Assessment are outlined in **Table 3-1** along with a reference to where the requirements are addressed in the report.

Table 3-1: Secretary's Environmental Assessment Requirements (SEAR Number SSD-25452459)

Aspect	Requirement	Section
Air Quality and Odour	A quantitative assessment of the potential air quality, dust and odour impacts of the development (construction and operation) on surrounding landowners, businesses and sensitive receptors, in accordance with the relevant Environment Protection Authority guidelines, including details of proposed mitigation, management and monitoring measures	This report

3.2 Liverpool Council

This Air Quality Impact Assessment has been prepared in accordance with the Liverpool City Council's requirement for the technical report to be prepared by suitably qualified and industry certified environmental consultants.

The author of this report is a Certified Air Quality Professional under the CAQP program of the Clean Air Society of Australia and New Zealand (CASANZ).

4 AIR QUALITY CRITERIA

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the likely air emissions generated by the Project and the applicable air quality criteria.

4.1 NSW EPA Impact Assessment Criteria

Table 4-1 summarises the air quality goals that are relevant to this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

The air quality goals for key pollutants relate to the total pollutant burden in the air and not just the contribution from the Project. Consideration of background pollutant levels needs to be made when using these goals to assess potential impacts.

Table 4-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Percentile	Criterion	Assessment location
Total suspended particulates (TSP)	Annual	100	90 µg/m³	Receptor
Particulate matter ≤10µm (PM_{10})	Annual	100	25 µg/m³	Receptor
	24 hour	100	50 µg/m³	Receptor
Particulate matter ≤2.5µm ($PM_{2.5}$)	Annual	100	8 µg/m³	Receptor
	24 hour	100	25 µg/m³	Receptor
Deposited dust	Annual	100	2 g/m²/month	Receptor
		100	4 g/m²/month	Receptor
Nitrogen dioxide (NO_2)	1 hour	100	246 µg/m³	Receptor
	Annual	100	62 µg/m³	Receptor

Source: **NSW EPA, 2017**

µm = micrometre µg/m³ = micrograms per cubic metre g/m²/month = grams per square metre per month

4.2 Protection of the Environment Operations Act 1997

The general obligations of the NSW *Protection of the Environment Operations Act, 1997* (POEO Act) and the relevant Regulations made under the POEO Act (namely the NSW *Protection of the Environment Operations (Clean Air) Regulation, 2021*) would be followed for the Project.

These obligations include managing and mitigating potential emissions so as to reduce overall environmental harm or impact in the surrounding area due to operations from the Project. It is anticipated the Project would operate in accordance with the relevant regulatory framework for air quality to ensure compliance with this legislation.

4.3 Odour emissions

Whilst odour emissions have some potential to arise from the diesel exhaust emissions of on-site plant equipment during construction, these odorous emissions are generally considered to be too low to generate any significant off-site pollutant concentrations and have not been assessed further in this study.

Odour emissions are also not considered to be a significant source at the Project based on the proposed operational activities and unlikely to result in any adverse impact in the surrounding environment. Nevertheless, potential odour emissions from the operational activity have been assessed.

Table 4-2 presents the odour impact assessment criteria as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW EPA, 2017**).

The criteria considers the population densities of specific areas and is based on a 99th percentile of dispersion model predictions calculated as 1-second averages (nose-response time). Odour concentrations are used and are defined in odour units (OU). The number of odour units represents the number of times that the odour would need to be diluted to reach a level that is just detectable to the human nose. Thus by definition, odour less than one odour unit (1 OU), would not be detectable to most people.

Table 4-2: Odour impact assessment criteria for complex mixtures of odorous air pollutants (nose-response-time average, 99th percentile)

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (OU)
Urban (≥~2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

Source: **NSW EPA, 2017**

5 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and meteorological conditions in the area surrounding the Project.

5.1 Local climatic conditions

Long-term climatic data from the Bureau of Meteorology (BoM) weather station at Badgerys Creek Automatic Weather Station (AWS) (Site No. 067108) were analysed to characterise the local climate in the proximity of the Project. The weather station at Badgerys Creek AWS is located approximately 10km east of the Project.

Table 5-1 and **Figure 5-1** present a summary of data from the Badgerys Creek AWS collected over an approximate 14 to 26-year period for the various meteorological parameters.

The data indicate that, on average, January is the hottest month with a mean maximum temperature of 30.3°C, and July is the coldest month with a mean minimum temperature of 4.1°C.

Rainfall peaks during the summer months and declines during the winter months, with an annual average rainfall of 658.1 mm over 67.4 days. The data show February is the wettest month with an average rainfall of 108.4 mm over 7.4 days, and July is the driest month with an average rainfall of 24.5 mm over 3.8 days.

Humidity levels exhibit variability over the day and seasonal fluctuations. Mean 9am humidity levels range from 62% in October to 84% in June. Mean 3pm humidity levels vary from 44% in August and September, to 56% in June.

As expected, wind speeds during the warmer months have a greater spread between the 9am and 3pm conditions compared to the colder months. The mean 9am wind speeds range from 8.4 km/h in March to 11.8 km/h in October. The mean 3pm wind speeds vary from 13.7 km/h in June to 19.9 km/h in October.

Table 5-1: Monthly climate statistics summary – Badgerys Creek AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	30.3	28.8	26.8	24.1	20.8	17.8	17.5	19.2	22.6	25.0	26.7	28.6	24.0
Mean min. temp. (°C)	17.3	17.1	15.3	11.4	7.7	5.6	4.1	4.7	7.7	10.6	13.6	15.5	10.9
Rainfall													
Rainfall (mm)	74.8	108.4	95.1	45.1	38.0	58.6	24.5	36.7	34.9	52.9	66.9	55.0	658.1
No. of rain days (≥1mm)	7.0	7.4	7.8	5.4	3.7	5.6	3.8	3.3	4.8	5.6	6.7	6.3	67.4
9am conditions													
Mean temp. (°C)	21.8	21.2	19.0	17.3	13.7	10.5	9.8	11.7	15.5	18.1	19.1	20.9	16.6
Mean R.H. (%)	73	80	83	76	80	84	81	72	66	62	69	69	75
Mean W.S. (km/h)	9.4	8.7	8.4	9.8	9.6	9.1	9.6	10.6	11.7	11.8	11.0	9.8	10.0
3pm conditions													
Mean temp. (°C)	28.1	26.9	25.3	22.4	19.4	16.7	16.1	17.9	21.0	22.8	24.3	26.5	22.3
Mean R.H. (%)	49	55	55	52	53	56	50	44	44	45	50	48	50
Mean W.S. (km/h)	17.9	15.9	14.5	14.4	13.9	13.7	15.4	17.8	19.2	19.9	18.9	18.5	16.7

Source: **BoM, 2021 (accessed September 2021)**

°C = degrees Celsius   mm = millimetres   % = percent   km/h = kilometres per hour

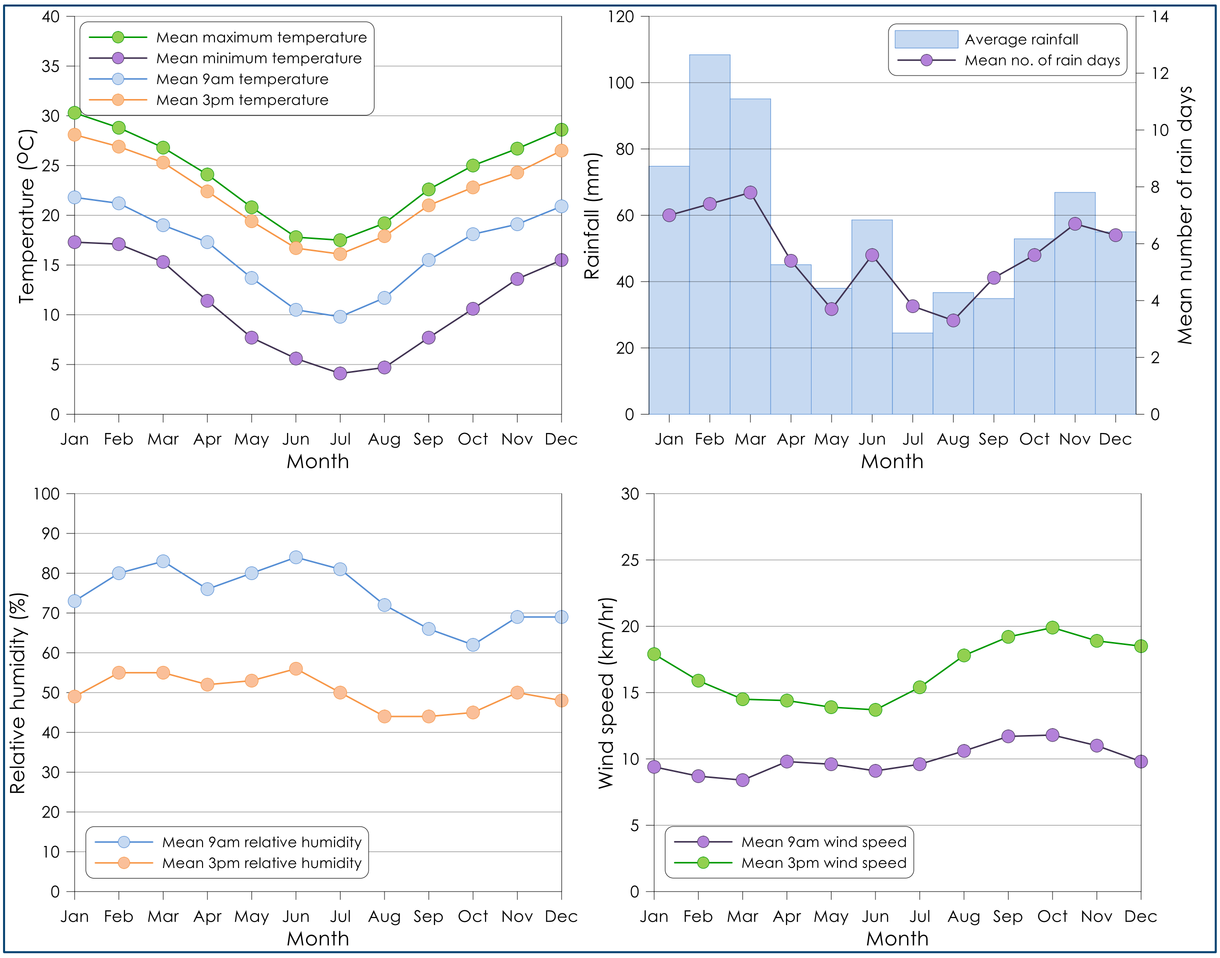

Figure 5-1: Monthly climate statistics summary – Badgerys Creek AWS

5.2 Local meteorological conditions

Annual and seasonal windroses for the Badgerys Creek weather station during the 2020 calendar period are presented in **Figure 5-2**.

The 2020 calendar year was selected as the meteorological year for the dispersion modelling based on an analysis of long-term data trends in meteorological data recorded for the area as outlined in **Appendix A**.

On an annual basis, winds typically occur along a southwest to north-northeast axis with a high portion of winds from the east-southeast. In summer, strong winds typically range from the north-northeast to south (clockwise) with few winds from the northwest. The autumn distribution is similar to the annual distribution with a high proportion of winds originating from the southwest. During winter, winds are predominately from the southwest and west-southwest. In spring, winds from the north-northeast are most dominant.

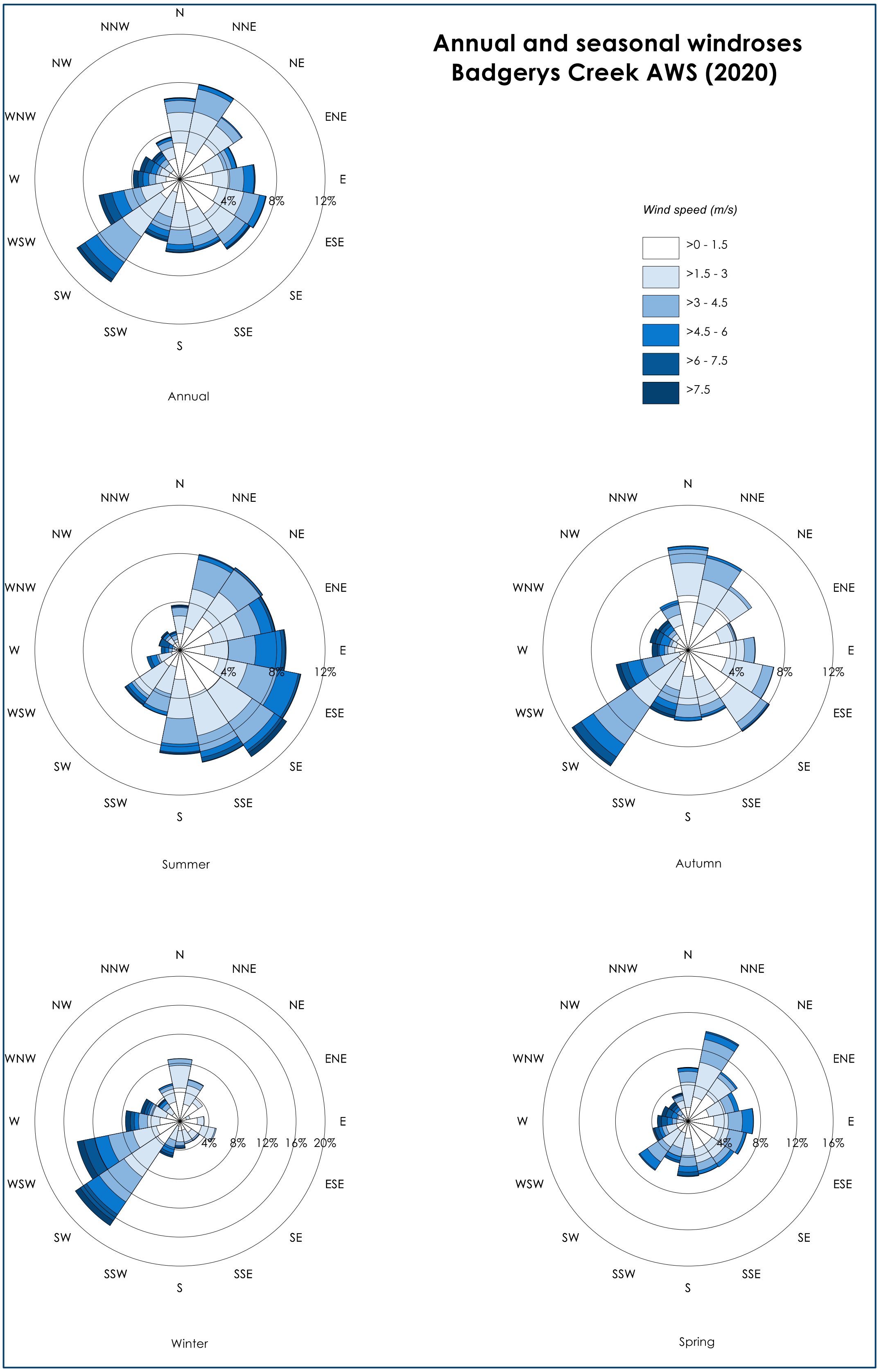

Figure 5-2 : Annual and seasonal windroses – Badgerys Creek AWS (2020)

5.3 Local air quality

The main sources of air pollutants in the wider area surrounding the Project include industrial and commercial operations and local anthropogenic activities such as wood heaters and motor vehicle exhaust.

This section reviews the available ambient air quality monitoring data sourced from the nearest air quality monitors operated by the New South Wales (NSW) Department of Planning, Industry and Environment (DPIE) at Liverpool, Bringelly, St Marys and Camden. **Figure 5-3** shows the approximate location of each of the monitoring stations with reference to the Project.

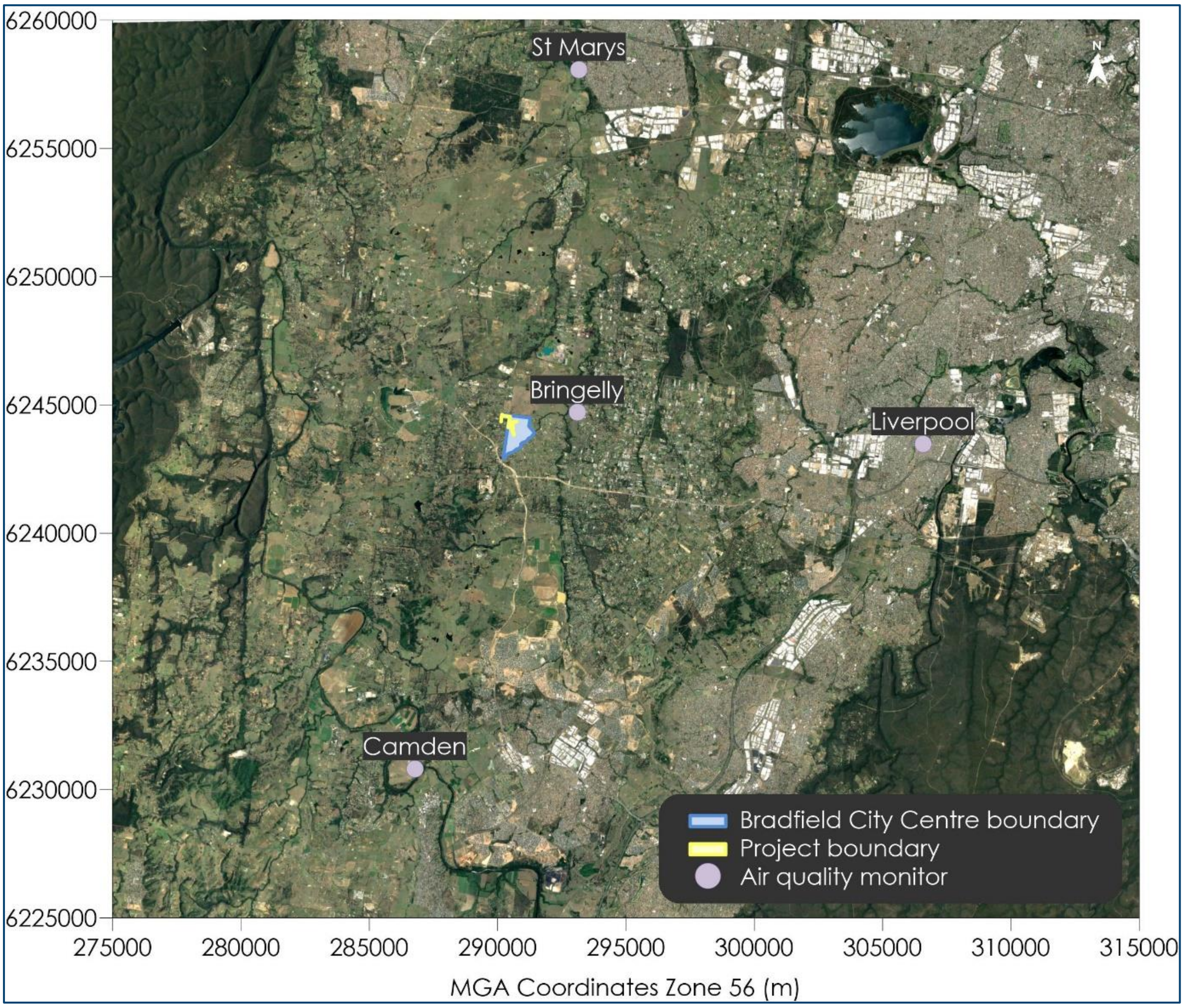

Figure 5-3: Location of DPIE air quality monitors

5.3.1 PM_{10} monitoring

A summary of the available PM_{10} monitoring data from 2015 to 2021 for the DPIE monitoring stations is presented in **Table 5-2**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 5-4**.

