This document has been prepared for **EMKC Cubed DevCo1 Pty Ltd** by:

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The report has been prepared by Dr Martin Doyle, Certified Air Quality Practitioner (CAQP) administered by the Clean Air Society of Australia and New Zealand (CASANZ)

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Badgerys Creek Warehouse

Updated Air Quality Impact Assessment

Addressee(s):	EMKC Cubed DevCo1 Pty Ltd
Site Address:	230 Martin Road, Badgerys Creek NSW
Report Reference:	24.1015.FR1V7
Date:	23 March 2026
Status:	Revised Final

air quality | environment | sustainability

Quality Control

Study	Status	Prepared by	Checked by	Authorised by
INTRODUCTION	Final	Northstar	MD, GCG	MD
THE PROPOSAL	Final	Northstar	MD, GCG	MD
LEGISLATION, REGULATION AND GUIDANCE	Final	Northstar	MD, GCG	MD
EXISTING CONDITIONS	Final	Northstar	MD, GCG	MD
APPROACH TO ASSESSMENT	Final	Northstar	MD, GCG	MD
CONSTRUCTION AIR QUALITY IMPACT ASSESSMENT	Final	Northstar	MD, GCG	MD
OPERATIONAL AIR QUALITY IMPACT ASSESSMENT	Final	Northstar	MD, GCG	MD
MITIGATION AND MANAGEMENT	Final	Northstar	MD, GCG	MD
CONCLUSION	Final	Northstar	MD, GCG	MD

Report Status

Northstar References		Report Status	Report Reference	Version
Year	Job Number	(Draft: Final)	(R*x*)	(V*x*)
24	1015	Revised Final	R1	V7
Based upon the above, the specific reference for this version of the report is:				24.1015.FR1V7

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.

Martin Doyle **23 March 2026**

Non-Technical Summary

Northstar Air Quality Pty Ltd was engaged by EMKC Cubed DevCo1 Pty Ltd to perform an air quality impact assessment for the construction and operation of an industrial warehouse development to be located at 230 Martin Road, Badgerys Creek NSW.

The prediction of potential impacts associated with construction and operational phase activities has been performed in general accordance with the requirements of the NSW Environment Protection Authority *'Approved Methods for the Modelling and Assessment of Air Pollutants in* NSW' guidance document, using an approved and appropriate dispersion modelling technique. The estimation of emissions has been performed using referenced emission factors.

The construction phase assessment indicates no additional exceedances of the relevant air quality criteria are predicted to occur at surrounding land uses. Additionally, the appropriate implementation of a Trigger Action Response Plan would be expected to adequately manage construction phase emissions as to not result in adverse air quality impacts at the identified receptor locations.

The findings of the assessment indicate that the operation of the warehouse development is not predicted to result in any additional exceedance of the air quality criteria. Good site management practices such as the minimisation of vehicle idling whilst on site, would be sufficient to ensure that impacts are minimised during warehouse operation.

Emission controls associated with any manufacturing activities would be implemented, once detailed design of the facility has occurred. Given the scale and nature of the manufacturing activities proposed, it is considered that this would be easily achievable.

Whilst the site is located in close proximity to a number of industrial activities, the demonstrated low incremental impacts associated with the warehouse operation is not likely to result in adverse cumulative impacts at surrounding receptor locations.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

EMKC Cubed DevCo1 Pty Ltd (EMKC[3]) (the Applicant) has engaged Northstar Air Quality Pty Ltd (Northstar) to perform an air quality impact assessment (AQIA) for the construction and operation of an industrial warehouse development (the Proposal) to be located at 230 Martin Road, Badgerys Creek NSW (the Proposal site).

This AQIA has been undertaken to support a State Significant Development Application (SSDA) to be submitted to NSW Department of Planning, Housing and Infrastructure (DPHI). The AQIA assesses the potential risks to local air quality associated with the construction and operation of the Proposal.

The AQIA has been prepared by Martin Doyle, a suitably qualified and experienced air quality consultant and Certified Air Quality Professional (CAQP) accredited by the Clean Air Society of Australia and New Zealand (CASANZ).

1.1. Secretary Environmental Assessment Requirements

NSW Planning Secretary's Environmental Assessment Requirements (SEARs) have been provided for the Proposal (SSD-65529236) by the NSW DPHI on 21 December 2023.

Table 1 below identifies the SEARs relevant to this AQIA report, along with other regulatory comments received and the relevant sections of the report in which they have been addressed.

Table 1 Industry Specific Secretary's Environmental Assessment Requirements

Regulatory Authority	Requirement	Addressed
DPHI	An air quality impact assessment prepared in accordance with the relevant NSW Environment Protection Authority (EPA) guidelines, including:	
	- identification of significant air emission sources at the proposed development during construction and operation	Section 2.3
	- an assessment of the potential for adverse off-site air quality impacts	Section 6 and Section 7
	- details of proposed management and mitigation measures.	Section 8
Liverpool City Council	The air quality/odour assessment is to be undertaken in accordance with the NSW EPA's Approved Methods for the Modelling and Assessment of Air Pollutants (revised 2016, published 2017), Technical Framework for the Assessment and Management of Odour from Stationary sources in NSW produced by the Department of Environment and	Section 5 Section 6 Section 7

Regulatory Authority	Requirement	Addressed
	Conservation November 2006, administered by the NSW Environment Protection Authority and any subsequent documents. Detailed guidance is also provided in the Technical Notes: Assessment and Management of Odour from Stationary Sources in NSW produced by the Department of Environment and Conservation November 2006, administered by the NSW Environment Protection Authority.	
	The assessment must include modelling of the odour impact at the nearest affected receptor. Recommendations resulting from the report shall be in accordance with AS/NZS 1668.1-2015, AS 1668.2-2012 (if required) and relevant NSW EPA Guidelines.	See Section 2.3
	Note: A 'suitably qualified and experienced air quality consultant" is a person who is a Certified Air Quality Professional CAQP member administered by the Clean Air Society of Australia and New Zealand (CASANZ) or is a Certified Environmental Practitioner (CEnvP) administered by The Environment Institute of Australia and New Zealand (EIANZ).	Section 1

1.2. Update to Assessment

It is noted that a previous air quality impact assessment has previously been submitted as part of SSD-65529236 which included a risk-based assessment for the construction phase of the Proposal. With reference to the construction phase assessment the Department of Planning, Housing and Infrastructure (DPHI) provided the following comment:

> *Recent experience in the past six months of development in the Aerotropolis and Mamre Road Precinct has highlighted the risk of air quality amenity impacts during construction, given the transitioning nature of the precinct with both legacy rural-residential uses and emerging industry A new comment has been added to request a quantitative air quality impact assessment for construction impacts.*

In response to the DPHI comment, this updated AQIA includes a quantitative impact assessment associated with construction phase emissions presented in Section 6.

2. THE PROPOSAL

The following provides a description of the context, location and scale of the Proposal, and a description of the processes and development activities on site. It also identifies the potential for emissions to air associated with the operation of the Proposal.

2.1. Environmental Setting

The Proposal site is located at 230 Martin Road, Badgerys Creek in the Liverpool City Council Local Government Area (LGA). A map showing the location of the Proposal site is provided in Figure 1.

The closest residential property is located approximately 87 metres (m) to the west of the Proposal site boundary. The western part of the Proposal site and immediate area surrounding the Proposal site is zoned ENT (enterprise) under the State Environmental Planning Policy (SEPP) for Western Parkland City 2021 – Western Sydney Metropolis. The eastern portion of the Proposal site is zoned ENZ (environment and recreation) under the Western Parkland City SEPP.

2.2. Overview and Purpose

DA approval is sought for two contemporary warehouse or distribution centre buildings at the Proposal site. The overall scope of the Proposal is briefly outlined below:

- Site clearance works, including the removal of existing structures and trees;
- Bulk earthworks and the installation and augmentation of utilities infrastructure and other services;
- Construction and operational use of two warehouse or distribution centres containing ancillary offices, amenities and manufacturing use (in lot 1 only) with associated, parking, landscaping and access; and
- Other ancillary works.

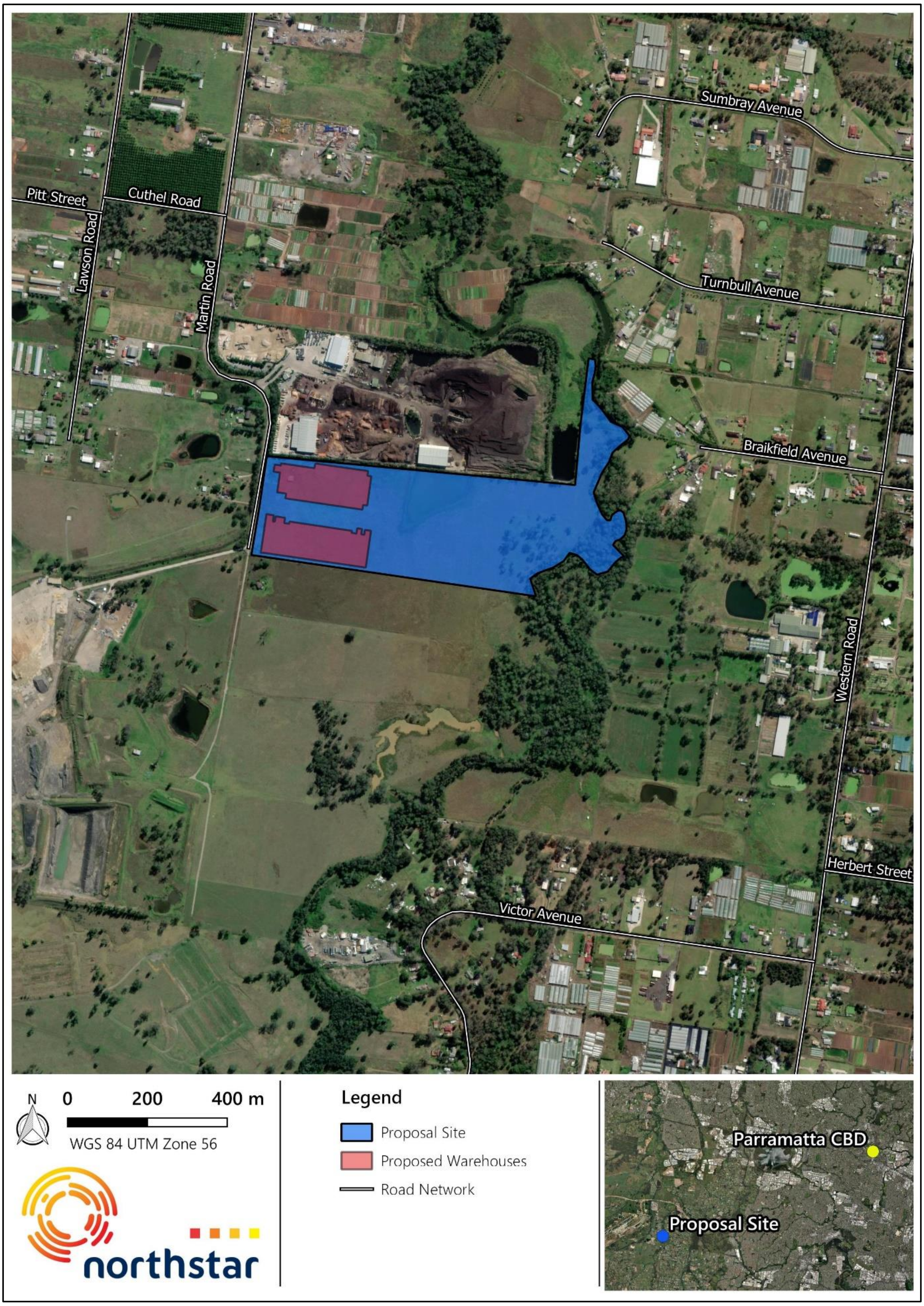
The gross floor areas (GFA) of the warehouse buildings are outlined in Table 2 and the layout of the Proposal site are provided in Figure 2.

Table 2 Warehouse gross floor areas

Warehouse	Gross floor area (m^2)
Lot 1 warehouse	17 102
Lot 2 warehouse	19 668

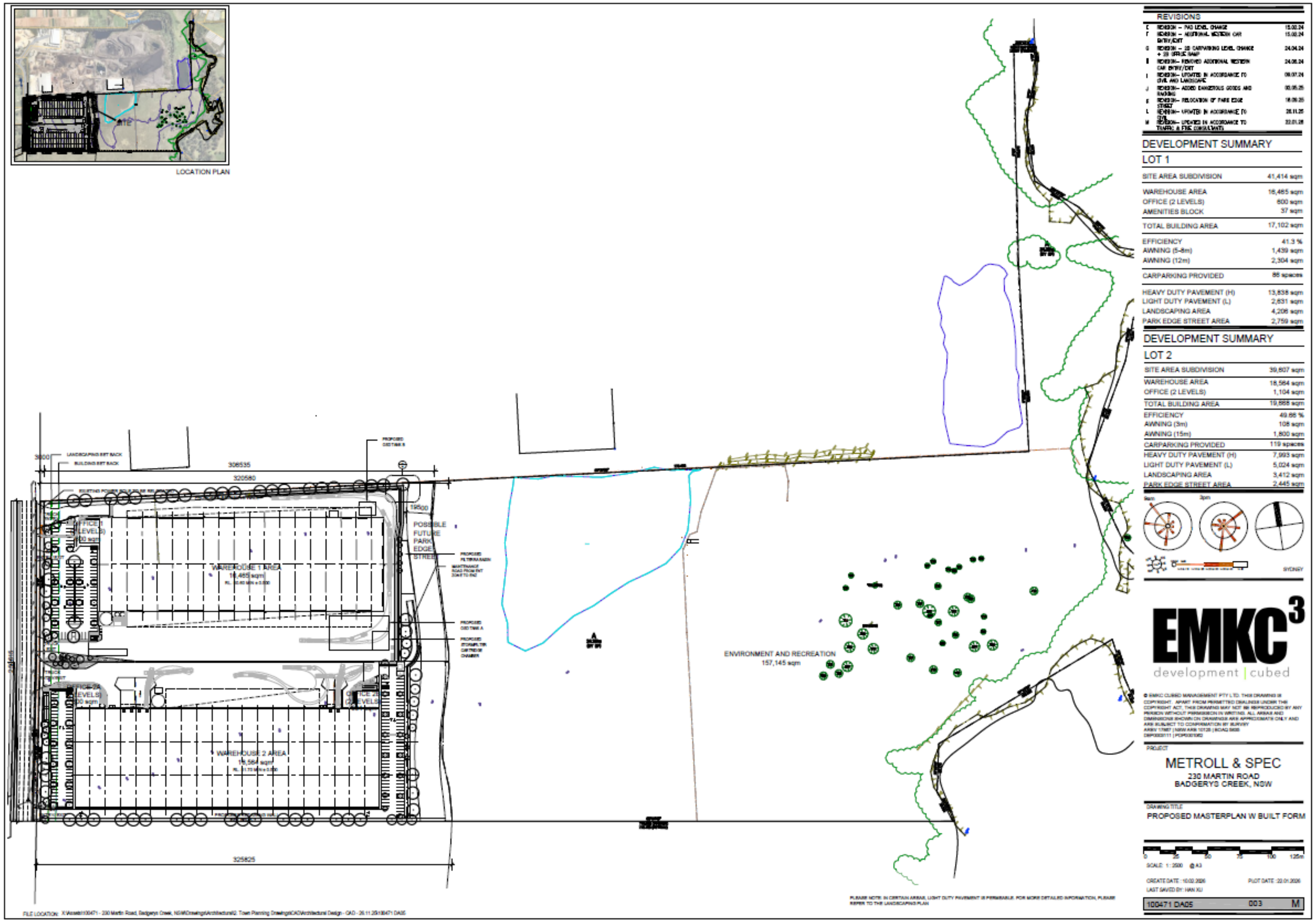
Lot 1 will be occupied by Metroll, a manufacturer and supplier of steel building products. The proposed building will be used primarily as a warehouse for storage and distribution however may contain a minor ancillary manufacturing component related to the forming, rolling and cutting of steel. No steel manufacturing is proposed to occur at the Proposal site.

Figure 1 Proposal site location



Source: Northstar

Figure 2 Proposal site layout



Source: EMKC3

2.3. Identification of Potential Emissions to Atmosphere

2.3.1. Construction

Construction of the Proposal would involve minor demolition works, bulk earthworks, construction of the two warehouses or distribution centre buildings and associated infrastructure, carparking, site access points and landscaping.

Specifically, the primary sources of emissions to air during the construction phase of the assessment would include:

- Excavation and filling of topsoil and overburden;
- Haulage of topsoil and overburden on unpaved access roads;
- Wind erosion of exposed surfaces and stockpiles; and
- Diesel fuel combustion from heavy vehicles, plant and equipment.

Each of the construction phase activities identified above would be expected to generate emissions of particulate matter (PM) as:

- Total suspended particles (TSP);
- PM_{10};
- $PM_{2.5}$; and
- Deposited dust.

Given that bulk earthworks have the highest potential for generating emissions of PM during the construction phase of the Proposal, an assessment of air quality impacts resulting from construction phase earthworks activities is presented in Section 6.

2.3.2. Operation

During the operation of the Proposal, the following activities are anticipated to have the potential to result in emissions to air:

- Movement of vehicles around the internal roadways of the Proposal site on paved road surfaces;
- Diesel and petrol combustion emissions from the consumption of fuel in trucks importing and exporting materials, and cars accessing the car park. The potential emissions would particulate matter (assessed as PM_{10} and $PM_{2.5}$) and oxides of nitrogen (NO_x), including nitrogen dioxide (NO_2). There would additionally be some less significant emissions of carbon monoxide (CO), sulphur

dioxide (SO_2) and air toxics (including benzene and 1,3-butadiene) but for the purposes of this assessment, it is comfortably assumed that the principal gaseous pollutant would be NO_x.

Experience in performing assessments of the impact of combustion-related emissions from the use of vehicles indicates that the principal indicator pollutants are particulate matter (PM_{10} and $PM_{2.5}$) and NO_2 associated with relevant short-term criteria. NO_X/NO_2 concentrations have been used within this assessment as an indicator pollutant for all other combustion-related gaseous emissions resulting from traffic.

