AIR QUALITY ASSESSMENT

BUS DEPOT AT 21 MIDDLETON ROAD CROMER

McNally Management

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Job Number 20111211

Prepared by
Todoroski Air Sciences Pty Ltd
Suite 2B, 14 Glen Street
Eastwood, NSW 2122
Phone: (02) 9874 2123
Fax: (02) 9874 2125
Email: info@airsciences.com.au

Air Quality Assessment
Bus Depot at 21 Middleton Road Cromer

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for McNally Management. It presents an assessment of the potential air quality impacts associated with the operation of a proposed Bus Depot at 21 Middleton Road Cromer, New South Wales (NSW) (hereafter referred to as the Project).

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

- A background and description of the Project;
- A review of the meteorological and air quality environment surrounding the Project site;
- A description of the dispersion modelling approach used to assess potential air quality impacts; and,
- Presentation of the predicted results and a discussion of the potential air quality impacts.

This air quality impact 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**).

2 PROJECT BACKGROUND

2.1 Local setting

The Project site is located within an existing industrial precinct approximately 5 kilometres (km) northeast of Frenchs Forrest and 8.1km north of Manly. The surrounding industries include various industrial and commercial services.

The nearest identified residential area to the Project is located approximately 100 metres (m) to the north. **Figure 2-1** presents the location of the Project and the nearest residential locations.

Figure 2-1: Project location

Figure 2-2 presents a representative three dimensional visualisation of the terrain features surrounding the Project location. The local topography is undulating, increasing to higher elevations to the west of the site. The Pacific Ocean is located approximately directly east of the site and would foster good dispersion in the area due to sea-breeze effects.

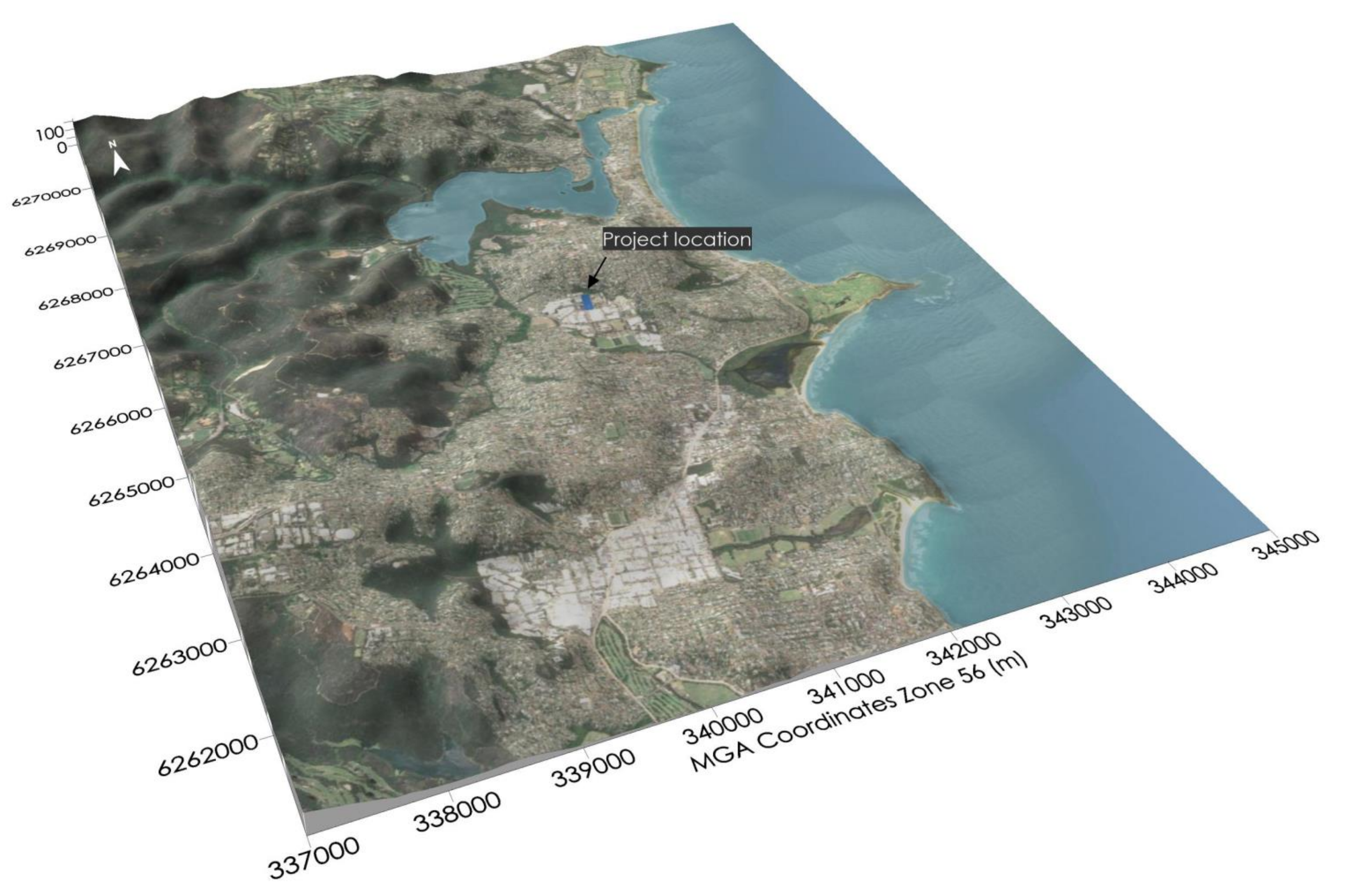

Figure 2-2: Representative visualisation of the local topography surrounding the Project

2.2 Project description

The Project proposes to construct and operate a bus depot at the site. There is an existing warehouse at the site which would be used to accommodate a total of 60 buses parked on-site. The Project would include features such as a fuel bay, office and amenities.

The potential air emissions for the Project have been identified as associated with the bus exhaust emissions which arise from idling buses during start-up and when manoeuvring on-site primarily when the buses are within the warehouse.

The fuel bay at the site would be used to store petroleum to refuel the buses at the site. The petroleum would be stored in a self-bunded fuel storage tank with an overhead canopy and electric bowser. The only petroleum product stored and dispensed at the fuel bay would be diesel. Unlike other petroleum products, diesel does not vaporise at normal outdoor temperatures and as such would not generate any Volatile Organic Compounds (VOCs)[1]. Therefore, there would be no volatile pollutants associated with the storage or dispensing of diesel at the site and these have not been considered further in this assessment.

Figure 2-3 presents an indicative site layout of the Project.

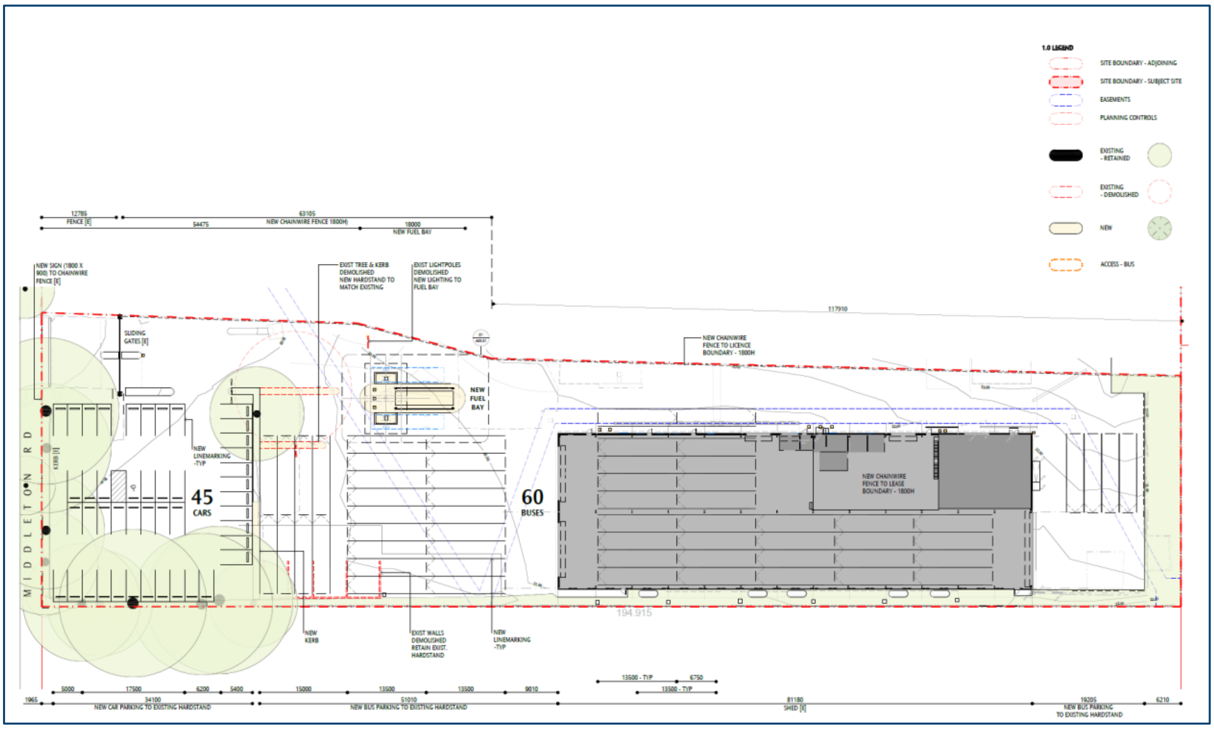

Figure 2-3: Indicative site layout

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[1] VOCs are defined by the National Pollutant Inventory (NPI) as any chemical compound based on carbon chains or rings with a vapour pressure greater than 0.01kPA at 293.15K (i.e. 20°C) (**NPI, 2009**).