A review of **Table 5-2** indicates that the annual average PM_{10} concentrations for the monitoring stations were below the relevant criterion of 25µg/m^3 for all years of the review period, except for Liverpool in 2019. The maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m³ on occasion for all years of the review period, with the exception of Camden in 2016 and Camden and St Marys in 2017.

Figure 5-4 shows the monitors following similar trends with regional events recorded at both monitoring stations. The high PM_{10} concentration recorded at both monitors from November 2019 to January 2020 is attributed to wildfires and the drought period affecting NSW.

Table 5-2: Summary of PM_{10} levels from monitoring stations (µg/m³)

Year	Liverpool	Bringelly	St Marys	Camden	Criterion
	Annual average				
2015	18.4	15.8	15.0	13.8	**25**
2016	19.5	16.9	16.1	14.4	**25**
2017	20.6	19.8	16.2	14.7	**25**
2018	24.2	21.2	19.4	17.5	**25**
2019	**27.7**	23.6	24.7	22.5	**25**
2020	20.8	18.3	18.9	16.6	**25**
2021 [1]	18.2	15.4	16.4	12.9	**25**
Year	**Maximum 24-hour average**				**Criterion**
2015	**68.6**	**57**	**53**	**62.4**	**50**
2016	**68.7**	**61.6**	**100.2**	43.6	**50**
2017	**73.6**	**83.7**	49.8	48.4	**50**
2018	**101.5**	**92.9**	**100.5**	**68.1**	**50**
2019	**178.9**	**134**	**159.8**	**139.2**	**50**
2020	**195.1**	**241.8**	**260.3**	**268.6**	**50**
2021 [1]	**61.7**	**69**	**54.9**	**66.2**	**50**

[1] Data available till October 2021

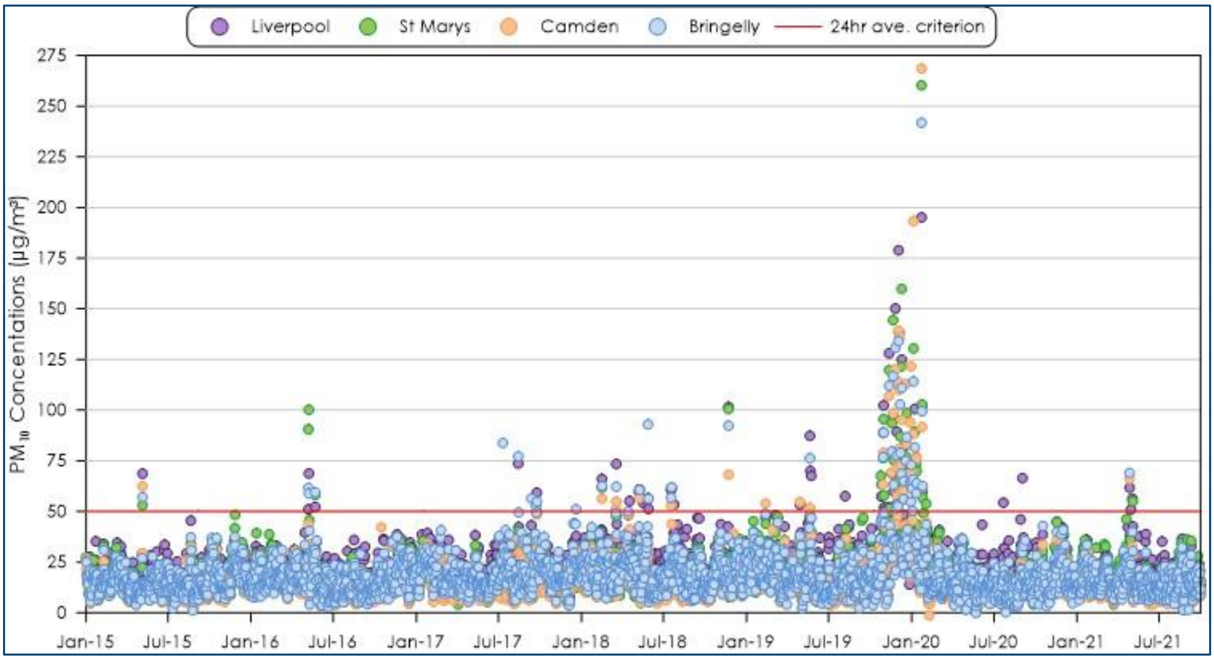

Figure 5-4: 24-hour average PM_{10} concentrations

5.3.2 $PM_{2.5}$ monitoring

A summary of the available data from 2015 to 2021 for the DPIE monitoring stations is presented in **Table 5-3**. Recorded 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 5-5**.

Table 5-3 indicates that the annual average $PM_{2.5}$ concentrations were above the annual average criterion of 8µg/m^3 for all years at the Liverpool monitor, during 2019 and 2020 at the Bringelly monitor and during 2019 at the St Marys and Camden monitors. The maximum 24-hour average $PM_{2.5}$ concentrations at all monitoring station were found to be above the relevant criterion of 25µg/m^3 on occasion for all years with the exception of 2016 at Bringelly and 2015 at Camden. Similar to the PM_{10} monitoring data, the mass bushfires affecting NSW in 2019 and 2020 are seen in the $PM_{2.5}$ monitoring data in **Figure 5-5**.

Table 5-3: Summary of $PM_{2.5}$ levels from monitoring stations (µg/m^3)

Year	Liverpool	Bringelly [2]	St Marys [3]	Camden	Criterion
	Annual average				
2015	**8.5**	-	-	6.2	**8**
2016	**8.8**	-	7.9	6.4	**8**
2017	**8.9**	7.5	7.0	6.7	**8**
2018	**10.1**	8.0	7.8	7.2	**8**
2019	**12.8**	**11.3**	**9.8**	**11.8**	**8**
2020	**9.1**	**8.5**	7.6	7.7	**8**
2021 [1]	**8.6**	7.7	6.2	6.4	**8**
Year	**Maximum 24-hour average**				**Criterion**
2015	**32.2**	-	-	25	**25**
2016	**50.8**	21.6	**93.2**	**36**	**25**
2017	**59.2**	**55.7**	**38.2**	**27.7**	**25**
2018	**45.4**	**55.6**	**80.5**	**37**	**25**
2019	**156**	**178**	**88.3**	**155.3**	**25**
2020	**73.6**	**78.1**	**82.5**	**149.3**	**25**
2021 [1]	**52.2**	**57.4**	**40.3**	**66.7**	**25**

[1] Data available till October 2021 [2] Data available from 30 June 2016 [3] Data available till 15 March 2016

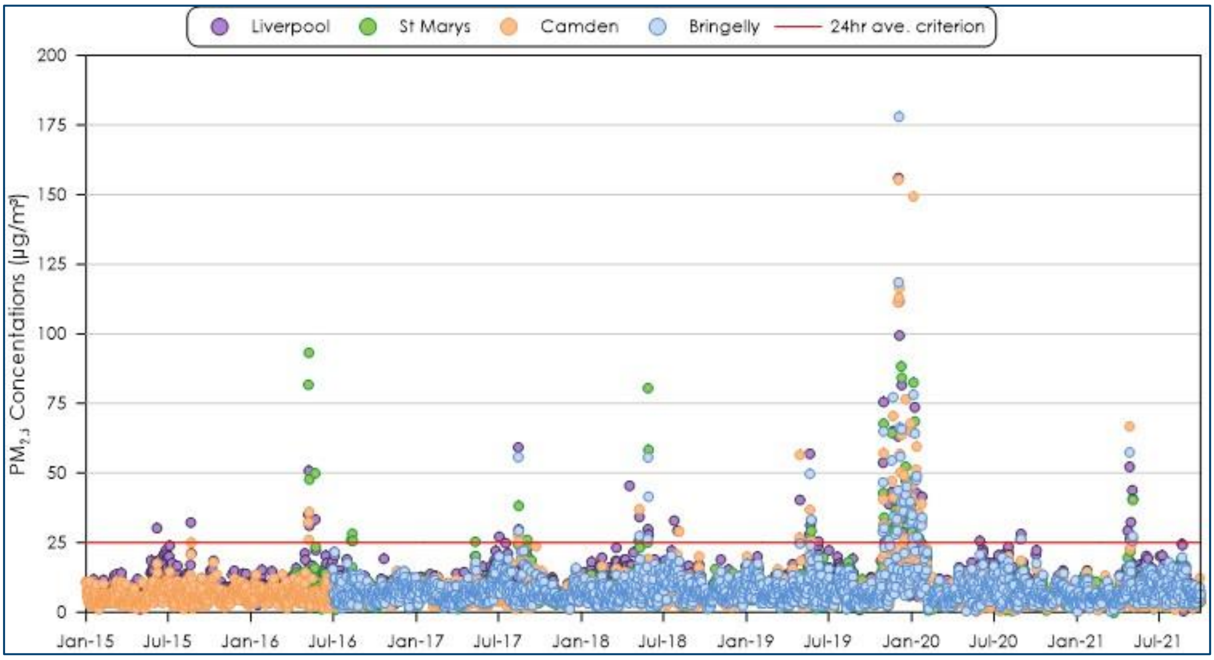

Figure 5-5: 24-hour average $PM_{2.5}$ concentrations

5.3.3 NO_2 monitoring

Figure 5-6 presents the daily 1-hour average maximum NO_2 concentrations from the DPIE monitoring stations available for 2015 to 2021.

The ambient air quality monitoring data include emissions from all sources such as industrial and commercial facilities as well as other various combustion sources. The monitoring data recorded are well below the NSW EPA 1-hour average goal of 246µg/m³ during the review period. The monitoring data shows a seasonal trend with NO_2 concentrations highest during cooler months.

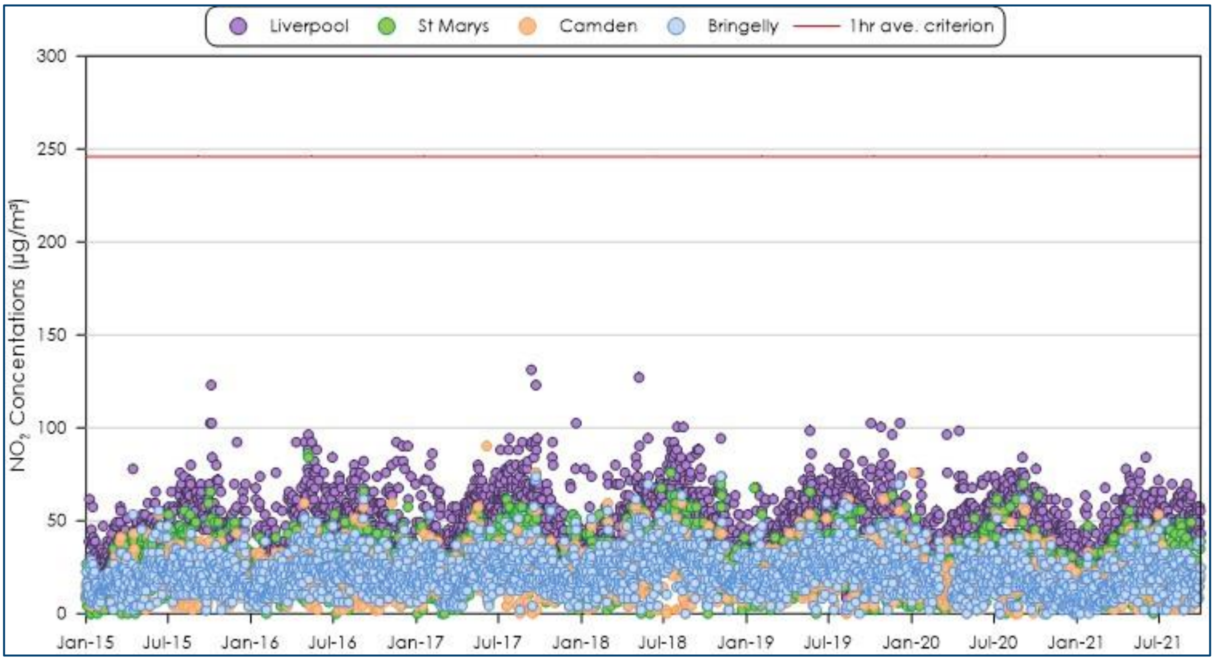

Figure 5-6: Daily 1-hour average maximum NO_2 concentrations

5.3.4 Campaign air quality monitoring

An ambient air quality monitoring campaign to assist with the characterisation of background air quality levels at the Project was conducted from 16 September 2021 to 21 October 2021. The ambient air quality monitoring campaign included continuous monitoring of particulate matter ($PM_{2.5}$ and PM_{10}) and nitrogen dioxide (NO_2) and the measured levels are compared with the nearest DPIE air quality monitor at Bringelly for the contemporaneous period.

The location of the air monitor relative to the Project site is shown in **Figure 5-7**. The DPIE Bringelly air quality monitor is located approximately 2.5km east of the air monitor location.

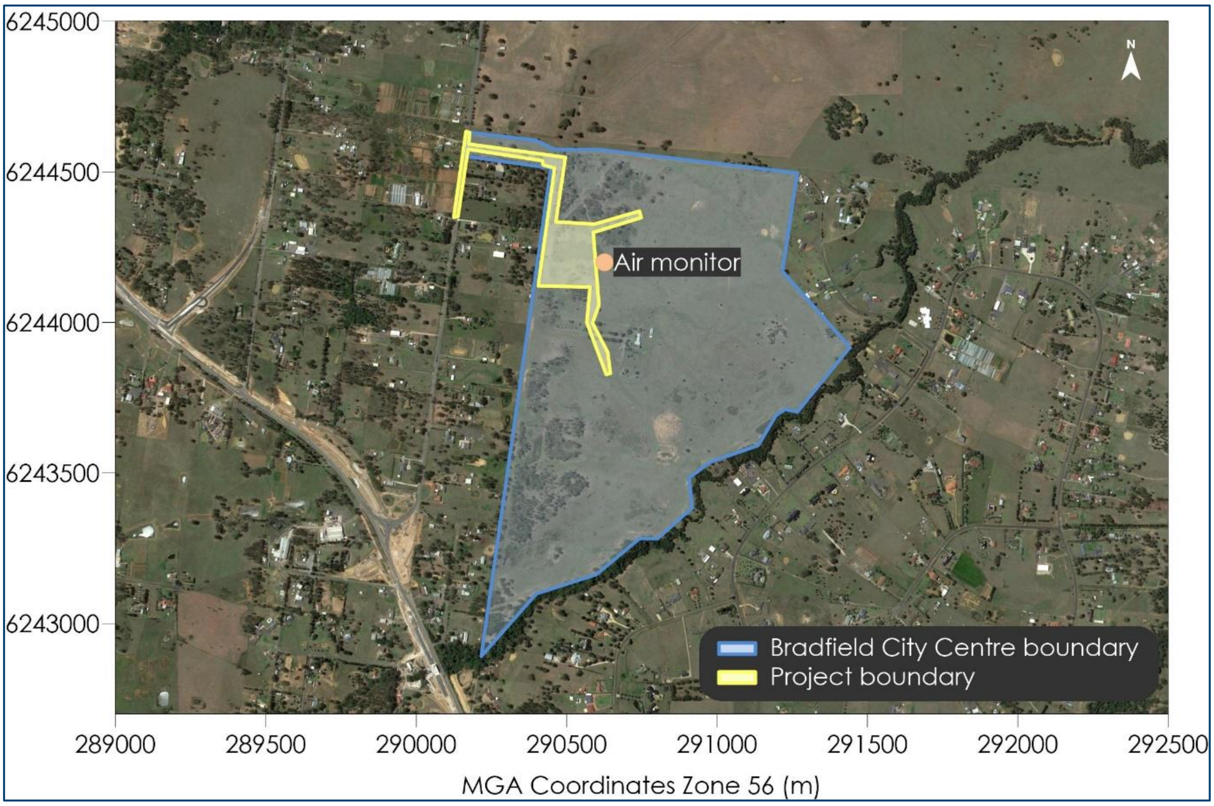

Figure 5-7: Location of air monitor

Figure 5-8 presents a comparison of the recorded 24-hour average PM_{10} concentrations for the air monitor and the DPIE Bringelly monitor. The 24-hour average PM_{10} concentrations recorded at the air monitor were below the relevant NSW EPA criterion of 50µg/m^3 and compare reasonably well with the measured concentrations at the Bringelly monitor.

Figure 5-9 presents a comparison of the recorded 24-hour average $PM_{2.5}$ concentrations for the air monitor and the DPIE Bringelly monitor. The 24-hour average $PM_{2.5}$ concentrations recorded at the air monitor were below the relevant NSW EPA criterion of 25µg/m^3. Overall, the DPIE Bringelly monitor records slightly higher $PM_{2.5}$ concentrations relative to the air monitor and may be attributed to the different monitoring methodologies and the location with the Bringelly monitor closer to a roadway.