Experience gained across a number of similar developments and review of other air quality reports for comparable developments, indicates that in relation to road traffic emissions, impacts associated with particulate matter and NO_2 are the 'limiting factor' to compliance with air quality criteria.

For clarity, SO_2 and CO would not be routinely assessed as part of an air quality study of this nature and scale as the risks are very low.

The hardstand nature of the Proposal site, and the nature of the activities being performed (warehousing and distribution, with minor ancillary manufacturing [refer Section 2.2]) would result in the Proposal site roads having a low silt loading, and correspondingly the potential for wheel generated particulate matter at the Proposal site is anticipated to be minimal and has not been subject to quantitative assessment. It is noted however that particulate emissions from brake and tyre wear, in addition to that generated through fuel combustion, have been assessed in this AQIA, associated with both truck and passenger vehicle movements.

A summary of the emission sources and potential emissions to air during the operation of the Proposal, which have been subject to assessment, is presented in Table 3.

Table 3 Identified potential sources of air emissions

Source	Particulate emissions			Gaseous emissions
	TSP	PM_{10}	$PM_{2.5}$	NO_X
Exhaust emissions and brake and tyre wear – trucks and passenger vehicles	✓	✓	✓	✓

The proposed occupant of Lot 1 (Metroll) is a leading Australian manufacturer and supplier of steel building products including roofing, cladding, rainwater, structural and fencing materials. It is anticipated that the manufacturing activities to occur at Lot 1 of the Proposal site would include the rolling, forming, and cutting of steel, rather than the manufacture of products from raw materials.

Review of separation distance guidelines (EPA VIC, 2024), (ACT Government, 2018), (EPA SA, 2016), indicates that this activity is not of significant concern and does not warrant a specific separation distance to protect the public from air quality or odour related impacts. Given that the metal forming and cutting processes would be performed within a building, this would offer a significant amount of emission control. It would also be assumed that emission controls would be included within the building to protect workers health, and this would be determined during the detailed design phase. In any case, it is not anticipated that emissions from these processes would be significant and can be easily managed through the implementation of best practice emission controls, such as those outlined in the relevant Best Practice reference documents (BREF) for the ferrous and non-ferrous metals industries[1][2].

Construction phase activities have the potential to generate short-term emissions of particulates. Generally, these are associated with uncontrolled (or 'fugitive') emissions and are typically experienced by neighbours as amenity impacts, such as dust deposition and visible dust plumes, rather than associated with health-related impacts. Localised engine-exhaust emissions from construction machinery and vehicles may also be experienced, but given the scale of the proposed works, fugitive dust emissions are likely to have the greatest potential to give rise to downwind air quality impacts.

Modelling of dust from the construction of Proposals is generally not considered appropriate, as there is a lack of reliable emission factors from construction activities upon which to make predictive assessments, and the rates would vary significantly, depending upon local conditions. However, at the request of DPHI, a quantitative assessment has been provided.

2.3.3. Odour

As presented in Table 1, Liverpool City Council have outlined the requirement for this AQIA to include a dispersion modelling assessment of odour impacts at the nearest affected receptor. However, given the nature of the development at this Proposal site, it is not anticipated that odour would be emitted in any significant quantity during either construction or operation.

For clarity, the Proposal does not include any significant odour sources to be considered within a dispersion modelling assessment and correspondingly, an assessment of odour impacts has not been performed in this AQIA.

[1] https://eippcb.jrc.ec.europa.eu/reference/ferrous-metals-processing-industry

[2] https://eippcb.jrc.ec.europa.eu/reference/non-ferrous-metals-industries-0

3. LEGISLATION, REGULATION AND GUIDANCE

The following outlines the legislation and air quality criteria which are applicable to the activities being performed at the Proposal site.

3.1. NSW Government Air Quality Planning

NSW EPA has formed a comprehensive strategy with the objective of driving improvements in air quality across the State. This comprises several drivers, including:

- **Legislation**: formed principally through the implementation of the *Protection of the Environment Operations Act* 1997, and the Protection of the Environment Operations (Clean Air) Regulation 2022. The overall objective of the legislative instruments is to achieve the requirements of the National Environment Protection (Ambient Air Quality) Measure;
- **Clean Air for NSW**: The 10-year plan for the improvement in air quality;
- **Inter-agency Taskforce on Air Quality in NSW**: a vehicle to co-ordinate cross-government incentives and action on air quality;
- **Managing Particles and Improving Air Quality in NSW**; and
- **Diesel and Marine Emission Management Strategy**.

In regard to the relevance of the NSW Government's drive to improve air quality across the State and this AQIA, it is imperative that this Proposal demonstrates leadership in the development of the NSW economy (in terms of activity and employment) and concomitantly not cause detriment in achieving its objectives.

3.2. Ambient Air Quality Standards

State air quality guidelines adopted by the NSW EPA are published in the '*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*' (the Approved Methods (NSW EPA, 2022)), which has been consulted during the preparation of this AQIA.

The Approved Methods lists the statutory methods that are to be used to model and assess emissions of criteria air pollutants from stationary sources in NSW. Section 7.1 of the Approved Methods clearly outlines the impact assessment criteria to be applied.

The criteria listed in the Approved Methods (NSW EPA, 2022) are derived from a range of sources (including National Health and Medical Research Council [NHMRC], National Environment Protection Council [NEPC], and World Health Organisation [WHO]).

The criteria specified in the Approved Methods are the defining ambient air quality criteria for NSW. The standards adopted to protect members of the community from health impacts in NSW for pollutants relevant to the Proposal are presented in Table 4.

Table 4 NSW EPA impact assessment criteria for air pollutants

Air Pollutant	Averaging period	Units	Criterion	Notes
Nitrogen dioxide (NO_2)	1 hour	$\mu g{\cdot}m^{-3}$ [a]	164	Numerically equivalent to the AAQ NEPM[b] standards and goals.
	Annual	$\mu g{\cdot}m^{-3}$ [a]	31	
Particulates (as PM_{10})	24 hours	$\mu g{\cdot}m^{-3}$ [a]	50	
	1 year	$\mu g{\cdot}m^{-3}$ [a]	25	
Particulates (as $PM_{2.5}$)	24 hours	$\mu g{\cdot}m^{-3}$ [a]	25	
	1 year	$\mu g{\cdot}m^{-3}$ [a]	8	
Particulates (as TSP)	1 year	$\mu g{\cdot}m^{-3}$ [a]	90	

Notes: (a) micrograms per cubic metre of air

(b) National Environment Protection (Ambient Air Quality) Measures

4. EXISTING CONDITIONS

4.1. Surrounding Land Sensitivity

4.1.1. Discrete Receptor Locations

Air quality assessments typically use a desk-top mapping study to identify 'discrete receptor locations', which are intended to represent a selection of locations that may be susceptible to changes in air quality. In broad terms, the identification of sensitive receptors refers to places at which humans may be present for a period representative of the averaging period for the pollutant being assessed. Typically, these locations are identified as residential properties, although other sensitive land uses may include schools, medical centres, places of employment, recreational areas, or ecologically sensitive locations.

It is noted that in addition to the identified 'discrete' receptor locations, the entire modelling area is gridded with 'uniform' receptor locations (see Section 4.1.2) that are used to plot out the predicted impacts, and as such the accidental non-inclusion of a location sensitive to changes in air quality does not render the AQIA invalid, or otherwise incapable of assessing those potential risks.

To ensure that the selection of discrete receptors for the AQIA are reflective of the locations in which the population of the area surrounding the Proposal site reside, population density data has been examined. Population density data based on the 2021 census have been obtained from the Australian Bureau of Statistics (ABS) for a 1 square kilometre (km^2) grid, covering mainland Australia (ABS, 2022). Using a Geographical Information System (GIS), the locations of sensitive receptor locations have been confirmed with reference to their population densities.

For clarity, the ABS use the following categories to analyse population density (persons·km^{-2}):

- Very high >8,000
- High >5,000
- Medium >2,000
- Low >500
- Very low <500
- No population 0

Using ABS data in a GIS, the population density of the area surrounding the Proposal site is presented in Figure 3. The Proposal site is located in an area of very low population densities (<500 persons·km^{-2}).

Identified receptors adopted for use within this AQIA are presented in Table 5.

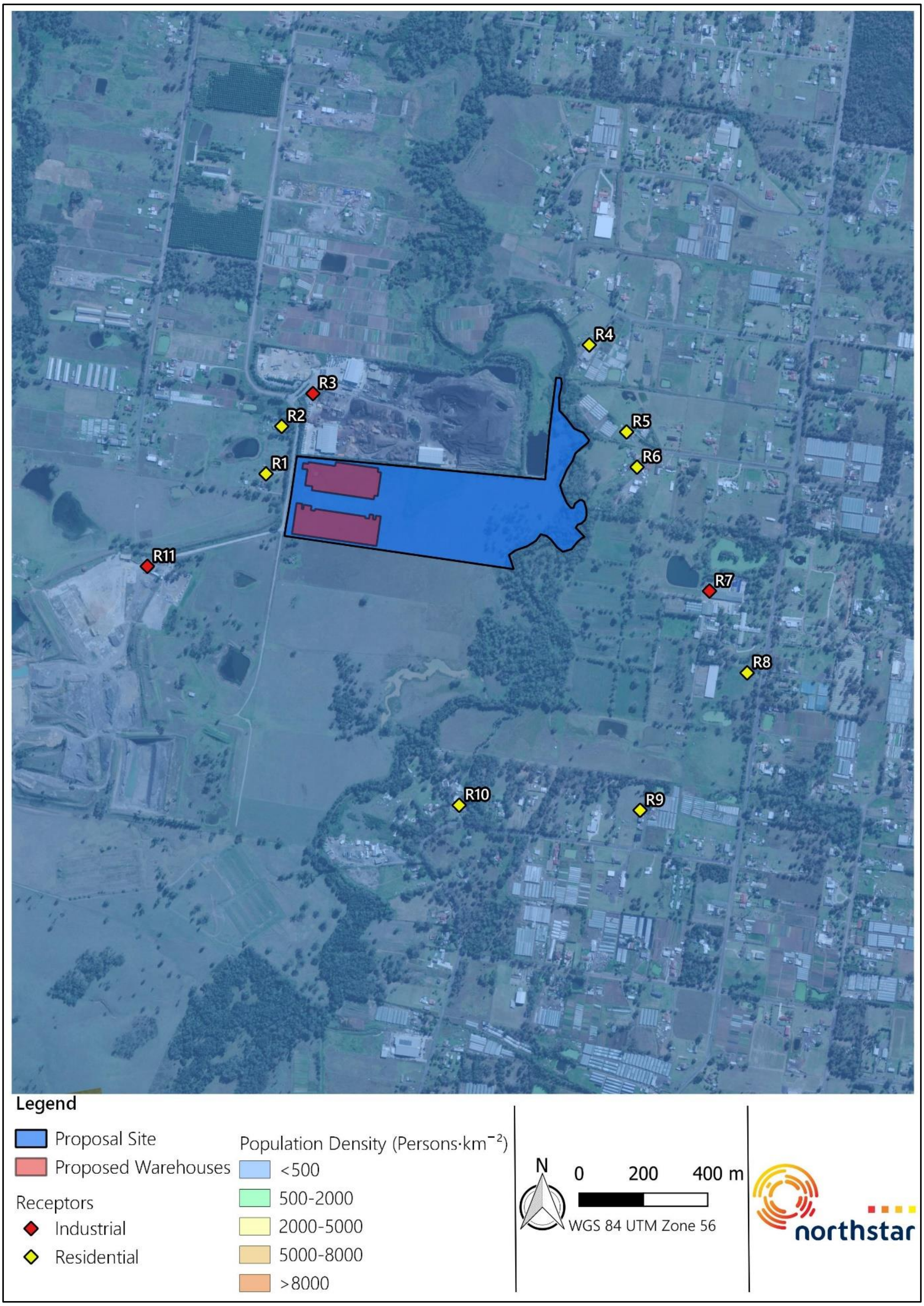
Table 5 Receptor locations used in the AQIA

ID	Location	Land use	Coordinates (UTM)	
			mE	mS
R1	Martin Road, Badgerys Creek	Residential	292 969	6 247 571
R2	Martin Road, Badgerys Creek	Residential	293 018	6 247 719
R3	Martin Road, Badgerys Creek	Industrial	293 116	6 247 821
R4	Turnbull Avenue, Kemps Creek	Residential	293 975	6 247 972
R5	Braikfield Avenue, Kemps Creek	Residential	294 091	6 247 702
R6	Braikfield Avenue, Kemps Creek	Residential	294 124	6 247 592
R7	Western Avenue, Kemps Creek	Industrial	294 349	6 247 207
R8	Western Avenue, Kemps Creek	Residential	294 466	6 246 953
R9	Victor Avenue, Kemps Creek	Residential	294 133	6 246 525
R10	Victor Avenue, Kemps Creek	Residential	293 570	6 246 541
R11	Martin Road, Bradfield	Industrial	292 600	6 247 284

4.1.2. Uniform Receptor Locations

Additional to the sensitive receptors identified in Section 4.1.1, a grid of uniform receptor locations has been used in the AQIA to allow presentation of contour plots of predicted impacts.

Figure 3 Receptor locations



Source: Northstar

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 meteorological conditions surrounding the Proposal site have been characterised using data collected by the Australian Government Bureau of Meteorology (BoM) at a number of surrounding automatic weather stations (AWS).

Two meteorological stations operated by BoM were identified proximate to the Proposal site. A summary of the relevant AWS is provided in Table 6 below (listed by proximity).

Table 6 Details of meteorological monitoring surrounding the Proposal site

Site name	Source	Approximate location		Approximate distance
		mE	mS	km
Badgerys Creek AWS – station #067108	BoM	289 920	6 246 951	3.1
Horsley Park Equestrian Centre AWS – station #067119	BoM	301 708	6 252 298	9

Data from Badgerys Creek AWS for the period 2018-2022 have been analysed for use in this study. The wind roses presented in Appendix B indicate that from 2018 to 2022, winds at Badgerys Creek AWS show generally similar wind distribution patterns across the years assessed, with predominant south-westerly wind directions with north-easterly components also evident.

The majority of wind speeds experienced at the Badgerys Creek AWS between 2018 and 2022 are generally in the range 1.5 meters 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 mostly westerly directions. Winds of this speed are rare and occur during 1.7 % of the observed hours during the years while calm winds (< 0.5 $m{\cdot}s^{-1}$) occur during 9.4 % of hours on average across the years 2018-2022.

An analysis of the correlation coefficients between each year for wind speed, wind direction and particulate matter data distribution was performed to select a representative year for the meteorological modelling (refer Appendix B). Following this analysis, the year 2021 was selected as the most representative year for further assessment.

To provide a characterisation of the meteorology which would be expected at the Proposal site, a meteorological modelling exercise has also been performed. A summary of the inputs and outputs of the meteorological modelling assessment, including validation of those outputs is presented in Appendix B.

4.3. Background Air Quality

The air quality experienced at any location will be a result of emissions generated by natural and anthropogenic sources on a variety of scales (local, regional and global). The relative contributions of sources at each of these scales to the air quality at a location, will vary based on a wide number of factors including the type, location, proximity and strength of the emission source(s), prevailing meteorology, land uses and other factors affecting the emission, dispersion and fate of those pollutants.

When assessing the impact of any particular source of emissions on the potential air quality at a location, the impact of all other sources of an individual pollutant should also be assessed. These 'background' (sometimes called 'baseline') air quality conditions will vary depending on the pollutants to be assessed and can often be characterised by using representative air quality monitoring data.

Two AQMS have been identified proximate to the Proposal site, operated by NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW). These locations (listed by proximity) are briefly summarised in Table 7.

Table 7 Closest AQMS to the Proposal site

AQMS location	Distance to site (km)	2021 data	Measurements			
			PM_{10}	$PM_{2.5}$	TSP	NO_2
Bringelly	2.9	✓	✓	✓	×	✓
St Marys	10.3	✓	✓	✓	×	✓

The closest representative AQMS with data available for the year 2021 (consistent with the meteorological modelling) is noted to be located at Bringelly. Correspondingly, data from Bringelly for the year 2021 have been adopted for use in this assessment.

Appendix C provides a detailed assessment of the background air quality monitoring data used in this AQIA.

It is noted that neither of the AQMS identified in Table 7 measure concentrations of TSP. This pollutant is of relevance to the expected emissions from the Proposal. Other sources of data have been adopted to allow representation of the TSP environment in the area surrounding the Proposal site, and a full discussion is provided in Appendix C.

Bringelly AQMS recorded three days where particulate matter concentrations were above the national standard in 2021. This was primarily driven by extensive hazard reduction burning performed in the Greater Sydney region (NSW DPE, 2023). A summary of the particulate matter exceedances monitored at Bringelly AQMS in 2021 as outlined in the New South Wales Annual Compliance Report 2021 (NSW DPE, 2023) is provided in Table 8.

Table 8 Summary of PM exceedances, Bringelly AQMS 2021

Date	PM_{10} concentration ($\mu g \cdot m^{-3}$)	$PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$)	Event classification
27 April 2021	69.0	57.4	Exceptional event – hazard reduction burning
3 May 2021	39.9	25.7	Exceptional event – hazard reduction burning
4 May 2021	30.5	27.3	Exceptional event – hazard reduction burning

A summary of the air quality monitoring data and assumptions adopted within this AQIA are presented in Table 9.