3 AIR QUALITY CRITERIA

3.1 Preamble

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 potential air emissions generated by the Project and the applicable air quality criteria.

The NSW EPA has developed criteria and methods for assessing acceptable levels of exposure to benzene in NSW. The criteria that apply in NSW are set out in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

3.2 Assessed pollutants

Exhaust diesel emissions in the form of VOCs, oxides of nitrogen (NO_x), carbon monoxide (CO) and diesel particulate emissions have been considered. The key VOC pollutants from the diesel vapours with scope for any impact are benzene, formaldehyde, polycyclic aromatic hydrocarbons (PAH), toluene and xylene on the basis of composition in the fuel and potential for impact. Non-exhaust emissions associated with tyre, brake and road wear would be in the form of particulate emissions.

Table 3-1 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**).

Table 3-1: Applicable air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Percentile	Criterion (µg/m³)	Criteria basis
TSP	Annual	Total	100	90	Health
PM_{10}	Annual	Total	100	25	Health
	24 hour	Total	100	50	Health
$PM_{2.5}$	Annual	Total	100	8	Health
	24 hour	Total	100	25	Health
NO_2	1 hour	Total	100	246	Health
	Annual	Total	100	62	Health
CO	1 hour	Total	100	30,000	Health
	Annual	Total	100	10,000	Health
Benzene	1 hour	Incremental	99.9	29	Health
Formaldehyde	1 hour	Incremental	99.9	20	Health
PAH (as benzo[a]pyrene)	1 hour	Incremental	99.9	0.4	Health
Toluene	1 hour	Incremental	99.9	360	Amenity (odour)
Xylenes	1 hour	Incremental	99.9	190	Amenity (odour)

Source: **NSW EPA, 2017**

It is noted that other pollutants would be present in the VOC vapours. These other substances do not require assessment as they are never present in the exhaust emissions at concentrations which would lead to greater impacts than would arise for the VOC pollutants assessed above. In other words, when the concentrations of the VOC pollutants assessed above are within criteria, all other VOC substances present in exhaust emissions will also be at concentrations within criteria.

Individual odorous air pollutants (i.e. toluene, xylene) have been assessed in this assessment. The criteria for these pollutants relate to odour amenity and the toluene and xylene concentrations would exceed the odour based criteria before exceeding health criteria.

It is also important to note that in NSW, the criteria for the some of the relevant pollutants apply without consideration of background levels. In NSW, the criteria for these pollutants are set at stringent levels on the basis that only the effect due to the Project in isolation is assessed against the criterion value, i.e. the pollutant is assessed for incremental impact only. For those pollutants at which the pollutant is assessed for total impact, these apply with consideration of ambient background levels.

4 EXISTING ENVIRONMENT

This section describes the existing climate in the area surrounding the Project.

4.1 Local climate

Long-term climatic data from the Bureau of Meteorology weather station located at Sydney Observatory Hill (Site No. 066062) were analysed to characterise the local climate in the proximity of the Project site.

Table 4-1 and **Figure 4-1** present a summary of data from the Sydney (Observatory Hill) site collected over an approximate 37 to 162-year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 26.0 degrees Celsius (°C), July is the coldest month with mean minimum temperatures of 8.1°C.

Rainfall is generally higher during the first half of the year, with an average annual rainfall of 1213.4 millimetres (mm) over 99.5 days. The data show June is the wettest month with an average rainfall of 133.1mm over 8.8 days and September is the driest month with an average rainfall of 68.1mm over 7.1 days.

Relative humidity levels exhibit some variability over the year and seasonal fluctuations. Mean 9am relative humidity levels range from 61% in October to 74% in February, March, May and June. Mean 3pm humidity levels vary from 49% in August to 64% in February.

Wind speeds have a greater spread between the 9am and 3pm conditions during the cooler months of the year compared to the warmer months. The mean 9am wind speeds range from 7.9 kilometres per hour (km/h) in March to 13.3km/h in August. The mean 3pm wind speeds vary from 12.7km/h in May to 19.5km/h in December.

Table 4-1: Monthly climate statistics summary – Sydney (Observatory Hill)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	26.0	25.8	24.8	22.5	19.5	17.0	16.4	17.9	20.1	22.2	23.7	25.2	21.8
Mean min. temp. (°C)	18.8	18.9	17.6	14.8	11.6	9.3	8.1	9.0	11.1	13.6	15.7	17.6	13.8
Rainfall													
Rainfall (mm)	101.2	119.3	131.6	126.5	117.4	133.1	96.3	80.2	68.1	76.7	83.8	77.1	1213.4
No. of rain days	8.6	9.0	9.9	8.9	8.6	8.8	7.4	7.1	7.1	7.9	8.3	7.9	99.5
9am conditions													
Mean temp. (°C)	22.5	22.3	21.1	18.2	14.6	11.9	10.9	12.5	15.7	18.5	19.9	21.6	17.5
Mean R.H. (%)	71	74	74	72	74	74	71	66	62	61	66	67	69
Mean W.S. (km/h)	8.6	8.2	7.9	8.8	10.5	11.9	13.1	13.3	12.4	12.2	11.0	9.8	10.6
3pm conditions													
Mean temp. (°C)	24.8	24.9	24.0	22.0	19.4	16.9	16.4	17.5	19.2	20.7	22.1	23.8	21.0
Mean R.H. (%)	62	64	62	59	57	57	51	49	51	56	58	59	57
Mean W.S. (km/h)	17.9	16.8	15.2	13.8	12.7	13.6	15.3	17.6	18.3	19.1	19.4	19.5	16.6

Source: **Bureau of Meteorology, 2020**

RH = Relative Humidity, WS = Wind speed

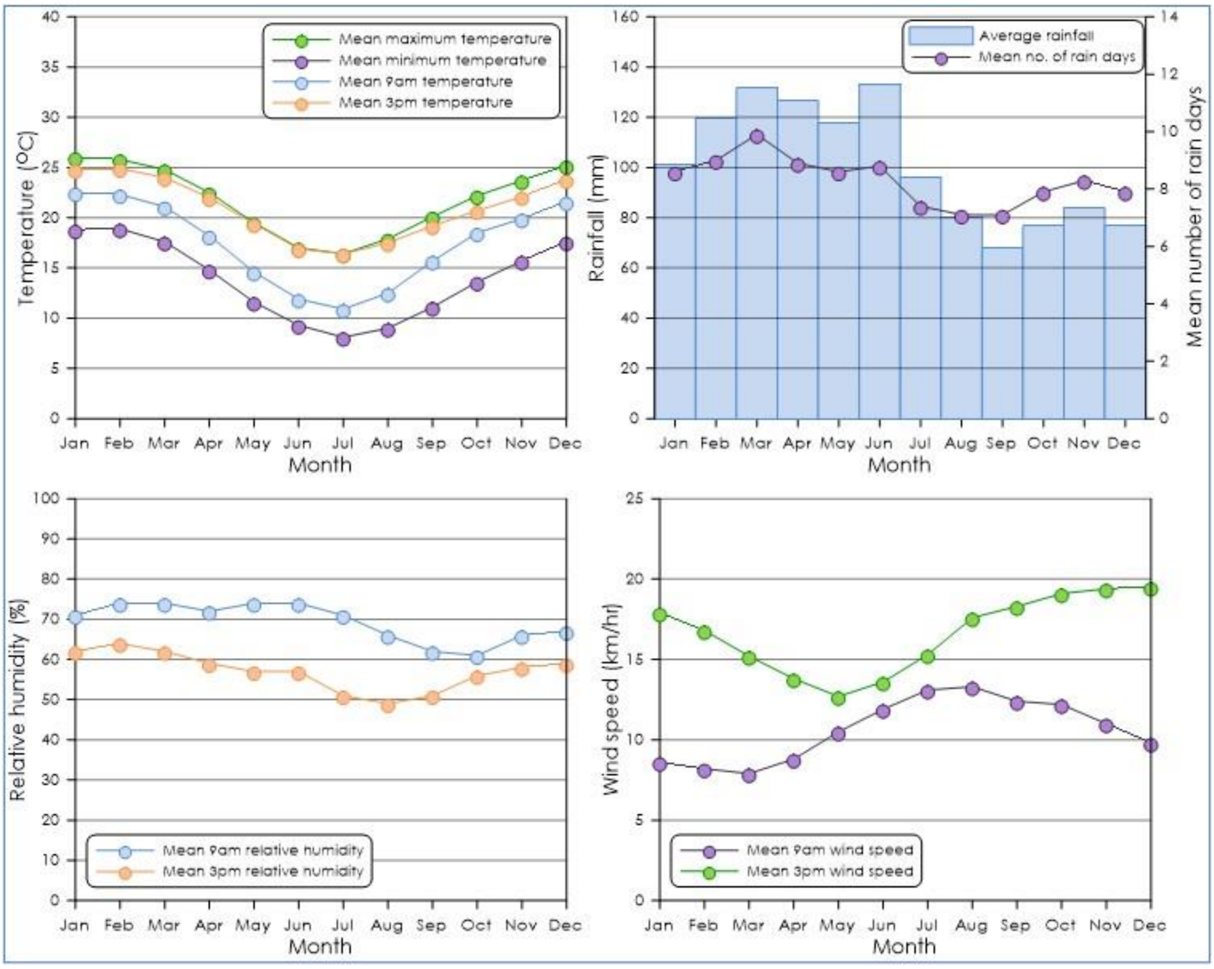

Figure 4-1: Monthly climate statistics summary – Sydney (Observatory Hill)

4.2 Local meteorological conditions

Annual and seasonal windroses generated from data collected at the Terry Hills Automatic Weather Station (AWS) during 2015 are presented in **Figure 4-2**. The Terry Hills AWS is located approximately 7.2km northwest of the Project.