Figure 5-10 presents a comparison of the recorded daily maximum 1-hour average NO_2 concentrations for the air monitor and the DPIE Bringelly monitor. The air monitor indicates higher NO_2 concentrations compared to the Bringelly monitor, this is likely due to the different monitoring methodologies as there are no identifiable sources of NO_2 located near the air monitor.

Overall, the air monitor indicates that the Bringelly site provides a reasonable indication of the background air quality levels at the Project site.

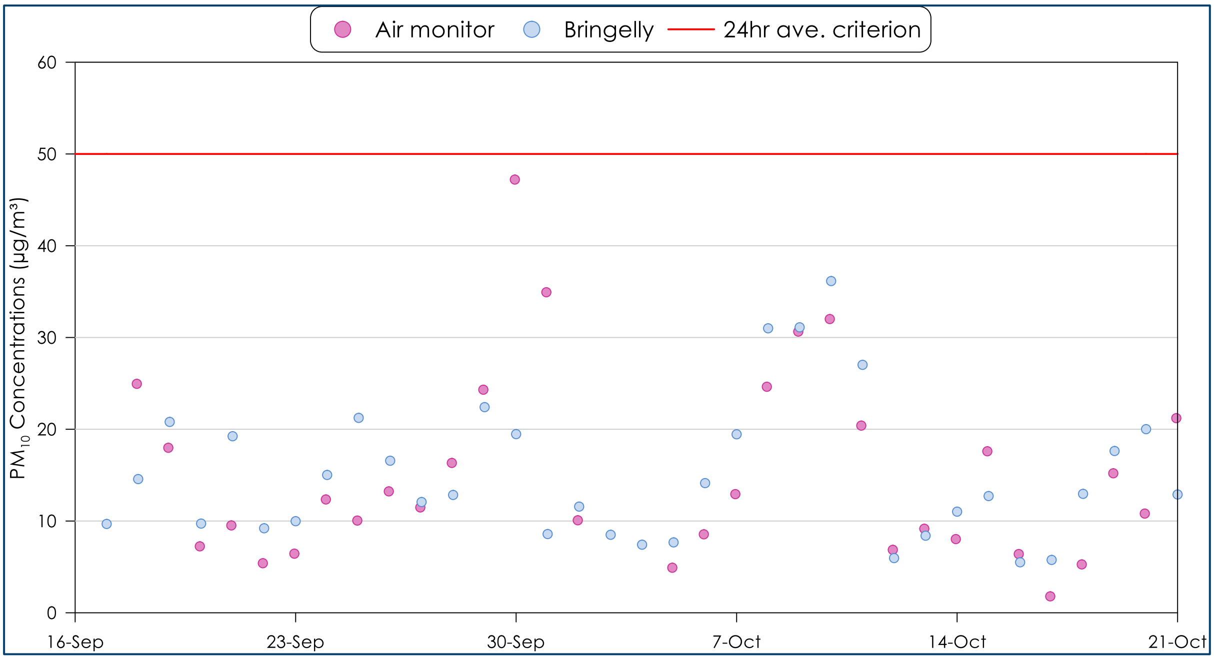

Figure 5-8: Comparison of 24-hour average PM_{10} concentrations during monitoring campaign

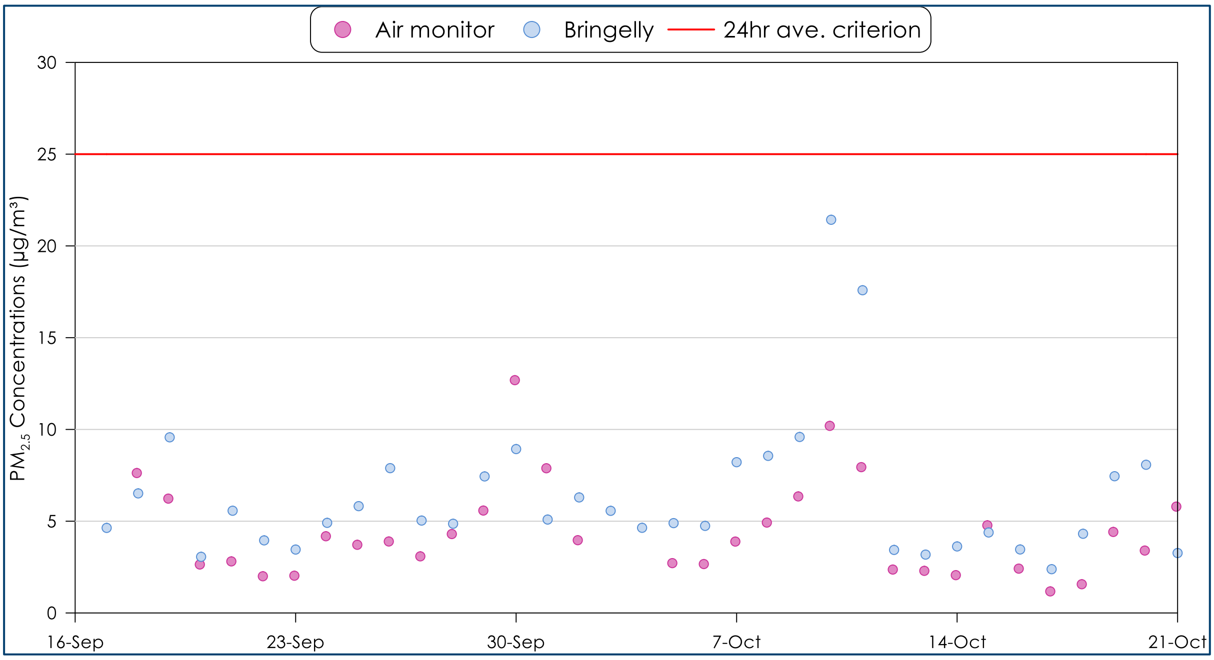

Figure 5-9: Comparison of 24-hour average $PM_{2.5}$ concentrations during monitoring campaign

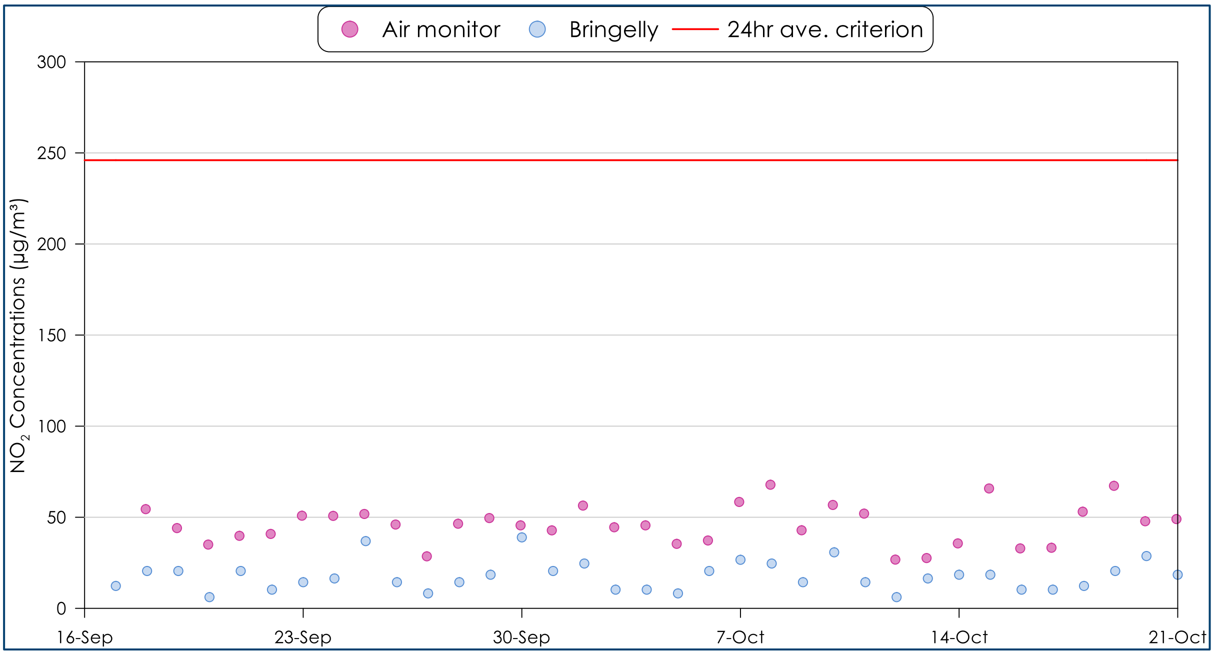

Figure 5-10: Comparison of daily maximum 1-hour average NO_2 concentrations during monitoring campaign

5.3.5 Estimated background levels

To assess the potential impacts associated with the Project against the relevant air pollutants in **Section 4**, consideration of background air quality levels needs to be applied.

The measured background air quality levels from the Bringelly monitor for the 2020 calendar year period correspond to the period selected for the meteorological modelling (as outlined in **Appendix A**) and is chosen to represent the background levels for the Project.

Estimates of the annual average background TSP and dust deposition concentrations have been determined from a relationship with the measured PM_{10} levels. This relationship assumes that an annual average PM_{10} concentration of 25µg/m^3 corresponds to a TSP concentration and dust deposition level of 90µg/m^3 and 4g/m^2/month, respectively, based on the NSW EPA air quality impact criteria. Applying this relationship with the measured annual average PM_{10} concentration of 18.3µg/m^3 during 2020 equates to an annual average TSP concentration of 65.9µg/m^3 and an annual average dust deposition level of 2.9g/m^2/month.

The background air quality levels applied in this assessment are summarised in **Table 5-4**.

Table 5-4: Summary of background air quality levels

Pollutants	Averaging period	Background level	Units
TSP	Annual	65.9	µg/m³
PM_{10}	Annual	18.3	µg/m³
	24-hour	Daily varying / 43.5*	µg/m³
$PM_{2.5}$	Annual	8.5	µg/m³
	24-hour	Daily varying	µg/m³
Dust deposition	Annual	2.9	g/m²/month
NO_2	Annual	17.7	µg/m³
	1-hour	62.0	µg/m³

*Highest measured level less than 50µg/m³

It is noted that existing background levels of annual average $PM_{2.5}$ are above the EPA criteria for 2020 calendar year period at the Bringelly monitoring station, indicating that $PM_{2.5}$ annual background levels would be above the criteria regardless of the Project. In such cases, the key consideration is whether any increase in average exposure (such as may occur from the operation of the Project) causes any significant increase in health impacts and ensuring the emitted $PM_{2.5}$ levels are consistent with best practice. For this reason, a cumulative assessment cannot be used to show compliance or not, hence the incremental approach has been adopted.

In this regard, work by (**Capon A & Wright J, 2019**), is generally applied in NSW to determine what an acceptable or tolerable level of additional $PM_{2.5}$ impact is. For annual $PM_{2.5}$ exposure, an annual average $PM_{2.5}$ from 0.02 to 1.7 $\mu g/m^3$ (due to the Project in isolation) is considered acceptable or tolerable, so long as best practice measures are used to mitigate the emissions. For the purpose of this assessment, we have adopted the $PM_{2.5}$ exposure limit of $1.7 \mu g/m^3$.

6 DISPERSION MODELLING APPROACH

6.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach applied for the assessment. The CALPUFF is an advanced air dispersion model which can deal with the effects of complex local terrain on the dispersion meteorology over the modelling domain in a three-dimensional, hourly varying time step.

The model was setup in general accord with the methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC**, **2011**).

6.2 Modelling methodology

Modelling was undertaken using a combination of the CALPUFF Modelling System and The Air Pollution Model (TAPM). The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

6.2.1 Meteorological modelling

TAPM was applied to the available data to generate a three dimensional (3D) upper air data file for use in CALMET. The centre of analysis for TAPM was 33deg55.5min south and 150deg44min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

CALMET modelling domain was run for a 10 x 10 km area with 0.1km grid resolution. The 2020 calendar year was selected as the meteorological year for the dispersion modelling based on analysis of long-term data trends in meteorological data recorded for the area as outlined in **Appendix A**. The available meteorological data from the Badgerys Creek BoM weather station and Bringelly DPIE weather station was included in the simulation.

The outputs of the CALMET modelling are evaluated using visual analysis of the wind fields and extracted data.

Figure 6-1 presents a visualisation of the wind field generated by CALMET for a single hour of the modelling period. The wind fields are seen to follow the terrain well and indicate the simulation produces realistic fine scale flow fields (such as terrain forced flows) in surrounding areas.

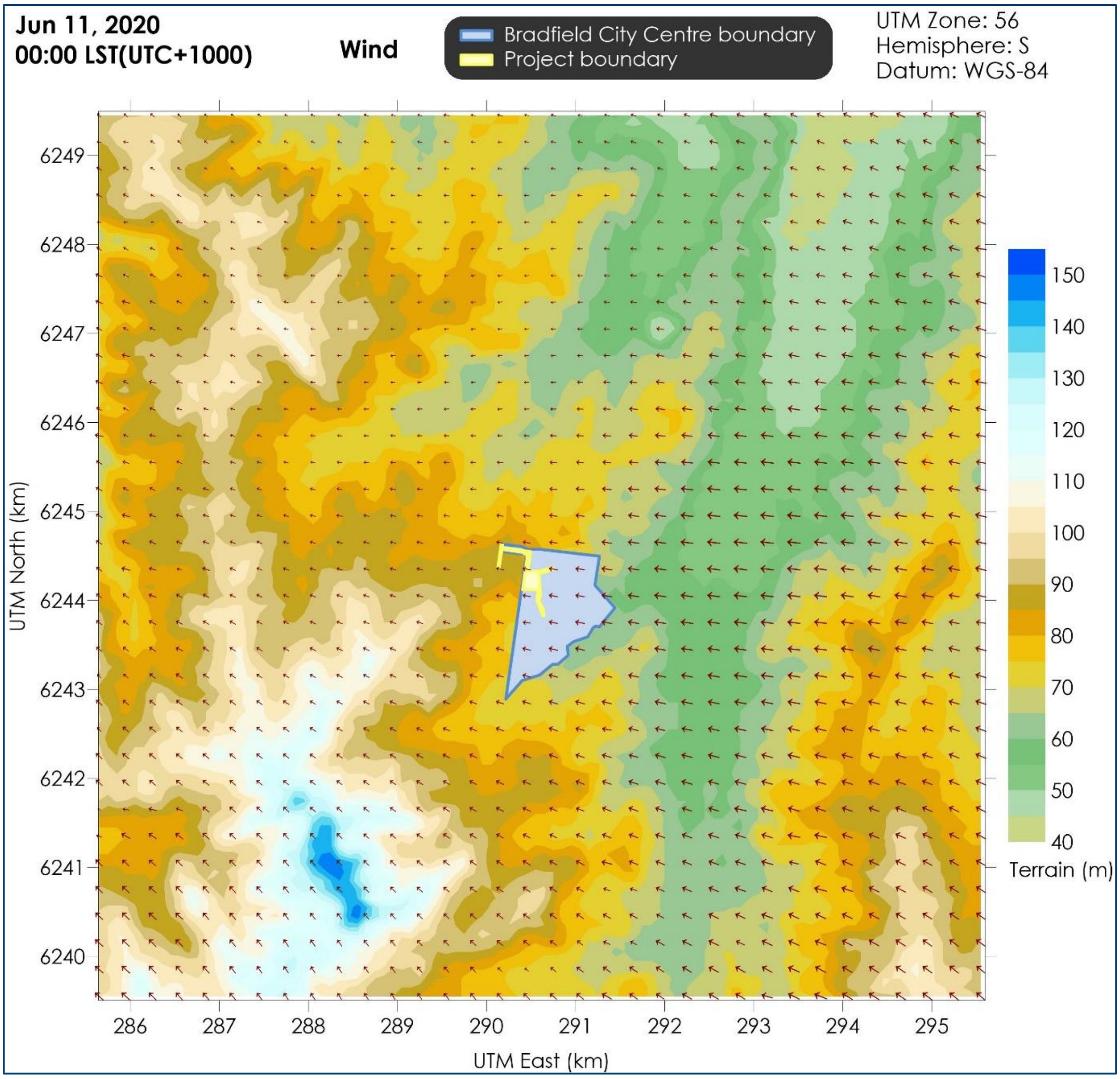

Figure 6-1: Representative snapshot of wind field for the Project

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 6-2** and **Figure 6-3**.

Figure 6-2 presents the annual and seasonal windroses from the CALMET data. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds.

Figure 6-3 includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and show sensible trends considered to be representative of the area.