Table 9 Summary of background air quality used in the AQIA

Pollutant	Averaging period	Units	Measured value	Notes
Particles (as TSP)	Annual	µg·m^{-3}	31.4	Estimated on a TSP:PM_{10} ratio of 2.0551: 1
Particles (as PM_{10})	24-hour	µg·m^{-3}	Daily varying	The 24-hour maximum PM_{10} concentration in 2021 was 69.0 µg·m^{-3}
	Annual	µg·m^{-3}	15.3	
Particles (as $PM_{2.5}$)	24-hour	µg·m^{-3}	Daily varying	The 24-hour maximum $PM_{2.5}$ concentration in 2021 was 57.4 µg·m^{-3}
	Annual	µg·m^{-3}	7.2	
Nitrogen dioxide (NO_2)	1-hour	µg·m^{-3}	49.2	Hourly maximum 1-hr average in 2021
	Annual	µg·m^{-3}	7.1	Annual average in 2021

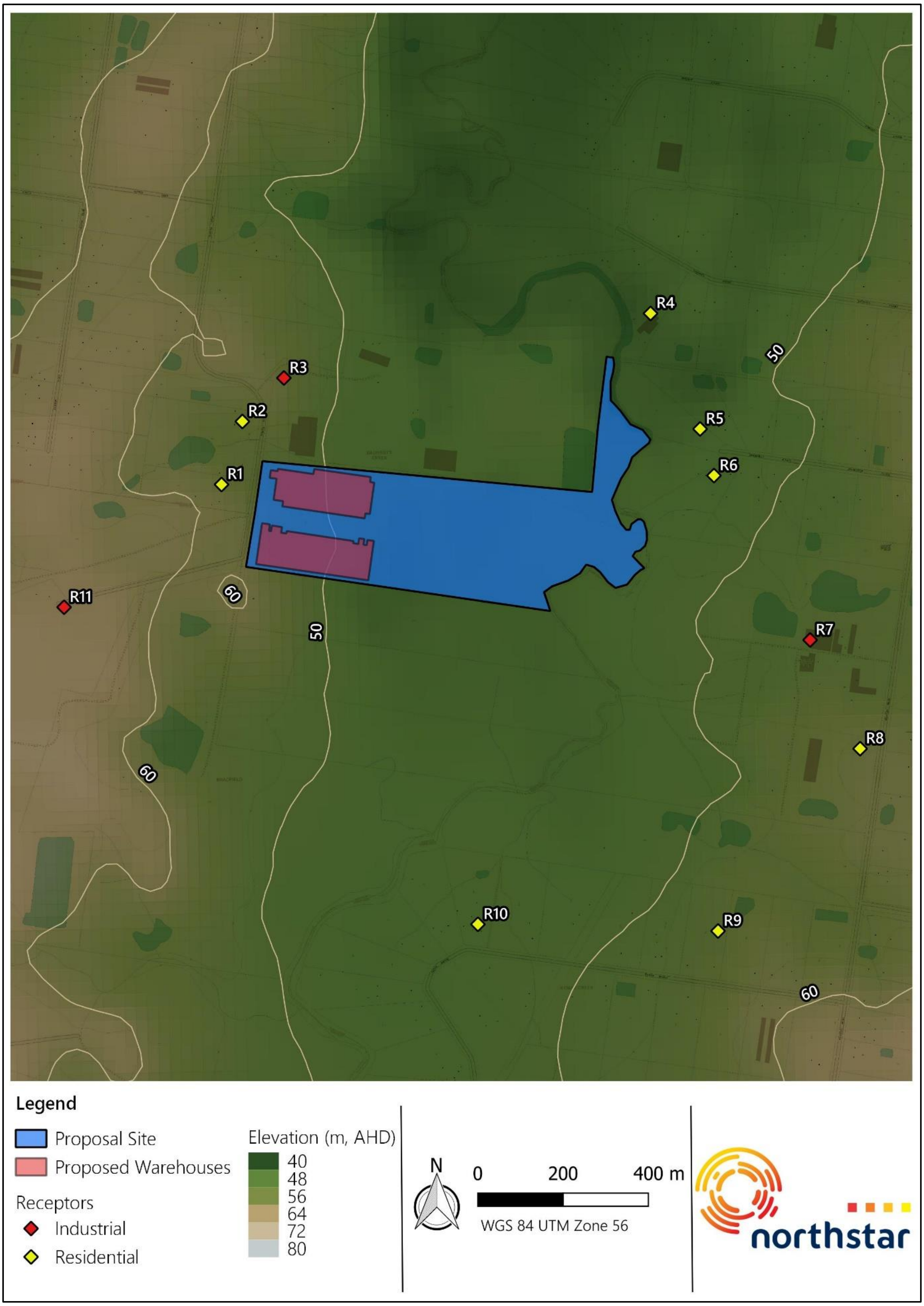
Note: Reference should be made to Appendix C

4.4. Topography

The Proposal site is located within an area which has a relatively flat surface terrain with little height variation. The elevation of the Proposal site is approximately 50 m Australian Height Datum (AHD). The topography between the Proposal site and the nearest identified sensitive receptor locations is relatively consistent with elevation variances of less than 10 m within the immediate locality. In dispersion modelling terms, the topography is relatively uncomplicated, and does not need to be explicitly accounted for in the dispersion modelling exercise.

The topography surrounding the Proposal site is presented in Figure 4.

Figure 4 Local topography surrounding Proposal site



Source: Northstar

4.5. Sources Proximate to the Proposal Site

Given the industrial and agricultural nature of the area surrounding the Proposal site, there is the potential for emissions generated as part of the Proposal and other surrounding facilities to impact cumulatively on nearby sensitive receptors. Additionally, there is potential for surrounding sources to result in adverse air quality impacts being experienced at the Proposal site.

A desktop survey identified a number of facilities proximate to the Proposal site as summarised in Table 10.

Table 10 Identified proximate facilities

Facility	Activities performed	Location	Distance to Proposal site
Existing Development			
Australian Native Landscapes	- Stockpile management - Composting - Vehicle movements	210 Martin Road, Badgerys Creek	Immediately north of the Proposal site
Boral Quarry and Brickworks	- Extraction activities - Brick manufacturing - Stockpile management - Vehicle movements	235 Martin Road, Bradfield	400 m to the southwest of the Proposal site
Approved Development			
Western Sydney International (WSI) Airport. Construction is currently ongoing, with the airport anticipated to open in 2026.	- Aircraft movements - Vehicle movements - Ancillary activities	Badgerys Creek	2 km to west of Proposal site
Elizabeth Drive upgrades. The upgraded road will provide two lanes in each direction together with a median island, landscaping and paths. The proposed upgrades relate to 11.4 km of road.	- Road construction - Vehicle movements	Elizabeth Drive, Badgerys Creek	1.9 km to north of Proposal site
SSI-9364 - M12 Motorway - A new dual-carriageway motorway to connect the M7 Motorway with the WSI Airport and The Northern Road.	- Road construction - Vehicle movements	Kemps Creek, Badgerys Creek	Between 2.5 km and 3.5 km northwest to northeast from the Proposal site
SSI-10051 - A new metro line to service WSI Airport, the Western Sydney	- Construction	Six new stations will be constructed at St Marys, Orchard Hills,	Various (nearest station at the WSI, over 2 km to the west of the Proposal site)

Facility	Activities performed	Location	Distance to Proposal site
Aerotropolis and interchanging with the T1 Western Line at St Marys.		Luddenham, Bradfield, and with the airport site (the airport terminal and airport business park)	
SSD-25452459 - First Building, Bradfield City Centre	- Robotics - Nanotechnology - Additive manufacturing	215 Badgerys Creek Road, Bringelly	4.2 km southwest of Proposal site
Likely Future Development			
Boral Badgerys Creek Industrial Area (Proposed)	- Concrete batching activities - Stockpile management - Waste management - Vehicle movements	225 Martin Road, Bradfield	Immediately south of the Proposal site
DA-723/2022 - Development Application	- Construction - Warehousing	50 Martin Road, Badgerys Creek	1.4 km north of Proposal site
WSA_MP01 – Ingham Property Group have prepared a masterplan for this 182-hectare site.	- Construction - Warehousing - Residential - Local centre	475 Badgerys Creek Road, Bradfield	Approximately 2 km to 3 km to the southwest of the Proposal site
WSA_MP02 – the Western Parkland City Authority have prepared a masterplan for Bradfield City Centre.	- Various (masterplan)	215 Badgerys Creek Road	4 km southwest of the Proposal site
WSA_MP03 - Greenfields Development Company are preparing a masterplan for this site for industrial and agribusiness purposes.	- Various (masterplan)	1675 The Northern Road, Greendale	5.9 km southwest of the Proposal site
SSD-48438209 – Altis Warehousing Estate – Construction and operation of a warehouse and distribution centre.	- Construction - Warehousing	2289-2309, 2311 Elizabeth Drive, Luddenham	6.5 km northwest of the Proposal site
SSD-58591961 – Building 2 Advanced Manufacturing Research Facility	- Construction - Robotics - Nanotechnology - Additive manufacturing	Bradfield City Centre	Approximately 4 km southwest of Proposal site
SSD-65490715 - Construction of the Central Park including	- Construction	Bradfield City Centre	Approximately 4 km southwest of Proposal site

Facility	Activities performed	Location	Distance to Proposal site
associated structures and landscaping works.			

The large majority of the facilities identified in Table 10 are located over 1.5 km from the Proposal site and surrounding receptors, and given the activities to be performed, the potential for cumulative impacts with the Proposal is considered to be minimal.

Of those activities located within 1.5 km of the Proposal site (Australian Native Landscapes [ANL], Boral Badgerys Creek Industrial Area, Boral Brickworks and Quarry, DA-723/2022), it is noted that publicly available documents regarding air quality assessment performed specifically for these facilities could not be found. However, an air quality assessment for the Western Sydney Aerotropolis (WSA) development performed by Northstar in December 2021 (Northstar Air Quality, 2021) included an assessment of potential emissions from ANL in conjunction with a number of additional waste management and agricultural sources within the WSA study area.

The findings of the WSA study have been adopted to comment on the potential for dust and odour emissions generated from ANL to result in adverse impacts at the Proposal site. It is noted that given that information regarding activity rates for ANL are not publicly available, the emissions from ANL in (Northstar Air Quality, 2021) were estimated based on a number of assumptions based on throughputs outlined in the relevant Environment Protection License (EPL)[3]. Correspondingly, the findings of the WSA study cannot be used to determine realistic short-term impacts of dust and odour at the Proposal site or estimate the potential cumulative impacts at nearby sensitive receptors. Additionally, given the abovementioned limitations, the WSA study adopted a qualitative risk assessment approach to identify areas with potential to experience adverse air quality (including odour) impacts.

Application of the study findings indicates that the Proposal site is located in an area of medium and high risks of adverse air quality and odour impacts. For clarity, this is an estimation not based on accurate activity rates performed at ANL and is not representative of pollutant concentrations that may be predicted at the Proposal site.

It is noted that the most recently updated land zoning map[4] for the WSA provided by NSW DPHI indicates that the western part of the Proposal site and ANL are located in areas zoned as Enterprise (ENT). Review of publicly available documentation regarding the development planning of the WSA states that "landscape materials supplies" activities are permitted with consent within Enterprise land use zones (NSW DPIE, 2019).

[3] https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=138341&SYSUID=1&LICID=4625

[4] https://eplanningdlprod.blob.core.windows.net/pdfmaps/SEPP_WSA_LZN_001_060_20200901.pdf

Correspondingly, the operational activities currently performed at ANL may be permitted under future land uses within the WSA study area.

The WSA study provided a number of recommendations for the Western Sydney Planning Partnership to manage the potential air quality and odour impacts within the study area as planning for the WSA progresses including:

- Eliminating sources by source removal or reprovision of land;
- Source substitution to relocate sources or sensitive land uses;
- Implementation of engineered controls at sources;
- Administrative measures through regulatory controls; and
- Implementation of controls at receptor locations.

The identified facilities within 1.5 km of the Proposal site are located in proximity to the receptors identified in Section 4.1.1, and would therefore be required to adopt a range of management practices to mitigate any potential impacts on those industrial and residential facilities. It is likely that those management measures would be sufficient to ensure that a suitable level of amenity is also achieved at the Proposal site, noting that a higher level of amenity would be anticipated at residential locations (further away from the Proposal site), when compared to that expected at the Proposal site. Those controls should ensure that an appropriate level of amenity is achieved at the Proposal site.

It is further noted that the existing facilities identified within 1.5 km of the Proposal site in Table 10 were developed prior to the assessment of the WSA. Additionally, the WSA and associated land use zones were approved by the NSW DPHI with the understanding that those facilities would remain operational during the establishment of the WSA. Furthermore, those facilities would have been approved with consideration of their contribution to the local air quality environment.

5. APPROACH TO ASSESSMENT

5.1. Construction Phase

5.1.1. Emissions Estimation

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. This assessment has adopted emission factors contained within the US EPA AP-42 emission factor compendium (US EPA, 1995 and updates) and the *National Pollutant Inventory Emission Estimation Technique Manual for Mining Version 3.1* (NPI, 2012) to represent the emission of particulate matter resulting from the construction phase earthworks activities occurring at the site. These factors are appropriate for adoption in Australia and are routinely adopted in the assessment of operations of this nature.

Given that earthworks are expected to have the most significant potential for emissions to air during the construction phase of the Proposal, the assessment has been performed to characterise the bulk earthworks activities being undertaken to assess against longer term (annual average) and shorter term (24-hour) criteria for particulate matter.

A summary of the earthworks activities occurring at the site is provided in Table 10.

The expected construction phase sources associated with earthworks considered for the dispersion modelling assessment are as follows:

- Topsoil scraping;
- Excavation associated with cutting works;
- Materials handling (loading / unloading);
- Grading;
- Materials haulage (topsoil export and fill import); and
- Wind erosion.

Table 11 Summary of earthworks activities

Parameter	Units	Value
Earthworks volumes		
Topsoil strip	t	22 153 [a]
Cut material	t	60 631 [a]
Fill material	t	136 056 [a]
Imported fill material	t	75 425 [a]
Construction hours		
	Monday – Friday	7:00 am to 6:00 pm
	Saturday	8:00 am to 1:00 pm
	Sunday	Closed
	Total bulk earthworks period	6 months

Notes: (a) Assumed density = 1 370 kg·m^{-3}

With reference to the volumes outlined in Table 11, estimated emissions of volume sources occurring have been combined, and subsequently divided by the area of expected earthworks activities.

A full description of the emission sources included in the construction phase assessment, and the emission factors adopted are presented in Appendix D.

5.1.2. Emissions Controls

Emission controls are anticipated to be employed during the bulk earthworks phase of the Proposal. The application of these controls results in quantifiable reductions in the quantity of particulate matter being emitted as part of the Proposal operation.

A summary of the emission reduction measures that would be expected as part of the Proposal construction is presented in Table 12. These emission reductions are reflected in the *National Pollution Inventory Emission Estimation Technique Manual for Mining, Version 3.1* (NPI, 2012).

It is noted that although the control methods outlined in Table 12 have been adopted as part of the assessment to examine potential air quality impacts from bulk earthworks activities, it is anticipated that those methods would be applied during all stages of construction, where appropriate.

Additionally, an average <u>active</u> disturbance area of 50 % of the Proposal site has been assumed to approximate emissions of wind erosion during the bulk earthworks period. For clarity, the erosion potential of an exposed area significantly decreases during periods when those areas are undisturbed and comparatively, each time a disturbance event occurs, the erosion potential is restored. For example, the potential for wind erosion increases considerably following a vehicle haulage event on an unpaved surface, given that the surface materials have been disturbed. For the purposes of this report, it is assumed that approximately half of the Proposal site may be subject to active disturbances at any one time and correspondingly, the potential for wind erosion at other areas would be significantly lower.

Table 12 Summary of emission control methods adopted as part of the construction phase

Emission control method	Control efficiency (%)	Activities control method applied to	Reference
Water sprays keeping materials damp	50	• Scraping • Excavation • Grading	(NPI, 2012)
Water carts keeping haulage route surface damp (level 2 watering)	75	• Material haulage	(NPI, 2012)
Water sprays	50	• Loading/unloading	(NPI, 2012)
Minimise drop heights	30	• Loading/unloading	(NPI, 2012)
Vehicle speed limits of 15 $km{\cdot}h^{-1}$	85	• Material haulage	(NPI, 2012)
Assumed 50% average active disturbance area	50	• Wind erosion	-

5.1.3. Atmospheric Dispersion Model

A dispersion modelling assessment has been performed using the NSW EPA approved CALPUFF atmospheric dispersion model. The modelling has been performed in CALPUFF 2-dimensional (2-D) mode. Given the uncomplex terrain (refer Section 4.4) and (importantly) the proximity of the receptors to the site, a detailed assessment using a 3-D meteorological dataset is not warranted.

The modelling scenarios provide an indication of the air quality impacts associated with the construction phase of the Proposal. Added to these impacts are background air quality concentrations (where available and discussed in Section 4.3 and Appendix C) which represent the air quality which may be expected within the area surrounding the site, without the impacts of the Proposal itself.

5.2. Operation Phase

The air emissions assessment for the operational phase of the Proposal has utilised quantitative dispersion modelling techniques. This section outlines the approach taken in the AQIA for the operational phase of the Proposal.

5.2.1. Emission Estimation

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* (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[5].

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.

It is noted that for the purposes of this study, the fleet composition at the Proposal site has been disaggregated by light vehicles (cars) and heavy vehicles (rigid). Appropriate emission factors for the differing vehicles at the Proposal site have been adopted from NSW EPA GMR Emission Inventory On-Road emission assessment and COPERT4. Impacts from diesel and petrol-fuelled vehicles have also been considered following a review of the Motor Vehicle Census of Australia to estimate the distribution of diesel and petrol vehicles from the traffic generation resulting from the Proposal.

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.

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, the roads at the Proposal site have been assessed as being typified as a "local / residential" road (to represent conditions within the Proposal site):

> *Secondary roads with prime purpose of access to property. Characterised by low congestion and low levels of heavy vehicles. Generally one lane each way, undivided with speed limits of 50 $km{\cdot}h^{-1}$ maximum. Regular intersections, mostly unsignalised, low intersection delays.*

Traffic data for the Proposal has been provided by the Applicant. Traffic generation rates for the Proposal have been estimated for AM and PM peak hours as presented in Table 13. It is noted that the estimated AM and PM peak traffic data are equal to each other.

