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Proposed Childcare Centre – Springfield Drive, Lochinvar

Air Quality Impact Assessment

Addressee(s):	HPC Planning
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Status:	Draft

Quality Control

Study	Status	Prepared by	Checked by	Authorised by
INTRODUCTION	Draft	Northstar Air Quality	MD, GCG	Draft
THE PROPOSAL	Draft	Northstar Air Quality	MD, GCG	Draft
LEGISLATION, REGULATION AND GUIDANCE	Draft	Northstar Air Quality	MD, GCG	Draft
EXISTING CONDITIONS	Draft	Northstar Air Quality	MD, GCG	Draft
METHODOLOGY	Draft	Northstar Air Quality	MD, GCG	Draft
ASSESSMENT	Draft	Northstar Air Quality	MD, GCG	Draft
MITIGATION OPTIONS	Draft	Northstar Air Quality	MD, GCG	Draft
DISCUSSION AND CONCLUSION	Draft	Northstar Air Quality	MD, GCG	Draft
REFERENCES	Draft	Northstar Air Quality	MD, GCG	Draft

Report Status

Northstar References		Report Status	Report Reference	Version
Year	Job Number	(Draft: Final)	(R*x*)	(V*x*)
21	1130	Draft	R1	V1
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Final Authority

This report must by regarded as draft until the above study components have been each marked as final, and the document has been signed and dated below.

Unsigned **Undated** **Unnamed**

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Units Used in the Report

All units presented in the report follow the International System of Units (SI) conventions, unless derived from references using non-SI units. In this report, units formed by the division of SI and non-SI units are expressed as a negative exponent, and do not use the solidus (/) symbol. For example:

- 50 micrograms per cubic metre would be presented as 50 µg·m-3 and not 50 µg/m3; and,
- 0.2 grams per kilometre would be presented as 0.2 g·km-1 and not 0.2 g/km.

Common Abbreviations

Abbreviation	Term
AADT	annual average daily traffic
ABS	Australian Bureau of Statistics
AHD	Australian height datum
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AWS	automated weather station
BoM	Bureau of Meteorology
°C	degrees Celsius
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CV	commercial vehicle
EETM	emission estimation technique manual
EPA	Environmental Protection Authority
$g \cdot km^{-1}$	gram per kilometre
MGA	Map Grid of Australia
$mg \cdot m^{-3}$	milligram per cubic metre of air
$\mu g \cdot m^{-3}$	microgram per cubic metre of air
NEPM	National Environment Protection Measure
NO	nitric oxide
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide
O_3	ozone
OLM	ozone limiting method
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
TAPM	The Air Pollution Model
GRAL	GRAz Lagrangian model

1. INTRODUCTION

1.1 Background

HPC Planning has engaged Northstar Air Quality Pty Ltd (Northstar) to perform an air quality impact assessment (AQIA) to support a Development Application for a proposed child care centre (the Proposal) located at 857 & 853 New England Highway, Lochinvar, NSW (the Proposal site).

The objective of this AQIA is to determine whether there is an unacceptable risk for the development of the Proposal site for use as a child care centre as a result of road traffic exhaust emissions from vehicles using New England Highway.

Reference has been made to relevant Maitland City Council (Maitland City Council, 2011) DCP requirements, NSW Environment Protection Authority (EPA) air quality criteria, and guidance documents relating to development of child care centres in NSW.

The AQIA presents an assessment of the impacts of road traffic emissions at the Proposal site. The assessment has applied a quantitative dispersion modelling approach, performed in accordance with the relevant NSW EPA guidelines.

1.2 Pollutants Assessed

A review of the National Pollutant Inventory Emission Estimation Technique Manual (NPI EET) for Combustion Engines (DEWHA, 2008) identifies the primary pollutants from combustion engines as (in no order):

- Total volatile organic compounds (TVOCs).
- Carbon monoxide (CO).
- Oxides of nitrogen (NO_X).
- Particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$).
- Particulate matter less than 10 µm in aerodynamic diameter (PM_{10}).
- Sulphur dioxide (SO_2).

Lead (Pb) emissions has historically been a pollutant of concern from road traffic emissions, however this has been significantly reduced as a result of the introduction of unleaded petrol (NSW EPA, 2015), to the extent that NSW EPA has discontinued Pb monitoring in NSW in 2004 following a decrease in ambient lead levels to well within the national standard as a result of the decline in consumption of leaded fuel.

Consequently, Pb is not considered to be a pollutant of concern associated with road traffic and is not considered further within this assessment.

Volatile organic compounds (including benzene, toluene, ethylbenzene and xylenes [BTEX]) are emitted from the combustion of fuel in road vehicles. Monitoring of these pollutants within a Sydney CBD basement carpark indicated that concentrations were below international guideline concentrations adopted (NSW EPA, 2003). Concentrations within an enclosed carpark would be expected to be significantly higher than those experienced away from a road location. The assessment also concluded that 'elevated concentrations were found to be associated with non-occupational activities such as the use of lacquer thinners, resins and house paints and exposure to spilt petrol' (NSW EPA, 2003) rather than exposure to road traffic emissions. Furthermore, the *Fuel Standard (Petrol) Determination* 2001 limits the benzene concentration in petrol to 1 % v/v (date of effect, January 2006) which has significantly reduced ambient concentrations of benzene from that date. In air quality assessment studies, assessment of exposure to benzene (and VOCs in general) is typically only performed in close proximity to fuel service stations.

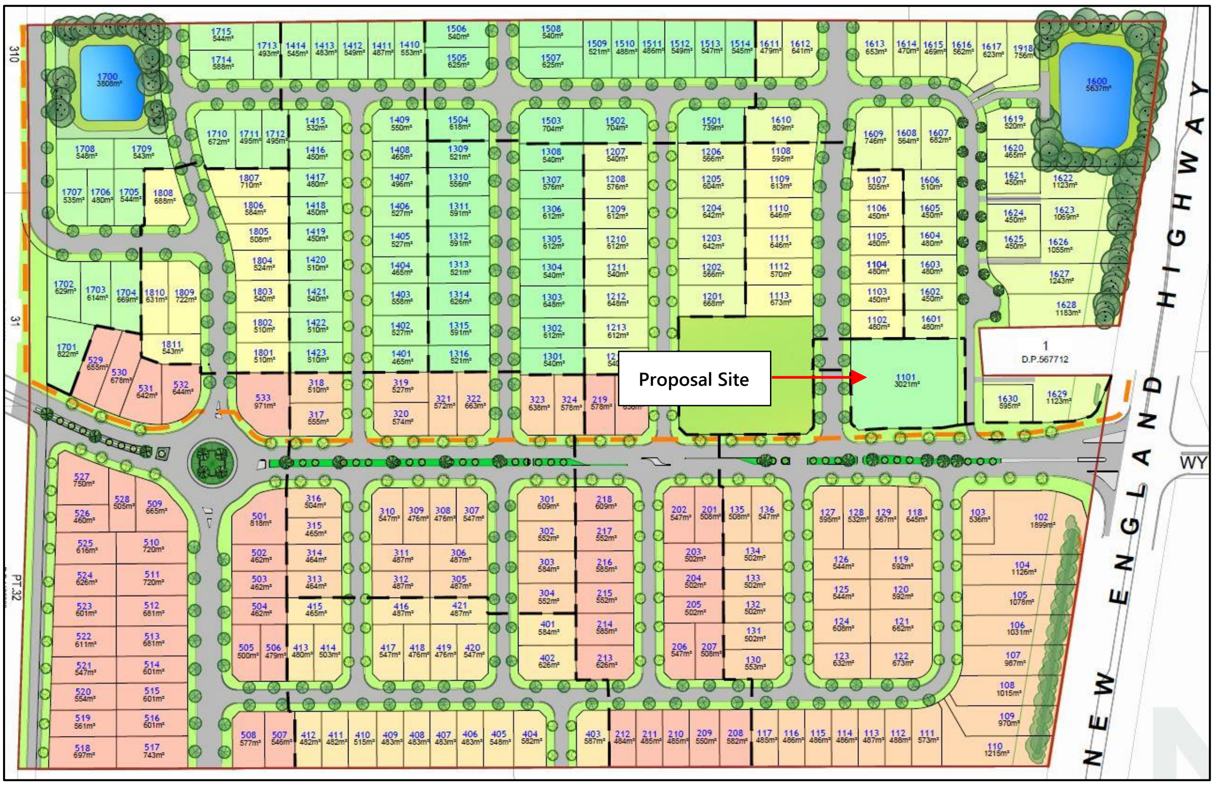
Particulate matter (as PM_{10} and $PM_{2.5}$), and nitrogen dioxide (NO_2) are generally considered to represent the key pollutants associated with road traffic emissions. Should concentrations of those pollutants be identified as not being of concern, concentrations of all other air pollutants would also be likely to meet the relevant air quality criteria.

For the reasons outlined above, only impacts associated with PM_{10}, $PM_{2.5}$ and NO_2 are considered within this AQIA.

2. THE PROPOSAL

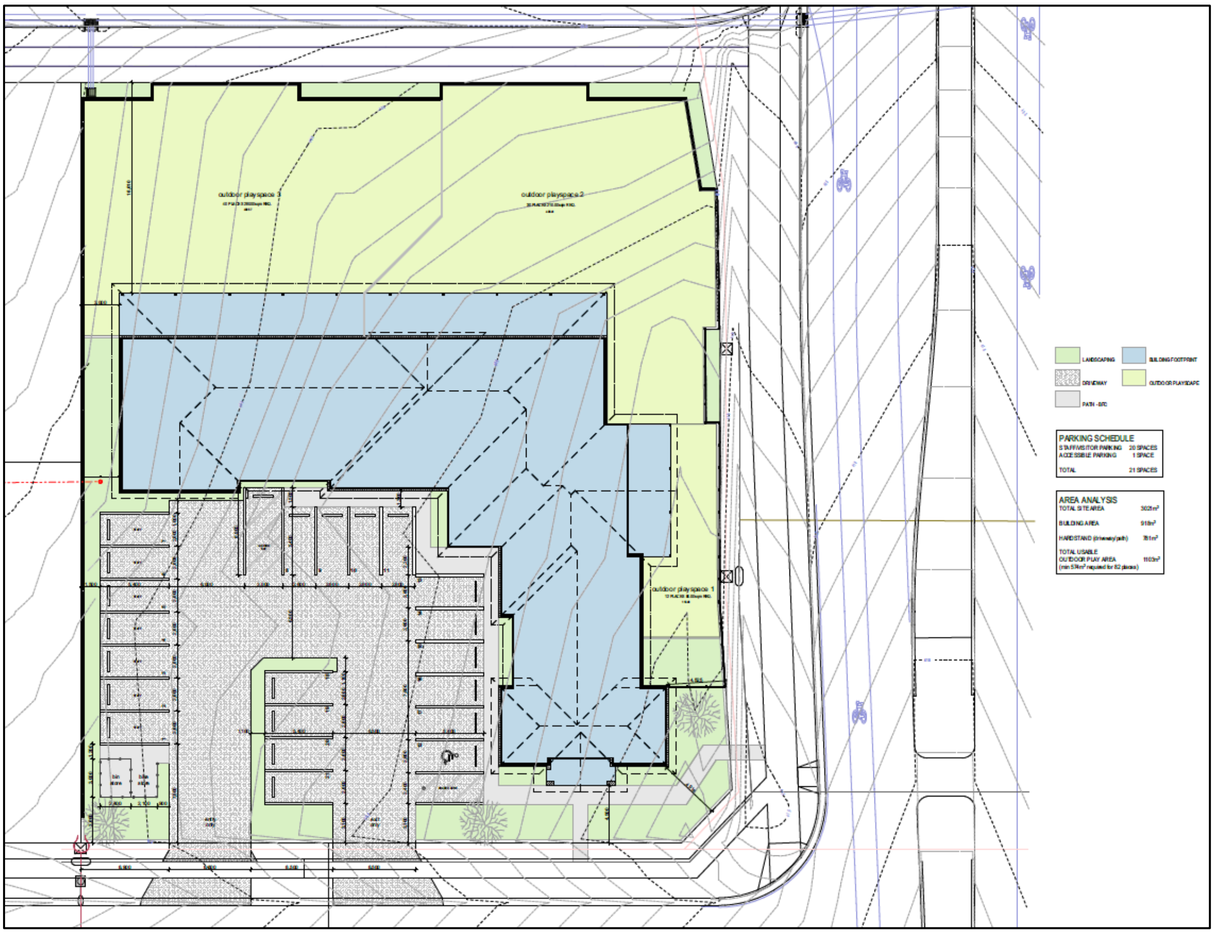
The Proposal site is located in lot 1101 of the Hereford Hill Subdivision, approximately 104 m from the New England Highway, Lochinvar, NSW as presented in **Figure 1**.