The 2015 calendar year was selected as the meteorological year for the dispersion modelling based on an analysis of statistical data trends in meteorological data recorded for the area as outlined in **Appendix A**.

On an annual basis, winds are varied and predominantly occur from the west and the west-northwest. In summer, winds predominantly occur from the northeast. The autumn distribution is similar to the annual distribution with varied winds predominantly from the west and west-northwest but with fewer winds from the northeast. In winter winds typically range from the southwest to the north. In spring, the winds from the northeast are most dominant.

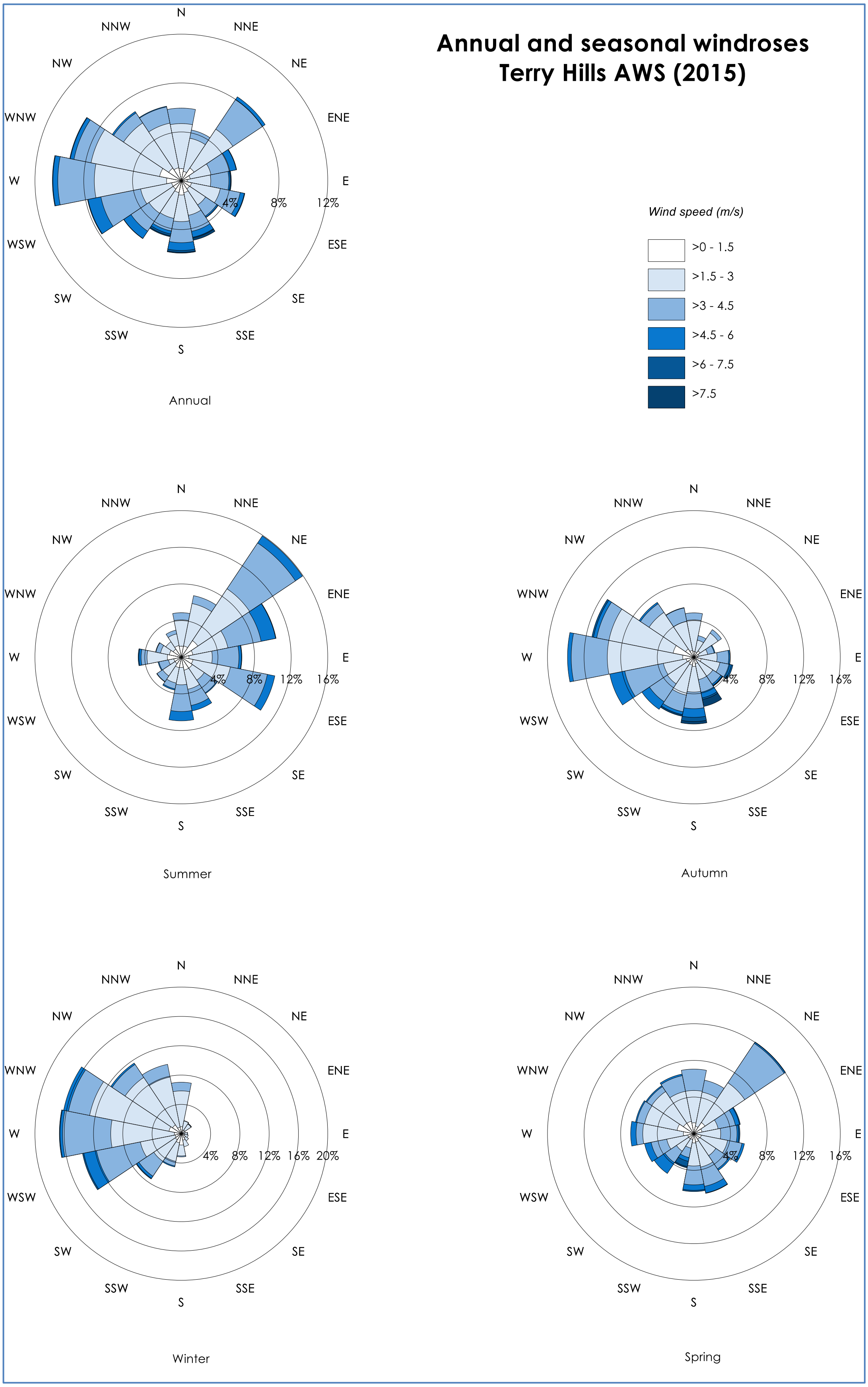

Figure 4-2: Annual and seasonal windroses for Terry Hills AWS (2015)

4.3 Local air quality monitoring

The main sources of air pollutants in the area surrounding the Project would include emissions from agricultural activities, anthropogenic activities such as various industrial and commercial activities, motor vehicle exhaust and also natural sources such as the local sand dunes.

Ambient air quality monitoring data from the Project site are not available. Therefore, the available data from air quality monitors operated by the NSW Department of Planning Industry & Environment (DPIE) were used to quantify the existing background level for assessed pollutants at the Project site.

These include the Lindfield, Macquarie Park, Rozelle, Parramatta North and Prospect monitors. The locations of these monitors relative to the Project site are approximately 13.5km, 15.7km, 18.2km, 27.4km and 34.9km, respectively.

4.3.1 PM_{10} monitoring

A summary of the available PM_{10} monitoring data from the NSW DPIE monitoring stations is presented in **Table 4-2**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-3.**

A review of **Table 4-2** indicates that the annual average PM_{10} concentrations for all monitoring stations reviewed were below the relevant criterion of 25µg/m^3 with the exception of the Parramatta North and the Prospect monitor which exceeded the relevant criterion during the 2019 calendar year. Note that where there are insufficient data (i.e. less than 75% data availability) an annual average is not calculated. The maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m^3 on occasion during the review period.

Table 4-2: Summary of PM_{10} levels from NSW DPIE monitoring (µg/m^3)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
	Annual average					
2015	14.0	-	16.7	-	17.6	**25**
2016	15.4	-	16.8	-	18.9	**25**
2017	16.0	-	18.1	-	18.9	**25**
2018	18.0	17.2	18.4	21.6	21.9	**25**
2019	-	19.9	22.7	**25.5**	**26.0**	**25**
	Maximum 24-hour average					
2015	**56.4**	-	**60.3**	-	**68.7**	**50**
2016	**68.9**	-	**58.8**	-	**110.1**	**50**
2017	46.3	49.6	**54.1**	35.1	**61.1**	**50**
2018	**89.7**	**85.6**	**88.3**	**107.4**	**113.3**	**50**
2019	**59.5**	**187.3**	**142.7**	**195.3**	**182.8**	**50**

It can be seen from **Figure 4-3** that PM_{10} concentrations nominally peak in spring and summer with the warmer weather raising the potential for drier ground, elevating the occurrence of windblown dust.

A brief examination of the elevated PM_{10} levels indicates that they typically correspond with regional dust events and bushfires which affect a wide area, this is particularly evident in 2019 as a result of the NSW bushfires in November and December (**NSW DPIE, 2019a & NSW DPIE, 2019b**). At other times, potential dust sources such as local agricultural sources, industrial activity and other such dust sources may have contributed to periods of elevated PM_{10} levels.