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

The daily total traffic generation has been provided by the Applicant and indicates that an average of 4 vehicle trips per 100 m^2 of GFA per day would be likely to be generated by this development. The total estimated daily vehicle movements associated with the Proposal is 1 471 vehicle movements, given the size of the development as outlined in Section 2.2. Note that the peak hour traffic data has been adopted for the assessment against short-term (1-hour) air quality criteria, with the daily total used to assess against longer term (24-hour and annual) criteria.

Additionally, it has been assumed that 27.5 % of vehicles would be commercial (heavy) vehicles for developments of this nature and correspondingly, this rate has been adopted to determine the split between light and heavy vehicles for the Proposal.

A summary of the adopted traffic generation for the Proposal is presented in Table 13.

Table 13 Adopted traffic data for this AQIA

Vehicle	AM peak (vehicles·hr^{-1})	PM peak (vehicles·hr^{-1})	Daily total (vehicles·day^{-1})
Light	133	133	1 066
Heavy	51	51	404
Total	184	184	1 471

In relation to emissions associated with idling trucks at the Proposal site, trucks are assumed to be idling at all docking locations at all times, which is considered to be conservative. In reality, given the layout of the Proposal site, the likelihood of trucks idling at all docks at all times is considered low.

Emission factors associated with idling trucks have been sourced from (USEPA, 2008). A summary of data used in the calculation of vehicle flows and emissions is presented in Table 14.

Table 14 Data used in the calculation of vehicle flows and emissions

Parameter	Source	Comments
Peak hour traffic flows	Refer Table 13	Peak AM and PM are equal to each other
Daily total traffic flows	Refer Table 13	Daily traffic generation rate provided by the Applicant.
Vehicle types	Refer Table 13	Traffic data split by cars (light) and rigid (heavy) vehicles.
Fuel types	ABS Motor Vehicle Census, 2020	Diesel and petrol fuel split for car, light commercial, light rigid, heavy rigid, articulated vehicles (most recent data available, not available by State or Territory)
Emissions	NSW EPA GMR Emissions Inventory 2008	NO_X, PM_{10} exhaust emissions, $PM_{2.5}$ from exhaust emission calculated to be 71.4% of PM_{10} PM_{10}, $PM_{2.5}$ brake and tyre wear emissions calculated for local/residential roads

5.2.2. Atmospheric 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 commonly 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, 2015b) used the GRAL model to predict operational impacts on ambient air quality and it is the preferred model of Traffic for NSW (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.

5.2.3. NO_X to NO_2 Conversion

Emissions of NO_X have been calculated, with subsequent ground-level concentrations predicted using dispersion modelling techniques. Given that NO_X is a mixture of NO_2 and nitric oxide (NO), conversion of NO_X predictions to NO_2 concentrations may be performed. Approximately 90 % - 95 % of NO_X from a combustion process will be emitted as NO, with the remaining 5 % - 10 % emitted directly as NO_2. Over time and after the point of discharge, NO in ambient air will be transformed by secondary atmospheric reactions to form NO_2, and this reaction often occurs at a considerable distance downwind from the point of emission, and by which time the plume will have dispersed and diluted significantly from the concentration at point of discharge.

Air quality impact assessments need to account for the conversion of NO to NO_2 to enable a comparison against the air quality criterion for NO_2. To perform this, various techniques are common, which are briefly outlined below:

- **100 % conversion**: the most conservative assumption is to assume that 100 % of the total NO_X emitted is discharged as NO_2, and that further reactions do not occur.
- **Jansen method**: where the location is represented by good monitoring data for NO and NO_X, the empirical relationship between NO and NO_2 may be used to derive 'steady state' relationships.
- **Ozone limiting method**: this method uses contemporaneous ozone data to estimate that rate at which NO is oxidised to NO_2 hour-on-hour using an established relationship.

This AQIA has used the 100 % conversion method to approximate the conversion of NO_X to NO_2, in accordance with the methodology described in (NSW EPA, 2022).

6. CONSTRUCTION AIR QUALITY IMPACT ASSESSMENT

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

- **Incremental impact** – relates to the concentrations predicted due to the operation of the Proposal in isolation; and,
- **Cumulative impact** – relates to the incremental concentrations predicted due to the operation of the Proposal PLUS background air quality concentrations discussed in Section 4.3.

The results are presented in this manner to allow examination of the likely impact of the Proposal in isolation and the contribution to air quality impacts in a broader sense.

In the presentation of results, the tables included shaded cells which represent the following:

Model prediction	Pollutant concentration / deposition rate less than the relevant criterion	Pollutant concentration / deposition rate equal to, or greater than the relevant criterion

6.1. Annual Average TSP, PM_{10} and $PM_{2.5}$ Concentrations

The predicted annual average particulate matter concentrations (as TSP, PM_{10} and $PM_{2.5}$) resulting from construction phase activities performed at the site are presented in Table 15.

The predictions presented in Table 15 take into account that the earthworks phase of construction is anticipated to take 6 months.

Including existing conditions, cumulative impacts are expected to be below the annual average criteria at all identified receptors.

Table 15 Predicted annual average TSP, PM_{10} and $PM_{2.5}$ concentrations – construction phase

Receptor	Annual average concentration (µg·m^{-3})								
	TSP			PM_{10}			$PM_{2.5}$		
	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.
Criterion	90			25			8		
Max. % of criterion	1.2	34.9	36.2	2.9	61.2	64.1	<0.1	90.0	90.6
R1	1.1	31.4	32.5	0.7	15.3	16.0	<0.1	7.2	7.3
R2	0.8	31.4	32.2	0.5	15.3	15.8	<0.1	7.2	7.3
R3	0.6	31.4	32.0	0.4	15.3	15.7	<0.1	7.2	7.3
R4	0.2	31.4	31.7	0.2	15.3	15.5	<0.1	7.2	7.3
R5	0.1	31.4	31.6	0.1	15.3	15.4	<0.1	7.2	7.3
R6	0.1	31.4	31.6	<0.1	15.3	15.4	<0.1	7.2	7.3
R7	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3

Receptor	Annual average concentration ($\mu g \cdot m^{-3}$)								
	TSP			PM_{10}			$PM_{2.5}$		
	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.
R8	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R9	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R10	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R11	0.2	31.4	31.7	0.2	15.3	15.5	<0.1	7.2	7.3

Note: Incr = Incremental impact, Bkg = Background, Cumul = Cumulative Impact

6.2. Annual Average Dust Deposition Rates

Table 16 presents the predicted annual average dust deposition rates due to construction phase activities being performed as part of the Proposal.

The predictions presented in Table 16 take into account that the earthworks phase of construction is anticipated to take 6 months.

The results indicate compliance with the relevant criterion at all surrounding receptor locations.

Table 16 Predicted annual average dust deposition – construction phase

Receptor	Annual average dust deposition ($g \cdot m^{-2} \cdot month^{-1}$)		
	Incr.	Bkg.	Cumul.
Criterion	2	-	4
Max. % of criterion	<0.1	-	52.5
R1	<0.1	2.0	<2.1
R2	<0.1	2.0	<2.1
R3	<0.1	2.0	<2.1
R4	<0.1	2.0	<2.1
R5	<0.1	2.0	<2.1
R6	<0.1	2.0	<2.1
R7	<0.1	2.0	<2.1
R8	<0.1	2.0	<2.1
R9	<0.1	2.0	<2.1
R10	<0.1	2.0	<2.1
R11	<0.1	2.0	<2.1

Note: Incr = Incremental impact, Bkg = Background, Cumul = Cumulative Impact

6.3. Maximum 24-Hour PM_{10} and $PM_{2.5}$ Concentrations

The predicted maximum 24-hour PM_{10} and $PM_{2.5}$ concentrations should be viewed with caution. Construction phase activities can vary in their magnitude, location and type, based on a number of factors, and trying to determine what the peak rates and types of these activities is difficult. The assessment has assumed that all earthworks activities would be operated concurrently, and whilst this is appropriate for the assessment of annual average impacts, it provides a level of conservatism in the assessment of shorter-term impacts. Further discussion is provided in Section 8.1. The predicted impacts have been derived on the assumption that emissions would be generated over a full year period, to ensure that the coincidence of worst-case emissions and worst-case meteorology has been appropriately assessed.

Table 17 presents the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted to occur at the nearest sensitive receptors as a result of the construction phase of the Proposal. No background concentrations are included within this table.

The predicted incremental concentrations of PM_{10} and $PM_{2.5}$, are demonstrated to be below the relevant criteria, with the highest incremental 24-hour PM_{10} and $PM_{2.5}$ impacts predicted at receptor R1.

Table 17 Predicted maximum incremental 24-hour PM_{10} and $PM_{2.5}$ concentrations – construction phase

Receptor	Maximum 24-hour average concentration (µg·m^{-3})	
	PM_{10}	PM_{10}
Criterion	50	25
Max. % of criterion	17.7	3.7
R1	8.9	0.9
R2	7.4	0.9
R3	6.4	0.6
R4	2.1	0.1
R5	1.8	0.1
R6	1.6	0.1
R7	0.8	<0.1
R8	0.6	<0.1
R9	0.7	<0.1
R10	1.5	<0.1
R11	3.1	0.1

A contemporaneous analysis of the 24-hour PM_{10} and $PM_{2.5}$ data has been performed where each predicted incremental concentration is added to the corresponding measured background concentration, in accordance with Section 11.2.3(b) of the Approved Methods (NSW EPA, 2022).

Table 18 and Table 19 present the predicted maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations resulting from the construction phase of the Proposal, with the corresponding background included for each day.

Results are presented for the receptor at which the highest incremental PM_{10} and $PM_{2.5}$ impacts have been predicted, and for the receptors at which the highest cumulative impacts (increment plus background) have been predicted. These may be different receptors than those at which the highest incremental impacts are predicted.

The left side of Table 18 and Table 19 indicates the predicted concentration on days with the highest cumulative impact (principally driven by the highest background concentrations), and the right side of the respective tables shows the total predicted concentration on days with the highest predicted incremental concentrations with the contemporaneous background values to derive the respective cumulative predictions.

For PM_{10}, the maximum cumulative impact (the left-hand side of Table 18), and the maximum incremental impact (the right-hand side of Table 18) are both predicted at receptor R1. For $PM_{2.5}$, the maximum cumulative impact (the left-hand side of Table 19) is predicted at R2 while the maximum incremental impact (the right-hand side of Table 19) is predicted at receptor R1. Predicted impacts will be lower at all other receptor locations.

Table 18 Summary of contemporaneous impact and background – PM_{10} concentrations – construction phase

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$) – R1			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$) – R1		
	Incr.	Bg.	Cumul.		Incr.	Bg.	Cumul.
27-04-21	2.0	69.0	71.0	30-06-21	8.9	10.7	19.6
03-05-21	5.7	39.9	45.6	01-03-21	7.5	15.1	22.6
09-10-21	3.1	36.1	39.2	02-05-21	7.3	15.7	23.0
23-01-21	4.6	33.5	38.1	03-06-21	6.7	21.3	28.0
04-05-21	4.2	30.5	34.7	01-07-21	6.1	17.3	23.4
08-10-21	1.9	31.1	33.0	08-04-21	6.0	7.4	13.4
21-08-21	0.1	32.2	32.3	01-05-21	5.8	14.5	20.3
02-06-21	2.3	29.7	32.0	03-05-21	5.7	39.9	45.6
01-06-21	2.2	29.3	31.5	15-12-21	5.7	21.4	27.1
07-10-21	0.2	31.0	31.2	20-02-21	5.6	12.4	18.0
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions (outlined in red) as a result of the operation of the Proposal				These data represent the highest Incremental Impact 24-hour PM_{10} predictions (outlined in blue) as a result of the operation of the Proposal.			

Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

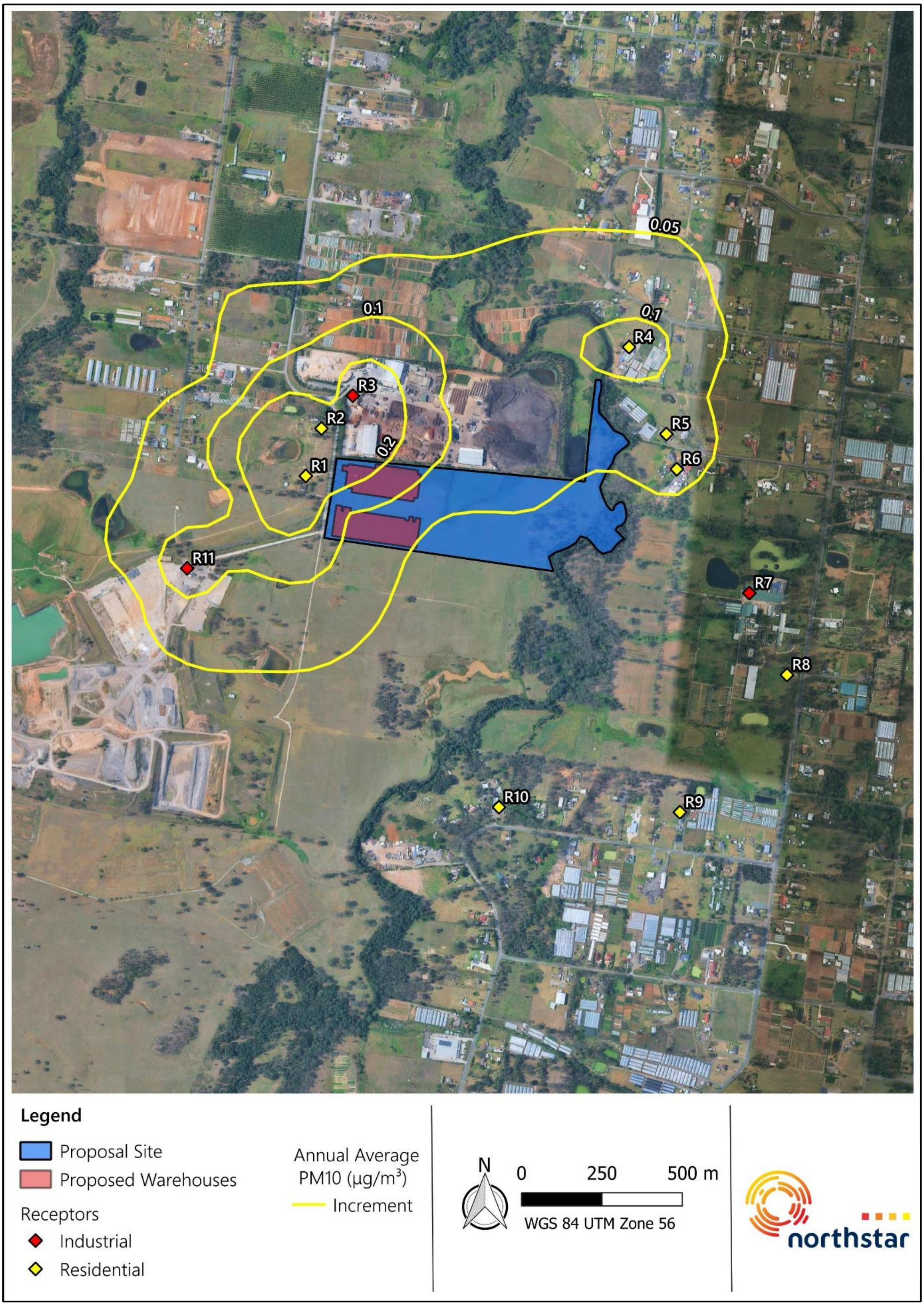
Table 19 Summary of contemporaneous impact and background – $PM_{2.5}$ concentrations – construction phase

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – R2			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – R1		
	Incr.	Bg.	Cumul.		Incr.	Bg.	Cumul.
27-04-21	0.1	57.4	57.5	03-06-21	0.9	14.7	15.6
04-05-21	0.3	27.3	27.6	29-08-21	0.7	15.9	16.6
03-05-21	<0.1	25.7	25.8	18-05-21	0.4	10.1	10.5
09-10-21	<0.1	22.8	22.9	08-04-21	0.4	4.7	5.1
21-08-21	<0.1	19.7	19.8	24-05-21	0.3	4.7	5.0
23-07-21	<0.1	18.0	18.1	07-04-21	0.3	2.7	3.0
10-10-21	<0.1	17.6	17.7	30-08-21	0.3	15.2	15.5
28-04-21	<0.1	17.0	17.1	30-06-21	0.3	8.2	8.5
29-04-21	<0.1	16.6	16.7	01-06-21	0.3	14.3	14.6
22-07-21	<0.1	16.6	16.7	06-04-21	0.3	6.6	6.9
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposal.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposal.			

Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

Table 18 and Table 19 indicate that with inclusion of contemporaneous background data there are no predicted additional exceedances of the relevant 24-hour criteria resulting from earthworks activities. Contour plots of the incremental contribution of the proposed construction phase activities performed at the site to the annual average PM_{10} and $PM_{2.5}$ concentrations are presented in Figure 5 and Figure 6.