Figure 1 Proposal site location



The Proposal includes a child care centre with carparking and three outdoor play areas. The first outdoor play area is 110 square metres (m^2) in area, located to the east of the Proposal. The second outdoor play area of 493 m^2 and the third outdoor play area of 499 m^2 are both located to the northside of the child care centre are illustrated in **Figure 2**.

Figure 2 Concept plan



3. LEGISLATION, REGULATION AND GUIDANCE

3.1 Maitland Development Control Plan 2011

The Maitland Development Control Plan 2011 (MDCP) Part C.2 outlines requirements for the location of child care centres to '*ensure that developers consider site selection criteria to minimise impacts such as traffic generation and parking, acoustic and visual privacy on adjoining development as well as providing an appropriate space for the children in their care*'.

In relation to air quality, the following requirements of the MDCP are considered to be applicable:

Location (Section 2.1)

Objectives

- *a. To ensure Child Care Centres provide a safe and healthy environment for staff, children and visitors.*
- *b. To ensure that the child care centre is compatible with adjoining land uses in terms of air and noise pollution, traffic and parking.*
- *c. To ensure that the child care centre is consistent with the objectives of the zone within which it is located.*

Development Controls

- *e. To ensure that child care centres provide a safe and healthy environment for staff and children, Council will not consider any application that proposes the location of a child care centre:*

  ..

  - *ii. within 125m of a classified road (as defined in the MLEP 2011) without the submission of a report detailing the results of air quality and noise level testing.*
  - *iii. within 100m of heavy industry (as defined in the MLEP 2011) without the submission of a report detailing the results of air quality and noise level testing.*

Note that the section numbers reproduced above from the MDCP are those that specifically relate to air quality.

3.2 Ambient Air Quality Standards

The NSW EPA document "Approved Methods for the Modelling and Assessment of Air Quality in NSW" (Approved Methods) (NSW EPA, 2017) outlines the air quality criteria which should not be exceeded at any "sensitive receptor" location. Such locations include those people may be likely to reside or work and can include dwellings, schools, hospitals, offices or public recreation area. In relation to this assessment the sensitive receptor is the childcare centre.

The criteria listed in the Approved Methods are derived from a range of sources (including NHMRC, NEPC, DoE, WHO and ANZECC). Where relevant to this assessment (coincident with the potential emissions identified in **Section 1.2**), the criteria have been adopted as set out in Section 7.1 of NSW EPA (2017) which are presented in **Table 1**.

Table 1 NSW EPA air quality standards and goals

Pollutant	Averaging period	Units[(b)]	Criterion
Nitrogen dioxide (NO_2)	1 hour	$\mu g \cdot m^{-3}$ [(a)]	246
	Annual	$\mu g \cdot m^{-3}$	62
Particulates (as PM_{10})	24 hours	$\mu g \cdot m^{-3}$	50
	1 year	$\mu g \cdot m^{-3}$	25
Particulates (as $PM_{2.5}$)	24 hours	$\mu g \cdot m^{-3}$	25
	1 year	$\mu g \cdot m^{-3}$	8

Notes: **(a):** micrograms per cubic metre of air **(b):** Gas volumes are expressed at 25 °C (298 K) and at an absolute pressure of 1 atmosphere (101.325 kPa)

3.3 State Environmental Planning Policy

The specific SEPP applicable to the Proposal site is the *NSW State Environmental Planning Policy (Infrastructure) 2007* (the 'Infrastructure SEPP'). More specifically, the Infrastructure SEPP refers to guidelines which must be taken into account where development is proposed in, or adjacent to, specific roads and railway corridors under clause 101 – *Development with Frontage to Classified Road*[1].

The objectives of clause 101 are to ensure that new development does not compromise the effective and ongoing operation and function of classified roads and to reduce the potential of traffic noise and/or vehicle emissions on development adjacent to classified roads. The New England Highway is classified as a 'State Road' under the *Roads Act* 1993.

[1] The NSW State Roads Act 1986 No. 85 defines 'classified road' as a main road, a secondary road, a state highway, a tourist road, a state work, a freeway or a controlled access road.

3.4 Guidance Documents

The "*Child Care Centre Planning Guideline*" (NSW DP&E, 2017) (the Child Care Guideline) seeks to inform on how good design can maximise the safety, health and overall care of young children. In relation to air quality issues of relevance to this assessment, the Child Care Guideline requires that:

- Consideration be given to the potential impacts on the health and safety of children, staff and visitors with regard to air pollution, for proposed development in commercial and industrial zones;
- A child care facility should be located to avoid risks to children, staff or visitors arising from proximity to: heavy or hazardous industry, waste transfer depots or landfill sites; LPG tanks or service stations; odour generating use (current and potential future);
- The minimum setback to a classified road is 10 m;
- Child care facilities are located on sites which avoid or minimise the potential impact of external sources of air pollution such as major roads and industrial development;
- The location of play areas, sleeping areas and outdoor areas should be as far as practicable from the major source of air pollution;
- Landscaping should be used to act as a filter for air pollution generated by traffic and industry; and,
- Ventilation design should be incorporated into the design of the facility.

Clause 28 of the Child Care Guideline outlines the requirement for an air quality assessment to ensure that air quality is acceptable where child care facilities are proposed close to external sources of air pollution such as major roads and industrial development:

A suitably qualified air quality professional should prepare an air quality assessment report to demonstrate that proposed child care facilities close to major roads or industrial developments can meet air quality standards in accordance with relevant legislation and guidelines. The air quality assessment report should evaluate design considerations to minimise air pollution such as:

- *creating an appropriate separation distance between the facility and the pollution source. The location of play areas, sleeping areas and outdoor areas should be as far as practicable from the major source of air pollution*
- *using landscaping to act as a filter for air pollution generated by traffic and industry. Landscaping has the added benefit of improving aesthetics and minimising visual intrusion from an adjacent roadway*
- *incorporating ventilation design into the design of the facility.*

Reference is also made to the NSW Department of Planning document "*Development Near Rail Corridors and Busy Roads – Interim Guideline*" (NSW DoP, 2008) (the Roads Guideline) which supports the specific rail and road provisions of the Infrastructure SEPP. An aim of the Roads Guideline is to assist in reducing the health impacts of adverse air quality from road traffic on sensitive adjacent development and assists in the planning, design and assessment of development in, or adjacent to busy roads (NSW DoP, 2008).

The Roads Guideline also provides those situations in which air quality should be a design consideration as follows:

- Within 10 m of a congested collector road (traffic speeds of less than 40 km·hr^{-1} at peak hour) or a road grade > 4 %, or heavy vehicle percentage flows > 5 %;
- Within 20 m of a freeway or main road (with more than 2 500 vehicles per hour, moderate congestions levels of less than 5 % idle time and average speeds of greater than 40 km·hr^{-1});
- Within 60 m of an area significantly impacted by existing sources of air pollution (road tunnel portals, major intersection / roundabouts, overpasses or adjacent major industrial sources); or,
- As considered necessary by the approval authority based on consideration of site constraints, and associated air quality issues.

3.5 Application of Legislation, Regulation and Guidance

This assessment presents a quantitative (modelling) assessment of potential air quality impacts across the Proposal site, including the location of the proposed three outdoor play areas. Dispersion modelling has been performed based on traffic flows in 2010 (refer **Section 5.1**) which takes into account the location of the New England Highway, and the Proposal site. Meteorological conditions have been considered through the generation of a site-specific meteorological file (refer **Section 4.2** and **Section 5.4**). Emissions of air pollutants along the New England Highway have been estimated based on , measured diurnal variations and measured vehicle fleet composition data in 2010 (refer **Section 5.2** and **Appendix A**).

This assessment therefore considers the requirements of the MDCP, by considering the potential impacts of the proximate road on children using the child care centre.

The air quality criteria as outlined by NSW EPA (NSW EPA, 2017) are used as the defining criteria for the Proposal, with a cumulative impact (impacts associated with the New England Highway plus all other likely sources (refer **Section 4.3**) being considered and assessed.