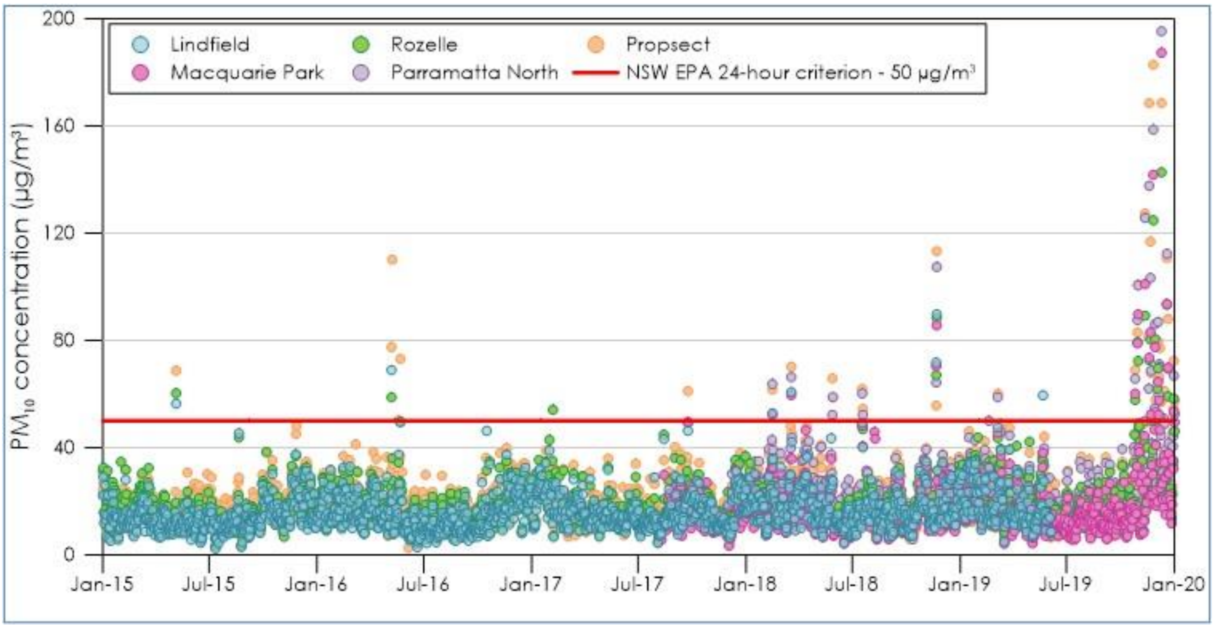

Figure 4-3: 24-hour average PM_{10} concentrations

4.3.2 $PM_{2.5}$ monitoring

A summary of the available data from the NSW DPIE monitoring stations is presented in **Table 4-3**. Recorded 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 4-4**. It is noted that the Lindfield monitor does not record measured $PM_{2.5}$ data.

Table 4-3 indicates that the annual average $PM_{2.5}$ concentrations for the monitoring stations were below the annual average criterion of 8µg/m^3 with the exception of the Prospect monitor in 2015 and 2016, the Prospect and Parramatta North monitors in 2018 and in 2019 all monitors were above the annual average criterion. Note that where there are insufficient data (i.e. less than 75% data availability) an annual average is not calculated. The maximum 24-hour average $PM_{2.5}$ concentrations were found to exceed the relevant criterion of 25µg/m^3 on occasion during the review period.

Table 4-3: Summary of $PM_{2.5}$ levels from NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
	Annual average					
2015	-	-	7.2	-	**8.2**	**8**
2016	-	-	7.4	-	**8.7**	**8**
2017	-	-	7.2	-	7.7	**8**
2018	-	7.0	-	**9.2**	**8.5**	**8**
2019	-	**9.2**	**10.3**	**10.5**	**11.9**	**8**
	Maximum 24-hour average					
2015	-	-	**36.0**	-	**29.6**	**25**
2016	-	-	**49.4**	-	**84.9**	**25**
2017	-	24.1	**36.3**	13.9	**30.1**	**25**
2018	-	**58.4**	19.2	**42.1**	**47.5**	**25**
2019	-	**152.0**	**101.8**	**130.1**	**134.1**	**25**

It can be seen from **Figure 4-4** that 24-hour average $PM_{2.5}$ concentrations follow a seasonal trend with peaks occurring in winter periods and are likely associated with wood heater emissions. This is opposite to the seasonal trend for PM_{10} concentrations which have elevated levels during the warmer months. As mentioned, the very high $PM_{2.5}$ levels seen in late 2019 are a result of the widespread NSW bushfires.

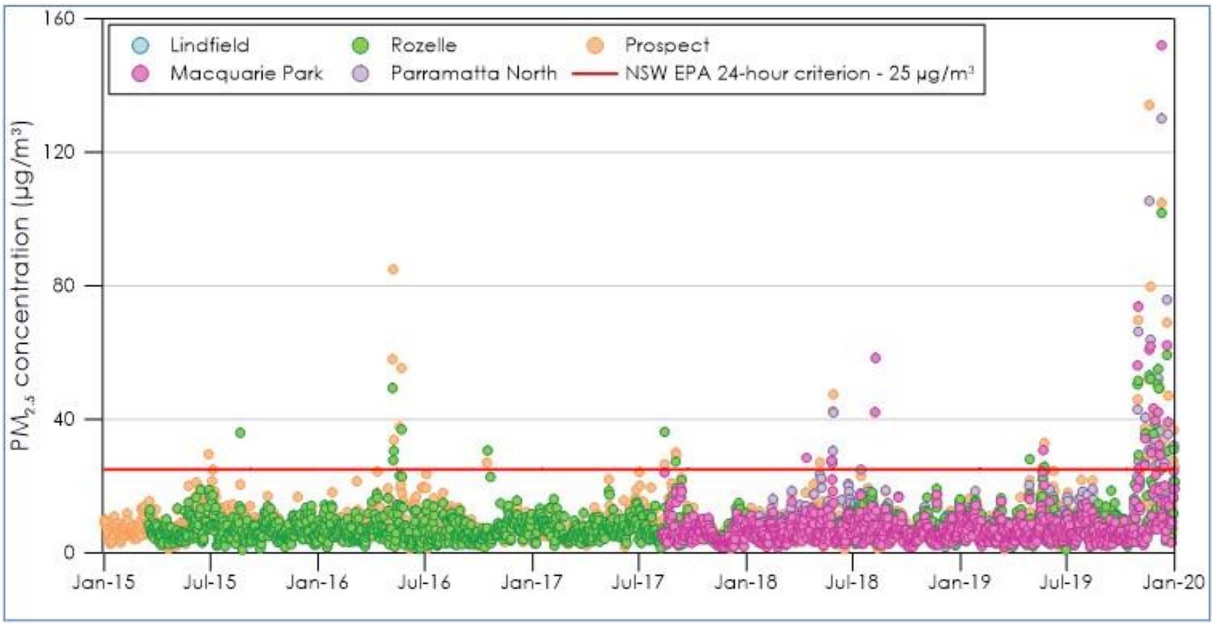

Figure 4-4: 24-hour average $PM_{2.5}$ concentrations

4.3.3 NO_2 monitoring

A summary of the available NO_2 data from the NSW DPIE monitoring stations is presented in **Table 4-4**. The daily 1-hour maximum NO_2 concentrations are presented in **Figure 4-5**.

Table 4-4 indicates that the annual and maximum 1-hour average NO_2 concentrations for all monitors during the review period were below the respective criterion. It can be seen from **Figure 4-5** that concentrations are generally higher in cooler months when temperatures are low and there is less sunlight, making it more difficult for NO_2 to convert to ozone (**DECCW, 2010**).

Table 4-4: Summary of NO_2 levels from available NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
	Annual average					
2015	15.4	-	21.9	-	21.6	**62**
2016	14.4	-	21.9	-	20.1	**62**
2017	15.8	-	23.5	-	20.1	**62**
2018	15.5	11.4	20.2	22.0	18.7	**62**
2019	-	11.0	19.5	21.2	17.7	**62**
	Maximum 1-hour average					
2015	82.0	-	123.0	-	108.7	**246**
2016	67.7	-	102.5	-	108.7	**246**
2017	84.1	75.9	125.1	82.0	123.0	**246**
2018	80.0	61.5	116.9	131.2	104.6	**246**
2019	65.6	53.3	184.5	143.5	100.5	**246**

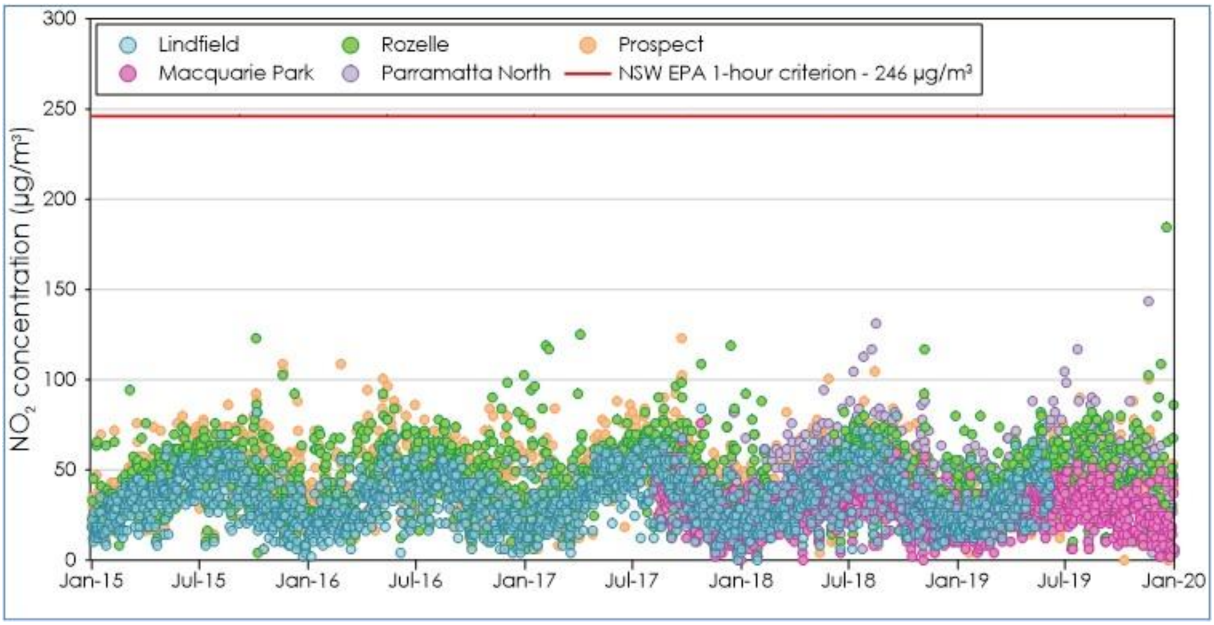

Figure 4-5: Daily 1-hour maximum NO_2 concentrations

4.3.4 CO monitoring

A summary of the available CO data from the NSW DPIE monitoring stations is presented in **Table 4-5**. The daily 1-hour maximum CO concentrations are presented in **Figure 4-6**. It is noted that the Lindfield monitor does not record measured CO data.