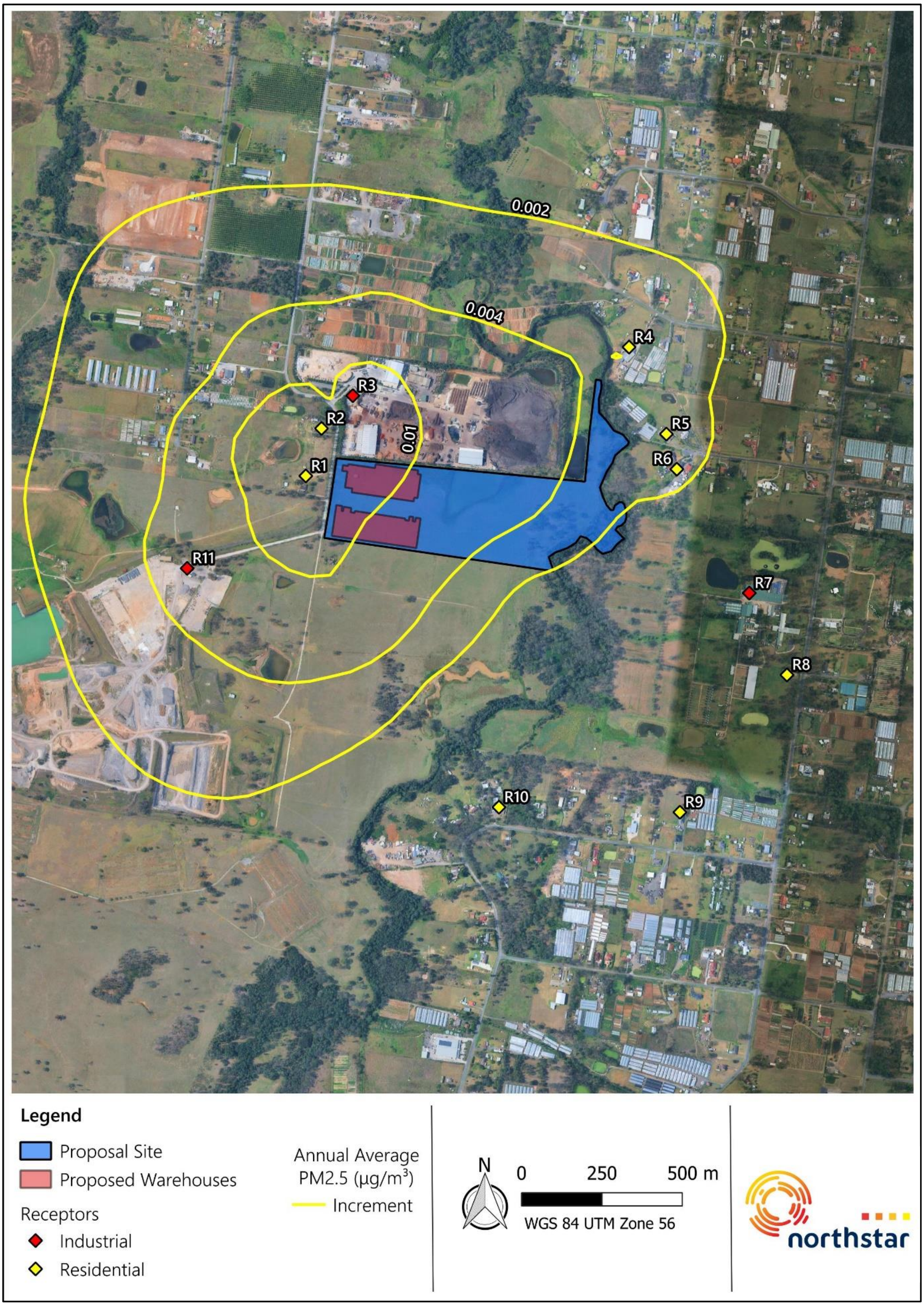
Figure 5 Predicted incremental annual average PM_{10} concentrations – construction phase



Source: Northstar

Note: Criterion = 50 µg·m-3 (cumulative)

Figure 6 Predicted incremental annual average $PM_{2.5}$ concentrations – construction phase



Source: Northstar

Note: Criterion = 25 µg·m⁻³ (cumulative)

7. OPERATIONAL AIR QUALITY IMPACT ASSESSMENT

Similar to the presentation of results for the construction phase assessment (refer Section 6), the operational phase assessment results are presented below as incremental and cumulative impacts.

7.1. Particulate Matter

7.1.1. Annual Average TSP, PM_{10} and $PM_{2.5}$

The predicted annual average particulate matter concentrations (as TSP, PM_{10} and $PM_{2.5}$) resulting from the operations at the Proposal site are presented in Table 20.

No contour plots of annual average TSP, PM_{10} or $PM_{2.5}$ are presented, given the minor contribution from the Proposal at the nearest relevant sensitive receptors.

Table 20 Predicted annual average TSP, PM_{10} and $PM_{2.5}$ concentrations – operational phase

Receptor	Annual average concentration (µg·m^{-3})								
	TSP			PM_{10}			$PM_{2.5}$		
	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.
Criterion	90			25			8		
Max. % of criterion	<0.1	34.9	34.9	<0.1	61.2	61.4	1.1	90.0	90.6
R1	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R2	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R3	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R4	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R5	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R6	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R7	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R8	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R9	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R10	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3
R11	<0.1	31.4	31.5	<0.1	15.3	15.4	<0.1	7.2	7.3

Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

The performance of the Proposal does not result in any exceedances of the annual average particulate matter impact assessment criteria.

7.1.2. Maximum 24-hour PM_{10} and $PM_{2.5}$

Presented in Table 21 are the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted to occur at the nearest sensitive receptors as a result of the operation of the Proposal. No background concentrations are included within this table.

The predicted incremental concentrations of PM_{10} and $PM_{2.5}$, are demonstrated to be minor.

Table 21 Predicted maximum incremental 24-hour PM_{10} and $PM_{2.5}$ concentrations – operational phase

Receptor	Maximum 24-hour average concentration ($\mu g \cdot m^{-3}$)	
	PM_{10}	PM_{10}
Criterion	50	25
Max. % of criterion	1.2	2.3
R1	0.6	0.6
R2	0.4	0.4
R3	0.4	0.3
R4	0.2	0.1
R5	0.2	0.1
R6	0.1	0.1
R7	<0.1	<0.1
R8	<0.1	<0.1
R9	<0.1	<0.1
R10	<0.1	<0.1
R11	0.2	0.2

As per the construction phase assessment (refer Section 6), a contemporaneous analysis of the 24-hour PM_{10} and $PM_{2.5}$ data has been performed. Table 22 and Table 23 present the predicted maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations resulting from the operation of the Proposal, with the corresponding background included for each day. Results are presented in Table 22 and Table 23 for those receptors at which the greatest impacts have been predicted (refer Table 21).

For PM_{10}, the maximum cumulative impact (the left hand side of Table 22), and the maximum incremental impact (the right hand side of Table 22) are both predicted at receptor R1.

For $PM_{2.5}$, the maximum cumulative impact (the left hand side of Table 23), and the maximum incremental impact (the right hand side of Table 23) are both predicted at receptor R1.

Table 22 Summary of contemporaneous impact and background – PM_{10} – operational phase

Date	24-hour average PM_{10} concentration (µg·m⁻³) – R1			Date	24-hour average PM_{10} concentration (µg·m⁻³) – R1		
	Incr.	Bg.	Cumul.		Incr.	Bg.	Cumul.
27-04-21	0.2	69.0	69.2	06-04-21	0.6	13.8	14.4
03-05-21	<0.1	39.9	40.0	01-12-21	0.6	9.5	10.1
09-10-21	<0.1	36.1	36.2	23-12-21	0.6	17.7	18.3
23-01-21	<0.1	33.5	33.6	21-03-21	0.5	13.7	14.2
21-08-21	<0.1	32.2	32.3	19-02-21	0.5	15.8	16.3
08-10-21	<0.1	31.1	31.2	20-02-21	0.5	12.4	12.9
07-10-21	<0.1	31.0	31.1	29-01-21	0.5	9.9	10.4
04-05-21	<0.1	30.5	30.6	09-02-21	0.5	12.8	13.3
14-04-21	<0.1	30.4	30.5	24-12-21	0.5	10.7	11.2
02-06-21	0.1	29.7	29.8	24-02-21	0.5	14.4	14.9
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions (outlined in red) as a result of the operation of the Proposal				These data represent the highest Incremental Impact 24-hour PM_{10} predictions (outlined in blue) as a result of the operation of the Proposal.			

Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

Table 23 Summary of contemporaneous impact and background – $PM_{2.5}$ – operational phase

Date	24-hour average $PM_{2.5}$ concentration (µg·m⁻³) – R1			Date	24-hour average $PM_{2.5}$ concentration (µg·m⁻³) – R1		
	Incr.	Bg.	Cumul.		Incr.	Bg.	Cumul.
27-04-21	0.2	57.4	57.6	06-04-21	0.6	6.6	7.2
04-05-21	<0.1	27.3	27.4	23-12-21	0.5	7.7	8.2
03-05-21	<0.1	25.7	25.8	19-02-21	0.5	4.3	4.8
09-10-21	<0.1	22.8	22.9	01-12-21	0.5	6.5	7.0
21-08-21	<0.1	19.7	19.8	09-02-21	0.5	5.1	5.6
23-07-21	<0.1	18.0	18.1	24-02-21	0.4	3.1	3.5
10-10-21	<0.1	17.6	17.7	29-01-21	0.4	1.6	2.0
28-04-21	0.1	17.0	17.1	21-03-21	0.4	5.6	6.0
29-04-21	0.1	16.6	16.7	24-12-21	0.4	5.7	6.1
22-07-21	<0.1	16.6	16.7	20-02-21	0.4	4.8	5.2
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposal.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposal.			

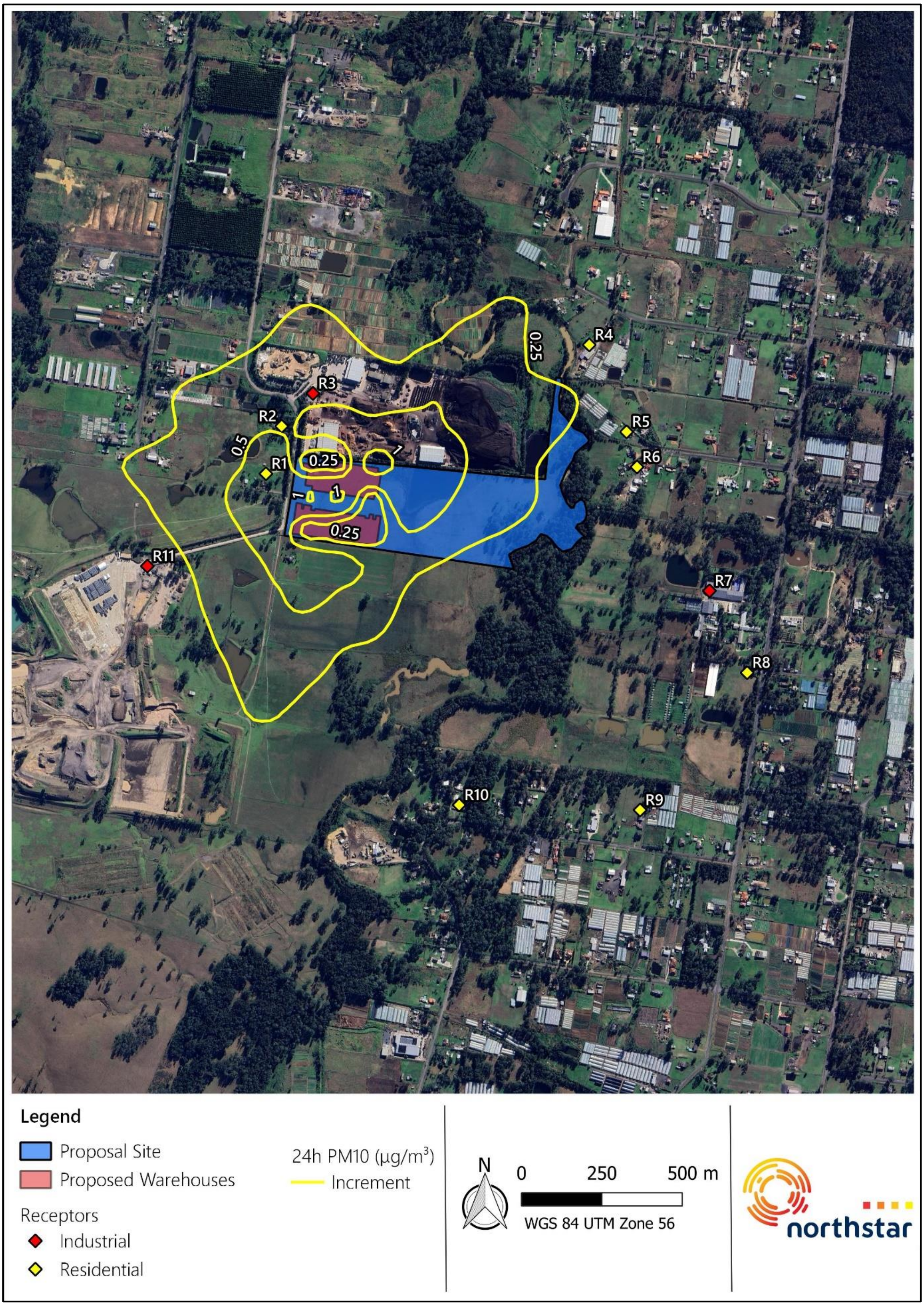
Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

It is noted that a number of exceedances are indicated in the 'background' air quality data, and as discussed in Section 4.3, these were due to extensive hazard reduction burning performed during April and May in 2021 (NSW DPE, 2023). However, the operation of the Proposal is not predicted to result in any additional exceedances of those criteria.

The performance of the Proposal does not result in any additional exceedances of the 24-hour average particulate matter impact assessment criteria.

Contour plots of the predicted incremental 24-hour PM_{10} concentrations associated with the Proposal are presented in Figure 7 to allow examination of the distribution of particulate matter in the area surrounding the Proposal.

Figure 7 Predicted maximum incremental 24-hour PM_{10} impacts – operational phase



Source: Northstar

Note: Criterion = 50 µg·m^{-3} (cumulative)

7.2. Nitrogen Dioxide

Results are presented in this section for the predictions of nitrogen dioxide (NO_2). The averaging periods associated with the criteria for these pollutants is 1 hour maximum and annual average as specified in Table 4.

Emissions of NO_X have been calculated, with subsequent ground-level concentrations predicted using dispersion modelling techniques. Given that NO_X is a mixture of NO_2 and nitric oxide (NO), conversion of NO_X predictions to NO_2 concentrations may be performed. Within this assessment, it has been assumed that 100 % of the total NO_X emitted is discharged as NO_2 (refer Section 5.2.3)

The predicted maximum 1-hour and annual average NO_2 concentrations resulting from the Proposal operations are presented in Table 24.

It is noted that the predicted 1-hour average concentrations are shown for the hour resulting in the maximum cumulative impacts at sensitive receptor locations rather than the hour associated with the maximum incremental concentrations.

Table 24 Predicted 1-hour and annual NO_2 concentrations

Receptor	Nitrogen dioxide (NO_2) concentration ($\mu g \cdot m^{-3}$)					
	1-hour average			Annual average		
	Incr.	Bg.	Cumul.	Incr.	Bg.	Cumul.
Criterion	164			31		
Max. % of criterion	15.8	30.0	45.8	9.5	22.9	32.4
R1	25.9	49.2	75.1	3.0	7.1	10.1
R2	20.3	49.2	69.5	2.0	7.1	9.1
R3	17.5	49.2	66.7	1.5	7.1	8.6
R4	9.1	49.2	58.3	0.8	7.1	7.9
R5	9.8	49.2	59.0	0.4	7.1	7.5
R6	9.3	49.2	58.5	0.3	7.1	7.4
R7	8.0	49.2	57.2	0.1	7.1	7.2
R8	5.4	49.2	54.6	<0.1	7.1	7.2
R9	6.4	49.2	55.6	<0.1	7.1	7.2
R10	8.2	49.2	57.4	0.1	7.1	7.2
R11	12.9	49.2	62.1	0.6	7.1	7.7

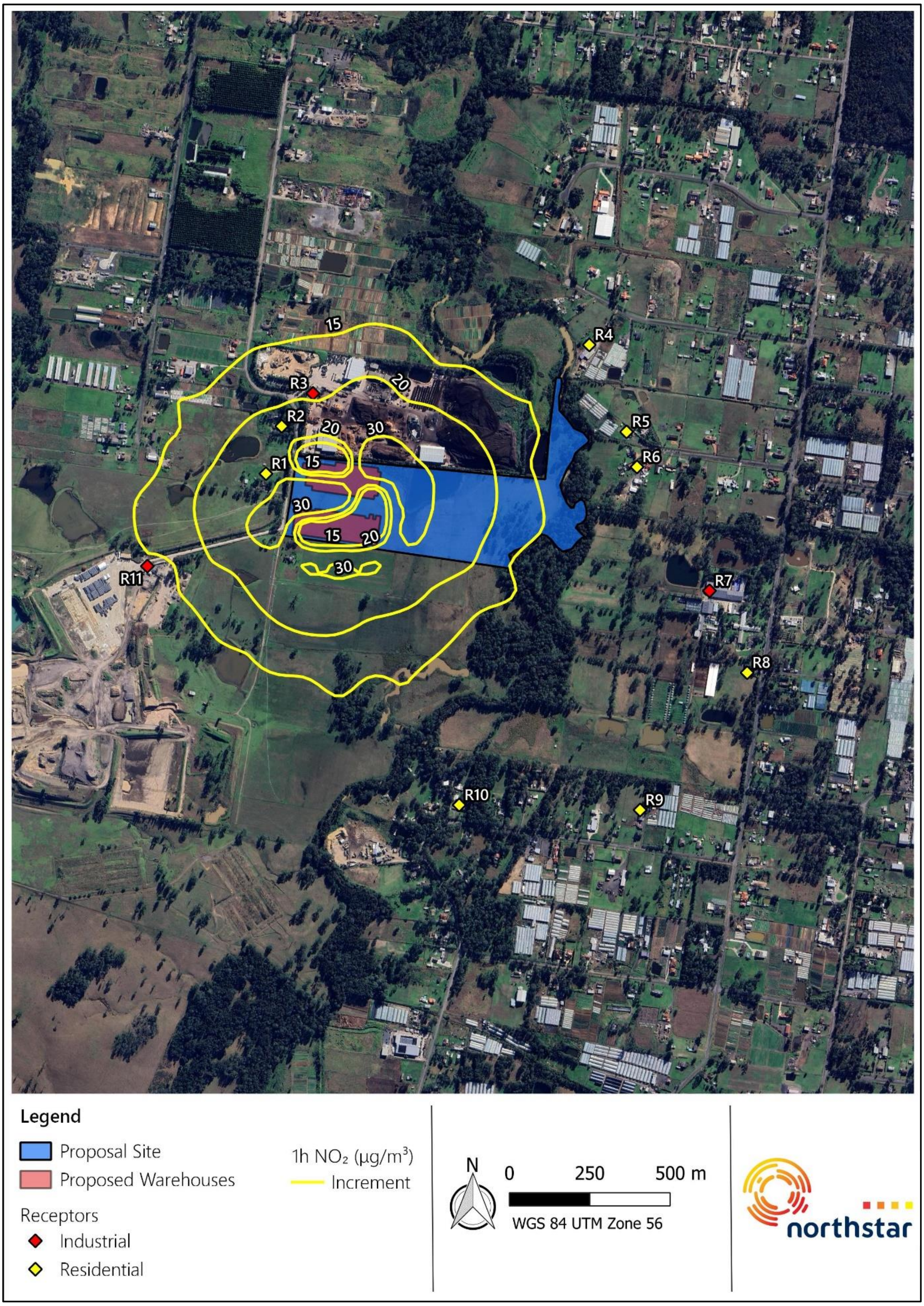
Note: Incr = Incremental impact, Bg = Background, Cumul = Cumulative Impact

The results indicate that predicted incremental concentrations of combustion-related pollutants (characterised by NO_2), are below the criteria at all surrounding receptor locations. At the worst affected receptor (R1), predicted increments are shown to be 15.8 % of the 1-hour average criterion and 9.5 % of the annual average criterion as a result of the Proposal. The calculated cumulative impacts (Proposal plus background) are shown to result in impacts less than the criteria.