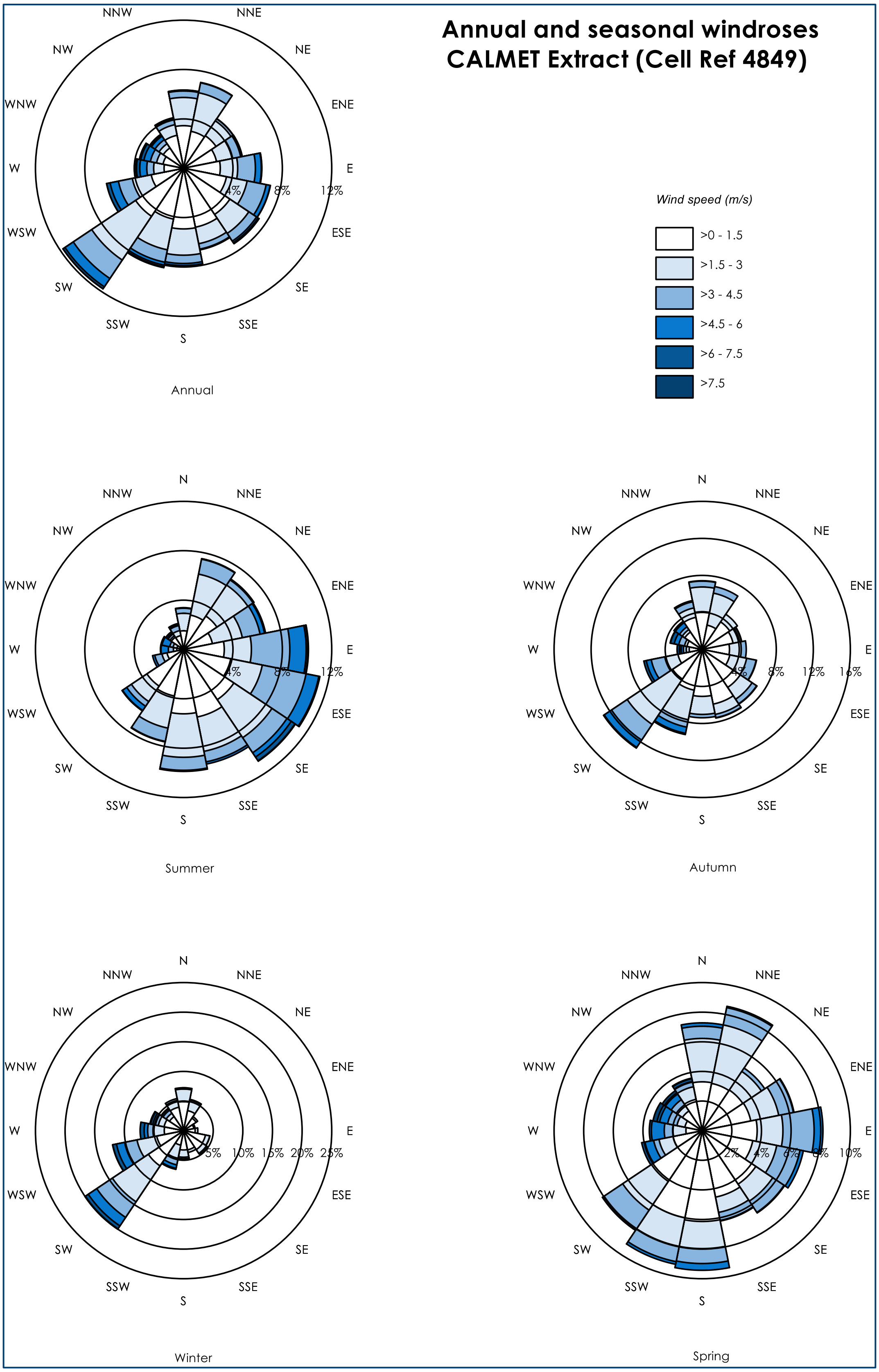

Figure 6-2: Annual and seasonal windroses from CALMET (Cell reference 4849)

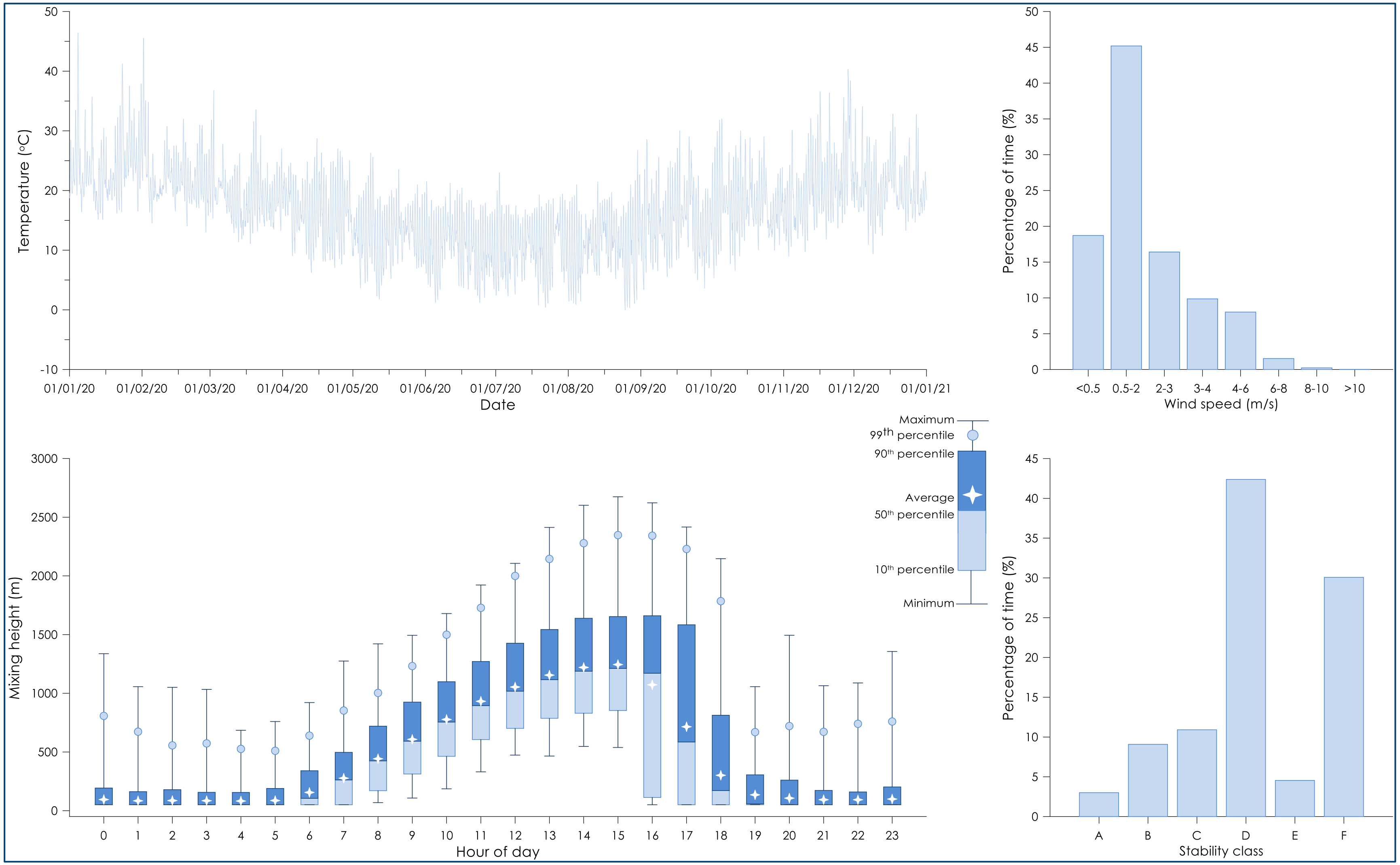

Figure 6-3: Meteorological analysis of CALMET (Cell Ref 4849)

6.2.2 Dispersion modelling

Air dispersion modelling of the key air emission sources was conducted to predict potential air quality impacts from the Project.

Fugitive dust emissions associated with the construction activity of the Project were represented by a series of volume sources and were included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source. It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

The air emission for the assumed operational sources were represented by a point source positioned adjacent to the First Building. The stack parameters for the modelled point sources are outlined in **Table 6-1**.

Table 6-1: Modelled stack parameters

Parameter	Value	Unit
Stack height	12	m
Stack diameter	0.5	m
Exit temperature	293	K
Exit velocity	12	m/s
Flow rate	2.4	Am^3/s
Flow rate	2.2	Nm^3/s

The modelled point source location for the Project is shown in **Figure 6-4**. The model included consideration of potential 'building' wake effects on air dispersion that arise due to the effect of winds passing over the buildings at the site.

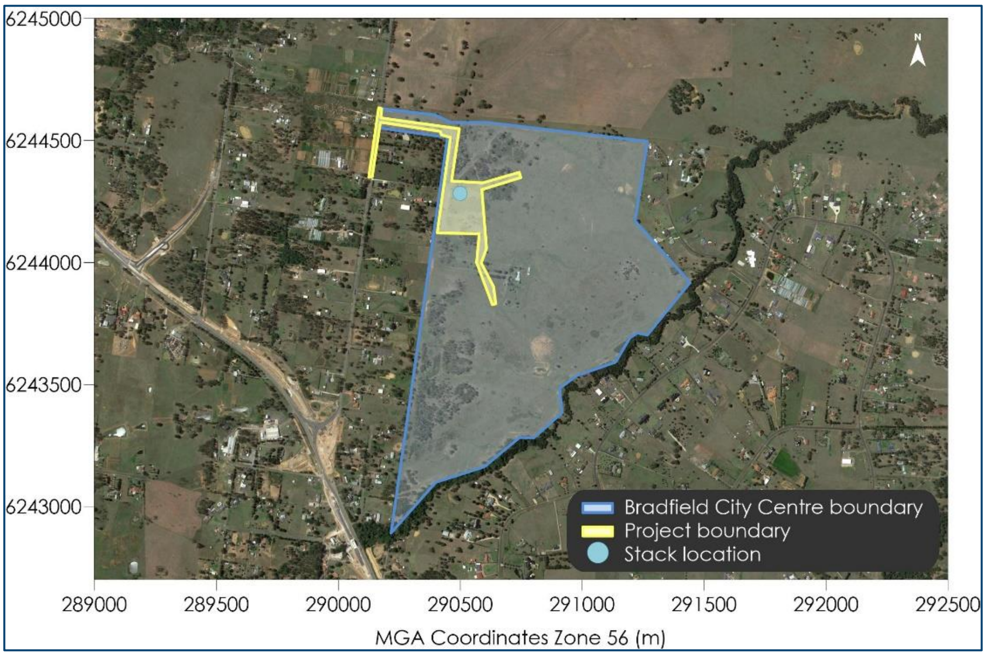

Figure 6-4: Modelled point source location

6.3 Emission estimation

6.3.1 Construction emissions

Construction activities at the Project involve land preparation through a cut and fill to level the site prior to establishment of the building. It is estimated approximately 49,000 tonnes of material would cut and filled at the site with an approximate additional 13,000 tonnes of fill required to assist with the land preparation.

Potential construction dust emissions have been estimated by analysing the dust generating activities and utilising suitable emission factors. The emission factors were sourced from both locally developed and United States Environmental Protection Agency (US EPA) developed documentation.

A summary of the estimated TSP, PM_{10} and $PM_{2.5}$ emissions from all significant activities for the construction is presented in **Table 6-2**. Full emission inventories and associated calculations are presented in **Appendix B**. The estimated emissions are commensurate with utilising reasonable best practice dust mitigation applied where feasible.

Table 6-2: Summary of estimated dust emissions for the Modification (kg/annum)

Activity	TSP	PM_{10}	$PM_{2.5}$
Dozer working	6,527	1,577	685
Excavator loading cut to haul truck	51	24	4
Hauling cut material to emplacement (unpaved)	496	128	13
Unloading material at fill emplacement	51	24	4
Rehandle material	10	5	1
Hauling import material onsite (paved)	224	43	10
Hauling import material to emplacement (unpaved)	133	34	3
Unloading import material at emplacement	14	6	1
Rehandle material	3	1	0
Wind erosion from exposed areas	1,955	978	147
Exhaust emissions	275	275	267
Total emissions	**9,740**	**3,096**	**1,135**

6.3.2 Operational emissions

During operations it is assumed the specialised equipment and machinery available may generate some air emissions. These air emissions would arise from the different processes and equipment installed at the site and would be suitably captured and controlled prior to being dispersed into the atmosphere via a purpose-built stack. It has been assumed that air pollutants generated may include PM_{10}, NO_X and odour.

For this assessment, a conservative approach has been applied to estimate the likely air emissions of the pollutants generated. In the absence of specific data for the proposed operations, the Protection of the Environment Operations (POEO) (Clean Air) Regulation limits for the selected pollutants have been used in the emission rate calculations. For odour an assumed stack concentration of 1,000 OU has been applied.

Table 6-3 presents a summary of the operational air emissions.

Table 6-3: Summary of operation air emissions

Pollutant	Stack concentration (mg/m³)	Emission rate (g/s)
Solid particles as PM_{10}	50 mg/m³	0.11 g/s
NO_X	350 mg/m³	0.76 g/s
Odour	1,000 OU	2,159 OU/s

6.3.3 Background dust from other construction activity

Estimated background dust levels in **Section 5.3.5** would include contribution from all existing dust sources in the general vicinity of the Project. There is potential for transient additional dust contributions during construction activity associated with the Sydney Metro Aerotropolis Station.

The *Sydney Metro – Western Sydney Airport Environmental Impact Statement* (**M2A, 2020**) includes an assessment of the potential air quality impacts associated with the proposed construction activity. The potential air quality impacts are assessed using a semi-quantitative risk-based approach developed by the UK Institute of Air Quality Management (**IAQM, 2014**).

The result of the assessment indicates that with dust mitigation measures in place, the potential risk of dust impacts due to proposed construction activity at the Aerotropolis Station would be negligible or low. Thus, on this basis the potential for cumulative dust impacts associated with the Project is likely to be minimal and no prolonged effect is predicted to arise.

7 DISPERSION MODELLING RESULTS

This section presents the predicted impacts on air quality which may arise from air emissions generated by the Project.

7.1 Construction activity

The dispersion model predictions presented in this section include those for the operation of the Project in isolation (incremental impact) and the operation of the Project with consideration of other sources (cumulative impact).

It is important to note that when assessing impacts per the maximum 24-hour average levels, these predictions are based on the highest predicted 24-hour average concentrations which were modelled at each point within the modelling domain for the worst day (i.e. a 24-hour period) in the one year long modelling period.

Associated isopleth diagrams of the dispersion modelling results are presented in **Appendix C**.

Table 7-1 presents the predicted incremental particulate dispersion modelling results at each of the assessed receptor locations. The results show that minimal incremental effects would arise at the receptor locations due to the Project.

Furthermore, the incremental annual average $PM_{2.5}$ concentrations are well below 1.7µg/m^3 at any of the receptor locations. Therefore, it is determined that the operation of the Project would not lead to any unacceptable level of environmental harm or impact in the surrounding area.

Table 7-1: Particulate dispersion modelling results for assessed receptors during construction – Incremental impact

Receptor ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD^ (g/m²/month)
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average
	Air quality impact criteria					
	-	1.7*	-	-	-	2
R1	1.1	0.1	2.2	0.2	0.4	<0.1
R2	1.3	0.1	2.5	0.2	0.5	<0.1
R3	1.2	0.1	2.3	0.3	0.7	<0.1
R4	1.3	0.2	2.6	0.4	0.9	<0.1
R5	1.8	0.3	3.6	0.6	1.4	0.1
R6	1.7	0.3	4.1	0.6	1.5	0.1
R7	1.7	0.3	3.8	0.6	1.5	0.1
R8	1.2	0.1	2.5	0.3	0.7	<0.1
R9	1.8	0.2	4.0	0.6	1.5	0.1
R10	3.0	0.5	6.4	1.2	3.1	0.1
R11	1.9	0.2	4.1	0.5	1.3	<0.1
R12	4.6	0.6	10.0	1.5	4.3	0.2
R13	1.4	0.1	3.1	0.3	0.7	<0.1
R14	1.4	0.1	3.1	0.3	0.8	<0.1
R15	0.3	<0.1	0.7	<0.1	0.1	<0.1
R16	0.2	<0.1	0.5	<0.1	0.1	<0.1
R17	0.2	<0.1	0.6	<0.1	0.1	<0.1

^Deposited dust *incremental annual average $PM_{2.5}$ criterion

The cumulative impact is defined as the modelling impact associated with the operation of the Project combined with the estimated ambient background levels in **Section 5.3.5**.

The predicted cumulative annual average $PM_{2.5}$, PM_{10}, TSP and dust deposition levels due to the Project with the estimated background levels are presented in **Table 7-2**. The results in **Table 7-2** indicate that all of the assessed receptors are predicted to experience levels below the relevant criteria for each of the assessed dust metrics with the exception of $PM_{2.5}$. It is to be noted that the existing annual background level for $PM_{2.5}$ is already above the relevant criterion and thus the cumulative assessment cannot be used to show compliance or not (refer to **Section 5.3.5**).

Table 7-2: Particulate dispersion modelling results for assessed receptors during construction – Cumulative impact

Receptor ID	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Annual average			
	Air quality impact criteria			
	8	**25**	**90**	**4**
	Background level			
	8.5	**18.3**	**65.9**	**2.9**
R1	**8.6**	18.5	66.3	2.9
R2	**8.6**	18.5	66.4	2.9
R3	**8.6**	18.6	66.5	3.0
R4	**8.7**	18.7	66.7	3.0
R5	**8.8**	18.9	67.3	3.0
R6	**8.8**	18.9	67.4	3.0
R7	**8.8**	18.9	67.4	3.0
R8	**8.6**	18.6	66.6	3.0
R9	**8.7**	18.9	67.4	3.0
R10	**9.0**	19.5	69.0	3.1
R11	**8.7**	18.8	67.1	3.0
R12	**9.1**	19.8	70.2	3.1
R13	**8.6**	18.6	66.5	3.0
R14	**8.6**	18.6	66.7	3.0
R15	**8.5**	18.3	66.0	2.9
R16	**8.5**	18.3	66.0	2.9
R17	**8.5**	18.3	66.0	2.9

7.2 Assessment of cumulative 24-hour average $PM_{2.5}$ and PM_{10} concentrations

A Level 2 contemporaneous assessment approach where the measured background levels are added to the day's corresponding predicted dust level from the Project is applied to assess for cumulative 24-hour average $PM_{2.5}$ and PM_{10} impacts.

Ambient (background) $PM_{2.5}$ and PM_{10} concentration data corresponding with the year of modelling (2020) from the NSW DPIE monitoring site at Bringelly have been applied in this case to represent the prevailing background levels in the vicinity of the Project and applied for representative receptor locations (R6, R10, R11 and R12) surrounding the Project likely to experience the highest impact.

The Level 2 assessment at the representative receptor locations for both $PM_{2.5}$ and PM_{10} indicate the Project does not increase the number of days above the 24-hour average criterion. Detailed tables of the contemporaneous assessment results are provided in **Appendix D**.

Time series plots of the predicted cumulative 24-hour average $PM_{2.5}$ and PM_{10} concentrations Receptor R12, are presented in **Figure 7-1**. The orange bars in the figure represent the contribution from the Project and the blue bars represent the background levels. It is clear from the figures that the Project has a relatively small influence at the assessed receptor locations.