4. EXISTING CONDITIONS

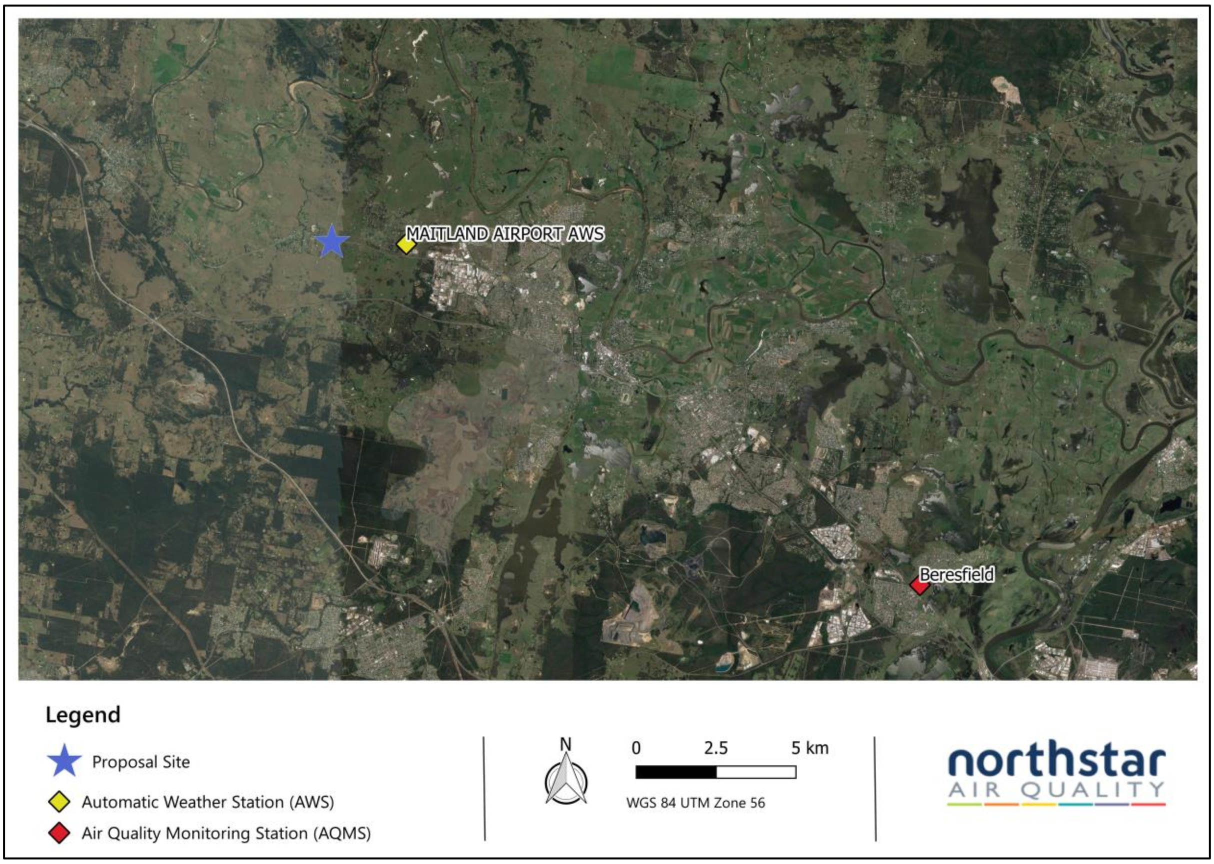
4.1 Topography

The elevation of the Proposal site ranges from approximately 42 m to 44 m Australian Height Datum (AHD). The topography of the surrounding area can be considered to be gently undulating and for the purposes of this assessment, and given the proximity of the Proposal site to the New England Highway, it is considered to be flat and the roads assessed at grade.

4.2 Meteorology

The meteorology experienced within an area can govern the generation (in the case of wind dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. The meteorology of the area surrounding the Proposal site has been examined using data collected by the Australian Government Bureau of Meteorology (BoM) at the Maitland Airport Automatic Weather Station (AWS), which is approximately 2.3 km east of the Proposal site (**Figure 3**).

Figure 3 Meteorological and air quality stations surrounding the Proposal site

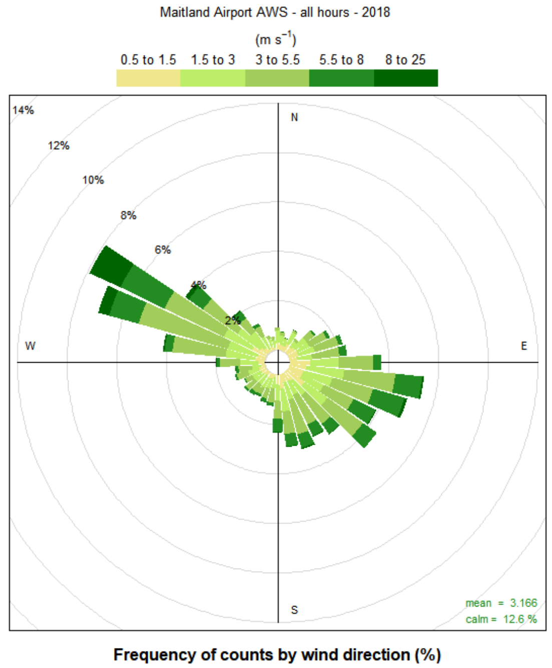


Source: Northstar Air Quality

This AWS is considered the most representative station for the area surrounding the Proposal site to determine a 'typical' or representative dataset for use in dispersion modelling. Please refer to **Appendix B** for further details of the meteorology prevailing at Maitland Airport AWS and at the Proposal site.

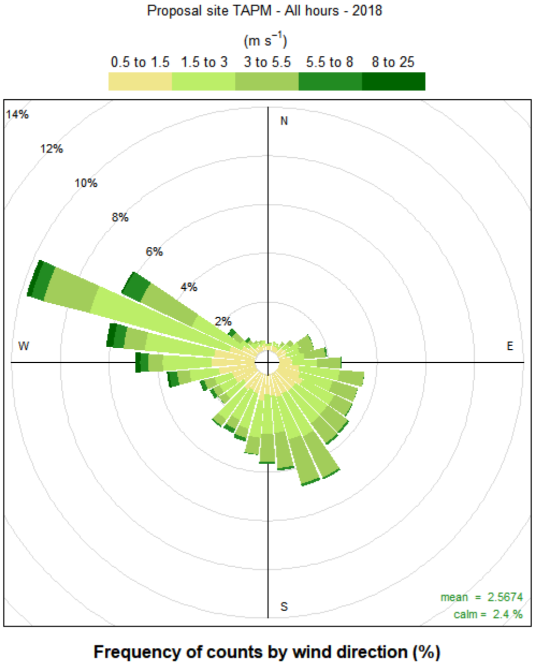
Data from the year 2018 have been selected for use in the assessment to provide an approximation of 'representative' conditions surrounding the Proposal site. The year 2018 was selected as being most representative, as wind speed and direction measured at Maitland Airport AWS in 2018 were considered to be most representative of the four most recent years (2017 to 2020). The wind rose summarising the annual wind direction and speed distribution over the year 2018 at the Maitland Airport AWS is presented in **Figure 4**.

Figure 4 Annual wind rose 2018, Maitland Airport AWS



To provide the meteorological parameters which would be used in the dispersion modelling, a meteorological modelling exercise has also been performed using The Air Pollution Model (TAPM, v 4.0.5). The wind rose summarising the annual wind direction and speed distribution modelled over the year 2018 at the Proposal site is presented in **Figure 5**.

Figure 5 Modelled wind rose 2018, Proposal site



A summary of the inputs and outputs of the meteorological modelling assessment, including meteorological data analysis and model validation, is presented in **Appendix B**.

4.3 Air Quality

The NSW Department of Planning, Industry & Environment (DPIE) maintain and operate a number of ambient air quality monitoring stations (AQMS) across NSW. The closest and most representative AQMS to the Proposal site is located at Beresfield (**Figure 3**), which was commissioned in May 2013. Of relevance to this assessment, concentrations of PM_{10}, $PM_{2.5}$, NO_X and ozone (O_3), are measured continuously and have been used to approximate a 'background' dataset to which the modelled impacts associated with the New England Highway have been added to determine compliance with the criteria outlined in **Section 3.2**.

The background data derived from the monitoring data is summarised in **Table 2**. Data for the year 2018 has been selected, mainly on the basis of the representative nature of the meteorology of the area.

A number of exceedances of the NSW EPA 24-hour average PM_{10} criterion were measured at the Beresfield AQMS in 2018. This mainly was driven by the intense drought conditions, with an increase in hazard reduction burns around Sydney and the Illawarra from April to August and the increasing frequency of widespread dust storms throughout the year (NSW OEH, 2018).

A near exceedance of the NSW EPA 24-hour average $PM_{2.5}$ criterion was measured at the Beresfield AQMS on 22 November 2018. An extensive dust storm occurred throughout NSW from 21 to 23 November 2018. On 22 November 2018, most regions of New South Wales experienced very poor to hazardous air quality.

Air quality was affected by long-range transport of dust particles from South Australia and drought-affected regions of New South Wales, during with the passage of a cold front. (NSW OEH, 2018).

Table 2 Summary of assumed background concentrations, Beresfield 2018

Pollutant	Averaging Period	Concentration Value Assumed	Notes
Particulates (as PM_{10})	24-hour	Daily varying	Maximum 24-hour PM_{10} concentration at Beresfield in 2018 was 149.1 $\mu g \cdot m^{-3}$
	annual average	21.6 $\mu g \cdot m^{-3}$	Annual average PM_{10}, Beresfield, 2018
Particulates (as $PM_{2.5}$)	24-hour	Daily varying	Maximum 24-hour $PM_{2.5}$ concentration at Beresfield in 2018 was 24.9 $\mu g \cdot m^{-3}$
	annual average	8.7 $\mu g \cdot m^{-3}$	Annual average $PM_{2.5}$, Beresfield, 2018
Nitrogen dioxide (NO_2)	1 hour	Hourly varying	Maximum 1-hour NO_2 concentration at Beresfield in 2018 was 82 $\mu g \cdot m^{-3}$
	annual average	17.5 $\mu g \cdot m^{-3}$	Annual average NO_2, Beresfield, 2018
Ozone (O_3)	1 hour	Hourly varying	Maximum 1-hour O_3 concentration at Beresfield in 2018 was 229 $\mu g \cdot m^{-3}$

Graphs presenting the daily variations in PM_{10}, $PM_{2.5}$ and hourly variations in NO_2 concentrations are presented in **Figure 6**,

Figure 7 and **Figure 8**, respectively.