The performance of the Proposal does not result in any exceedances of the criteria for combustion related pollutants.

A contour plot of the predicted maximum 1-hour incremental NO_2 impact is presented in Figure 8.

Figure 8 Predicted maximum incremental 1-hour NO_x as NO_2 impacts



Source: Northstar

Note: Criterion = 164 µg·m^{-3} (cumulative)

8. MITIGATION AND MANAGEMENT

8.1. Construction Phase

The construction air quality impact assessment presented in Section 6 indicates that no additional exceedances of the relevant PM criteria are predicted to be experienced at any surrounding receptor locations during the construction phase of the Proposal.

It is noted that for the purposes of the construction phase assessment, it has been assumed (given limitations with dispersion modelling) that all earthworks activities are occurring during all operational hours which is not representative of the daily variation and staging of activities performed at the Proposal site. For example, topsoil scraping, excavating and grading activities would not concurrently occur within the same area, however, the estimated emissions associated with those activities have been assessed as if they were occurring during the same hours. Correspondingly, given the high level of conservatism included within the construction phase assessment, the predicted incremental concentrations presented in Section 6 are likely to be considerably greater than what may be practicably expected.

Furthermore, short-term emissions generated during the construction phase of the Proposal would be managed through a trigger action response plan (TARP), to proactively manage emissions of particulate matter prior to potential exceedances of the relevant criteria occurring. Appropriate management of short-term emissions would subsequently mitigate the risks of potential adverse long-term air quality impacts being experienced at surrounding receptor locations.

A brief summary of how the TARP would adequately control emissions resulting from construction phase activities performed as part of the Proposal is provided in Section 8.1.1.

8.1.1. Trigger Action Response Plan

A TARP has been developed for the construction phase of the Proposal which describes the actions to be taken when specific triggers are exceeded.

The purpose of the TARP is to provide a process to identify conditions that may lead to unacceptable dust impacts if not adequately managed, and to provide proactive and reactive actions to manage that risk. Triggers have been defined to assist the contractor to meet dust management obligations when:

- Ground-level concentrations at the monitoring locations have the potential to be elevated due to activities onsite; and
- Activities onsite are generating visible dust outside of the normal observed range.

Continuous real-time data would be collected by a monitoring network and provided as user-defined averages. To meet the objectives of the TARP, 1-hour average data will be used as a trigger under the TARP. Additionally, one monitoring location would include wind speed and wind direction monitoring to provide supplementary evidence in the case of complaints or dispute, and to allow a 'down wind increment' (DWI) to be calculated, which would assist in the identification of potential sources of any elevated measurements. The locations and specification of monitoring equipment will be detailed within the Construction Air Quality Management (CAQMP) prior to construction works commencing and will consider the dispersion of emissions generated from the Proposal site as presented in Section 6.

The siting of air quality monitoring would be in accordance with AS 3580.1.1 *Methods for sampling and analysis of ambient air, Guide to siting air monitoring equipment*, taking into account the objectives of the monitoring program and site constraints.

Siting of meteorological monitoring would be performed with reference to AS 3580.14 *Methods for sampling and analysis of ambient air, Meteorological monitoring for air quality monitoring applications*, as far as practicable, and taking into account site constraints and the purposes of the monitoring program.

The monitoring program would be designed to enable and facilitate proactive modification of site activities to ensure that unacceptable air quality impacts are not experienced at surrounding receptor locations, generally through the implementation of additional emissions control methods. In conditions when the background particulate environment is significantly affected by external sources (such as dust storms or bushfire), then modification of activities may not result in any meaningful reductions in off-site impacts associated with the activities on site. However, the TARP has been designed to enable pro-active control of the development impact in all conditions and includes wind speed triggers to allow modification of activities in increasing wind speeds.

Trigger Levels

Table 25 outlines the tiered trigger levels which allows an appropriate management response / action associated with increasing risk of off-site dust impacts. A hierarchy of management and mitigation options would be initiated should the trigger levels be reached (refer Table 26). To allow an appropriate management response / action associated with increasing risk of off-site particulate impacts, a 'traffic light' system is proposed, adopting a cascading action level.

Where the measured 1-hour average PM_{10} concentration is less than 50 $\mu g{\cdot}m^{-3}$ at all monitoring stations, and there is no observation of visible dust beyond the site boundary, the standard dust control measures (refer Section 5.1.2) will be implemented and reviewed on an ongoing basis.

Note that an exceedance of the 1-hour PM_{10} concentration provides opportunity for measures to be implemented to ensure that the 24-hour average (00 to 23 hours) concentration can be managed effectively.

Where the measured 1-hour average PM_{10} concentration is greater than 50 µg·m^{-3} at any monitoring station, the DWI will be calculated to determine the calculated 'site contribution' and the following actions will be undertaken:

- Where the calculated DWI is less than 5 µg·m^{-3}, or visible dust is observed beyond the site boundary, Action Level A will be triggered and the cascade response as described in Table 26 will be employed.
- Where the calculated DWI is greater than 5 µg·m^{-3} and less than 10 µg·m^{-3}, or visible dust is observed beyond the site boundary or there is a justified dust complaint, Action Level B will be triggered and the cascade response as described in Table 26 will be employed.
- Where the calculated DWI is greater than 10 µg·m^{-3}, or visible dust is observed beyond the site boundary or there is a justified dust complaint, Action Level C will be triggered and the cascade response as described in Table 26 will be employed.

It is noted that there may be instances where the 1-hour PM_{10} concentration is greater than or equal to 50 µg·m^{-3}, but the DWI cannot be calculated (due to lack of data collection or when, based on wind direction, there is no suitable downwind monitor). It is recommended that in this instance, a secondary trigger based on wind speed should be adopted as presented in Table 25.

Table 25 Trigger levels

Action Level	Primary trigger	Secondary trigger
None	Concentration at any monitor <50 µg·m^{-3} *and* No visible dust observed leaving the site boundary	Wind speeds < 5.4 m·s^{-1} (< 19.4 km·hr^{-1})
A	Concentration at any monitor ≥50 µg·m^{-3} *and* [1-hour average DWI <5 µg·m^{-3} *or* Visible dust observed leaving the site boundary]	Wind speeds ≥ 5.5 m·s^{-1} (≥ 19.8 km·hr^{-1})
B	Concentration at any monitor ≥50 µg·m^{-3} *and* [1-hour average DWI ≥5 µg·m^{-3} and <10 µg·m^{-3} *or* Visible dust observed leaving the site boundary *or* Receipt of a justified complaint]	Wind speeds ≥ 6.8 m·s^{-1} (≥ 24.5 km·hr^{-1})
C	Concentration at any monitor ≥50 µg·m^{-3} *and* [1-hour average DWI >10 µg·m^{-3} *or* Visible dust observed leaving the site boundary *or* Receipt of a justified complaint]	Wind speeds ≥ 8 m·s^{-1} (≥ 28.8 km·hr^{-1})

Response to Trigger Levels

Should trigger levels outlined in Table 25 be reached, then a hierarchy of management and mitigation options will be initiated as identified in Table 26 and Appendix E. These controls will be implemented appropriate to the activities being performed at the development at that time and are reflective of increased risk of dust generation and potential impact of dust emissions.

Table 26 outlines the actions and responsibilities if a level is triggered.

Table 26 Action level responses

Action level	Response
None	No response required beyond the continued implementation of standard dust controls
A	Identify activities being performed and determine whether any additional emission controls can be applied to those activities
B	Apply the controls identified during Action Level A
C	Depending on the activities being performed, progressively decrease the rate of activity or cease operations if emissions cannot be adequately controlled

The identification of additional control measures should include, but not be limited, to the measures outlined in Appendix E.

8.2. Operation Phase

Based on the findings of the operational air quality impact assessment as presented in Section 7, it is considered that the level of activity being performed at the Proposal site would result in the achievement of all air quality criteria, even following the adoption of potential worst-case operating conditions.

Accounting for the background air quality assumptions, and adopting worst-case assumptions in relation to truck idling, the assessment does not predict any additional exceedances of the respective criteria as a result of the operation of the Proposal, for the pollutants assessed.

Good site management practices, including the observation of speed limits on site, and the minimisation of vehicle use (through avoidance of engine idling) would be sufficient to ensure that off-site impacts are minimised.

Emission controls associated with any manufacturing activities would be implemented, once detailed design of the facility has occurred. Given the scale and nature of the manufacturing activities proposed, it is considered that this would be easily achievable.

8.3. Monitoring

Given the discussion presented above, taking into consideration the incremental contribution of the Proposal to air quality impacts in the surrounding area, no air quality monitoring is required or proposed during the operational phase. A discussion of the air quality monitoring to be performed during the construction phase is outlined above.

9. CONCLUSION

Northstar was engaged by EMKC[3] to perform an AQIA for the construction and operation of an industrial warehouse development to be located at 230 Martin Road, Badgerys Creek NSW.

The prediction of potential impacts associated with the construction and operational phases of the Proposal have been performed in general accordance with the requirements of the Approved Methods using an approved and appropriate dispersion modelling technique. The estimation of emissions has been performed using referenced emission factors.

The potential impacts at all the identified receptor locations have been presented in this study which documents those predictions as:

- **Incremental impact** – relates to the concentrations predicted as a result of the Proposal in isolation.
- **Cumulative impact** – relates to the concentrations predicted as a result of the Proposal PLUS the background air quality concentrations.

The findings of the AQIA indicate that the Proposal is not predicted to result in any additional exceedances of the air quality criteria during both the construction and operational phases. Construction phase impacts would additionally be managed through the implementation of a TARP while good site management practices such as the minimisation of vehicle idling whilst on site, would be sufficient to ensure that impacts are minimised during Proposal operation.

Whilst the Proposal site is located in close proximity to a number of industrial activities, the demonstrated low incremental impacts associated with the Proposal is not likely to result in adverse cumulative impacts at surrounding receptor locations.

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APPENDIX A

Commonly used units and abbreviations

Units Used in the Report

Units presented in the report follow the International System of Units (SI) conventions, unless derived from references using non-SI units.

Commonly used SI units

The following units are commonly used in Northstar reports.

Symbol	Name	Quantity
SI base units		
K	Kelvin	thermodynamic temperature
kg	kilogram	mass
m	metre	length
mol	mole	amount of substance
s	seconds	time
Non-SI units mentioned in the SI or accepted for use		
°	degree	plane angle
d	day	time
h	hour	time
ha	hectare	area
J	joule	energy
L	litre	volume
min	minute	time
N	newton	force or weight
t	tonne	mass
V	volt	electrical potential
W	watt	power

Multiples of SI and non-SI units

The following prefixes are added to unit names to produce multiples and sub-multiples of units:

Prefix	Symbol	Factor
T	tera-	10^{12}
G	giga-	10^{9}
M	mega-	10^{6}
k	kilo-	10^{3}
h	hector-	10^{2}
da	deca-	10^{1}

Prefix	Symbol	Factor
p	pico-	10^{-12}
n	nano-	10^{-9}
µ	micro-	10^{-6}
m	milli-	10^{-3}
c	centi-	10^{-2}
d	deci-	10^{-1}

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/m^{3}; and,

- 0.2 kilograms per hectare per hour would be presented as 0.2 $kg \cdot ha^{-1} \cdot hr^{-1}$ and not 0.2 kg/ha/hr.

Commonly used SI-derived and non-SI units

$g \cdot m^{-2} \cdot s^{-1}$	gram per square metre per second	rate of mass deposition per unit area
$g \cdot s^{-1}$	gram per second	rate of mass emission
$kg \cdot ha^{-1} \cdot hr^{-1}$	kilogram per hectare per hour	rate of mass deposition per unit area
$kg \cdot m^{-3}$	kilogram per cubic metre	density
$L \cdot s^{-1}$	litres per second	volumetric rate
m^2	square metre	area
m^3	cubic metre	volume
$m \cdot s^{-1}$	metre per second	speed and velocity
$mg \cdot m^{-3}$	milligram per cubic metre	mass concentration per unit volume
$mg \cdot Nm^{-3}$	milligram per normalised cubic metre (of air)	mass concentration per unit volume
$\mu g \cdot m^{-3}$	microgram per cubic metre	mass concentration per unit volume
$mg \cdot m^{-3}$	milligram per cubic metre	mass concentration per unit volume
Pa	pascal	pressure
ppb	parts per billion ($1x10^{-9}$)	volumetric concentration
pphm	parts per hundred million (1×10^{-5})	volumetric concentration
ppm	parts per million ($1x10^{-6}$)	volumetric concentration

Commonly used abbreviations

Abbreviation	Term
ABS	Australian Bureau of Statistics
ACT	Australian Commonwealth Territory
AGL	above ground level
AHD	Australian height datum
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AQRA	air quality risk assessment
AS/NZS	Australian Standard / New Zealand Standard
AWS	automatic weather station
BGL	below ground level
BOM	Bureau of Meteorology
CEMP	construction environment management plan
CO	carbon monoxide
CO_2	carbon dioxide
DEM	digital elevation model
EETM	emission estimation technique manual
EPA VIC	Environmental Protection Authority Victoria
GIS	geographical information system
IAQM	UK Institute of Air Quality Management
NCAA	National Clean Air Agreement

Abbreviation	Term
NEPM	National Environment Protection Measure
NO	nitric oxide
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide
NSW	New South Wales
NSW DPE	New South Wales Department of Planning and Environment
NSW EPA	New South Wales Environment Protection Authority
NT	Northern Territory
OEMP	operational environmental management plan
O_3	ozone
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
SA	South Australia
SEPP	State Environmental Protection Policy
SO_X	oxides of sulphur
SO_2	sulphur dioxide
TAPM	The Air Pollution Model
TAS	Tasmania
TSP	total suspended particulates
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VIC	Victoria

APPENDIX B

Meteorology

As discussed in Section 4.2, a meteorological modelling exercise has been performed to characterise the meteorology of the Proposal site in the absence of site-specific measurements. The meteorological monitoring has been based on measurements acquired from surrounding automatic weather stations (AWS) operated by the Australian Government Bureau of Meteorology (BoM).

A summary of the relevant monitoring sites is provided in Table B1.

Table B1 Details of the meteorological monitoring surrounding the Proposal site

Site name	Source	Approximate location		Approximate distance
		mE	mS	km
Badgerys Creek AWS – station #067108	BoM	289 920	6 246 951	3.1
Horsley Park Equestrian Centre AWS – station #067119	BoM	301 708	6 252 298	9

As discussed in Section 4.2, meteorological conditions at Badgerys Creek AWS have been examined to determine a 'typical' or representative dataset for use in dispersion modelling. Annual wind roses for the period 2018 to 2022 are presented in Figure B1. The annual wind speed frequency distribution for the five-year period is presented in Figure B2.

The correlation coefficient between each year and the five-year period for the distribution of wind speed, wind direction, PM_{10} and $PM_{2.5}$ are summarised in Table B2. The correlation coefficients were ranked and aggregated to select the representative year for the meteorological modelling. The rankings are also presented in Table B2.

The wind roses indicate that from 2018 to 2022, winds at Badgerys Creek AWS show generally similar wind distribution patterns across the years assessed, with predominant south-westerly wind directions evident.

The majority of wind speeds experienced at the Badgerys Creek AWS between 2018 and 2022 are generally in the range 1.5 meters 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 mostly north-westerly directions. Winds of this speed are rare and occur during 1.7 % of the observed hours during the years while calm winds (< 0.5 $m{\cdot}s^{-1}$) occur during 9.4 % of hours on average across the years 2018-2022.