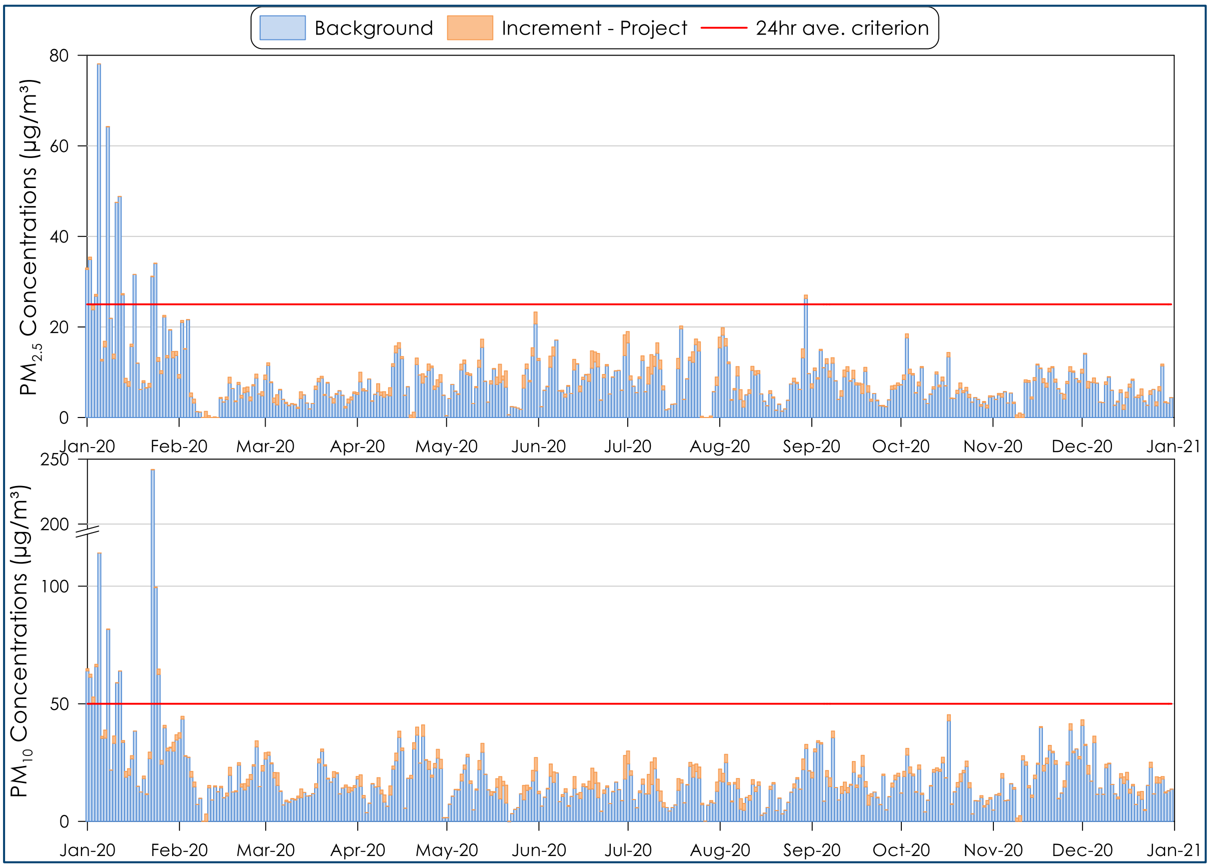

Figure 7-1: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ and PM_{10} concentrations for R12

7.3 Operational activity

Table 7-3 presents the predicted PM_{10}, NO_2 and odour dispersion modelling results at each of the assessed receptor locations for the operation of the Project. The NO_X emissions are assumed to have a maximum conversion rate of 30% to NO_2.

The results show that minimal incremental effects would arise at the receptor locations due to the operation of the Project and that all the assessed receptors are predicted to experience levels below the relevant impact assessment criteria.

Associated isopleth diagrams of the dispersion modelling results are presented in **Appendix C**.

Table 7-3: Dispersion modelling results for assessed receptors (µg/m³)

Receptor ID	PM_{10} (µg/m³)		NO_2 (µg/m³)		Odour (OU)
	24-hour average	Annual average	1-hour average	Annual average	99th percentile nose-response average
R1	1.1	0.1	10.6	0.3	<1
R2	1.4	0.2	12.8	0.3	<1
R3	1.6	0.2	13.1	0.4	<1
R4	1.9	0.2	15.5	0.5	<1
R5	2.5	0.3	19.7	0.7	<1
R6	2.8	0.4	21.3	0.8	<1
R7	2.7	0.4	24.4	0.8	<1
R8	1.4	0.2	17.6	0.4	<1
R9	2.2	0.3	20.3	0.7	<1
R10	3.6	0.6	29.3	1.2	<1
R11	2.0	0.3	19.1	0.6	<1
R12	4.4	0.5	29.8	1.1	<1
R13	1.4	0.1	13.3	0.3	<1
R14	1.2	0.1	14.6	0.3	<1
R15	0.3	0.0	3.5	0.0	<1
R16	0.3	0.0	3.4	0.0	<1
R17	0.2	0.0	3.3	0.0	<1
Maximum predicted level at receptor locations	4.4	0.6	29.8	1.2	<1
Background level	43.5	18.3	62.0	17.7	N/A
Maximum predicted level w/ background – cumulative impact	47.9	18.9	91.8	18.9	<1
Air quality impact criteria	**50**	**25**	**246**	**62**	**2**

8 AIR QUALITY MITIGATION AND MANAGEMENT RECOMMENDATIONS

To ensure activities associated with the construction and operation of the Project have a minimal effect on the surrounding environment and at receptor locations, it is recommended that best practice operational and physical mitigation measures should be implemented where feasible and reasonable as outlined in **Table 8-1**.

Table 8-1: Air quality mitigation and management measures

Source	Mitigation Measure
Construction	Visual monitoring of construction activities is to be undertaken to identify dust generation.
	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where reasonable levels of visible dust cannot be maintained).
	Vehicles and plant are to be fitted with pollution reduction devices where practicable.
	Construction vehicle traffic is to be restricted to designated routes.
	The extent of exposed surfaces and stockpiles is to be kept to a minimum.
	Exposed areas and stockpiles are either to be covered or are to be dampened with water as far as is practicable if dust emissions are visible or there is potential for dust emissions outside operating hours. Stockpiles of material that are going to remain in place for an extended period of time and have the potential to generate dust are to either be covered or vegetated.
	Dampen material when excessively dusty during handling.
	Reduce drop heights from loading and handling equipment where practical.
	Engines of on-site vehicles and plant to be switched off when not in use.
	Vehicles are to abide by site speed limits.
	Vehicle loads are covered when transporting material on and off-site.
General operational	The whole site (with the exception of landscaped areas) including trafficable areas are sealed.
	Yard area is kept clean, any incidental spills to be cleaned immediately.
	Regular sweeping and/ or hosing of hardstand area.
	Suitable air emission controls to be fitted to any air discharge associated with the Project
	Air emissions control technology to be regularly serviced and maintained per manufacturers specification.
Incident and complaints management	Record all air/odour/ dust incidents.
	Complaints are logged and investigated.

The modelling predictions for the construction phase of the Project do not indicate any exceedance of the relevant dust impact assessment criteria at the residential receptors. Given this situation, there are no specific ambient air quality monitoring recommendations for the Project. It is anticipated that the Project would develop a suitable Construction Dust Management Plan and would outline the measures to manage dust emissions at the site and include aspects such as key performance indications, response mechanisms, and complaints management.

The modelling predictions for the operations phase of the Project also indicate compliance with the relevant impact assessment criteria and no specific ambient air quality monitoring recommendations are made. It is recommended that the in-stack concentration monitoring be conducted as part of the commissioning phase to ensure the stack emissions comply with the applicable standards and that air emission control measures are working effectively.

9 SUMMARY AND CONCLUSIONS

This report has assessed the potential air quality impacts associated with the construction and operation of the First Building at the Bradfield City Centre.

Air dispersion modelling was used to predict the potential for off-site air quality impacts in the surrounding area due to the construction and operation of the Project. The estimated emissions of dust applied in the modelling are likely to be conservative and would overestimate the actual impacts.

It is predicted that all the assessed air pollutants generated by the operation of the Project would comply with the applicable assessment criteria at the receptors and therefore would not lead to any unacceptable level of environmental harm or impact in the surrounding area.

The site would apply appropriate air quality management measures to ensure it minimises the potential occurrence of excessive air emissions from the site. Overall, the assessment demonstrates that the Project can operate without causing any significant air quality impact at receptors in the surrounding environment.

10 REFERENCES

Bureau of Meteorology (2021)

Climate statistics for Australian locations, Bureau of Meteorology website, accessed September 2021. http://www.bom.gov.au/climate/averages

Capon A & Wright J (2019)

"An Australian incremental guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions", Public Health Research & Practice, vol 29, issue 4, accessed July 2021, https://doi.org/10.17061/phrp2941928

IAQM (2014)

“Guidance on the assessment of dust from demolition and construction”, UK Institute of Air Quality Management (IAQM), 2014.

Katestone Environmental Pty Ltd (2010)

"NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining", Katestone Environmental Pty Ltd prepared for DECCW, 2010.

M2A (2020)

“Sydney Metro – Western Sydney Airport Environment Impact Statement”, prepared for Sydney Metro by M2A Joint Venture (WSP and AECOM), October 2020.

NSW EPA (2017)

“Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales”, NSW Environment Protection Authority, January 2017.

TRC (2011)

"Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia", Prepared for the NSW Office of Environment and Heritage by TRC Environmental Corporation.

US EPA (1985 and update)

"Compilation of Air Pollutant Emission Factors", AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

Appendix A
Selection of Meteorological Year

Selection of meteorological year

The 2020 calendar year has been selected as the meteorological year for the dispersion modelling based on an analysis of the latest five years of meteorological data and wind patterns which reflect those patterns experienced in latest five years.

A statistical analysis of the latest five years of meteorological data from the nearest BoM weather station with suitable available data, Badgerys Creek AWS, is presented in **Table A-1**. The standard deviation of five years of meteorological data spanning 2016 to 2020 were analysed against the long-term measured wind speed, temperature and relative humidity. The analysis indicates that 2018 is closest to the average for wind speed and 2020 is the closest to the average for temperature and relative humidity.

Table A-1: Statistical analysis results of standard deviation from mean five year meteorological data at Badgerys Creek AWS

Year	Wind speed	Temperature	Relative humidity
2016	0.6	1.2	4.4
2017	0.4	1.1	4.3
2018	0.3	1.0	6.2
2019	0.4	1.2	5.2
2020	0.5	0.7	2.8

Figure A-1 shows the frequency distributions for wind speed, wind direction, temperature and relative humidity of the 2020 year compared with the mean of the 2016 to 2020 data set. The 2020 year data appear to be well aligned with the mean data for wind speed and wind direction which are the most critical parameters for dispersion.

Therefore, based on this analysis it was determined that 2020 is generally representative of the long-term trends compared to other years and is thus suitable for the purpose of modelling.

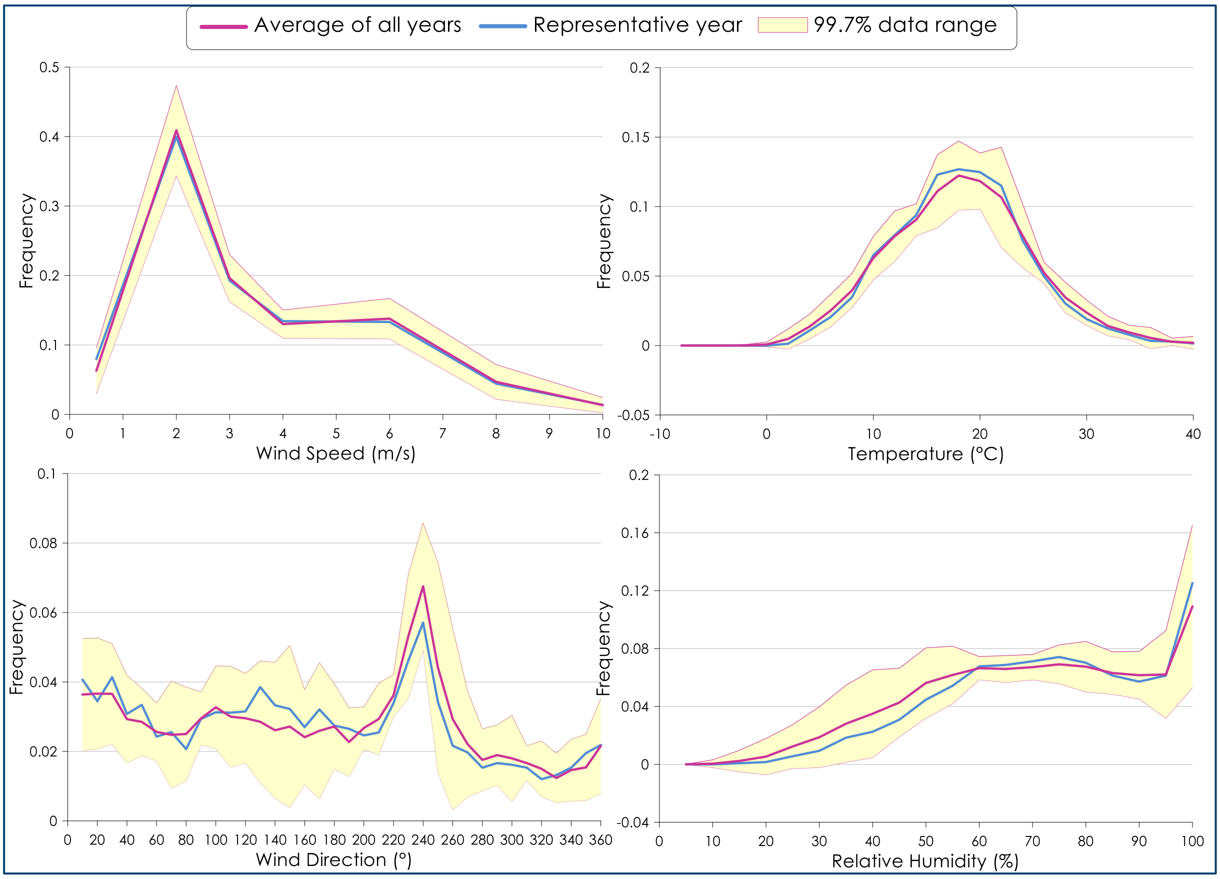

Figure A-1: Frequency distribution of meteorological parameters

Annual and seasonal windroses prepared from data collected for the 2020 calendar year are presented in **Figure A-2**.

A five-year annual and seasonal windrose for the Badgerys Creek AWS spanning 2016 to 2020 is presented in **Figure A-3**. The windrose indicates little variation when compared to the individual year presented in **Figure A-2** for the 2020 period. This further suggests that the 2020 calendar year is representative of the available data and is a suitable period for modelling.

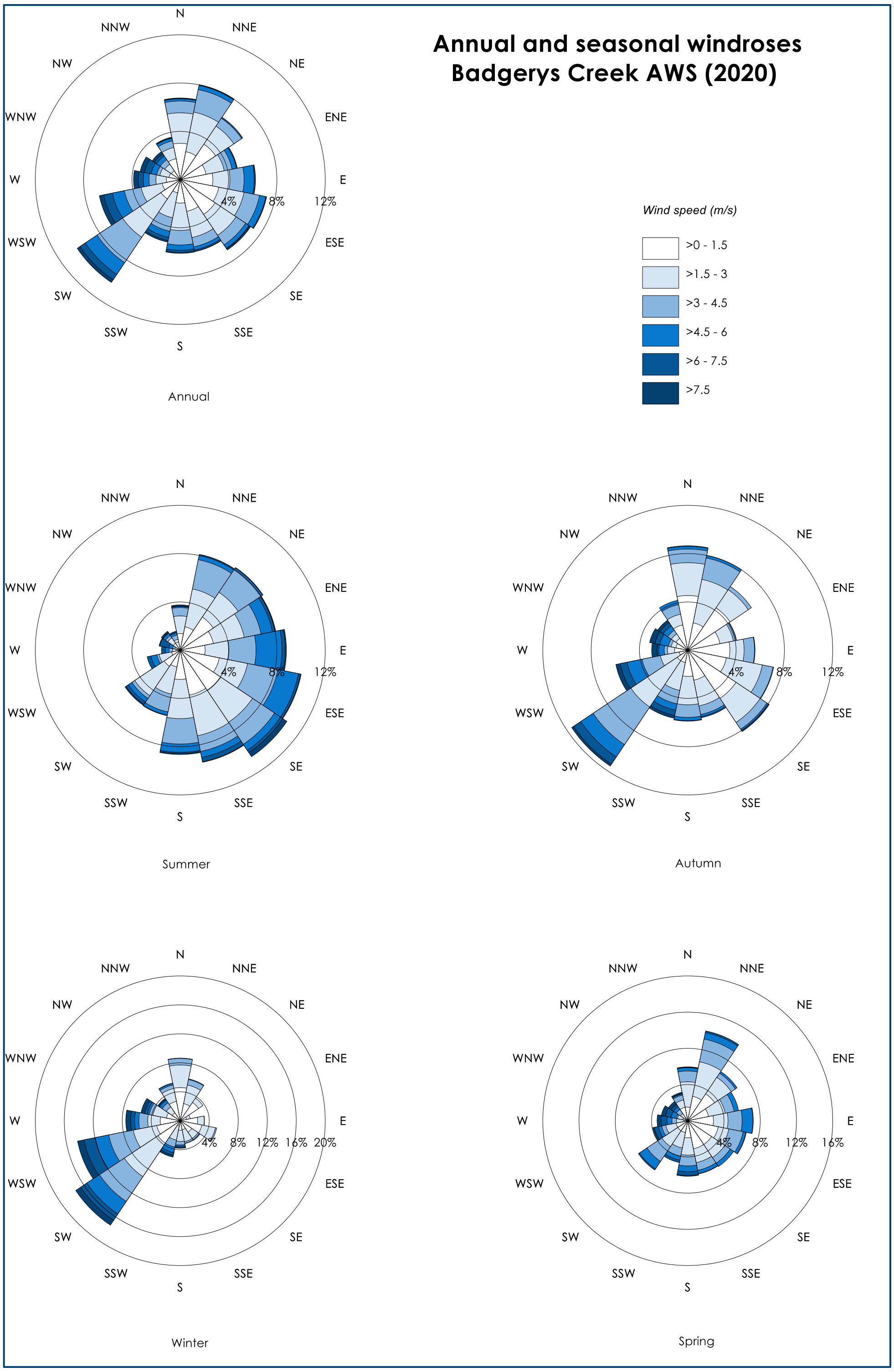

Figure A-2: Annual and seasonal windroses for Badgerys Creek AWS (2020)