Figure 6 Measured 24-hour PM_{10} concentrations – Beresfield 2018

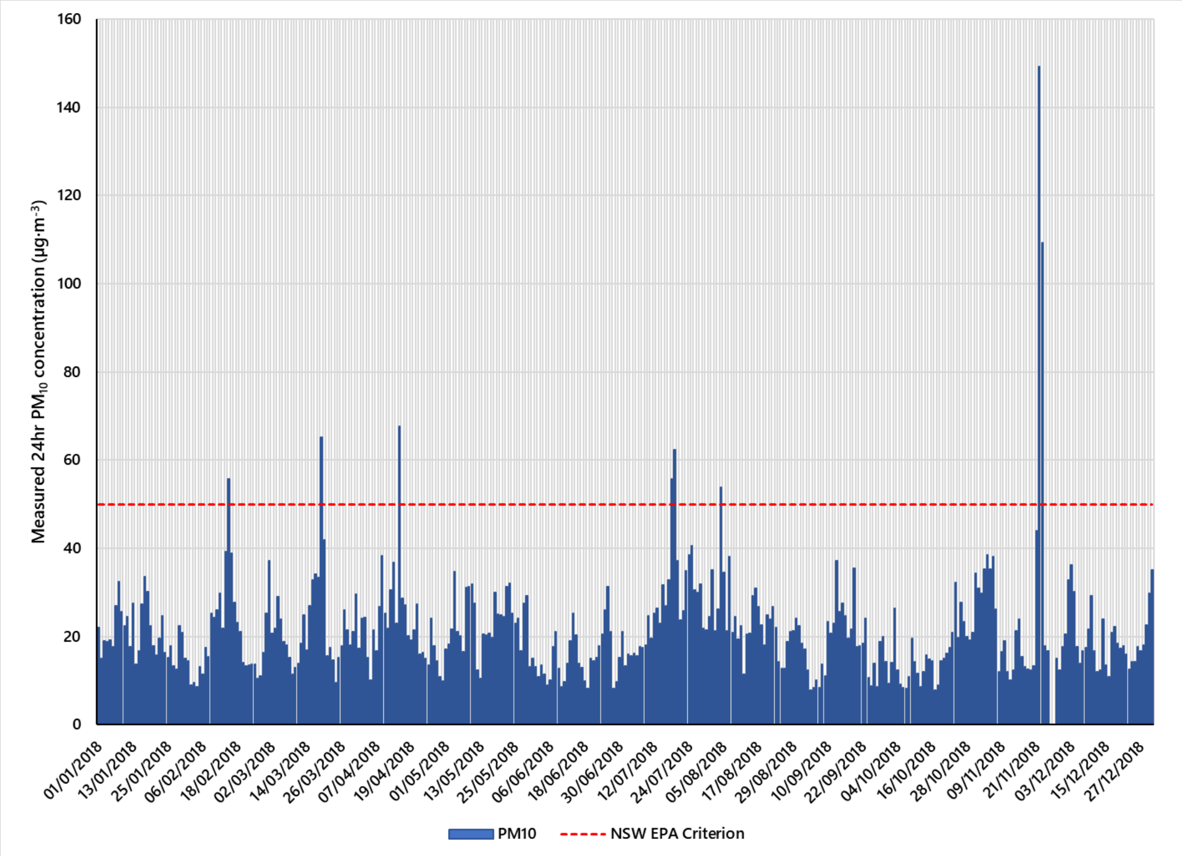


Figure 7 Measured 24-hour $PM_{2.5}$ concentrations – Beresfield 2018

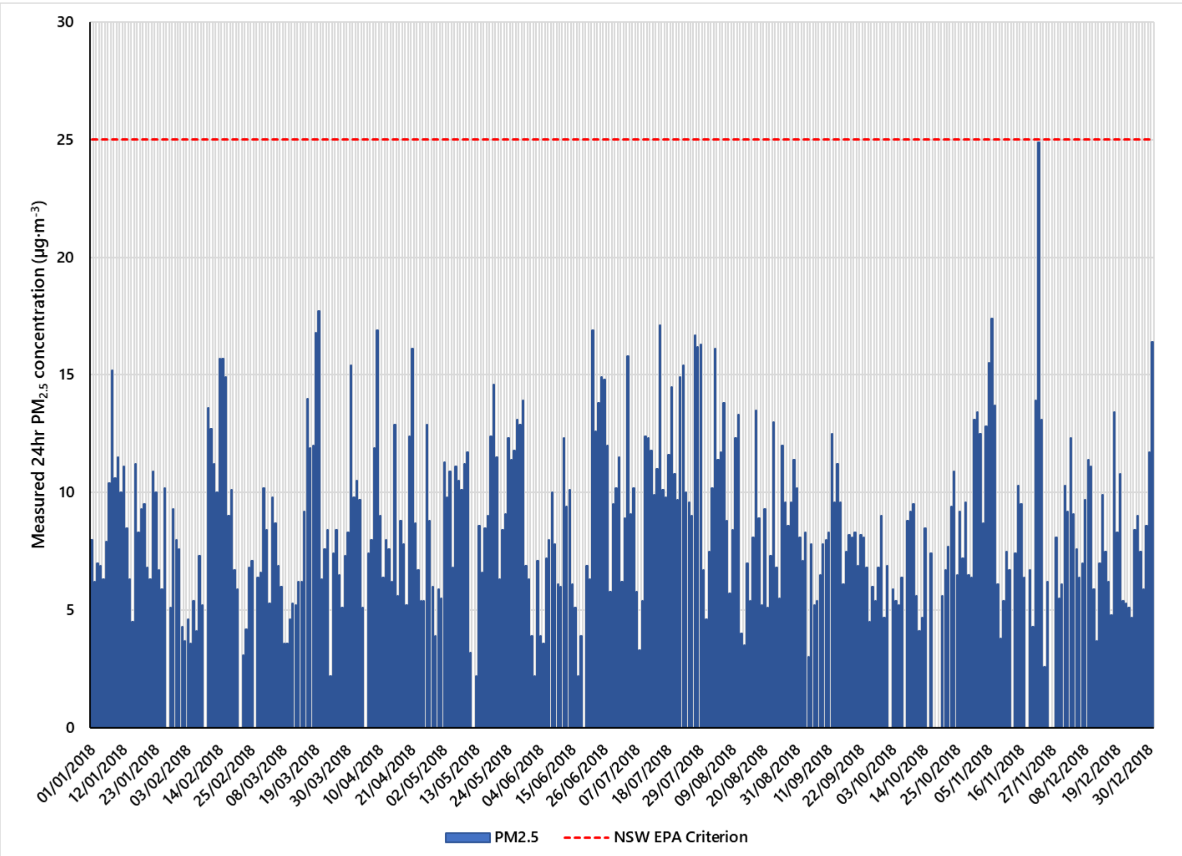
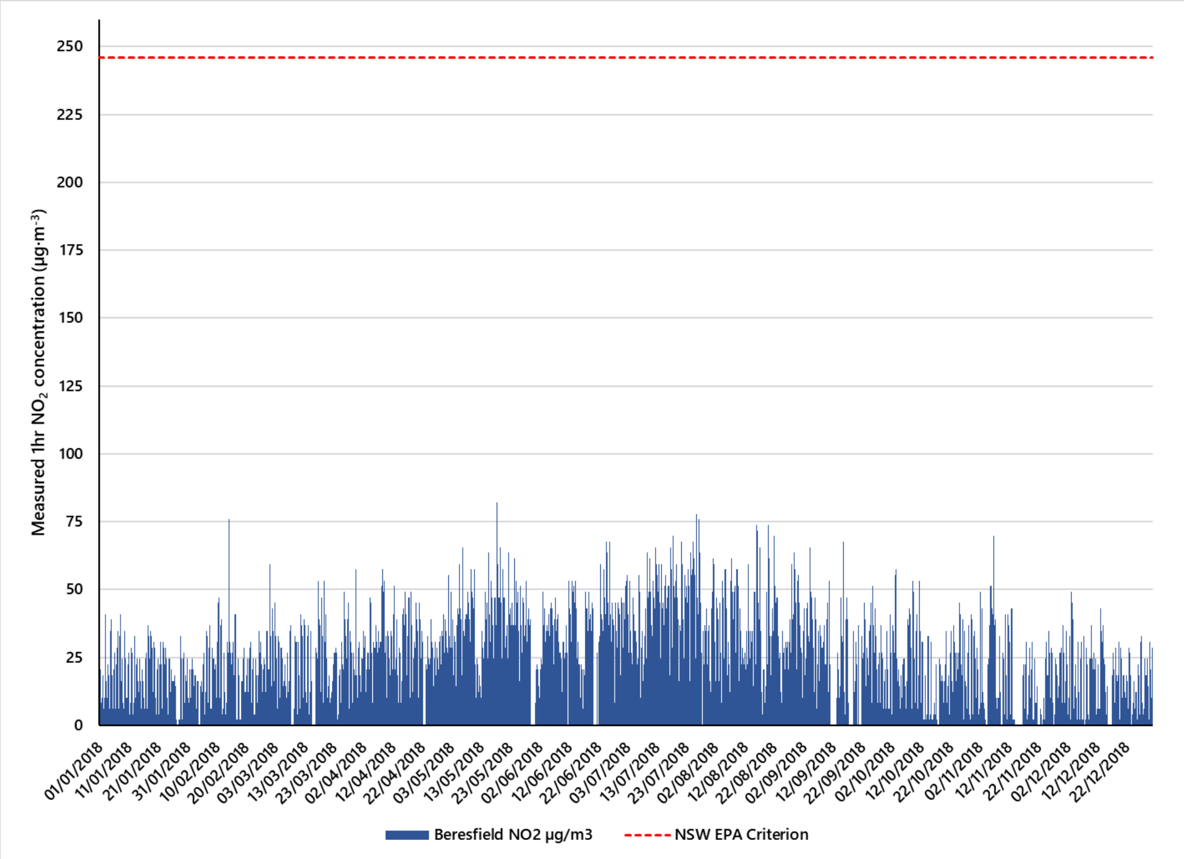


Figure 8 Measured 1-hour NO_2 concentrations – Beresfield 2018



5. METHODOLOGY

The AQIA has been performed using a quantitative assessment methodology, intended to be consistent with the general approach presented in the NSW EPA Approved Methods (NSW EPA, 2017).

5.1 General Approach

To provide a detailed assessment of the likely impacts of vehicle emissions across the Proposal site, sufficiently detailed information related to those vehicle emissions is required. For the purposes of this assessment, the data outlined in Table 2 has been obtained or calculated, with justification for use provided where required.

Detailed discussion of emissions estimation is presented in **Appendix A**.

5.2 Emission Factors

The estimation of emissions from a process is typically performed using direct measurement or through the application of factors which appropriately represent the processes under assessment. For road-traffic emissions, the assessment considered the applicability of emission factors presented in the National Pollutant Inventory (NPI) *Emission estimation technique manual for aggregated emissions from motor vehicles* (2000) (NPI, 2000). The emission factors were discounted due to the age of the emission factors, and the rapid improvements in engine performance over the last two decades. For example, a data set published in the year 2000 would utilise emission standards for passenger cars performing to Australian Design Rule (ADR) 37/01 (at best) which specifies (by way of example) a NO_X emission of 1.93 $g{\cdot}km^{-1}$ for petrol fuelled cars. For comparison, ADR7904 (type approval 2016) specify NO_X emission standard of 0.06 $g{\cdot}km^{-1}$ for petrol fuelled cars respectively, which represents 3 % of the ADR37/01 standard[2].

To better represent more modern emission performance, reference has been made to the fleet-average NSW EPA GMR Emission Inventory On-Road emission assessment, adapted for this study by assumptions relating to site-specific fleet composition, road gradient and traffic conditions. The model is a development of ADR emission performance standards, fleet distribution published by the Motor Vehicle Census for Australia, and numerous sources of published road-traffic emission databases, including COPERT4.

Emissions of non-exhaust PM, including brake wear, tyre wear and road wear are included as factors in the assessment of PM_{10} and $PM_{2.5}$ emissions.

[2] https://www.infrastructure.gov.au/vehicles/environment/emission/files/Emission_Standards_for_Petrol_Cars.pdf

Table 3 Data used in calculation of vehicle flows and emissions

ID	Parameter	Source	Data	Notes
1	Diurnal profile of traffic flows in 2010	TfNSW Traffic Volume Viewer	Traffic classifier data for counter 05030 (New England Highway, approx. 4.6 km to the west of the Proposal site)	2010 most recent data available
3	Diurnal profile of light and heavy vehicle flows in 2010	TfNSW Traffic Volume Viewer	Traffic classifier data for counter 05030 (New England Highway, approx. 4.6 km to the west of the Proposal site)	2010 most recent classifier data available
4	Vehicle types	Assumed	100 % light vehicles assumed to be cars 69 % of heavy vehicles assumed to be rigid 21 % of heavy vehicles assumed to be articulated 6 % of heavy vehicles assumed to be buses 3 % of heavy vehicles assumed to be B-Double	Based on typical fleet composition data
5	Fuel types	ABS Motor Vehicle Census, 2020	Diesel and petrol fuel split for car, light commercial, light rigid, heavy rigid, articulated vehicles and buses	Most recent data available, not available by State or Territory
6	Emissions	NSW EPA GMR Emissions Inventory 2008	NO_X, PM_{10} exhaust emissions PM_{10}, $PM_{2.5}$ brake and tyre wear emissions	Calculated for commercial arterial roads, $PM_{2.5}$ from exhaust emission calculated to be 71.4 % of PM_{10}

5.3 Road Type

The emission factors are provided as weighted by the road type, which helps provide definition of base vehicle speed and general traffic flow characteristics. For the purposes of this assessment, New England Highway has been assessed as being typified as a "commercial arterial" road:

> ***Major road for purpose of regional and inter-regional traffic movement. Provides connection between motorways and sub-arterials/collectors. May be subject to high congestion in peak periods. Speed limits 60-80 km/h, typically dual carriageway. Regular intersections, many signalised, characterised by stop-start flow, moderate to high intersection delays and queuing with higher V/C ratios.***

5.4 Dispersion Modelling

A dispersion modelling assessment has been performed using the GRAz Lagrangian model (GRAL). GRAL is developed at the Graz University of Technology, Austria, and supported by the Federal State Government of Styria, Austria.