Figure B1 Annual wind roses – Badgerys Creek AWS (2018 – 2022)

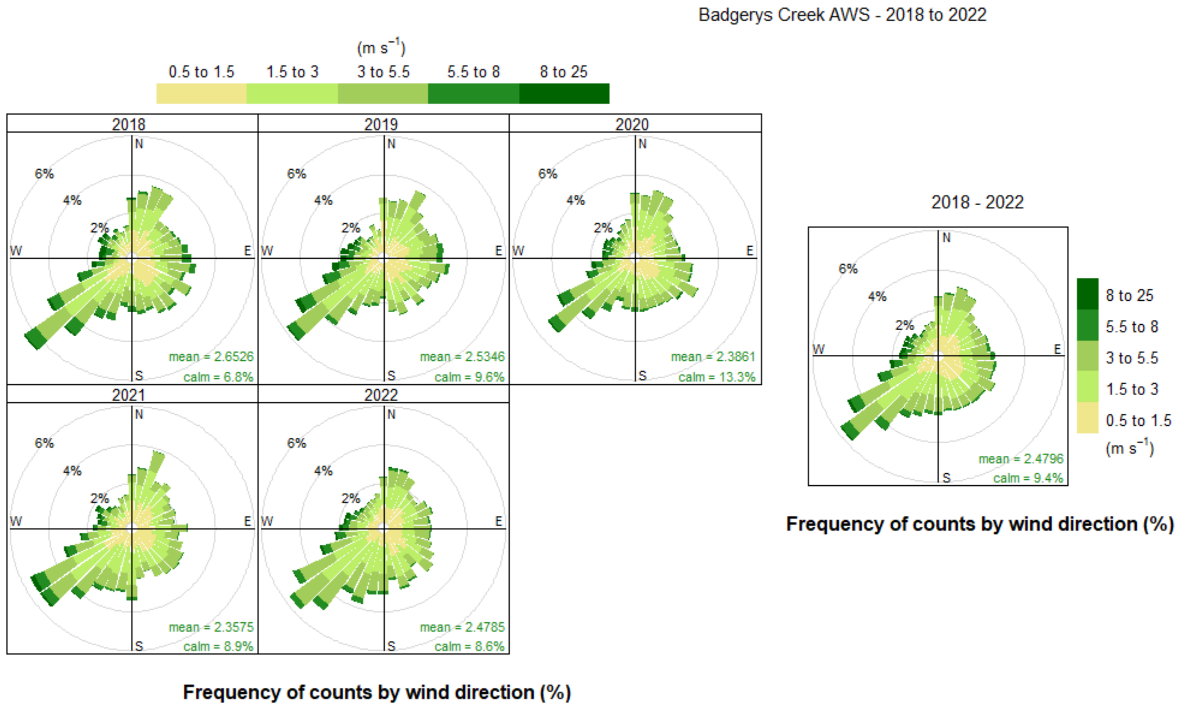


Figure B2 Annual wind speed and direction distributions – Badgerys Creek AWS (2018 – 2022)

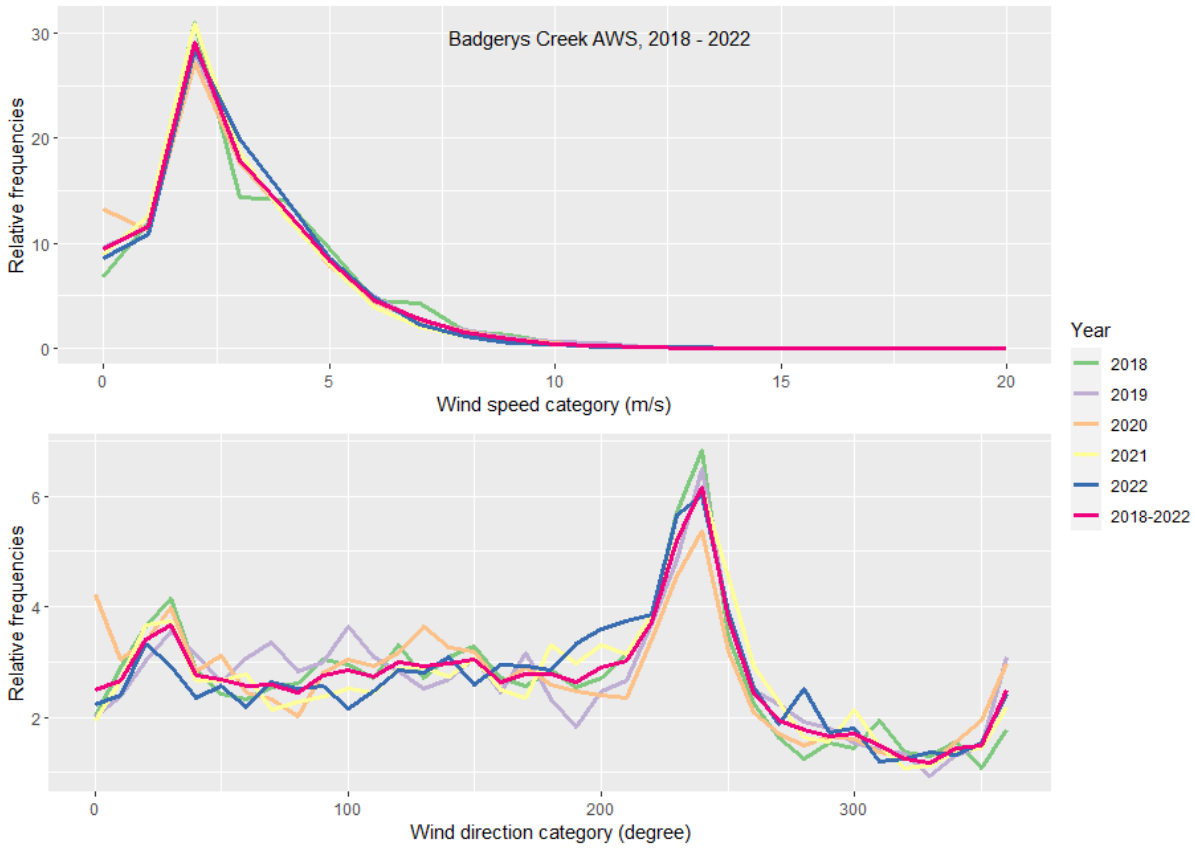


Table B2 Correlation coefficient analysis – Badgerys Creek AWS and Bringellyl AQMS (2018 – 2022)

Parameter	Wind speed		Wind direction		PM_{10}		$PM_{2.5}$		Aggregated rank
	Corr.	Rank	Corr.	Rank	Corr.	Rank	Corr.	Rank	
2018	0.988	5	0.972	1	0.897	5	0.964	4	5
2019	0.999	1	0.935	4	0.956	3	0.981	3	2
2020	0.992	4	0.890	5	0.989	2	0.993	2	3
2021	0.998	2	0.961	2	0.995	1	0.996	1	1
2022	0.997	3	0.940	3	0.930	4	0.928	5	4
2018-2022	1	-	1	-	1	-	1	-	-

Note: Corr. = correlation

Wind speed observations for each year correlated well against the wind speed over the five-year period, with each year having a correlation coefficient greater than 0.98. The year 2019 is the highest ranked for correlation against the wind speed over the five-year period.

Wind direction observations for each year are reasonably well correlated against the wind direction over the five-year period, with each year having a correlation coefficient greater than of 0.89. The year 2018 is the highest ranked for correlation against the wind direction over the five-year period.

Particulate matter concentrations for each year are also well correlated against particulate matter concentrations over the five-year period. Each year resulted in having a correlation coefficient greater than 0.897. The year 2021 is the highest rank for both PM_{10} and for $PM_{2.5}$.

The correlation coefficient analysis indicates that 2021 is the most representative year for meteorological modelling.

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 meteorology data has been performed.

In absence of any measured onsite meteorological data, site representative meteorological data for this Proposal was generated using The Air Pollution Model (TAPM, v 4.0.5) meteorological model in a format suitable for using in the GRAL dispersion model (refer Section 5.2.2).

Meteorological modelling using TAPM 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.

A comparison of the TAPM generated meteorological data, and that observed at Badgerys Creek AWS, are presented in Figure B3. These data generally compare well which provides confidence that the meteorological conditions modelled as part of this assessment are appropriate.

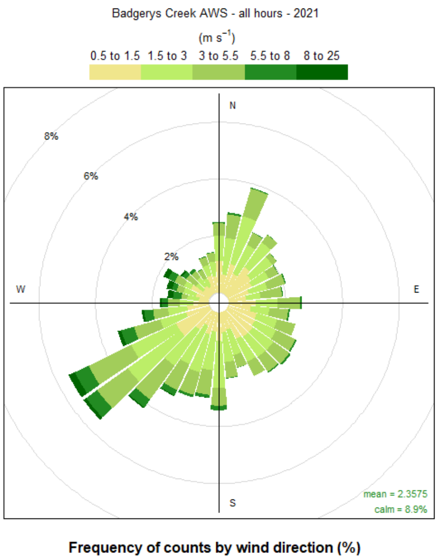
The parameters used in TAPM modelling are presented in Table B3.

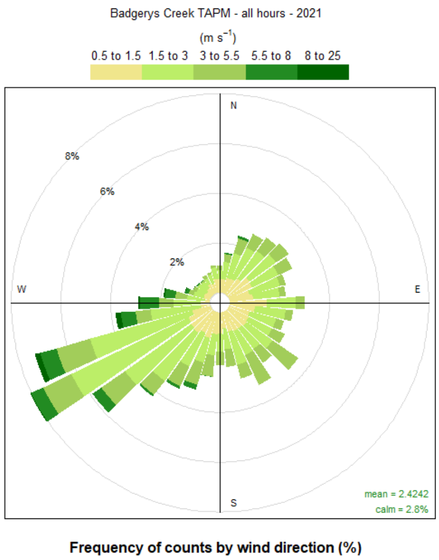
Table B3 TAPM meteorological parameters

TAPM v 4.0.5	
Modelling period	1 January 2021 to 31 December 2021
Centre of analysis	291 954 mE, 6 246 653 mS (UTM Coordinates)
Number of grid points	25 x 25 x 25
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	No assimilation

Figure B3 Modelled and observed meteorological data – Badgerys Creek AWS (2021)

Observed data	Modelled data



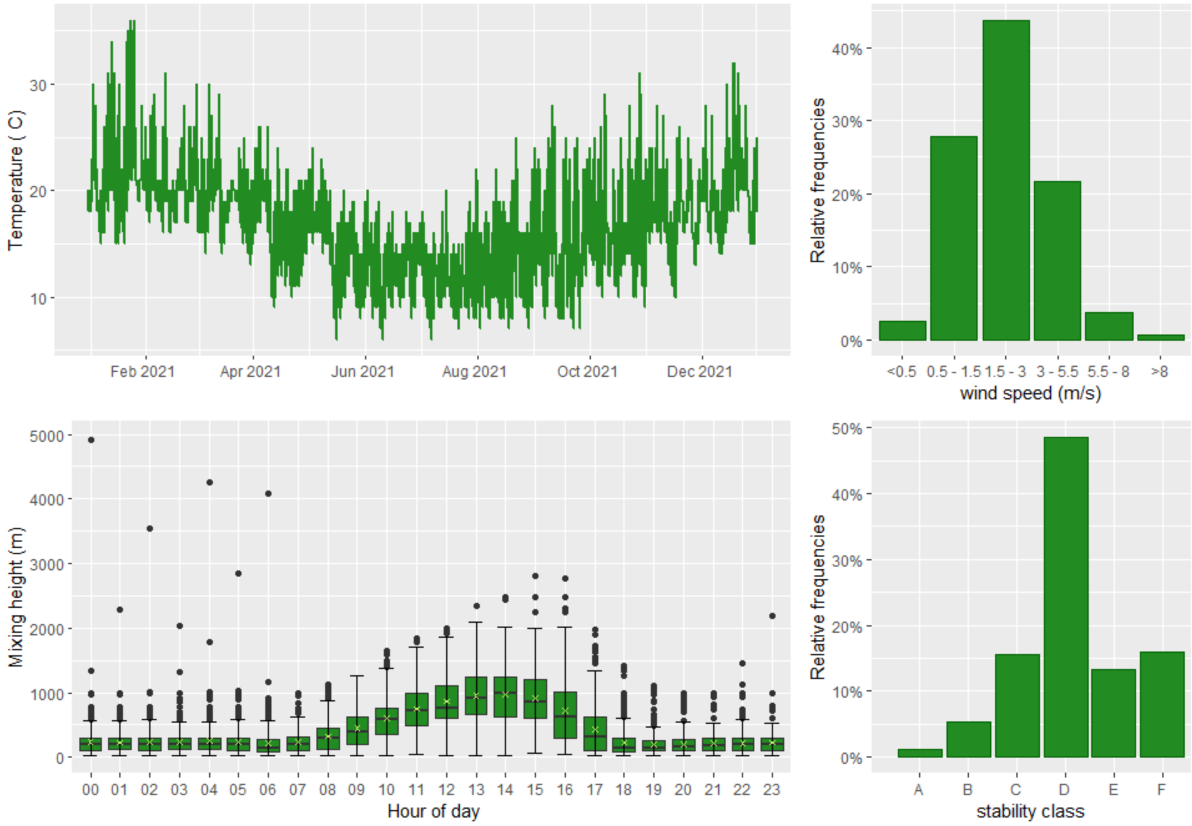


As generally required by the NSW EPA the following provides a summary of the modelled meteorological dataset. Given the nature of the pollutant emission sources at the Proposal site, detailed discussion of the humidity, evaporation, cloud cover, katabatic air drainage and air recirculation potential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

Diurnal variations in maximum and average mixing heights predicted by TAPM at the Proposal site during 2021 period are illustrated in Figure B4.

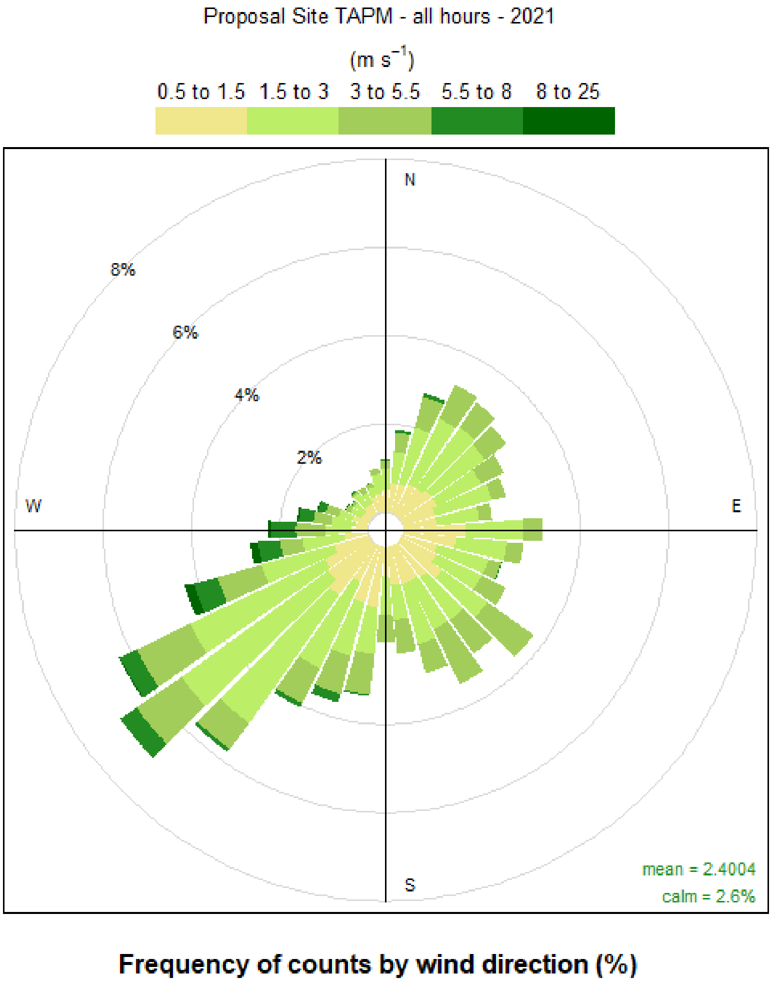
As expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and growth of the convective mixing layer.

Figure B4 Predicted mixing height, wind speed and stability class frequency at the Proposal site (2021)



The modelled wind speed and direction at the Proposal site during 2021 are presented in Figure B5.

Figure B5 Predicted wind speed and direction – Proposal site (2021)



APPENDIX C

Background Air Quality

Air quality is not monitored at the Proposal site and therefore air quality monitoring data measured at a representative location has been adopted for the purposes of this assessment. Determination of data to be used as a location representative of the Proposal site and during a representative year can be complicated by factors which include:

- the sources of air pollutant emissions around the Proposal site and representative AQMS; and
- the variability of particulate matter concentrations (often impacted by natural climate variability).

Air quality monitoring is performed by the NSW Department of Planning and Environment (DPE) at two air quality monitoring stations (AQMS) proximate to the Proposal site. Details of the monitoring performed at these AQMS is presented in Table C1.

Table C1 Details of closest AQMS surrounding the site

AQMS location	Distance to site (km)	2021 data	Measurements			
			PM_{10}	$PM_{2.5}$	TSP	NO_2
Bringelly	2.9	✓	✓	✓	×	✓
St Marys	10.3	✓	✓	✓	×	✓

Given the availability of data and its proximity to the Proposal site, data from Bringelly AQMS is considered to be the most representative air quality dataset and has correspondingly been adopted for use in this assessment. Particulate matter data for the period 2018 to 2022 has been analysed. The annual frequency distribution for the five-year period is presented in Figure C1.

The results of the correlation coefficient analysis provided in Appendix B indicates that meteorological and PM data measured in 2021 is the most appropriate dataset for use within this study.

Concentrations of TSP are not measured at any AQMS surrounding the Proposal site. An analysis of co-located measurements of TSP and PM_{10} in the Lower Hunter (1999 to 2011), Illawarra (2002 to 2004), and Sydney Metropolitan (1999 to 2004) regions is presented in Figure C2. The analysis concludes that, on the basis of the measurements collected in all regions between 1999 to 2011, the derivation of a broad TSP:PM_{10} ratio of 2.0551 : 1 (i.e. PM_{10} represents ~49% of TSP) from the Sydney Metropolitan location is appropriate. In the absence of any more specific information, this ratio has been adopted within this AQIA, resulting in a background annual average TSP concentration of 31.4 $\mu g \cdot m^{-3}$ being adopted.

Summary statistics for the selected data are presented in Table C2.