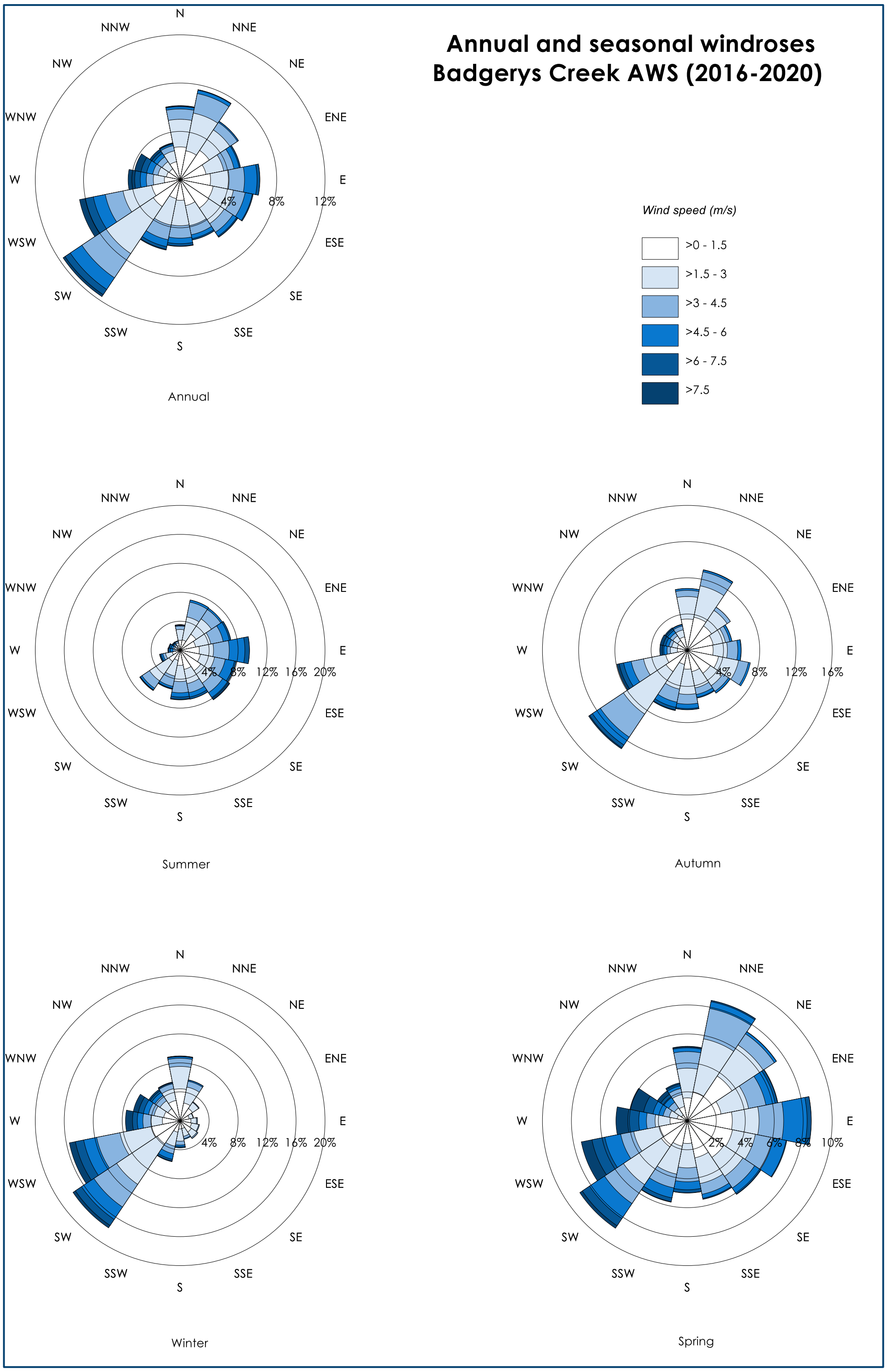

Figure A-3: Annual and seasonal windroses for Badgerys Creek AWS (2015-2019)

Appendix B

Emission Calculations

Emission Calculation

The dust emissions associated with the construction activity for the Project have been estimated from the operational description of the proposed activities provided by the Proponent and have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions and composition of the material being handled.

Emission factors and associated controls have been sourced from:

- United States (US) EPA AP42 Emission Factors (**US EPA, 1985 and Updates**);
- Office of Environment and Heritage document, "NSW Coal Mining Benchmarking Study: International Best Practise Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining", prepared by Katestone Environmental (**Katestone Environmental, 2010**).

The emission factor equations used for each dust generating activity are outlined in **Table B-1** below. A detailed emission inventory for the modelled period is presented in **Table B-2.**

Control factors include the following:

- Dozers travelling and working on moist material – 50% control.
- Hauling on unpaved surfaces – 75% control for watering of trafficked areas.
- Wind erosion on exposed areas and stockpiles – 50% control for watering.

Table B-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM_{10}	$PM_{2.5}$
Loading / emplacing material	$EF = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$
Hauling on sealed surfaces	$EF = 3.23 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$	$EF = 0.62 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$	$EF = 0.15 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$
Dozer working	$EF = 2.6 \times s^{1.2}/M^{1.3} kg/tonne$	$EF = 0.75 \times 0.45 \times s^{1.5}/M^{1.4} kg/tonne$	$0.105 \times TSP$
Wind erosion on exposed areas, stockpiles	$EF = 850 kg/ha/year$	$0.5 \times TSP$	$0.075 \times TSP$

EF = emission factor, U = wind speed (m/s), M = moisture content (%), s = silt content (%), VKT = vehicle kilometres travelled (km).

Table B-2: Emissions Inventory - Construction activity

Activity	TSP emission	PM10 emission	PM25 emission	Intensity	Units	EF - TSP	EF - PM10	EF - PM25	Units	Var 1	Units	Var 2	Units	Var 3 - TSP / PM10 / PM25	Units	Var 4	Units	Var 5	Units	Var 6	Units
Dozer working	6,527	1,577	685	780	h/yr	16.7	4.0	1.8	kg/t	10	S.C. %	2	M.C. %							50	C. %
Excavator loading cut to haul truck	51	24	4	49,018	t/yr	0.00104	0.00049	0.00007	kg/t	0.88	ave. ws (m/s)	2	M.C. %								
Hauling cut material to emplacement (unpaved)	496	128	13	49,018	t/yr	0.041	0.010	0.001	kg/t	28	t/l	0.5	km/rt	2.3 / 0.6 / 0.1	kg/VKT	5.0	S.C. %	32	Ave weight (t)	75	C. %
Unloading material at fill emplacement	51	24	4	49,018	t/yr	0.00104	0.00049	0.00007	kg/t	0.88	ave. ws (m/s)	2	M.C. %								
Rehandle material	10	5	1	9,804	t/yr	0.00104	0.00049	0.00007	kg/t	0.88	ave. ws (m/s)	2	M.C. %								
Hauling import material onsite (paved)	224	43	10	13,163	t/yr	0.0170	0.00327	0.00079	kg/t	28	t/l	0.9	km/rt	0.53 / 0.1 /0.02	kg/VKT	5	S.L. g/m2	32	Ave weight (t)		
Hauling import material to emplacement (unpaved)	133	34	3	13,163	t/yr	0.041	0.010	0.001	kg/t	28	t/l	0.5	km/rt	2.3 / 0.6 /0.1	kg/VKT	5.0	S.C. %	32	Ave weight (t)	75	C. %
Unloading import material at emplacement	14	6	1	13,163	t/yr	0.00104	0.00049	0.00007	kg/t	0.88	ave. ws (m/s)	2	M.C. %								
Rehandle material	3	1	0	2,633	t/yr	0.00104	0.00049	0.00007	kg/t	0.88	ave. ws (m/s)	2	M.C. %								
Wind erosion from exposed areas	1,955	978	147	4.6	ha	850	425	64	kg/ha/year											50	C. %
Exhaust emissions	275	275	267																		
Total emissions (kg/yr.)	**9,740**	**3,096**	**1,135**																		

Appendix C

Isopleth Diagrams

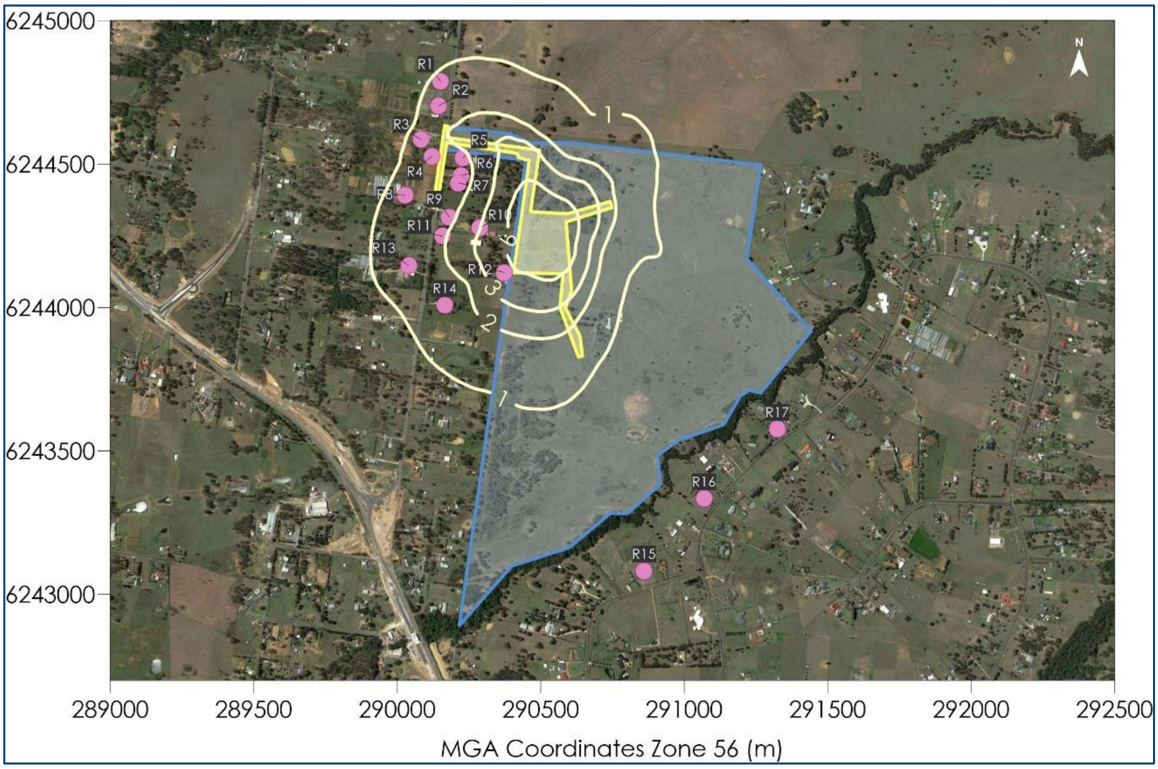

Figure C-1: Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations due to construction activity (µg/m³)

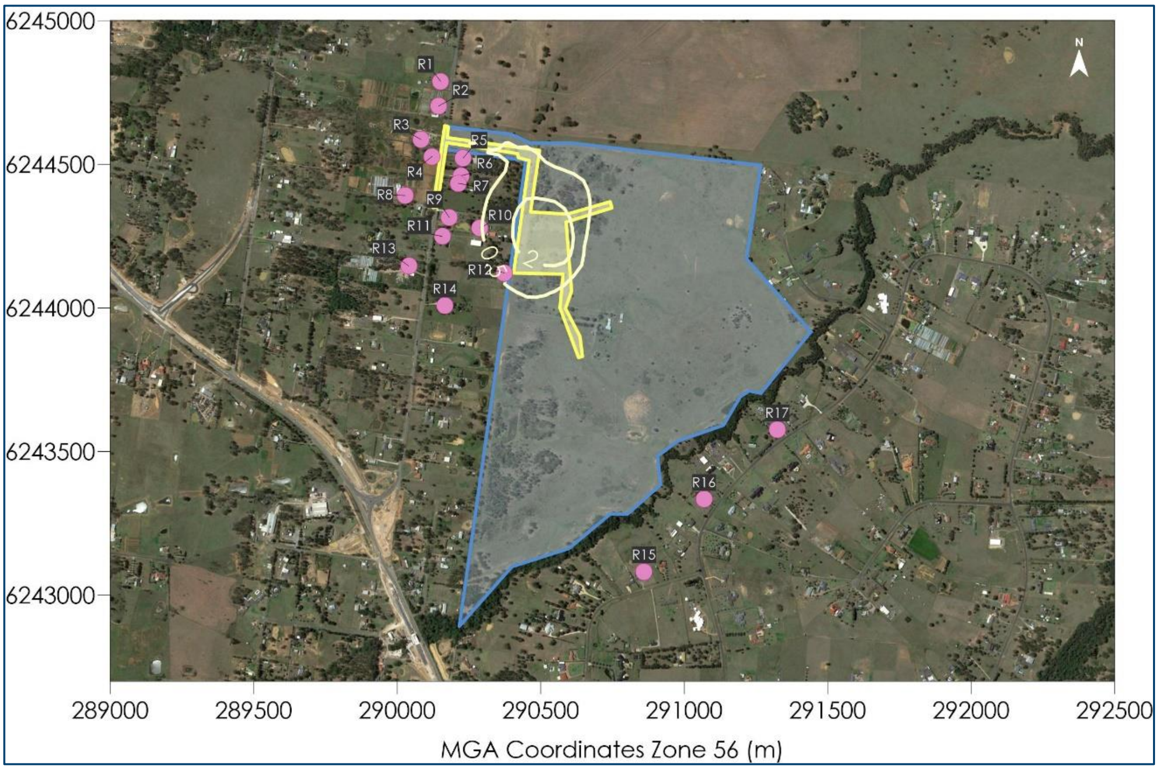

Figure C-2: Predicted incremental annual average $PM_{2.5}$ concentrations due to construction activity (µg/m³)

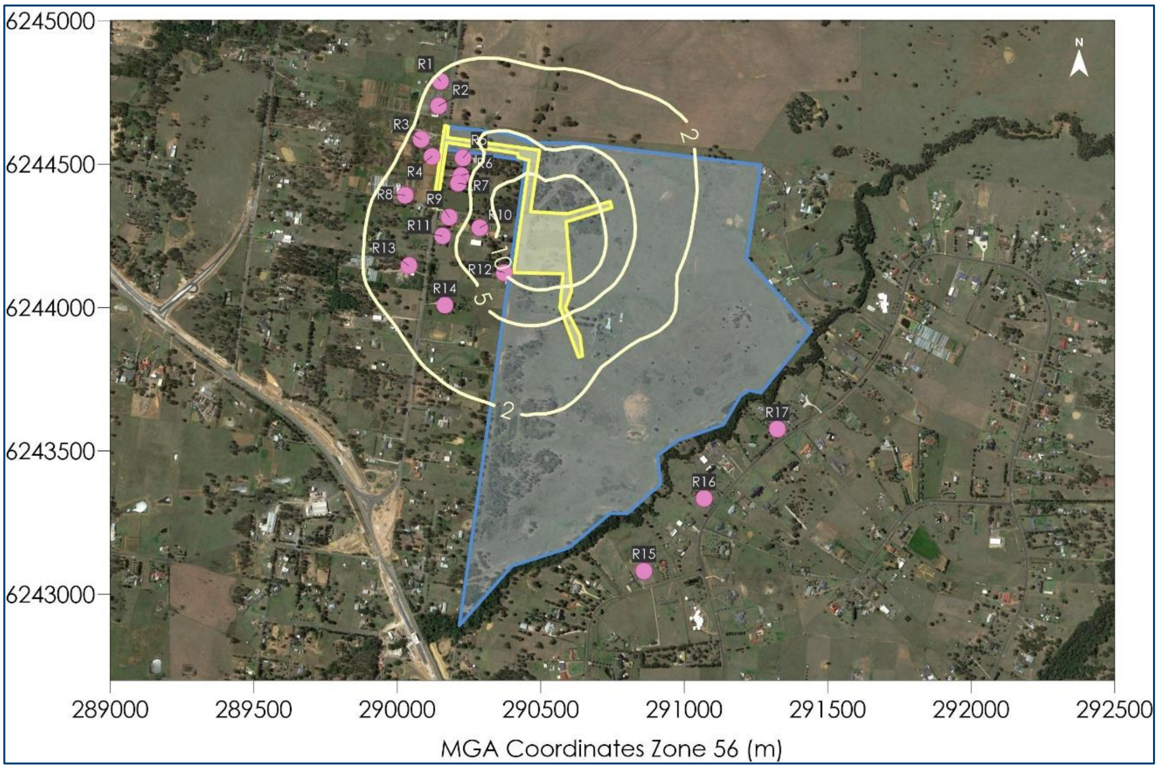

Figure C-3: Predicted incremental maximum 24-hour average PM_{10} concentrations due to construction activity (µg/m³)