The GRAL modelling system is increasingly used in Australia and New Zealand, with the 2019 Clean Air Society of Australia and New Zealand (CASANZ) conference featuring a GRAL stream for the first time due to its increased use in AQIA in Australia. The air quality assessments for the WestConnex M4 East (Pacific Environment, 2015) and New M5 (Pacific Environment, 2015) used the GRAL model to predict operational impacts on ambient air quality and it is the preferred model of TfNSW for assessment of recent road infrastructure projects.

The GRAL model was selected for the dispersion modelling for this assessment for the following reasons:

- It is suitable for regulatory applications and can utilise a full year of meteorological data;
- It is a particle model and has the ability to predict concentrations under low-wind-speed conditions (i.e. < 1 $m \cdot s^{-1}$) which is better performance under these conditions than most Gaussian models (e.g. CALINE, Cal3QHCR, Cal3/4);
- It is specifically designed for the simultaneous modelling of road transport networks, including line sources (surface roads), point sources (tunnel ventilation outlets) and other sources; and
- It can characterise pollution dispersion in complex local terrain, accounting for the effects of obstacles (e.g. buildings, walls and vegetation) on flow and turbulence patterns by using a microscale prognostic flow field model.

5.5 NO_X to NO_2 Conversion

Within this assessment, the conservative assumption that all NO is converted to NO_2 has been adopted (i.e. 100 % of NO_X is emitted as NO_2). This is in accordance with a Method 1, Level 2 assessment as outlined within the Approved Methods (section 8.1.1 of (NSW EPA, 2017)). In that method, the 1-hour dispersion model NO_X prediction is added to the contemporaneous 1-hour average NO_2 background concentration to provide a cumulative NO_2 impact.

This approach is highly conservative, and the results should be viewed with that consideration.

6. ASSESSMENT

This section presents the results of the dispersion modelling assessment and uses the following terminology:

- Increment – relates to the concentrations predicted as a result of the traffic flows along New England Highway in 2010 in isolation.
- Cumulative – relates to the concentrations predicted as a result of the traffic flows along New England Highway in 2010 PLUS the background air quality concentrations discussed in **Section 4.3**.

The results are presented in this manner to allow examination of the likely risk of impacts at the Proposal site from road vehicle emissions from New England Highway. Results are presented at the location of maximum impact within the outdoor play areas given that this is where children would likely to be present for long periods outside the enclosed building, and without any additional mitigation such as air conditioning.

The meteorological year adopted within dispersion modelling is 2018, as discussed in **Section 4.2**.

Any predicted exceedances of the air quality criteria (see **Section 3**) are highlighted in the tables. Please note that rounding of the results may have occurred as presented in the tables.

A summary of the predicted impacts is presented in **Table 4**, **Table 5** and **Table 6**. Isopleth plots for predicted incremental PM_{10}, $PM_{2.5}$ and NO_2 impacts are presented in **Appendix C**.

Table 4 Results summary – outdoor play areas

Pollutant	Averaging Period	Maximum Increment ($\mu g \cdot m^{-3}$)	Assumed Background ($\mu g \cdot m^{-3}$)	Predicted Cumulative ($\mu g \cdot m^{-3}$)	Criterion ($\mu g \cdot m^{-3}$)	Cumulative / Criterion (%)
NO_2	1-hour	148.6	26.7	175.3	246.0	71.2
	annual	6.3	17.5	23.8	62.0	38.3
PM_{10}	24-hour	See Table 5				
	annual	0.3	21.6	21.9	25.0	87.4
$PM_{2.5}$	24-hour	See Table 6				
	annual	0.2	8.7	8.9	8.0	110.8

The results presented in **Table 4** indicate that the maximum 1-hour and annual average NO_2 concentrations are below the criteria, even adopting a worst-case NO to NO_2 conversion method. Annual average PM_{10} concentrations are also below the relevant criterion. Annual average $PM_{2.5}$ concentrations are shown to be in exceedance of the criterion within the outdoor play area, although the contribution from New England Highway is minor, and 2.5 % of the criterion. The background (i.e. existing) annual average $PM_{2.5}$ concentration is already in exceedance of the criterion, and the mitigation options outlined in **Section 7**, and especially those in **Section 7.3**, will act to minimise the exposure of children to particulate matter within the outdoor play area.

The predicted maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted within the outdoor play areas, with background included are presented in **Table 5** and **Table 6**, respectively.

The left side of the tables show the predicted concentration on days with the highest predicted cumulative impact (typically driven by the days with highest regional background), and the right side shows the total predicted concentration on days with the highest predicted incremental concentrations due to emissions from vehicles using New England Highway, respectively.

The results summarised in **Table 5** predicted eight exceedances of the cumulative 24-hour PM_{10} criterion, however, as shown these exceedances occur on days with an already exceeding background PM_{10} concentration, with or without the contribution from New England Highway. Critically, there are no additional exceedances of the 24-hour average PM_{10} criterion predicted within the outdoor play areas of the Proposal site.

Table 5 Summary of contemporaneous impact and background, outdoor play areas – PM_{10}

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
22/11/2018	0.3	149.1	149.4	18/10/2018	1.3	8.9	10.2
23/11/2018	<0.1	109.3	109.4	30/03/2018	1.2	21.0	22.2
15/04/2018	0.2	67.6	67.8	24/03/2018	1.1	9.5	10.6
19/03/2018	0.1	65.2	65.3	2/04/2018	1.0	24.0	25.0
19/07/2018	0.5	62.3	62.8	8/04/2018	1.0	26.7	27.7
18/07/2018	0.3	55.7	56.0	7/05/2018	1.0	16.5	17.5
15/02/2018	<0.1	55.6	55.7	8/06/2018	1.0	21.1	22.1
4/08/2018	0.2	53.7	53.9	12/06/2018	1.0	13.9	14.9
21/11/2018	0.5	44.0	44.5	2/05/2018	1.0	18.2	19.2
20/03/2018	<0.1	41.9	42.0	22/06/2018	0.9	15.1	16.0
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions (outlined in red) as a result of impacts associated with New England Highway at the Proposal site				These data represent the highest Incremental Impact 24-hour PM_{10} predictions (outlined in blue) as a result of impacts associated with New England Highway at the Proposal site			

Note: Incr. = incremental impact, BG= background concentration, cumul. = cumulative impact (incr + BG)

Table 6 similarly presents the predicted 24-hour average $PM_{2.5}$ concentrations at the outdoor play areas. The modelled cumulative 24-hour $PM_{2.5}$ concentrations are predicted to result in one minor additional exceedance of the air quality criterion, on 22 November 2018.

As outlined in **Section 4.3**, a near exceedance of the NSW EPA 24-hour average $PM_{2.5}$ criterion was measured at the Beresfield AQMS on 22 November 2018 (24.9 µg·m^{-3}). An extensive dust storm occurred throughout NSW from 21 to 23 November 2018. On 22 November 2018, most regions of New South Wales experienced very poor to hazardous air quality.

The modelling predicts that the contribution of New England Highway to 24-hour $PM_{2.5}$ impacts within the outdoor play area on that day are minor, and 0.8 % of the criterion. Should the management and mitigation measures outlined in **Section 7.3** be appropriately implemented, the exposure of children to such elevated concentrations of $PM_{2.5}$ would be limited.

Table 6 Summary of contemporaneous impact and background, outdoor play areas – $PM_{2.5}$

Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})			Date	24-hour average $PM_{2.5}$ concentration (µg·m^{-3})		
	Incr.	BG	Cumul.		Incr.	BG	Cumul.
22/11/2018	0.2	24.9	25.1	18/10/2018	0.8	7.4	8.2
6/11/2018	0.4	17.4	17.8	24/03/2018	0.7	2.2	2.9
20/03/2018	<0.1	17.7	17.8	30/03/2018	0.7	8.3	9.0
22/06/2018	0.5	16.9	17.4	8/04/2018	0.6	11.9	12.5
15/07/2018	0.3	17.1	17.4	8/06/2018	0.6	10.0	10.6
9/04/2018	0.2	16.9	17.1	12/06/2018	0.6	12.3	12.9
27/07/2018	0.2	16.7	16.9	2/05/2018	0.6	11.3	11.9
19/03/2018	<0.1	16.8	16.9	2/04/2018	0.6	10.5	11.1
31/12/2018	0.3	16.4	16.7	7/05/2018	0.6	10.5	11.1
29/07/2018	0.3	16.3	16.6	3/05/2018	0.6	9.8	10.4
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of impacts associated with New England Highway at the Proposal site				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of impacts associated with New England Highway at the Proposal site			

Note: Incr. = incremental impact, BG= background concentration, cumul. = cumulative impact (incr + BG)

It is noted that the emissions from vehicles using New England Highway have been based on 2010 vehicle flows and have adopted emission factors for a 2008 vehicle fleet. Reductions in emissions are anticipated over time, as improvements and advancements in emissions control technology, fuel efficiency and increased used of electric vehicles is likely. These reductions are likely to offset any increases in vehicle numbers using New England Highway from the reference year adopted within this assessment.

Although predicted incremental impacts within the outdoor play area are anticipated to be minor, with any exceedances resulting from existing air quality impacts, and specifically resulting from regional particulate events (bushfires and dust storms), the following section provides additional information on how the potential risks to children resulting from elevated air pollutant exposures might be minimised.

7. MITIGATION OPTIONS

Options to reduce the risk of negative impacts associated with air pollution can be implemented at any stage of the ***source-pathway-receptor*** relationship. The range of mitigation options which could be considered to further reduce the minimal risks identified in the previous section are discussed below using that model.

7.1 Source Mitigation

Options to reduce air pollution impacts associated with the source of emissions would be related to the reduction in emissions from vehicles, either by reducing emissions from individual vehicles or by reducing the total load of emissions generated by vehicles (i.e. reducing the number of vehicles).

Reductions in emissions from individual vehicles is outside the scope of this assessment. It should be noted that as the broader vehicle fleet is progressively replaced by newer and more efficient vehicles, impacts would be expected to be proportionately reduced over time.

The smooth flow of traffic through the entry/exit of the child care centre should be maximised where possible and the frequency and duration of queuing / idling traffic should be minimised. During peak periods, the use of signs to encourage the switching off of engines may be considered, and staggered drop-off and pick-up times may avoid unnecessary queuing, should this be required.

7.2 Pathway Mitigation

The pathway of air pollution from the source to the receptor can be interrupted in several ways.