Table 4-5 indicates that the maximum 1-hour and 8-hour average CO concentrations for all monitors during the review period are well below the respective criterion. **Figure 4-6** shows a similar seasonal trend to the NO_2 data with levels increasing during the cooler months.

Table 4-5: Summary of CO levels from available NSW DPIE monitoring (µg/m³)

Year	Lindfield	Macquarie Park	Rozelle	Parramatta North	Prospect	Criterion
	Maximum 1-hour average					
2015	-	-	1,920	-	2,280	**30,000**
2016	-	-	2,040	-	1,920	**30,000**
2017	-	-	1,440	-	1,920	**30,000**
2018	-	5,280	-	1,560	1,560	**30,000**
2019	-	7,080	6,240	6,840	6,600	**30,000**
	Maximum 8-hour average					
2015	-	-	1,320	-	1,800	**10,000**
2016	-	-	1,440	-	1,800	**10,000**
2017	-	-	1,080	-	1,320	**10,000**
2018	-	3,000	-	1,320	1,320	**10,000**
2019	-	4,200	2,640	3,840	3,360	**10,000**

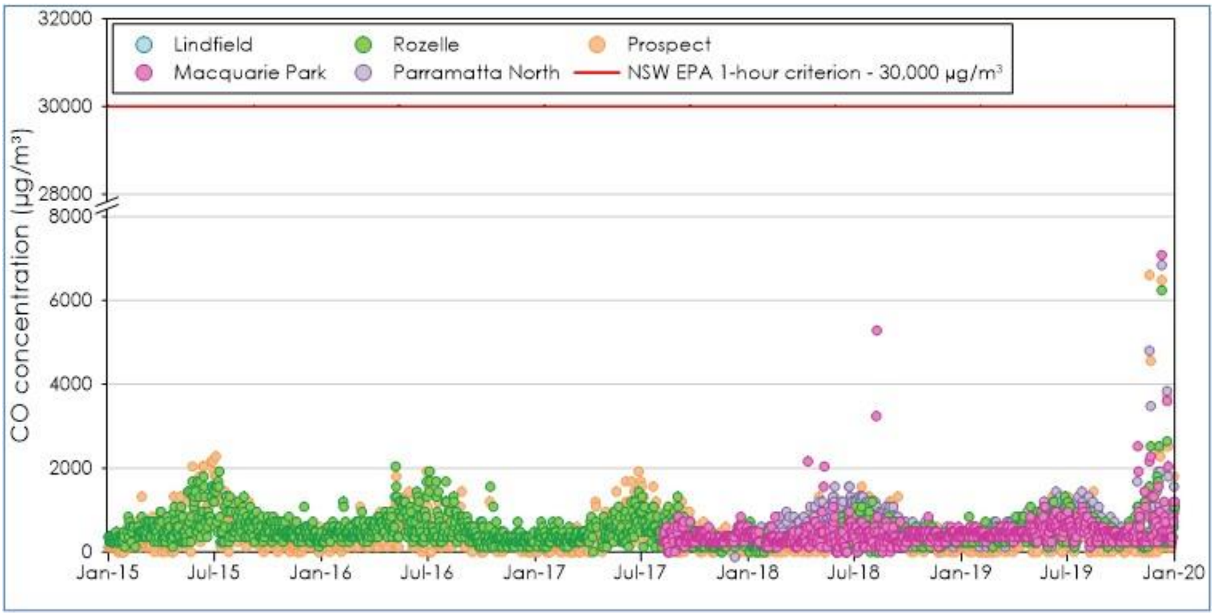

Figure 4-6: Daily 1-hour maximum CO concentrations

4.3.5 Estimated background levels

As outlined above, there are no readily available site-specific monitoring data, and therefore the background air quality levels from the nearest NSW DPIE monitoring station (Lindfield monitor) for the 2015 calendar year were used to represent the background levels for the Project.

The 2015 calendar period corresponds to the period of meteorological modelling based on an analysis of long-term data trends in meteorological data recorded for the area as outlined in **Appendix A**.

4.3.5.1 PM_{10}

Annual average PM_{10} values from the Lindfield monitor for the 2015 calendar year were used to represent the background levels for the Project. The maximum 24-hour recorded value at the Lindfield monitor for the 2015 (see **Table 4-2**) was above the relevant 24-hour average criterion of 50µg/m^3 and as such the second highest recording of 45.5µg/m^3 was applied to assess for cumulative 24-hour average impacts.

4.3.5.2 $PM_{2.5}$

As noted, the Lindfield monitor does not record measured $PM_{2.5}$ data. To account for this, the average ratio of $PM_{2.5}$ and PM_{10} concentrations from the other reviewed monitoring stations during 2015 was applied to the measured PM_{10} concentrations at the Lindfield monitor. This estimates an approximate annual average $PM_{2.5}$ concentration of 6.3µg/m^3. These estimated concentrations are comparable with levels measured at the Rozelle and Prospect monitors. The second highest 24-hour average PM_{10} level was used to estimate an applicable 24-hour average $PM_{2.5}$ level of 22.7µg/m^3 to assess for cumulative 24-hour average impacts.

4.3.5.3 TSP

In the absence of available data, estimates of the annual average background TSP and deposited dust concentrations can be determined from a relationship between PM_{10} and TSP concentrations and the measured PM_{10} levels.

This relationship assumes that an annual average PM_{10} concentration of 25µg/m^3 corresponds to a TSP concentration of 90µg/m^3. This assumption is based on the NSW EPA air quality impact criteria.

Applying this relationship with the measured annual average PM_{10} concentration of 14.0µg/m^3 indicates an approximate annual average TSP concentration and deposition value of 50.4µg/m^3.

4.3.5.4 NO_2

Maximum 1-hour average and annual average NO_2 values from the Lindfield DPIE monitor for the 2015 calendar year were used to represent the background levels for the Project (see **Table 4-4**).

4.3.5.5 CO

As noted, the Lindfield monitor does not record measured CO data. To account for this, the 1-hour and 8-hour average concentrations have been estimated as an average from the other reviewed monitoring stations during 2015. This estimates an approximate maximum 1-hour and 8-hour average CO concentration of 2,100µg/m^3 and 1,560µg/m^3, respectively.

4.3.5.6 Summary of background levels

The background air quality levels applied in this assessment are as follows:

- 24-hour average $PM_{2.5}$ concentrations – 22.7µg/m^3;
- Annual average $PM_{2.5}$ concentrations – 6.3µg/m^3;
- 24-hour average PM_{10} concentrations – 45.3µg/m^3;
- Annual average PM_{10} concentrations – 14.0µg/m^3;
- Annual average TSP concentrations – 50.4µg/m^3;
- 1-hour average NO_2 concentrations – 82µg/m^3;
- Annual average NO_2 concentrations – 15.4µg/m^3;
- 1-hour average CO concentrations – 2,100µg/m^3; and,
- 8-hour average CO concentrations – 1,560µg/m^3.

5 DISPERSION MODELLING APPROACH

5.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach.

For this assessment the CALPUFF modelling suite is applied to dispersion modelling. The CALPUFF model is an advanced "puff" model that can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a three dimensional, hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with 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 Environmental Corporation (TRC)**, **2011**).

5.2 Modelling methodology

Modelling was undertaken using a combination of The Air Pollution Model (TAPM) and the CALPUFF Modelling System. 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.

TAPM is a prognostic air model used to simulate the upper air data for CALMET input. The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for 3D simulations. The model predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analysis.

CALMET is a meteorological model which uses the geophysical information and observed/simulated surface and upper air data as inputs and develops wind and temperature fields on a 3D gridded modelling domain.

CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion processes along the way. It typically uses the 3D meteorological field generated by CALMET.

CALPOST is a post processor used to process the output of the CALPUFF model and produce tabulations that summarise the results of the simulation.