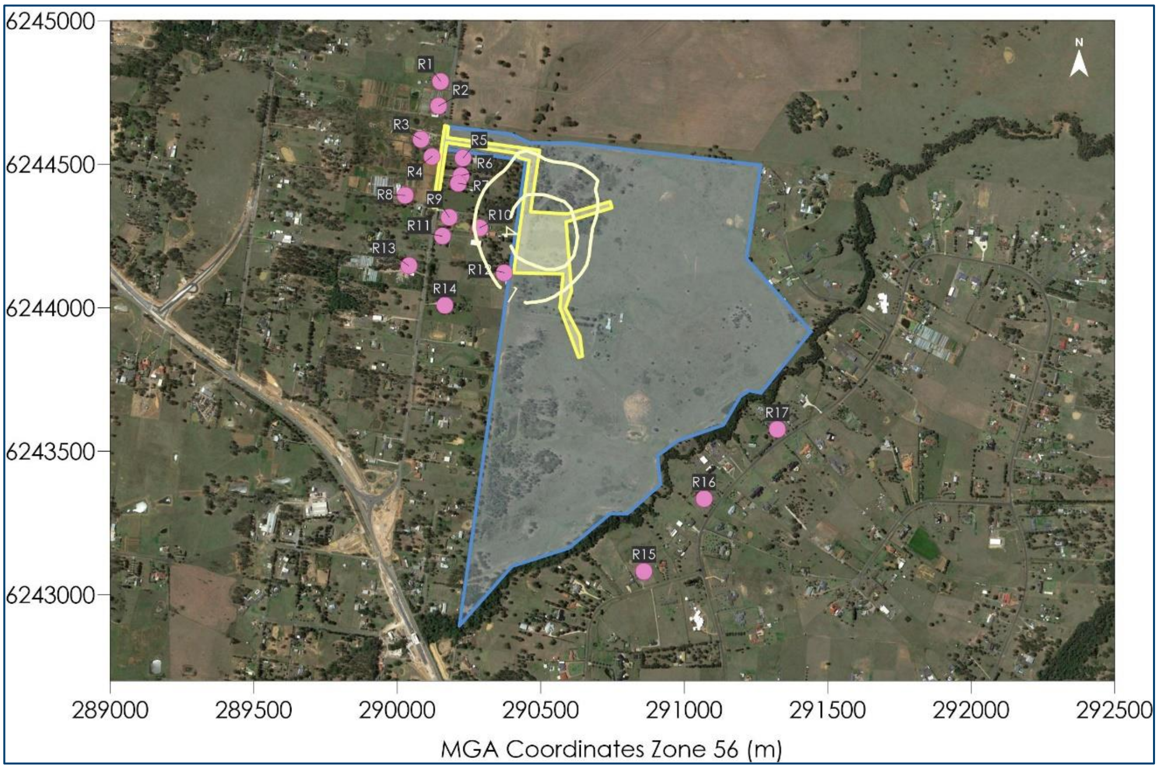

Figure C-4: Predicted incremental annual average PM_{10} concentrations due to construction activity (µg/m³)

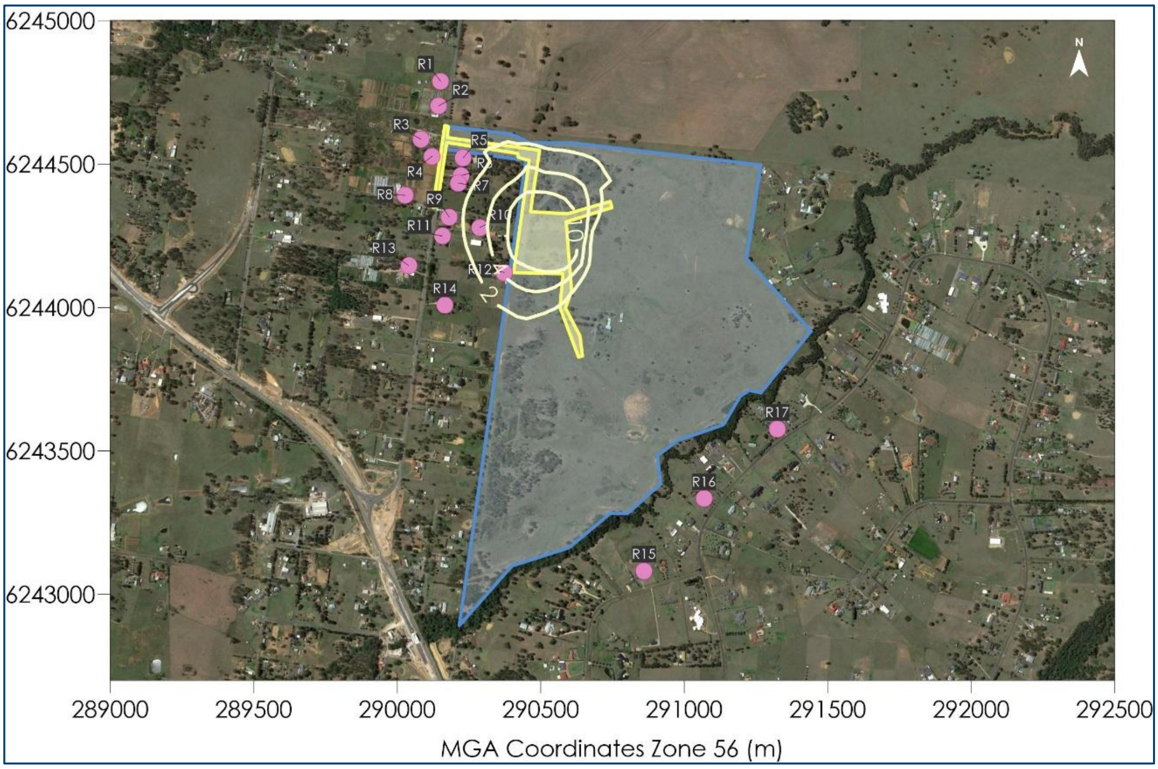

Figure C-5: Predicted incremental annual average TSP concentrations due to construction activity (µg/m³)

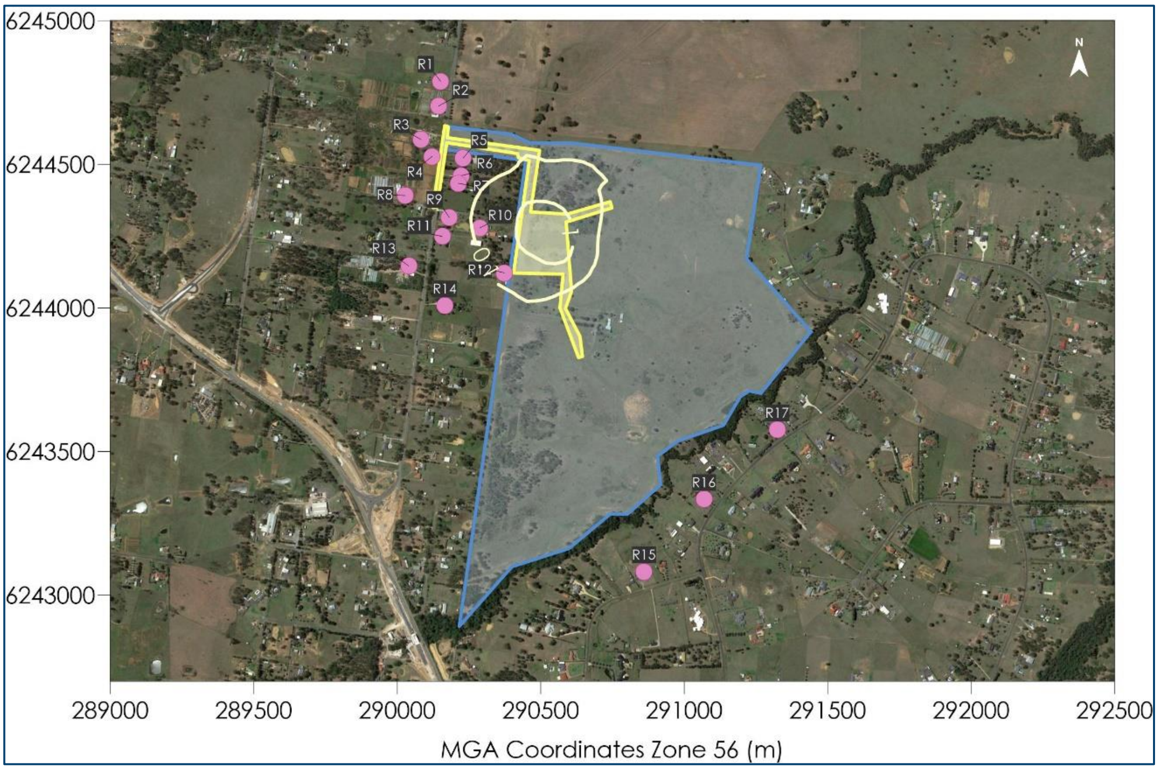

Figure C-6: Predicted incremental annual average dust deposition levels due to construction activity a(g/m²/month)

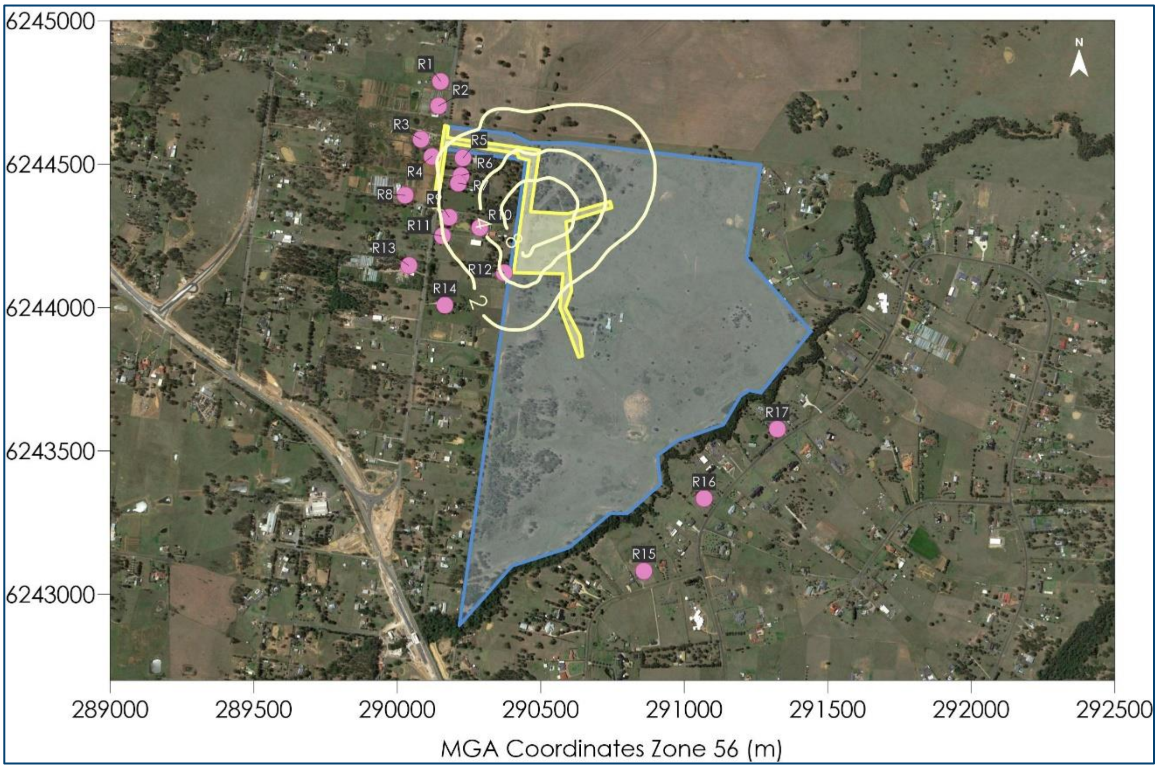

Figure C-7: Predicted incremental maximum 24-hour average PM_{10} concentrations due to operational activity (µg/m³)

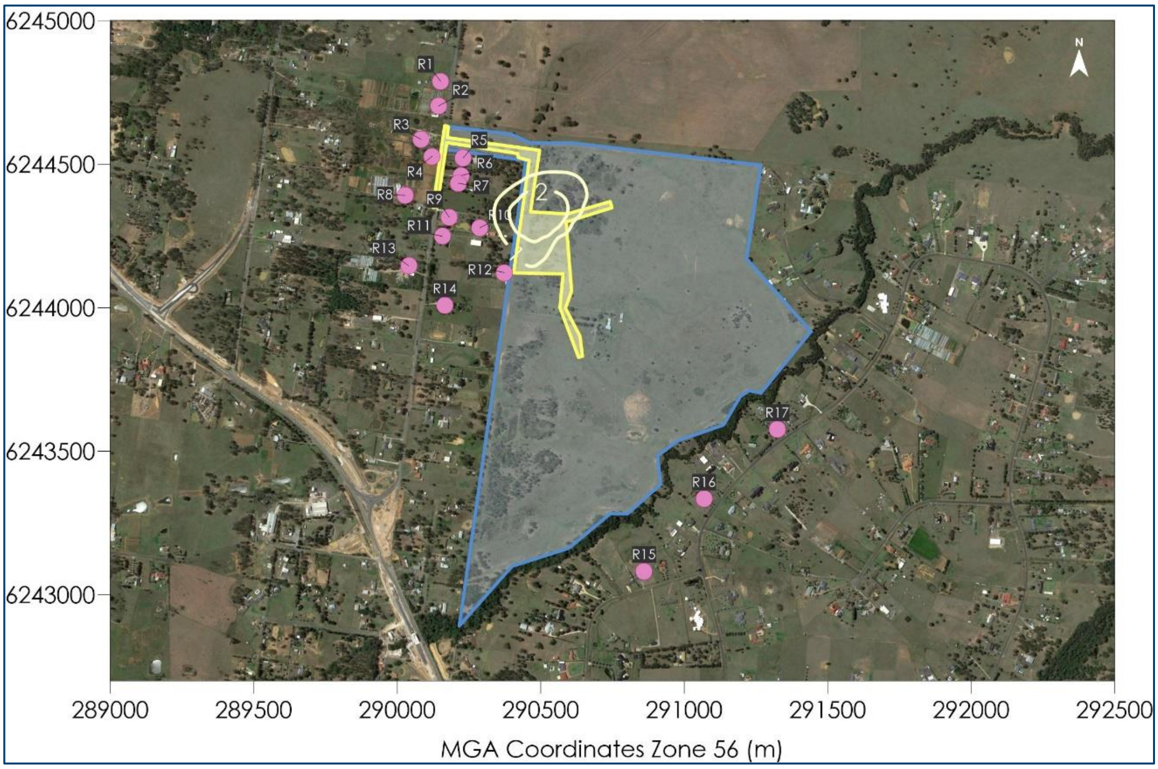

Figure C-7: Predicted incremental annual average PM_{10} concentrations due to operational activity (µg/m³)

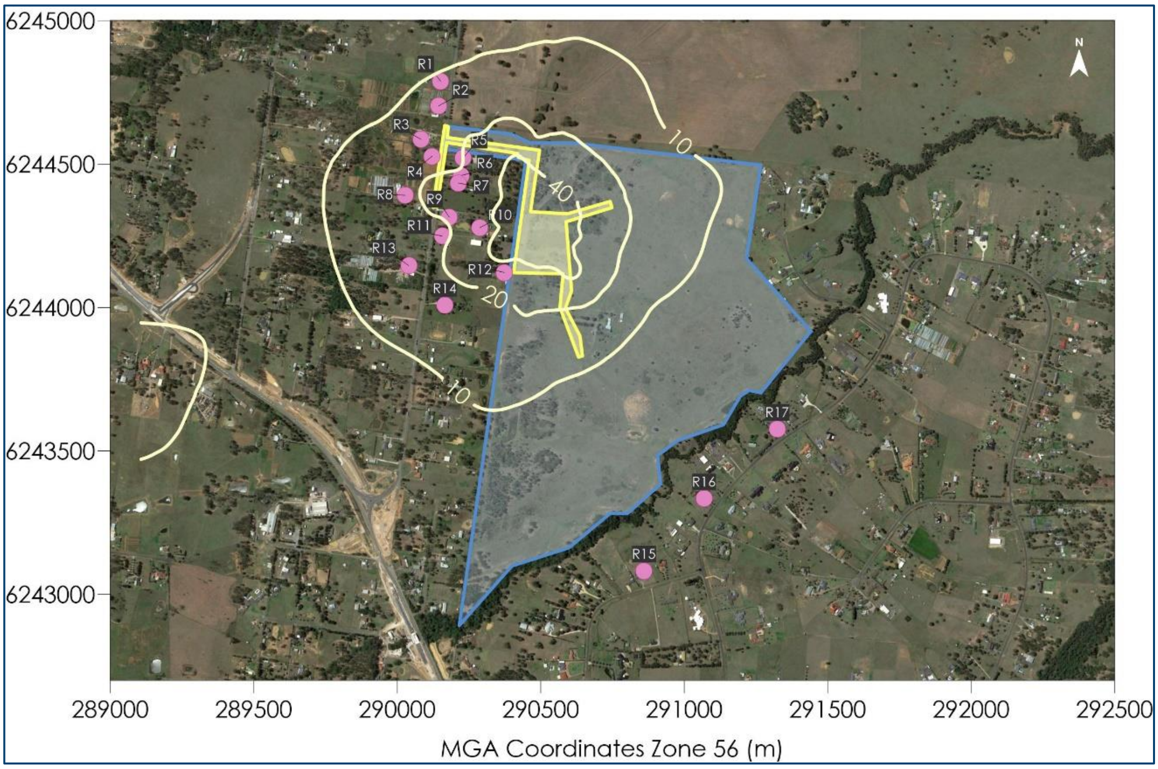

Figure C-9: Predicted incremental maximum 1-hour average NO_2 concentrations due to operational activity (µg/m³)

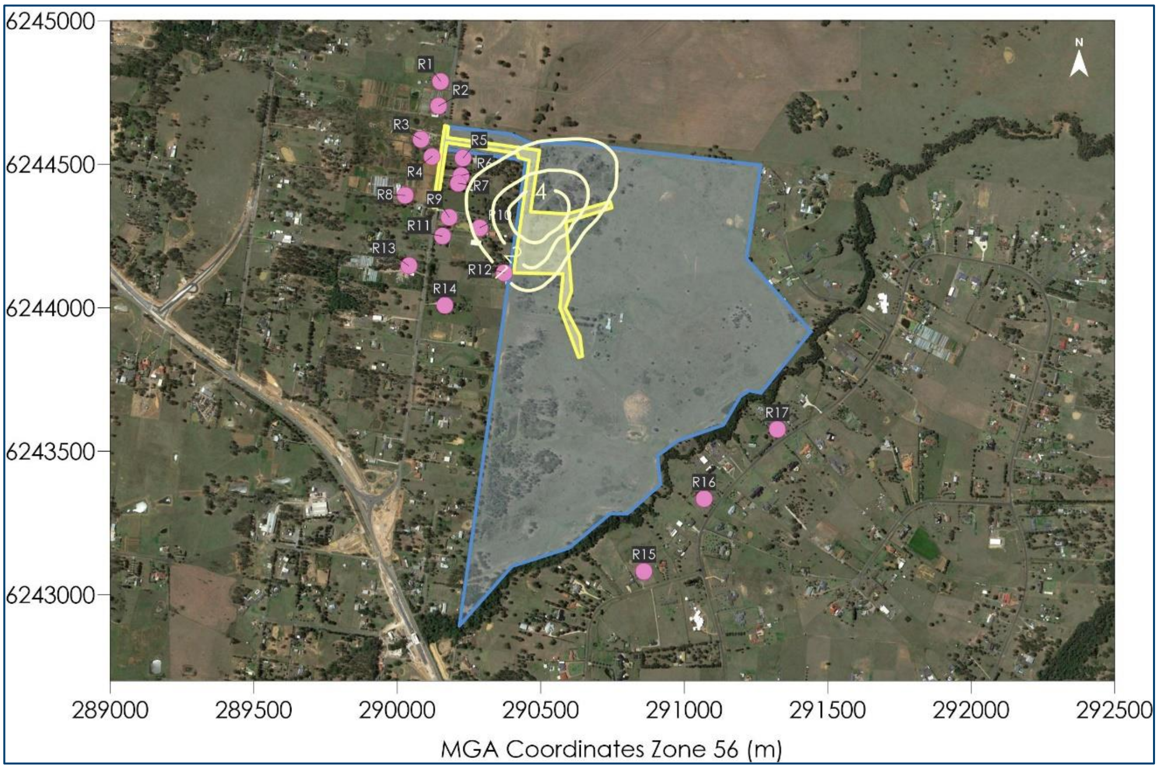

Figure C-10: Predicted incremental annual average NO_2 concentrations due to operational activity (µg/m³)