Firstly, the pathway could be made longer by moving the source of emissions further away from the receptor, that is, by moving the outdoor play areas away from New England Highway. The indoor areas of the proposed child care centre and the surrounding buildings could also then act as a barrier to any pollution generated from this road source.

The use of planted vegetation along the line of the retaining wall, and along the boundaries of the Proposal site where possible is recommended to provide further opportunity to minimise the effect of air pollution, in accordance with the recommendation presented in the Child Care Guideline (see **Section 3.4**).

7.3 Receptor Mitigation

Minimising the impacts of any air pollution on the receptors (children) can also be performed.

Ventilation design is an important consideration. For all indoor areas, mechanical ventilation should be used. Central HVAC units that serve multiple classrooms are typically more effective than single-room unit systems. In rooms where sufficient mechanical ventilation can be ensured, the building envelope should be sealed to prevent infiltration of external air through cracks around windows, doors, and HVAC ducts. The HVAC system should be operated with appropriate filtration to reduce particulate ingress into the classrooms. The filters should be inspected and replaced regularly according to manufacturer's recommendations.

To ensure that the HVAC system operates effectively, windows and doors should be kept closed to avoid bringing in unfiltered outdoor air. HVAC systems should be regularly serviced and maintained and operated correctly and air intakes for the HVAC system should be located at the maximum distance from all roadways, and other pollutant sources.

All teachers and staff should be trained on best ventilation practices, including keeping windows and doors closed in mechanically ventilated classrooms to minimise the ingress of external air, keeping HVAC systems turned on throughout the day and, keeping air vents clear of items that may block airflow.

It is recommended that staff should review the daily air quality forecast provided daily by the NSW DPIE[3], and adjust planned activities to account for the prevailing conditions, as summarised by the air quality category (AQC). The AQC is presented on a five-category scale (good, fair, poor, very poor and extremely poor) with guidance on adapting and curtailing activities presented in the Environmental Health Standing Committee's (enHealth) activity guide[4], which is reproduced below in **Table 7**:

Table 7 Air quality category activity guide (enHealth)

Air quality category	General health advice and recommended actions
	Sensitive groups including: • people with a heart or lung condition, including asthma • people over the age of 65 • **infants and children** • pregnant women
Good	**NO CHANGE** needed to your normal outdoor activities.
Fair	**REDUCE** outdoor physical activity if you develop symptoms such as cough or shortness of breath. Consider closing windows and doors until outdoor air quality is better. Follow the treatment plan recommended by your doctor. If you are concerned about symptoms call the 24-hour HealthDirect helpline on 1800 022 222 or see your doctor. In a health emergency, call triple zero (000) for an ambulance.

[3] https://www.dpie.nsw.gov.au/air-quality/sydney-forecast

[4] https://www.environment.nsw.gov.au/topics/air/understanding-air-quality-data/air-quality-categories

Air quality category	General health advice and recommended actions
	Sensitive groups including: • people with a heart or lung condition, including asthma • people over the age of 65 • infants and children • pregnant women
Poor	**AVOID** outdoor physical activity if you develop symptoms such as cough or shortness of breath. When indoors, close windows and doors until outdoor air quality is better. Follow the treatment plan recommended by your doctor. If you are concerned about symptoms call the 24-hour HealthDirect helpline on 1800 022 222 or see your doctor. In a health emergency, call triple zero (000) for an ambulance.
Very poor	**STAY INDOORS** as much as possible with windows and doors closed until outdoor air quality is better. If you feel that the air in your home is uncomfortable, consider going to a place with cleaner air (such as an air-conditioned building like a library or shopping centre) if it is safe to do so. Actively monitor symptoms and follow the treatment plan recommended by your doctor. If you are concerned about symptoms call the 24-hour HealthDirect helpline on 1800 022 222 or see your doctor. In a health emergency, call triple zero (000) for an ambulance.
Extremely poor	**STAY INDOORS** with windows and doors closed until outdoor air quality is better and reduce indoor activity. If you feel that the air in your home is uncomfortable, consider going to a place with cleaner air (such as an air-conditioned building like a library or shopping centre) if it is safe to do so. Actively monitor symptoms and follow the treatment plan recommended by your doctor. If you are concerned about symptoms call the 24-hour HealthDirect helpline on 1800 022 222 or see your doctor. In a health emergency, call triple zero (000) for an ambulance.

Further to the above, it is recommended that strenuous activities in the outdoor play areas should be planned during times with anticipated lower traffic volumes using the surrounding road network (i.e. non-peak hour). From traffic data obtained from TfNSW counter 05030, in 2010 the peak hours along New England Highway were between 5 am and 6 am (westbound traffic) and 9 am and 10 pm (eastbound traffic) in the morning, and between 5 pm and 6 pm (westbound traffic) and 4 pm and 5 pm (eastbound traffic) in the afternoon.

7.4 Mitigation Summary

In summary, the following mitigation measures should be considered for implementation at the proposed child care centre and should they be implemented, it is anticipated that impacts of any air pollution would be further minimised:

Traffic management

- Encourage the smooth flow of traffic through the entry/exit.
- During peak periods, use signs to encourage engine switching off.
- Staggered drop-off and pick-up schedules may be used to minimise queuing times.

Design and layout

- Locate outdoor play areas as far as possible from the main entry/exit route.
- Plant vegetated screens along the boundaries of the Proposal site.

Ventilation

- For all indoor areas, mechanical ventilation should be used.
- Central HVAC units that serve multiple classrooms are typically more effective than single-room unit systems.
- In rooms where sufficient mechanical ventilation can be ensured, the building envelope should be sealed to prevent infiltration of polluted air through cracks around windows, doors, and HVAC ducts.
- To ensure that the HVAC system operates effectively, windows and doors should be kept closed to avoid bringing in polluted outdoor air.
- HVAC systems should be regularly serviced and maintained and operated correctly.
- Air intakes for the HVAC system should be located at the maximum distance from all roadways, and other pollutant sources.
- The HVAC system should be operated with appropriate filtration to reduce particulate pollution exposure inside classrooms. These filters should be inspected and replaced regularly according to manufacturer's recommendation.
- All teachers and staff should be trained on best ventilation practices, including keeping windows and doors closed in mechanically ventilated classrooms to prevent entry of polluted outdoor air, keeping HVAC systems turned on throughout the day and, keeping air vents clear of items that may block airflow.

Daily exposure reduction strategies

- Daily check of the NSW DPIE Air Quality Category and adopting changes to planned activities in accordance with the enHealth Activity Guide.
- Any strenuous activities in the outdoor play areas should be planned during times with lower amounts of traffic using the surrounding road network.

8. DISCUSSION AND CONCLUSION

This report presents an AQIA for the proposed development of land at 857 & 853 New England Highway, Lochinvar, NSW for use as a child care centre.

Potential impacts associated with road traffic exhaust emissions on New England Highway has been presented in this report.

Typically for air quality studies related to road traffic emissions, the critical determinations are associated with 1-hour NO_2 impacts, and 24-hour PM_{10} and $PM_{2.5}$ impacts. The assessment predicts cumulative impacts below the relevant criteria for 1-hour NO_2, although exceedances of the 24-hour PM_{10} and $PM_{2.5}$ criteria are noted. In the case of PM_{10}, no additional exceedances of the 24-hour criteria are predicted within the outdoor area of the child care centre due to road traffic on New England Highway. In the case of $PM_{2.5}$, one minor additional exceedance is predicted, although the background concentration on that particular day was dominated by impacts associated with a regional dust storm. The incremental contribution from New England Highway on that day was minor.

Isopleth plots of incremental 1-hour NO_2, 24-hour PM_{10} and $PM_{2.5}$ are illustrated in **Appendix C**. The plots clearly illustrate a rapid decline in air pollutant concentrations with distance from the road, as would be anticipated.

This AQIA provides a range of recommendations are provided to reduce and manage the risk of air pollutants, including recommendations for:

- Traffic management
- Design and layout
- Ventilation
- Daily exposure reduction strategies

Should those measures be adopted appropriately, especially those associated with 'daily exposure reduction strategies', the potential for elevated background air quality resulting from regional particulate episodes would be able to be identified, and the exposure of children to any elevated conditions minimised.

Based upon the information presented in this AQIA, the study does not consider there is an air quality constraint associate with siting and running a child care centre at the Proposal site from road traffic exhaust emissions from New England Highway.

9. REFERENCES

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APPENDIX A – EMISSION ESTIMATION

Vehicle Fuel Split Assumptions

Vehicle Type	Diesel	Petrol
Passenger car (PC)	13%	87%
Light commercial vehicle (LCV)	69%	31%
Light rigid truck (LRT)	95%	5%
Heavy rigid truck (HRT)	97%	3%
Articulated truck (ART)	99%	1%
Bus (Bus)	80%	20%

Source: 2020 Motor Vehicle Census for Australia

Aggregated Vehicle Emission Factors (g·km^{-1})

Vehicle type	NO_X	PM_{10}	$PM_{2.5}$
Passenger car (petrol)	0.612	0.025	0.014
Passenger car (diesel)	1.133	0.075	0.050
Light commercial vehicle (diesel)	1.298	0.189	0.129
Light commercial vehicle (petrol)	1.463	0.045	0.026
Rigid truck (diesel)	5.277	0.451	0.313
Articulated truck (diesel)	16.092	0.447	0.310
Bus (diesel/petrol)	17.265	0.454	0.315
Heavy vehicle (petrol)	2.893	0.127	0.081
Motorcycle	0.169	0.039	0.026

Source: GMR Emissions Inventory, commercial arterial roads, includes non-exhaust emissions for PM_{10} and $PM_{2.5}$

Measured and calculated traffic flows (total) along New England highway (vehicles·hr^{-1})

Hour	2010 Westbound	2010 Eastbound
0	48	72
1	36	47
2	32	30
3	51	42
4	190	64
5	719	147
6	581	301
7	562	520
8	476	571
9	470	637
10	478	623
11	513	585
12	516	549
13	548	568
14	585	606
15	615	706
16	649	740
17	682	730
18	443	474
19	241	390
20	195	195
21	189	132
22	144	115
23	84	83
Total	**9,047**	**8,927**
Max AM	**719**	**637**
Max PM	**682**	**740**

Source: 2010 measured flows from classifier counter 05030.