5.2.1 Meteorological modelling

TAPM was applied to the available data to generate a 3D upper air data file for use in CALMET. The centre of analysis for TAPM was 33deg45.5min south and 151deg15.5min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET domain was run on a 10 x 10km area with 0.1km grid resolution. The available meteorological data for the 2015 calendar year from the Terry Hills AWS meteorological station was included in this run. The 2015 calendar year was selected as the meteorological year for the dispersion modelling based on analysis of statistical data trends in meteorological data recorded for the area as outlined in **Appendix A**.

Local land use and detailed topographical information was included in the simulation to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas (**Figure 5-1**).

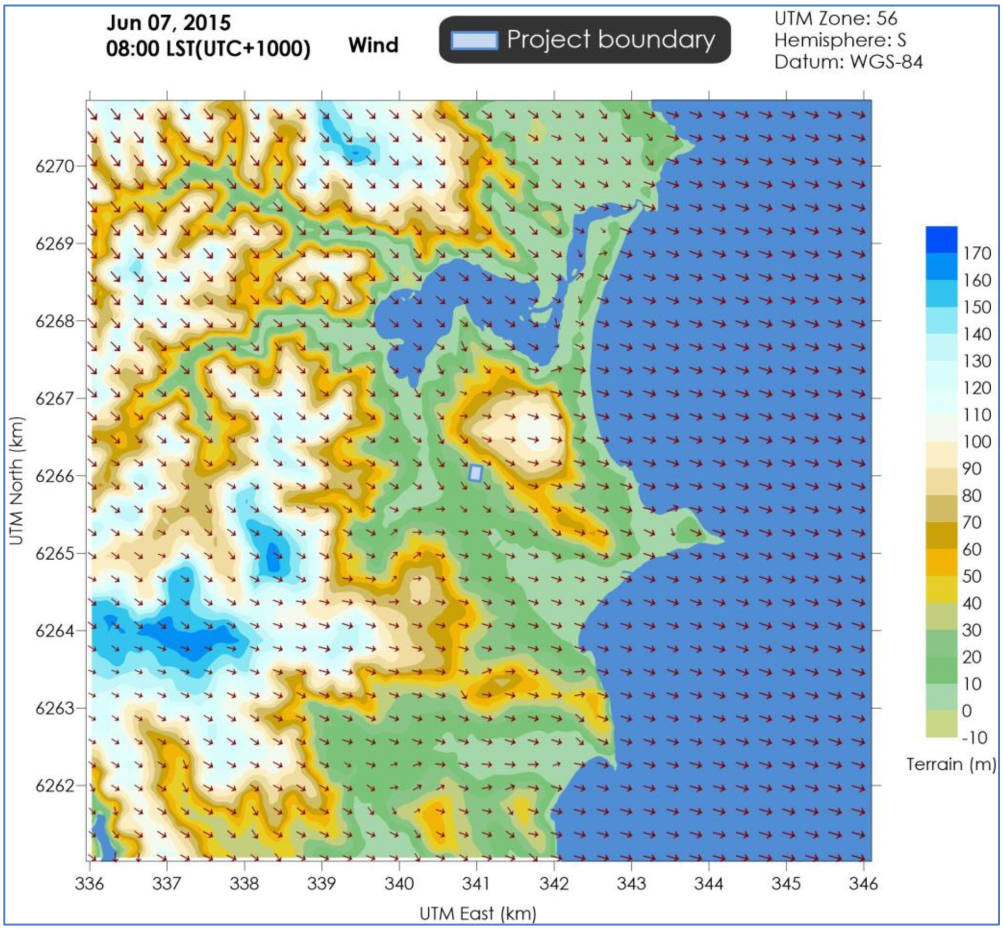

Figure 5-1: Representative snapshot of wind field for the Project

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 5-2** and **Figure 5-3**.

Figure 5-2 presents the annual and seasonal windroses from the CALMET data. On an annual basis, winds are varied and predominately occur from the north and west. In summer, winds predominantly occur from the north. The autumn distribution is similar to the annual distribution with varied winds predominantly from the west and south-southwest but with fewer winds from the north. In winter winds typically occur from the west. In spring, the winds from the north and north-northwest are most dominant.

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 5-3** 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.

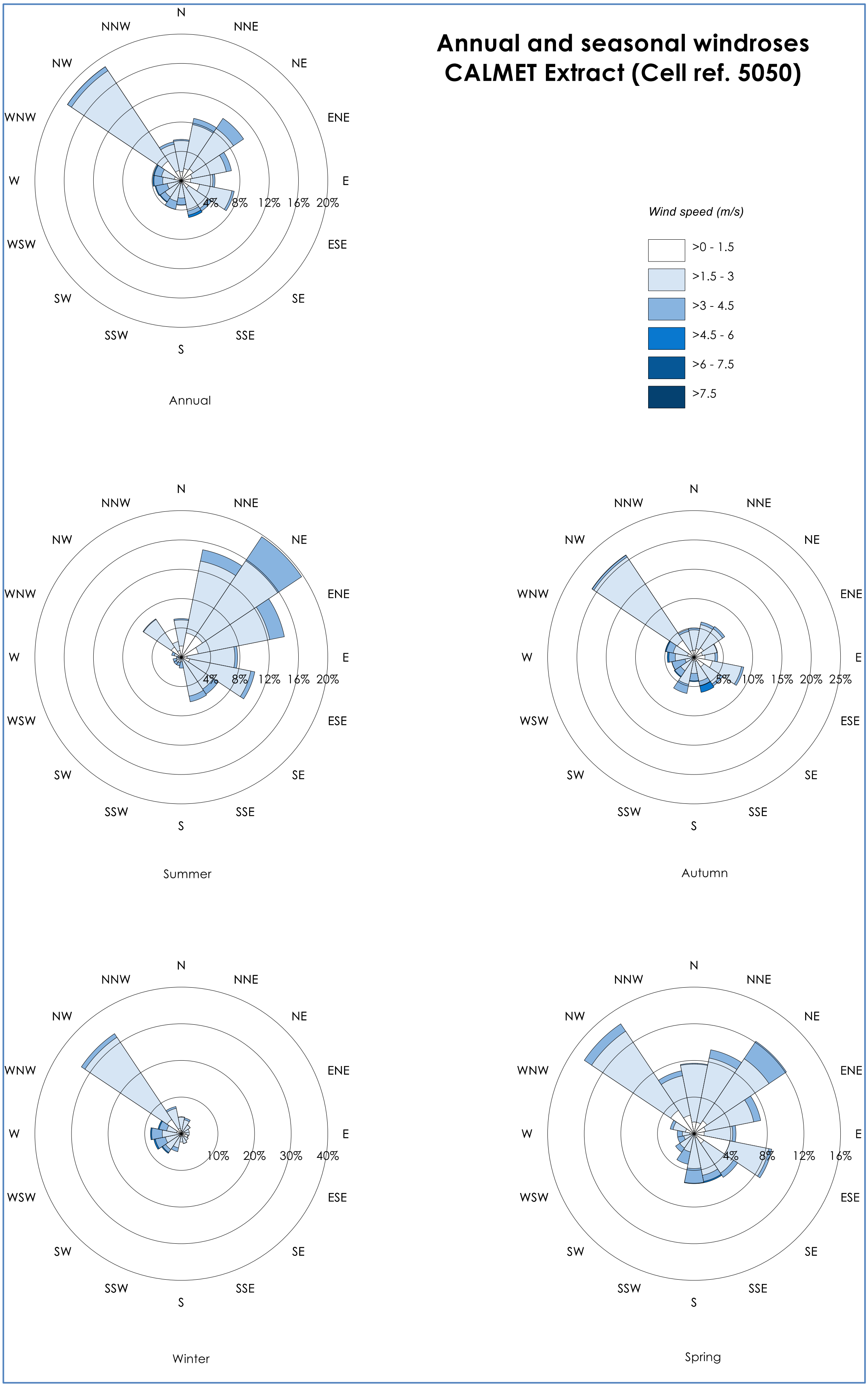

Figure 5-2: Annual and seasonal windroses from CALMET (cell ref 5050)