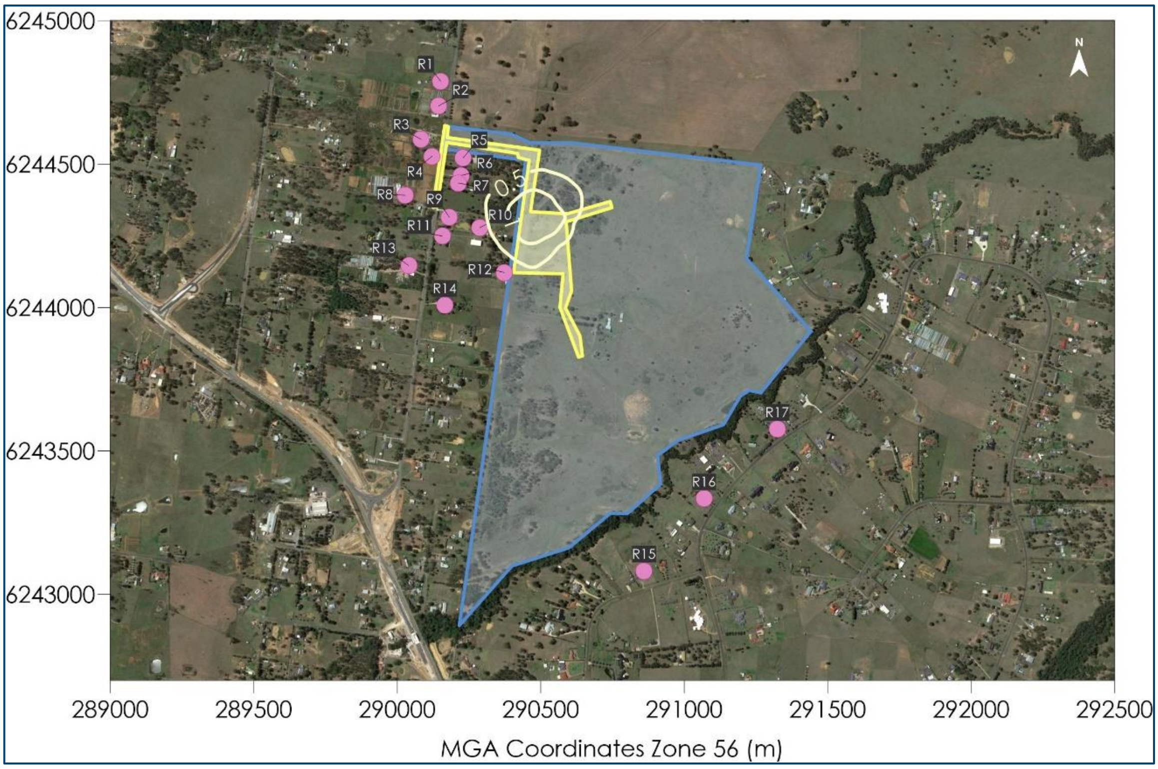

Figure C-11: Predicted 99th percentile nose-response average ground level odour concentrations due to operational activity (OU)

Appendix D

Further detail regarding 24-hour $PM_{2.5}$ and PM_{10} analysis

Further detail regarding 24-hour average $PM_{2.5}$ and PM_{10} analysis

The analysis below provides a cumulative 24-hour $PM_{2.5}$ and a 24-hour PM_{10} impact assessment in accordance with the NSW EPA Approved Methods; refer to the worked example on Page 46 to 47 of the Approved Methods.

The background level is the ambient level at Bringelly monitoring station for $PM_{2.5}$ and PM_{10}.

The predicted increment is the predicted level to occur at the receptor due to the project.

The total is the sum of the background level and the predicted level. The totals may have minor discrepancies due to rounding.

Each table assesses one receptor. The left half of the table examines the cumulative impact during the periods of highest background levels and the right half of the table examines the cumulative impact during the periods of highest contribution from the project.

The green shading represents days ranked per the highest background level but below the criteria.

The blue shading represents days ranked per the highest predicted increment level but below the criteria.

The orange shading represents days where the measured background level is already over the criteria.

Any value above the $PM_{2.5}$ criterion of 25µg/m^3 or above the PM_{10} criterion of 50µg/m^3 is in **bold red.**

Tables D-1 to **D-8** show the predicted maximum cumulative levels at each assessed receptor.

Table D-1: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R6

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
5/01/2020	**78.1**	0.6	**78.7**				
8/01/2020	**64.2**	0.6	**64.8**				
12/01/2020	**48.8**	0.4	**49.2**				
11/01/2020	**47.5**	0.3	**47.8**				
2/01/2020	**34.9**	0.3	**35.2**				
24/01/2020	**34**	0.3	**34.3**				
1/01/2020	**32.7**	0.3	**33.0**				
17/01/2020	**31.6**	0.0	**31.6**				
23/01/2020	**31.1**	0.0	**31.1**				
13/01/2020	**27.1**	0.1	**27.2**				
4/01/2020	**26.8**	0.1	**26.9**				
30/08/2020	**26.3**	0.1	**26.4**				
3/01/2020	23.8	0.2	24.0	6/07/2020	12.6	1.7	14.3
27/01/2020	22.2	0.2	22.4	7/08/2020	9.2	1.6	10.8
9/01/2020	21.9	0.5	22.4	29/05/2020	7.9	1.5	9.4
4/02/2020	21.6	0.3	21.9	16/05/2020	7.4	1.5	8.9
2/02/2020	21	0.3	21.3	4/06/2020	6.8	1.4	8.2
31/05/2020	20.7	0.4	21.1	29/06/2020	6	1.4	7.4
19/07/2020	19.6	0.2	19.8	11/05/2020	6.6	1.4	8.0
29/01/2020	19.3	0.3	19.6	10/06/2020	4.5	1.3	5.8
2/08/2020	18.2	0.2	18.4	28/06/2020	10.4	1.3	11.7
3/10/2020	17.6	0.1	17.7	8/04/2020	5.7	1.2	6.9

Table D-2: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R10

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
5/01/2020	**78.1**	0.3	**78.4**				
8/01/2020	**64.2**	0.9	**65.1**				
12/01/2020	**48.8**	0.3	**49.1**				
11/01/2020	**47.5**	0.4	**47.9**				
2/01/2020	**34.9**	1.1	**36.0**				
24/01/2020	**34**	0.5	**34.5**				
1/01/2020	**32.7**	0.7	**33.4**				
17/01/2020	**31.6**	0.0	**31.6**				
23/01/2020	**31.1**	0.0	**31.1**				
13/01/2020	**27.1**	0.8	**27.9**				
4/01/2020	**26.8**	0.1	**26.9**				
30/08/2020	**26.3**	0.2	**26.5**				
3/01/2020	23.8	0.8	24.6	23/07/2020	12.2	3.0	15.2
27/01/2020	22.2	0.8	23.0	10/06/2020	4.5	2.6	7.1
9/01/2020	21.9	0.3	22.2	16/05/2020	7.4	2.6	10.0
4/02/2020	21.6	0.6	22.2	9/07/2020	9.6	2.4	12.0
2/02/2020	21	1.0	22.0	6/07/2020	12.6	2.4	15.0
31/05/2020	20.7	0.4	21.1	21/05/2020	6.7	2.3	9.0
19/07/2020	19.6	0.3	19.9	18/05/2020	7.3	2.1	9.4

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
29/01/2020	19.3	1.0	20.3	27/05/2020	6.5	2.1	8.6
2/08/2020	18.2	0.2	18.4	25/07/2020	14.7	2.1	16.8
3/10/2020	17.6	0.3	17.9	8/04/2020	5.7	2.0	7.7

Table D-3: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R11

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
5/01/2020	78.1	0.0	78.1				
8/01/2020	64.2	0.3	64.5				
12/01/2020	48.8	0.1	48.9				
11/01/2020	47.5	0.1	47.6				
2/01/2020	34.9	0.5	35.4				
24/01/2020	34	0.2	34.2				
1/01/2020	32.7	0.3	33.0				
17/01/2020	31.6	0.0	31.6				
23/01/2020	31.1	0.0	31.1				
13/01/2020	27.1	0.4	27.5				
4/01/2020	26.8	0.0	26.8				
30/08/2020	26.3	0.1	26.4				
3/01/2020	23.8	0.4	24.2	23/07/2020	12.2	1.9	14.1
27/01/2020	22.2	0.3	22.5	16/05/2020	7.4	1.5	8.9
9/01/2020	21.9	0.0	21.9	10/06/2020	4.5	1.5	6.0
4/02/2020	21.6	0.2	21.8	9/07/2020	9.6	1.4	11.0
2/02/2020	21	0.5	21.5	18/05/2020	7.3	1.4	8.7
31/05/2020	20.7	0.2	20.9	27/05/2020	6.5	1.3	7.8
19/07/2020	19.6	0.1	19.7	25/07/2020	14.7	1.2	15.9
29/01/2020	19.3	0.4	19.7	6/07/2020	12.6	1.1	13.7
2/08/2020	18.2	0.1	18.3	21/05/2020	6.7	1.1	7.8
3/10/2020	17.6	0.1	17.7	8/04/2020	5.7	1.0	6.7

Table D-4: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R12

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
5/01/2020	78.1	0.0	78.1				
8/01/2020	64.2	0.1	64.3				
12/01/2020	48.8	0.0	48.8				
11/01/2020	47.5	0.0	47.5				
2/01/2020	34.9	0.5	35.4				
24/01/2020	34	0.1	34.1				
1/01/2020	32.7	0.3	33.0				

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
17/01/2020	**31.6**	0.0	**31.6**				
23/01/2020	**31.1**	0.1	**31.2**				
13/01/2020	**27.1**	0.3	**27.4**				
4/01/2020	**26.8**	0.4	**27.2**				
30/08/2020	**26.3**	0.7	**27.0**				
3/01/2020	23.8	0.9	24.7	30/06/2020	13.7	4.6	18.3
27/01/2020	22.2	0.4	22.6	9/07/2020	9.6	4.3	13.9
9/01/2020	21.9	0.0	21.9	19/05/2020	7.7	4.1	11.8
4/02/2020	21.6	0.0	21.6	19/06/2020	10.9	3.8	14.7
2/02/2020	21	0.4	21.4	8/07/2020	7.4	3.7	11.1
31/05/2020	20.7	2.6	23.3	21/05/2020	6.7	3.6	10.3
19/07/2020	19.6	0.6	20.2	21/06/2020	11.2	2.9	14.1
29/01/2020	19.3	0.1	19.4	27/05/2020	6.5	2.8	9.3
2/08/2020	18.2	1.6	19.8	31/05/2020	20.7	2.6	23.3
3/10/2020	17.6	0.9	18.5	1/07/2020	16.5	2.5	19.0

Table D-5: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R6

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
23/01/2020	**241.8**	0.1	**241.9**				
5/01/2020	**114.1**	2.0	**116.1**				
24/01/2020	**99.4**	0.8	**100.2**				
8/01/2020	**81.6**	1.6	**83.2**				
4/01/2020	**65.8**	0.1	**65.9**				
1/01/2020	**64**	1.0	**65.0**				
12/01/2020	**63.9**	0.9	**64.8**				
25/01/2020	**62.5**	0.4	**62.9**				
2/01/2020	**61.3**	0.6	**61.9**				
11/01/2020	**58.9**	0.8	**59.7**				
3/01/2020	**50.3**	0.5	**50.8**				
2/02/2020	43.5	0.9	44.4	9/02/2020		4.1	4.1
17/10/2020	42.8	0.6	43.4	6/07/2020	15.8	3.5	19.3
1/12/2020	40.8	0.4	41.2	29/05/2020	13.8	3.3	17.1
17/11/2020	39.9	1.2	41.1	29/06/2020	8.8	3.2	12.0
27/01/2020	39.8	0.5	40.3	7/08/2020	13.9	3.1	17.0
27/11/2020	38.8	0.4	39.2	28/06/2020	13.5	3.0	16.5
17/01/2020	38.4	0.0	38.4	16/05/2020	11.1	3.0	14.1
21/04/2020	36.7	0.2	36.9	4/06/2020	13.8	3.0	16.8
23/04/2020	36.2	0.3	36.5	11/05/2020	13.3	2.9	16.2
15/04/2020	35.7	0.6	36.3	10/06/2020	12.4	2.7	15.1

Table D-6: Cumulative 24-hour average $PM_{2.5}$ concentration (μg/m³) – Receptor R10

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
23/01/2020	241.8	0.0	241.8				
5/01/2020	114.1	0.9	115.0				
24/01/2020	99.4	1.5	100.9				
8/01/2020	81.6	2.4	84.0				
4/01/2020	65.8	0.2	66.0				
1/01/2020	64	2.6	66.6				
12/01/2020	63.9	0.8	64.7				
25/01/2020	62.5	1.8	64.3				
2/01/2020	61.3	3.3	64.6				
11/01/2020	58.9	1.2	60.1				
3/01/2020	50.3	2.9	53.2				
2/02/2020	43.5	3.2	46.7	23/07/2020	18.8	6.4	25.2
17/10/2020	42.8	0.8	43.6	10/06/2020	12.4	6.0	18.4
1/12/2020	40.8	0.7	41.5	16/05/2020	11.1	5.9	17.0
17/11/2020	39.9	3.1	43.0	6/07/2020	15.8	5.2	21.0
27/01/2020	39.8	2.6	42.4	9/07/2020	15.7	5.1	20.8
27/11/2020	38.8	1.1	39.9	21/05/2020	7.8	4.6	12.4
17/01/2020	38.4	0.0	38.4	25/07/2020	18.4	4.6	23.0
21/04/2020	36.7	0.5	37.2	18/05/2020	14.5	4.6	19.1
23/04/2020	36.2	0.4	36.6	27/05/2020	9.2	4.3	13.5
15/04/2020	35.7	1.0	36.7	8/04/2020	14.8	4.2	19.0

Table D-7: Cumulative 24-hour average $PM_{2.5}$ concentration (μg/m³) – Receptor R11

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
23/01/2020	241.8	0.0	241.8				
5/01/2020	114.1	0.1	114.2				
24/01/2020	99.4	0.5	99.9				
8/01/2020	81.6	0.7	82.3				
4/01/2020	65.8	0.1	65.9				
1/01/2020	64	1.0	65.0				
12/01/2020	63.9	0.2	64.1				
25/01/2020	62.5	0.8	63.3				
2/01/2020	61.3	1.5	62.8				
11/01/2020	58.9	0.4	59.3				
3/01/2020	50.3	1.3	51.6				
2/02/2020	43.5	1.4	44.9	23/07/2020	18.8	4.1	22.9
17/10/2020	42.8	0.3	43.1	10/06/2020	12.4	3.3	15.7
1/12/2020	40.8	0.3	41.1	16/05/2020	11.1	3.2	14.3
17/11/2020	39.9	1.1	41.0	18/05/2020	14.5	2.9	17.4
27/01/2020	39.8	1.2	41.0	9/07/2020	15.7	2.9	18.6
27/11/2020	38.8	0.4	39.2	25/07/2020	18.4	2.8	21.2
17/01/2020	38.4	0.0	38.4	27/05/2020	9.2	2.6	11.8
21/04/2020	36.7	0.2	36.9	6/07/2020	15.8	2.4	18.2
23/04/2020	36.2	0.2	36.4	9/04/2020	11.7	2.2	13.9

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/04/2020	35.7	0.5	36.2	21/05/2020	7.8	2.2	10.0

Table D-8: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R12

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
23/01/2020	**241.8**	0.3	**242.1**				
5/01/2020	**114.1**	0.0	**114.1**				
24/01/2020	**99.4**	0.3	**99.7**				
8/01/2020	**81.6**	0.2	**81.8**				
4/01/2020	**65.8**	1.0	**66.8**				
1/01/2020	**64**	0.9	**64.9**				
12/01/2020	**63.9**	0.1	**64.0**				
25/01/2020	**62.5**	2.3	**64.8**				
2/01/2020	**61.3**	1.3	**62.6**				
11/01/2020	**58.9**	0.0	**58.9**				
3/01/2020	**50.3**	2.6	**52.9**				
2/02/2020	43.5	1.2	44.7	30/06/2020	18	10.0	28.0
17/10/2020	42.8	2.5	45.3	9/07/2020	15.7	9.6	25.3
1/12/2020	40.8	2.4	43.2	19/05/2020	9.6	9.4	19.0
17/11/2020	39.9	0.4	40.3	19/06/2020	13.8	8.8	22.6
27/01/2020	39.8	1.0	40.8	8/07/2020	11.7	8.3	20.0
27/11/2020	38.8	2.7	41.5	21/05/2020	7.8	7.6	15.4
17/01/2020	38.4	0.0	38.4	21/06/2020	10.1	6.3	16.4
21/04/2020	36.7	3.4	40.1	27/05/2020	9.2	6.1	15.3
23/04/2020	36.2	4.8	41.0	31/05/2020	21.5	5.6	27.1
15/04/2020	35.7	2.7	38.4	1/07/2020	24.5	5.4	29.9