Calculated traffic flows (by vehicle type) along New England Highway (vehicles·hr^{-1})

Westbound + Eastbound (2010)	Vehicle Numbers											Emissions (g·km^{-1})		
	PCar	DCar	PRig	DRig	PBus	DBus	PArt	DArt	PBD	DBD	Total	NO_X	PM_{10}	$PM_{2.5}$
0:00	77.4	11.6	2.8	18.6	0.4	1.5	0.1	6.4	0.0	0.9	120	346.1	13.8	9.3
1:00	50.5	7.5	2.2	15.0	0.3	1.2	0.1	5.2	0.0	0.7	83	269.7	10.7	7.2
2:00	33.9	5.1	2.1	13.8	0.3	1.1	0.0	4.8	0.0	0.7	62	238.4	9.4	6.4
3:00	53.1	7.9	2.9	19.2	0.4	1.5	0.1	6.7	0.0	1.0	93	336.3	13.3	9.0
4:00	183.6	27.4	3.9	25.8	0.5	2.1	0.1	8.9	0.0	1.3	254	539.6	21.9	14.5
5:00	682.1	101.9	7.4	49.2	1.0	3.9	0.2	17.0	0.0	2.4	865	1,288.6	53.8	34.6
6:00	663.8	99.2	10.7	71.4	1.4	5.7	0.2	24.7	0.0	3.5	881	1,615.1	66.3	43.3
7:00	818.7	122.3	12.6	84.6	1.7	6.8	0.3	29.3	0.0	4.2	1,081	1,938.9	79.7	52.0
8:00	798.7	119.3	11.6	77.4	1.5	6.2	0.3	26.8	0.0	3.8	1,046	1,812.7	74.7	48.6
9:00	842.2	125.8	12.5	83.4	1.7	6.7	0.3	28.9	0.0	4.1	1,106	1,938.8	79.8	52.0
10:00	841.3	125.7	12.0	80.4	1.6	6.4	0.3	27.9	0.0	4.0	1,100	1,892.0	78.0	50.8
11:00	830.9	124.2	12.8	85.8	1.7	6.9	0.3	29.7	0.0	4.2	1,097	1,966.8	80.9	52.7
12:00	810.0	121.0	12.0	80.4	1.6	6.4	0.3	27.9	0.0	4.0	1,064	1,867.6	76.9	50.1
13:00	849.1	126.9	12.6	84.0	1.7	6.7	0.3	29.1	0.0	4.2	1,115	1,953.4	80.5	52.4
14:00	917.0	137.0	12.3	82.2	1.6	6.6	0.3	28.5	0.0	4.1	1,190	1,978.8	81.8	53.1
15:00	1,036.2	154.8	11.7	78.0	1.6	6.2	0.3	27.0	0.0	3.9	1,320	2,007.5	83.7	53.9
16:00	1,112.7	166.3	9.9	66.0	1.3	5.3	0.2	22.9	0.0	3.3	1,388	1,883.1	79.3	50.6
17:00	1,148.4	171.6	8.3	55.2	1.1	4.4	0.2	19.1	0.0	2.7	1,411	1,745.2	74.2	46.9
18:00	730.8	109.2	6.9	46.2	0.9	3.7	0.2	16.0	0.0	2.3	916	1,280.6	53.8	34.4
19:00	501.1	74.9	4.9	33.0	0.7	2.6	0.1	11.4	0.0	1.6	630	898.4	37.7	24.1
20:00	294.9	44.1	4.6	30.6	0.6	2.4	0.1	10.6	0.0	1.5	389	700.4	28.8	18.8
21:00	239.3	35.8	4.1	27.6	0.6	2.2	0.1	9.6	0.0	1.4	321	610.8	25.0	16.4
22:00	191.4	28.6	3.5	23.4	0.5	1.9	0.1	8.1	0.0	1.2	259	508.9	20.8	13.6
23:00	114.0	17.0	3.2	21.6	0.4	1.7	0.1	7.5	0.0	1.1	167	420.7	16.9	11.3

APPENDIX B – METEOROLOGY

The meteorology experienced within an area can govern the generation (in the case of wind dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. The meteorological conditions surrounding the Proposal site have been characterised using data collected by the Bureau of Meteorology (BoM) at a number of surrounding Automatic Weather Stations (AWS). A summary of the relevant AWS is provided in **Table B1** and also displayed in **Figure 3**.

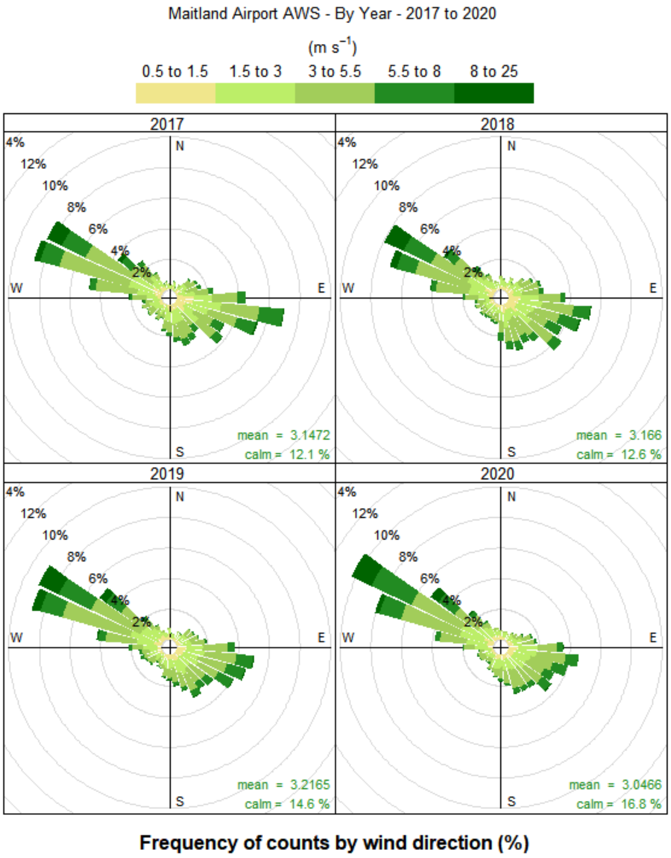
Table B1 Details of meteorological monitoring surrounding the Proposal site

Site Name	Source	Approximate Location (Latitude, Longitude)		Approximate Distance to Site
		˚S	˚E	km
MAITLAND AIRPORT AWS – Station # 061428	BoM	32.70	151.48	2.3

Meteorological conditions at Maitland Airport AWS have been examined to determine a 'typical' or representative dataset for use in dispersion modelling. Annual wind roses for the most recent years of available data (2017 to 2020) are presented in **Figure B1**.

The majority of wind speeds experienced at the Maitland Airport AWS between 2017 and 2020 are generally in the range 0.5 metres per second ($m{\cdot}s^{-1}$) to 5.5 $m{\cdot}s^{-1}$ with the highest wind speeds (greater than 8 $m{\cdot}s^{-1}$) occurring from westerly and easterly directions. Winds of this speed are rare and occur during 2.9 % of the observed hours during the years. Calm winds (<0.5 $m{\cdot}s^{-1}$) prevail and occur more than 14 % of hours across the years.

Figure B1 Annual wind roses 2017 to 2020, Maitland Airport AWS



Given the similarities in the wind distribution across the years examined, data for the year 2018 has been selected for further assessment. Presented in **Figure B2** are the annual wind rose for the 2017 to 2020 period and the year 2018 and in **Figure B3** the annual wind speed distribution for Maitland AWS. These figures indicate that the distribution of wind speed and direction in 2018 is very similar to that experienced across the longer-term period.

It is concluded that conditions in 2018 may be considered to provide a suitably representative dataset for use in dispersion modelling.

Figure B2 Annual wind roses 2017 to 2020, and 2018 Maitland Airport AWS

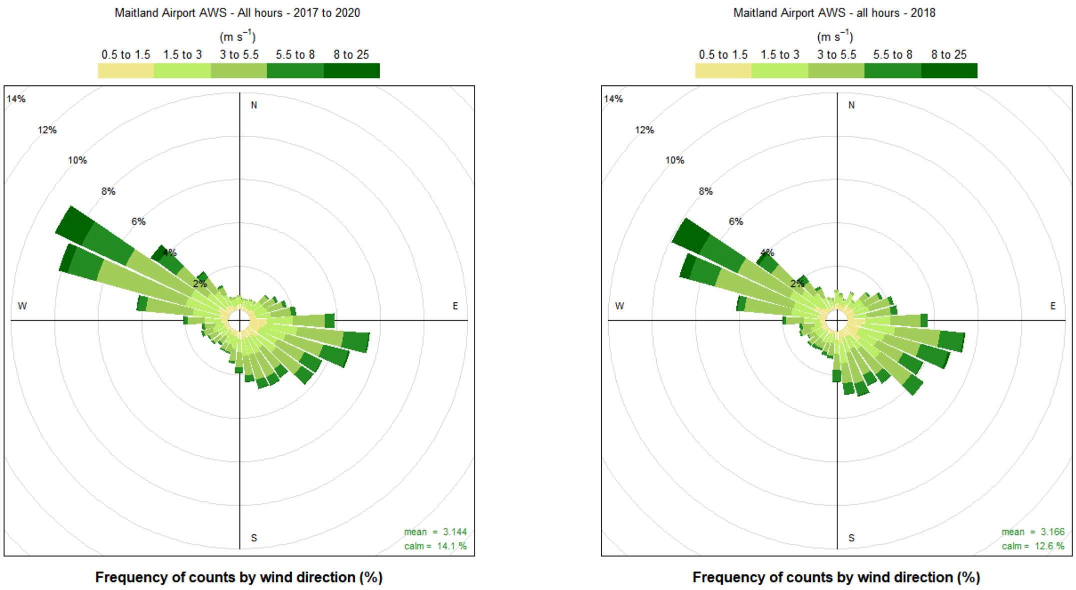
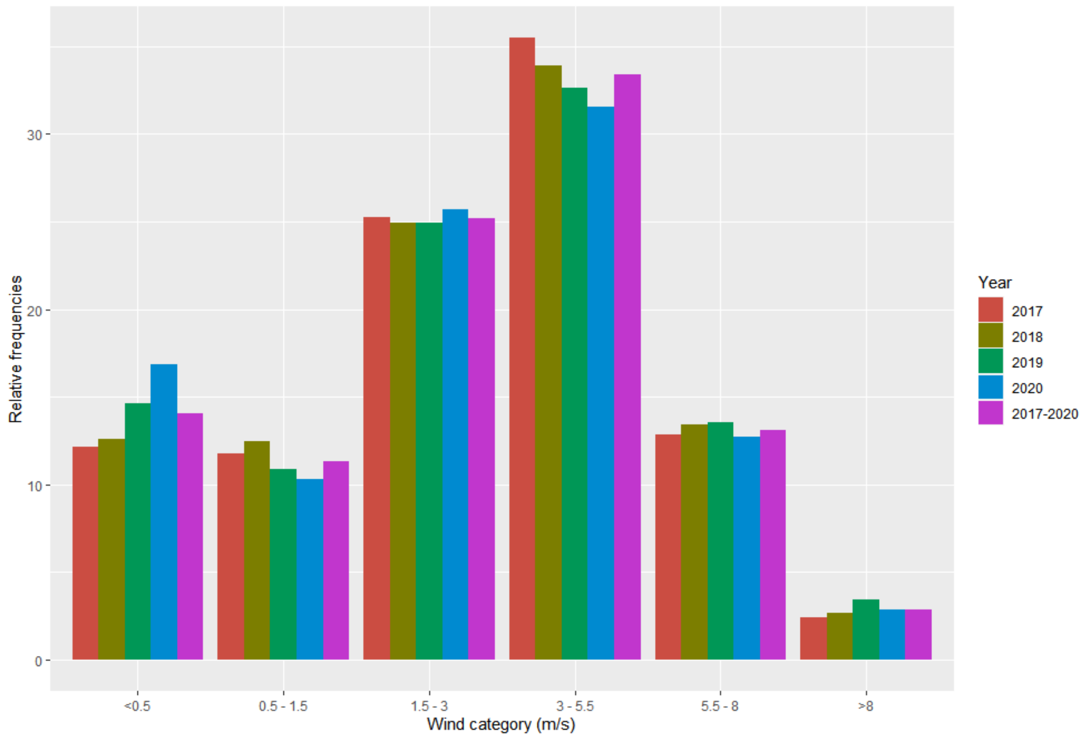


Figure B3 Annual wind speed distribution – Maitland Airport AWS



Meteorological Processing

The BoM data adequately covers the issues of data quality assurance, however it is limited by its location compared to the Proposal site. To address these uncertainties, a multi-phased assessment of the meteorological data has been performed.