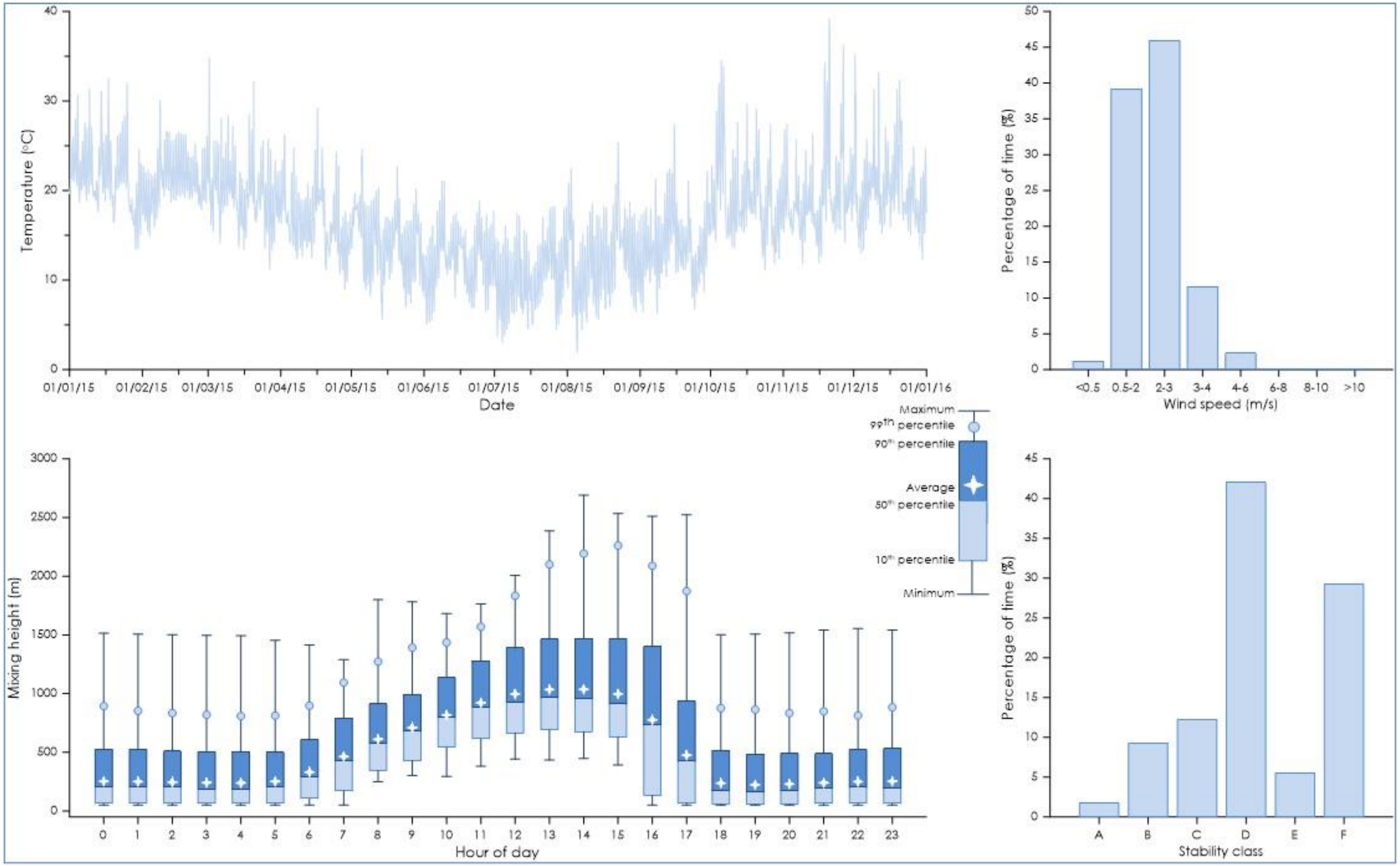

Figure 5-3: Meteorological analysis CALMET (cell ref 5050)

5.2.2 Dispersion modelling

Air dispersion modelling of the likely air emission sources identified for the Project was conducted using CALPUFF to predict potential air quality impacts in the surrounding environment.

Modelling of the key air emission sources was conducted using the emissions rates and parameters outlined in the following section and utilising the meteorological data described in the previous section.

The buses would generate the most exhaust emissions when idling and manoeuvring within the warehouse. These exhaust emissions would be diluted within the air space of the warehouse before gradually emitted into the environment and dispersing resulting in less impact in the surrounding environment. For the purposes of this assessment it is conservatively assumed that the exhaust emissions occur out in the open and therefore would overestimate the potential emissions released.

5.3 Emission estimation

An assessment of the potential air quality impacts associated with idling and travelling buses on-site have been considered in this assessment. Estimates of potential emissions from the buses on-site have been calculated using the methodology presented in the NSW EPA document *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions*, *On-Road Mobile Emissions* (**NSW EPA, 2012**).

Vehicles on-site are classified as heavy duty diesel buses (GVM >5 tonnes). Emissions have been estimated for the following activities:

- Hot running exhaust emissions from heavy duty diesel vehicles;
- Cold start extra exhaust emissions; and
- Non-exhaust particulate matter emissions.

Cold start extra exhaust emissions form when the vehicle is operated and when the engine has not reached optimum temperature. These emissions from vehicles are considerably higher than hot running exhaust emissions. It is noted that cold start extra exhaust emissions typically only apply for petrol or light duty diesel vehicles. However, as a conservative measure, cold start extra exhaust emissions from heavy duty diesel vehicles modelled in this assessment have been calculated for NO_x emissions by applying a cold start adjustment factor to the hot exhaust emission factors. The total exhaust emissions are the sum of the hot running and cold start extra emissions.

Emission factors for exhaust composite emissions and splitting factors characterised for residential/local roads, and non-exhaust particulate matter emissions were sourced from *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions*, *On-Road Mobile Emissions* (**NSW EPA, 2012**).

Non-exhaust particulate matter emissions are generated by tyre, brake and road wear. Speed corrections for non-exhaust particulate matter emissions have been applied assuming an average speed of less than 40 kilometres per hour on-site.

A summary of the estimated hourly incoming and outgoing vehicles at the Project is provided in **Figure 5-4** below. The emissions rates for exhaust and non-exhaust particulate matter per hour varied according to the number of vehicles on-site at any one time.

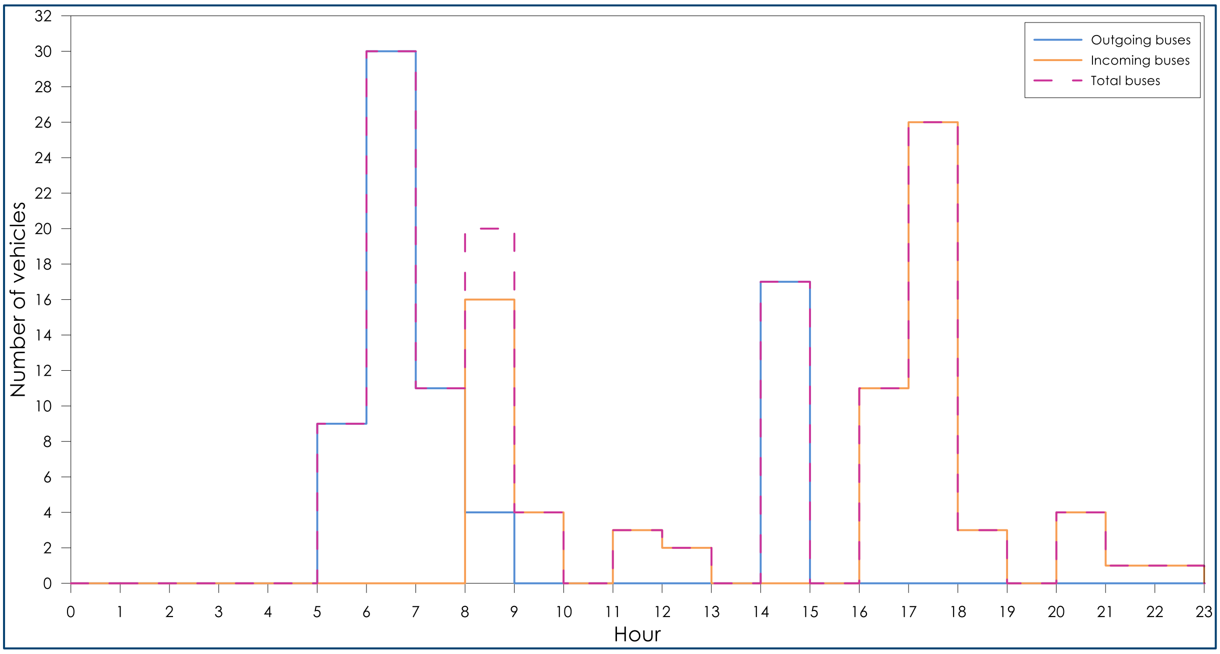

Figure 5-4: Projected departures and arrivals for the Project

Table 5-1 and **Table 5-2** below present a summary of the emission factors and emission rates used in the assessment.

Table 5-1: Summary of exhaust emissions for buses

Pollutant	Composite base hot emission factor (g/km)	Composite splitting factor	Hot emission rate (g/s)	Cold start emission rate (g/s)
TSP	0.30	1.22	2.29E-05	-
PM_{10}	0.29	1.20	2.27E-05	-
$PM_{2.5}$	0.28	1.17	2.20E-05	-
NO_2	15.00	1.33	1.28E-03	2.56E-05
CO	3.05	2.26	2.07E-04	
Benzene	0.007	0.017	7.25E-07	-
Toluene	0.003	0.007	3.19E-07	-
Xylenes	0.003	0.006	2.61E-07	-

Table 5-2: Summary of non-exhaust particulate matter emissions - combined tyre, break and road wear

Pollutant	Combined non-exhaust PM speed corrected emission factor (g/km)	Emission rate (g/s)
TSP	0.23	1.47E-05
PM_{10}	0.15	9.36E-06
$PM_{2.5}$	0.08	4.85E-06

6 DISPERSION MODELLING RESULTS

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

The spatial distribution of the dispersion modelling predictions is presented as isopleth diagrams in **Appendix B** showing ground level concentrations. The isopleth diagrams indicate the maximum incremental predicted levels to occur at the Project site and include predicted impacts from exhaust and non-exhaust particulate matter emissions combined.

Table 6-1 below presents the maximum predicted off-site (at any location) ground level concentrations for each pollutant.