In absence of any measured onsite meteorological data, site representative meteorological data for this project was generated using the TAPM meteorological model in a format suitable for using in the GRAL dispersion model (refer **Section 5.4**).

Meteorological modelling using The Air Pollution Model (TAPM, v 4.0.5) has been performed to predict the meteorological parameters required for GRAL. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

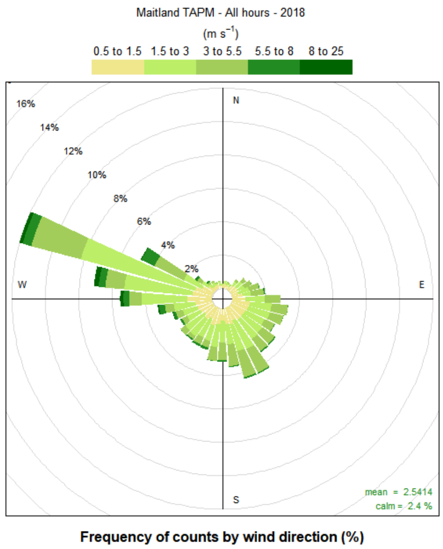
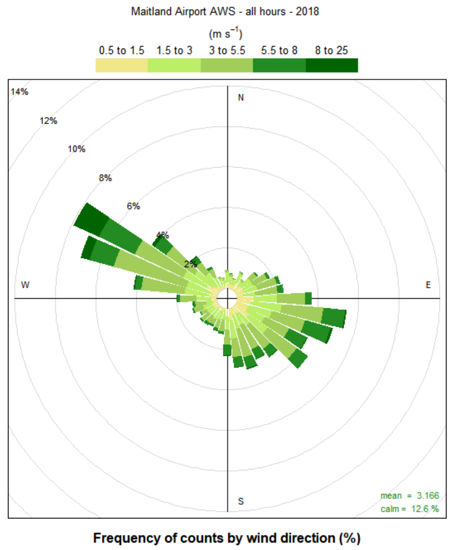
The parameters used in TAPM modelling are presented in **Table B2**.

Table B2 Meteorological parameters used for this study

TAPM v 4.0.5	
Modelling period	1 January 2018 to 31 December 2018
Centre of analysis	357 067 mS , 6 380 018 mN (UTM Coordinates)
Number of grid points	25 × 25 × 25
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	-

A comparison of the TAPM generated meteorological data and that observed at the Maitland Airport AWS is presented in **Figure B4**.

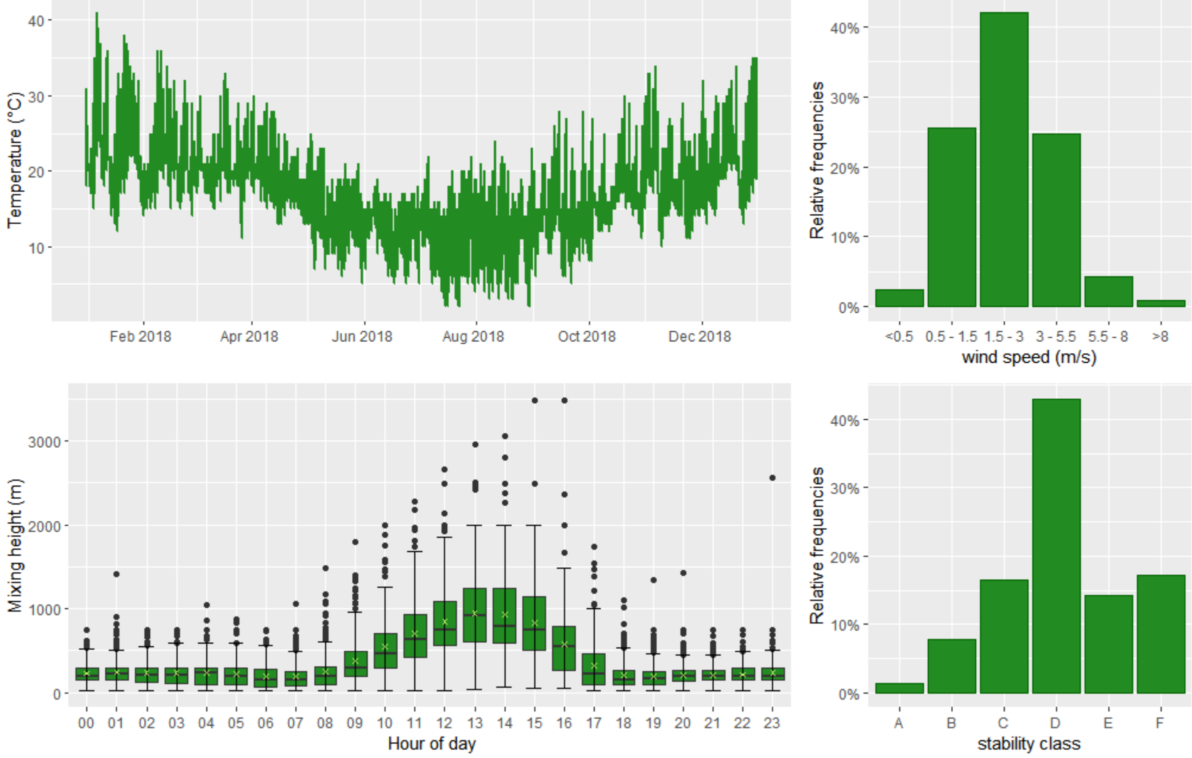
Figure B4 Modelled and observed meteorological data – Maitland Airport AWS, 2018

TAPM generated windrose	Observations at Maitland Airport AWS
	

As generally required by the NSW EPA the following provides a summary of the modelled meteorological dataset. Given the nature of the pollutant emission sources at the Proposal, detailed discussion of the humidity, evaporation, cloud cover, katabatic air drainage and air recirulation potential of the Proposal site has not been provided. Details of the TAPM predictions of wind speed and direction, mixing height, temperature and stability class at the Proposal site are provided in **Figure B5**.

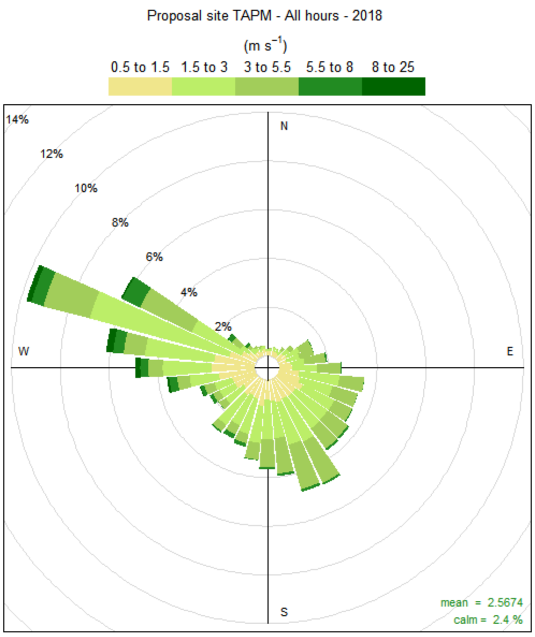
Diurnal variations in maximum and average mixing heights during the 2018 period shows that, as expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure B5 Predicted temperature, mixing height and wind speed frequency – Proposal site 2018



The modelled wind speed and direction at the Proposal site during 2018 are presented in **Figure B6**.

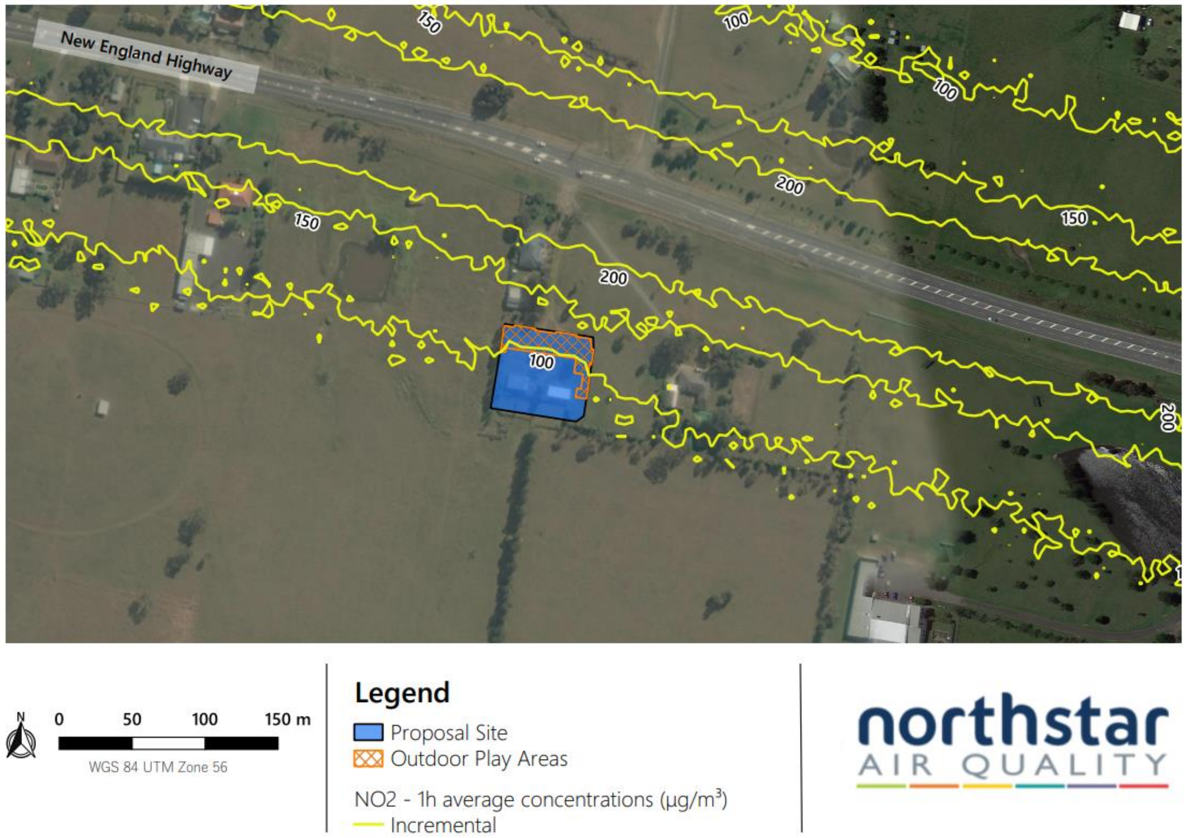
Figure B6 Predicted wind speed and direction – Proposal site 2018



Frequency of counts by wind direction (%)

APPENDIX C – ISOPLETH PLOTS

Predicted incremental 1-hour NO_2



Predicted incremental 24-hour particulate matter (PM_{10})

Predicted incremental 24-hour particulate matter ($PM_{2.5}$)