The modelling results in **Table 6-1** indicate the predicted levels are significantly below the relevant air quality criteria for the assessed pollutants.

The Project alone increment is small and is not predicted to result in any discernible impact relative to existing levels. As such, the Project is expected to have minimal influence at the nearby residential receptor locations and would be difficult to discern beyond the existing background levels.

Table 6-1: Summary modelling predictions – ground level concentrations

Pollutant	Averaging Period	Incremental maximum offsite impact			BG	Cumulative Impact	Criterion µg/m^3
		Exhaust emissions	Non-exhaust emissions	Total emissions			
TSP	Annual	0.03	0.004	0.04	50.4	50.4	**90**
PM$_{10}$	Annual	0.03	0.012	0.04	14.0	14.0	**25**
	24 hour	0.24	0.012	0.3	45.3	45.6	**50**
PM$_{2.5}$	Annual	0.03	0.006	0.04	6.3	6.3	**8**
	24 hour	0.2	0.006	0.24	22.7	22.9	**25**
NO$_2$	1 hour	129.9	-	129.9	82.0	212	**246**
	Annual	10.1	-	10.1	15.4	25.5	**62**
CO	1 hour	20.6	-	20.6	2,100	2,121	**30,000**
	8 hour	3.4	-	3.4	1,560	1,563	**10,000**
Benzene	1 hour	0.04	-	0.04	-	-	**29**
Formaldehyde	1 hour	0.4	-	0.4	-	-	**20**
PAH	1 hour	0.07	-	0.07	-	-	**0.4**
Toluene	1 hour	0.02	-	0.02	-	-	**360**
Xylenes	1 hour	0.02	-	0.02	-	-	**190**

7 SUMMARY AND CONCLUSIONS

This report has assessed the potential for air quality impacts associated with the operation of the proposed Bus Depot at 61 Middleton Road, Cromer.

Air dispersion modelling using the CALPUFF model was applied in this assessment using air emission factors provided in the *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Commercial Emissions*, *On-Road Mobile Emissions* (**NSW EPA, 2012**) to predict the likely air quality impacts associated with exhaust and non-exhaust particulate matter emissions which may occur due to idling buses at the Project site.

The dispersion modelling results indicate that the potential emissions from the Project would not lead to unacceptable impacts in the area surrounding the Project site. The modelling results demonstrate the predicted incremental levels would be significantly lower than the applicable NSW air quality criteria for the relevant pollutants and that it is unlikely to result in any discernible cumulative impact relative to existing levels.

The modelling is conservative as it does not consider the effect of the warehouse on the exhaust emissions and has assumed the sources are out in the open. As such, there is no specific requirement for ventilation of the warehouse regarding potential air quality impacts however this can be implemented to improve the air quality within the warehouse as needed.

Overall, the assessment demonstrates that the Project can operate without exceeding the applicable air quality criteria for both health and odour impacts, and hence it is concluded that there would not be any air quality impacts upon the surrounding environment due to the operation of the Project.

8 REFERENCES

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Appendix A

Selection of Meteorological Year

Selection of meteorological year

A statistical analysis of the of last five years of available meteorological data from the nearest BoM weather station with suitable available data, Terry Hills AWS, is presented in **Table A-1**.

The analysis of the five years indicates that 2016 is closest to the average for wind speed, 2015 is closest to the average for wind direction, 2018 is closest to the average for temperature, and 2016 is closest to the average for relative humidity followed by 2012.

A score weighting analysis was performed to consider the deviation from the average for each of the five years of meteorological data in **Table A-1**. The score value is based on the weighting of the different parameters as considered most relevant for the purposes of air dispersion modelling and assessment. The best score is achieved for 2015 and determined to be most representative for the purposes of air dispersion modelling.

Table A-1: Long term analysis results for Terry Hills AWS

Year	Wind speed	Wind direction	Temperature	Relative humidity	Score
2015	0.44	0.13	0.20	0.57	2.20
2016	0.38	0.30	0.16	0.21	2.35
2017	0.54	0.22	0.16	0.35	2.46
2018	0.52	0.18	0.11	0.61	2.50
2019	0.49	0.14	0.15	0.50	2.20

Figure A-1 shows the frequency distributions for wind speed, wind direction, temperature and relative humidity for the 2015 year compared with the mean and range of the combined 2015 to 2019 data set. The 2015 year data appear to be well aligned with the mean data.

Therefore, based on this analysis it was determined that 2015 is generally representative of the long-term trends compared to other years and is thus suitable for the purpose of modelling.

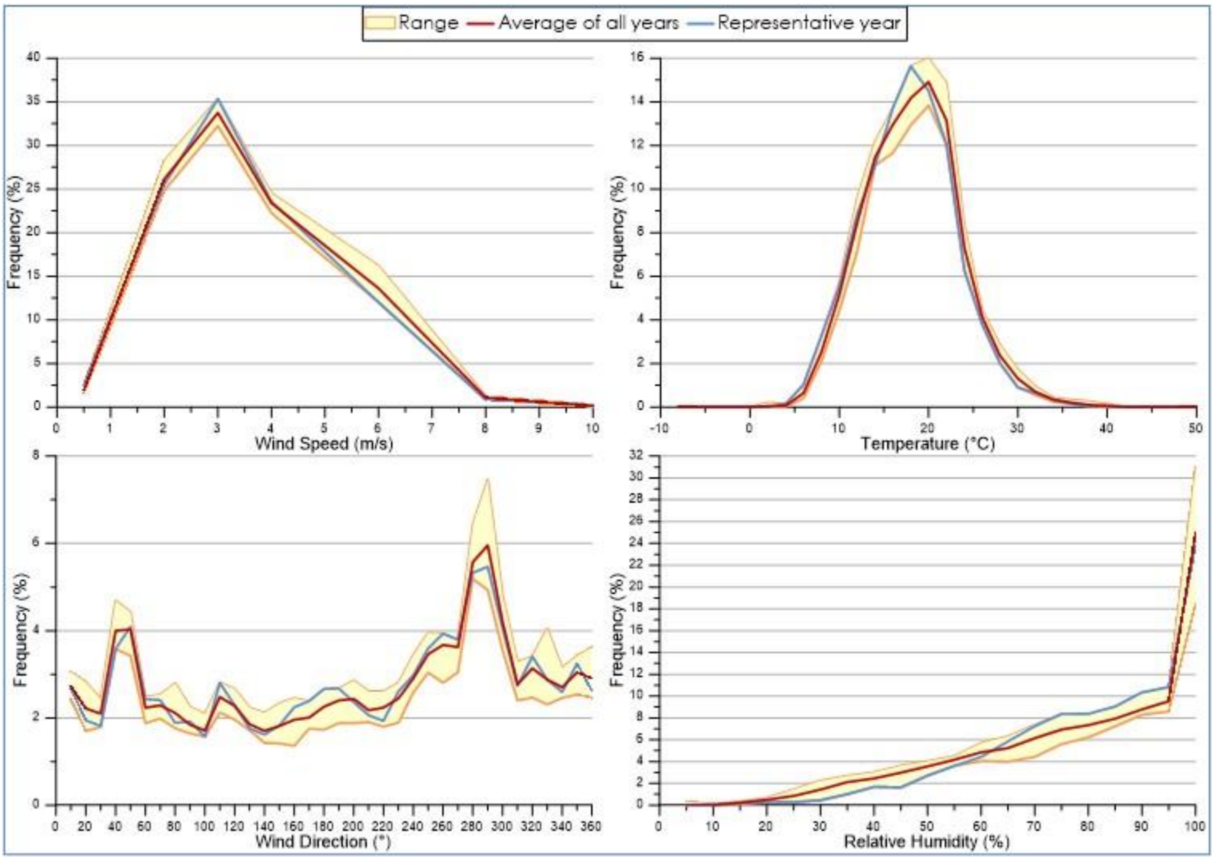

Figure A-1: Frequency distributions for wind speed, wind direction, temperature and relative humidity

Appendix B

Isopleth diagrams

Figure B-1: Predicted incremental 24-hour average $PM_{2.5}$ concentrations (µg/m³)

Figure B-2: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³)

Figure B-3: Predicted incremental 24-hour average PM_{10} concentrations (µg/m³)

Figure B-4: Predicted incremental annual average PM_{10} concentrations (µg/m³)

Figure B-5: Predicted incremental annual average TSP concentrations (µg/m³)

Figure B-6: Predicted incremental 1-hour average NO_2 concentrations (µg/m³)

Figure B-7: Predicted incremental annual average NO_2 concentrations (µg/m³)

Figure B-8: Predicted incremental 1-hour average CO concentrations (µg/m³)

Figure B-9: Predicted incremental 8-hour average CO concentrations (µg/m³)

Figure B-10: Predicted incremental 1-hour average benzene concentrations (µg/m³)

Figure B-11: Predicted incremental 1-hour average formaldehyde concentrations (µg/m³)

Figure B-12: Predicted incremental 1-hour average PAH concentrations (µg/m³)

Figure B-13: Predicted incremental 1-hour average toluene concentrations (µg/m³)

Figure B-14: Predicted incremental 1-hour average xylene concentrations (µg/m³)