Figure C1 Annual distribution at Bringelly AQMS for PM_{10} (2018 – 2022)

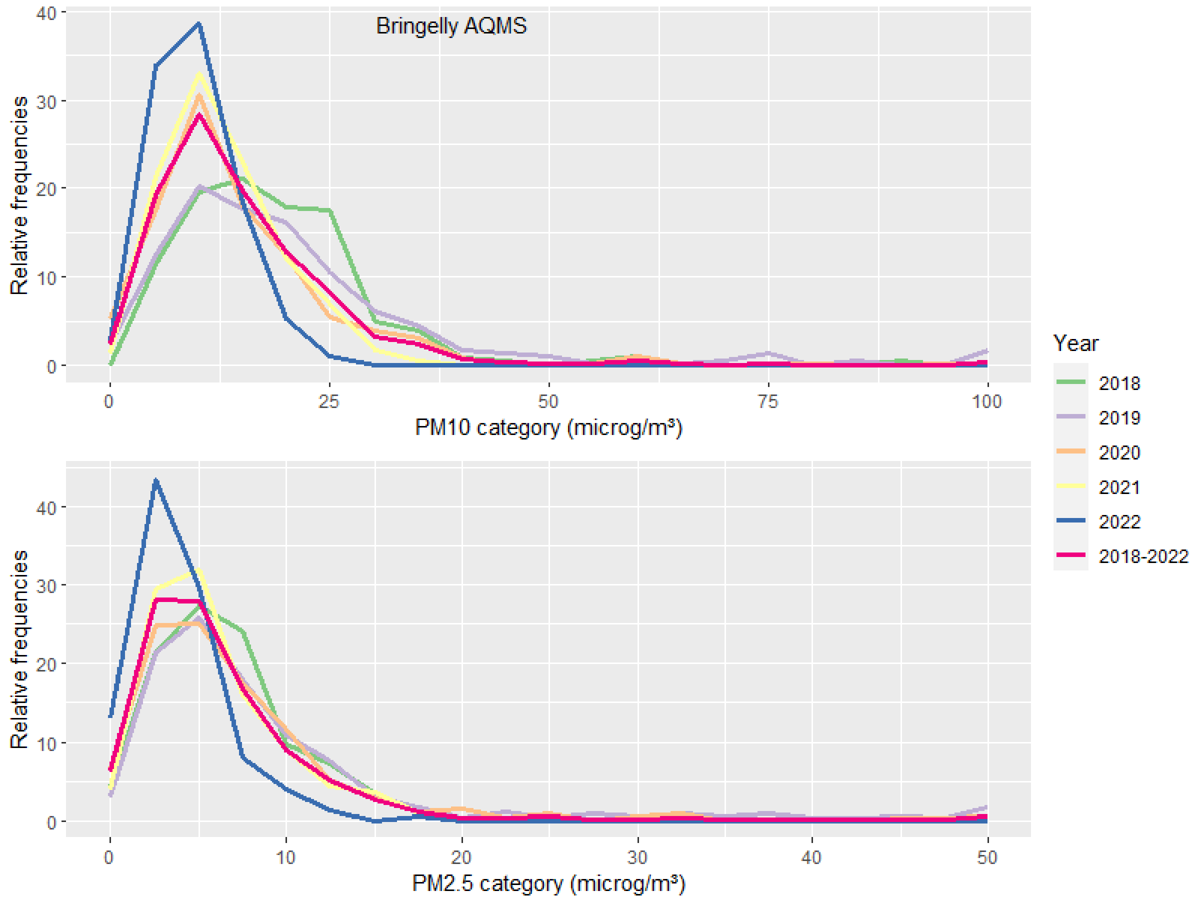


Figure C2 Co-located TSP and PM_{10} measurements – Lower Hunter, Sydney Metro and Illawarra

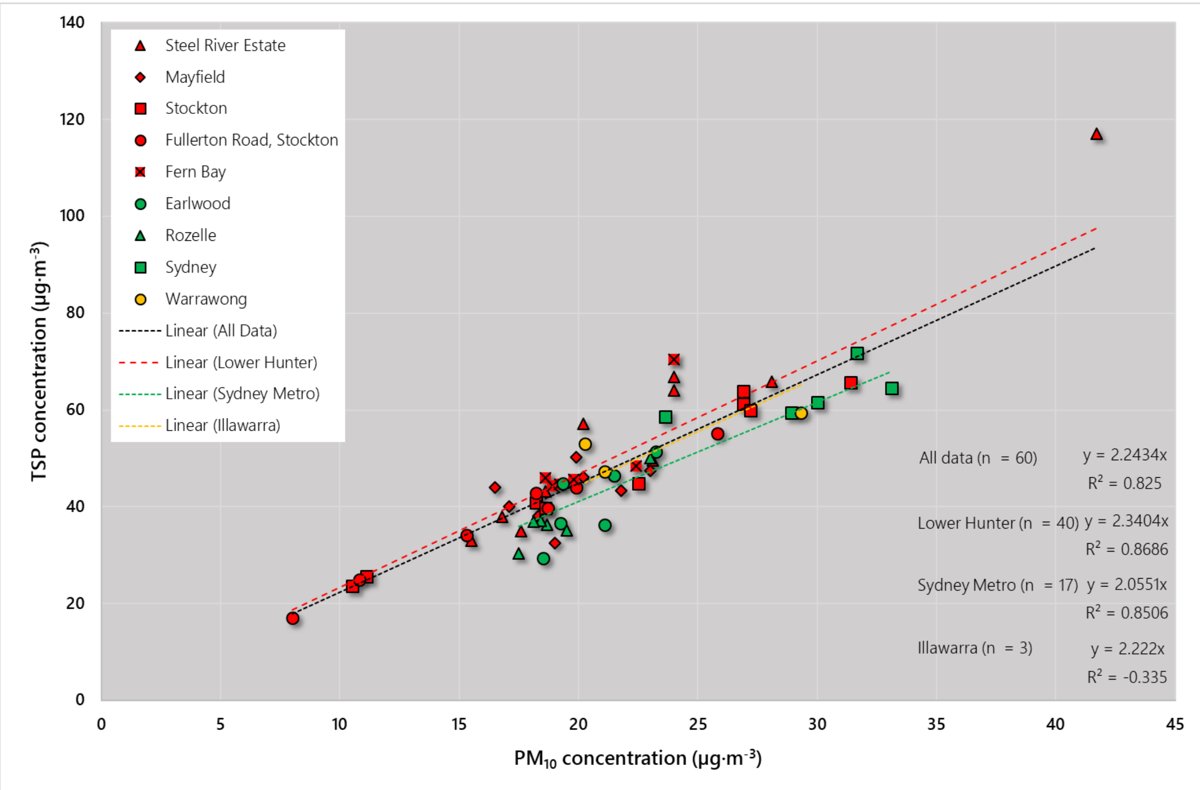


Table C2 Background air quality statistics – Bringelly AQMS (2021)

Pollutant	TSP ($\mu g \cdot m^{-3}$)	PM_{10} ($\mu g \cdot m^{-3}$)	$PM_{2.5}$ ($\mu g \cdot m^{-3}$)	NO_2 ($\mu g \cdot m^{-3}$)
Averaging period	**Annual**	**24-Hour**	**24-Hour**	**1 hour**
Data Points (number)	359	359	361	8 102
Mean	31.4	15.3	7.2	7.1
Standard deviation	-	7.0	4.7	7.3
Skew[1]	-	*1.7*	*4.1*	*1.3*
Kurtosis[2]	-	*9.1*	*35.6*	*2.4*
Minimum	-	-0.4	0.2	-6.2
Percentiles				
25th	-	10.6	4.4	2.1
50th	-	14.2	6.1	6.2
75th	-	19.3	8.8	10.3
90th	-	24.2	12.4	16.4
95t	-	27.2	15.2	20.5
97th	-	28.9	16.2	24.6
98th	-	30.5	16.9	26.7
99th	-	32.7	20.9	30.8
Maximum	31.4	69.0	57.4	49.2
Data Capture (%)	98.1	98.1	98.6	92.2

Notes: 1: Skew represents an expression of the distribution of measured values around the derived mean. Positive skew represents a distribution tending towards values higher than the mean, and negative skew represents a distribution tending towards values lower than the mean. Skew is dimensionless.

2: Kurtosis represents an expression of the value of measured values in relation to a normal distribution. Positive skew represents a more peaked distribution, and negative skew represents a distribution more flattened than a normal distribution. Kurtosis is dimensionless.

Graphs presenting the daily varying PM_{10}, $PM_{2.5}$ and NO_2 data recorded at Bringelly AQMS in 2021 are presented in Figure C3, Figure C4 and Figure C5 respectively.

Figure C3 PM$_{10}$ concentrations –Bringelly AQMS (2021)

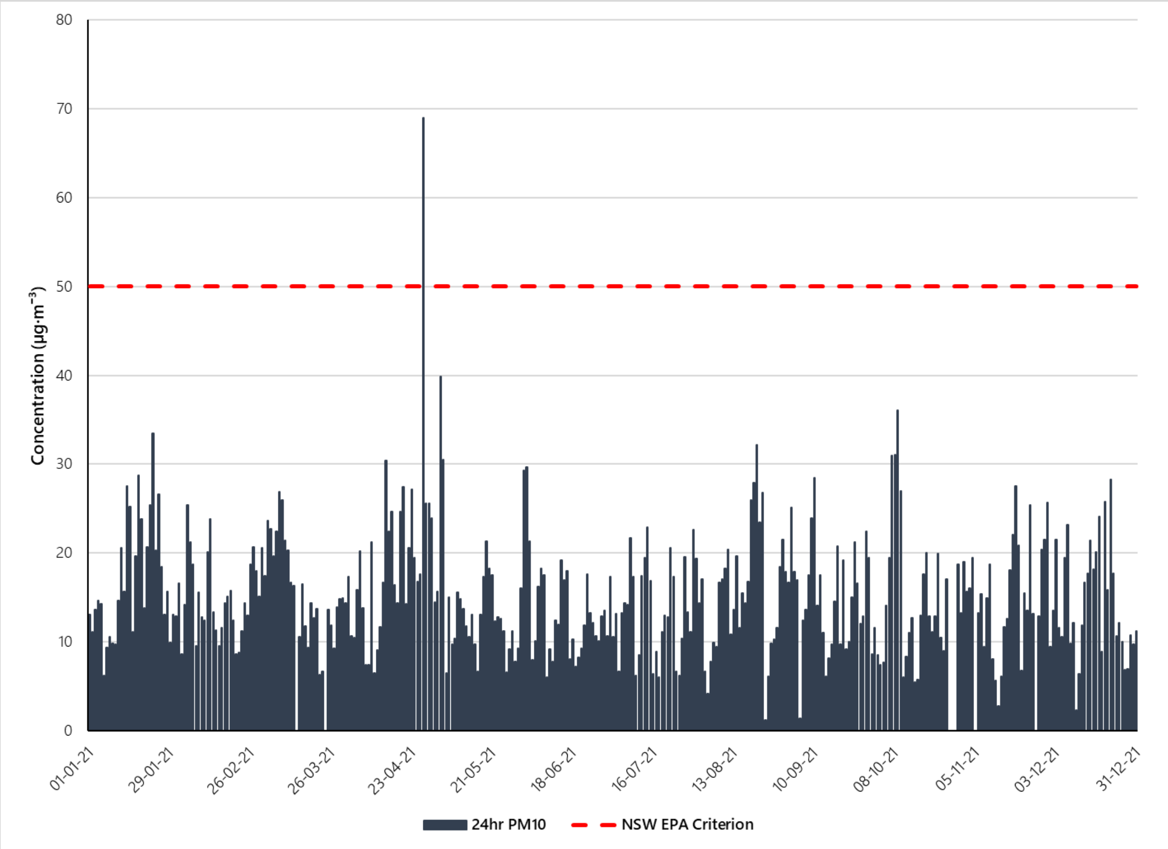


Figure C4 PM$_{2.5}$ concentrations –Bringelly AQMS (2021)

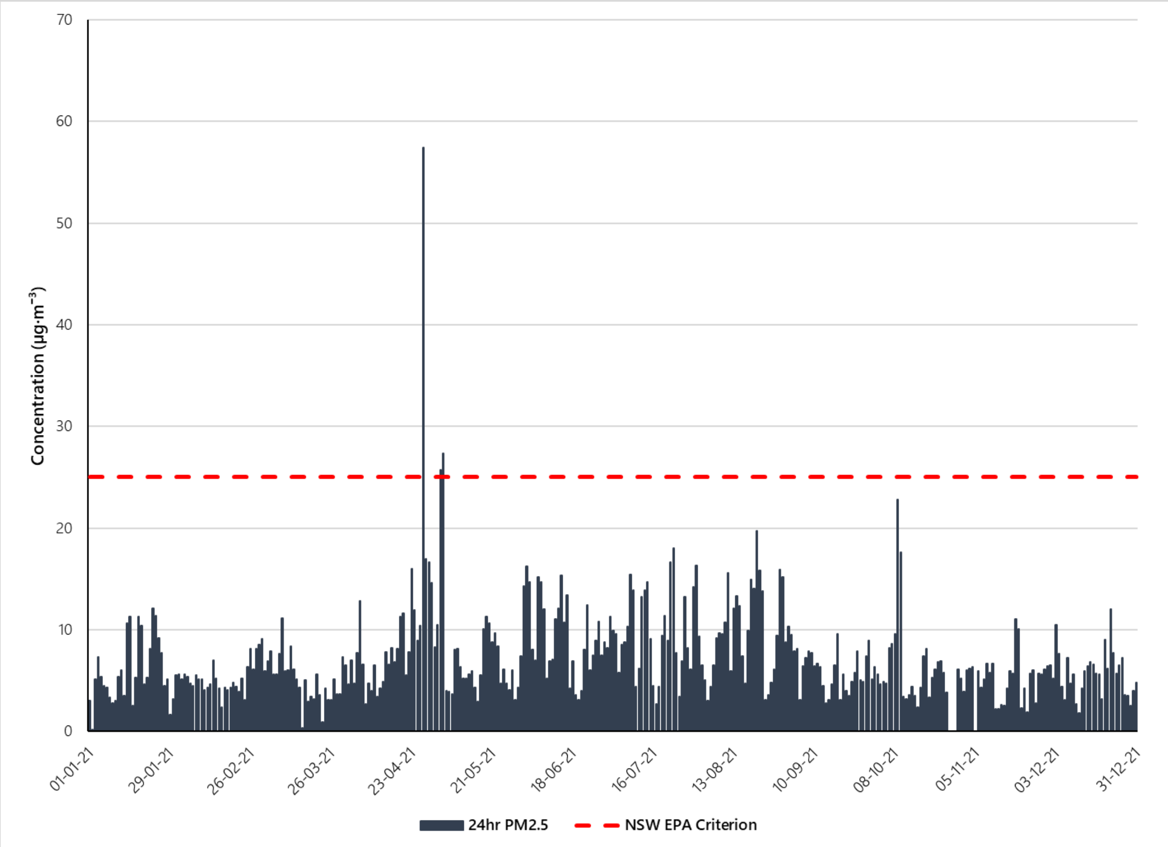
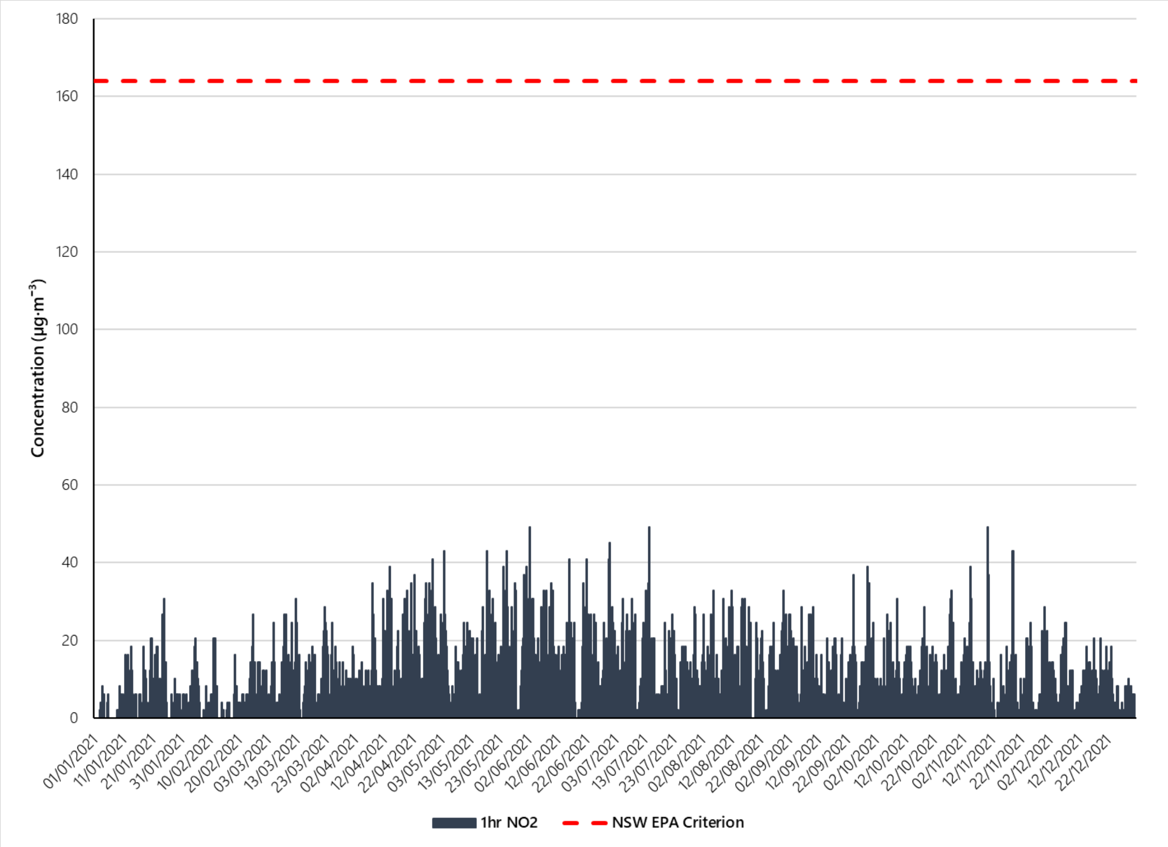


Figure C5 NO_2 concentrations – Bringelly AQMS (2021)



APPENDIX D

Construction Phase Emissions Estimation

Table D1 Construction phase emission rates

Source	Emission factor	Emission rate				Activity rate	Units	Emission controls	Controlled emissions ($kg \cdot yr^{-1}$)		
		TSP	PM_{10}	$PM_{2.5}$	Units				TSP	PM_{10}	$PM_{2.5}$
Scraper topsoil stripping	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	22,153	t	Watering 50%	14.7	6.9	1.1
Topsoil unloading from scraper	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	22,153	t	Watering 50%	14.7	6.9	1.1
Topsoil loading to truck	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	22,153	t	Watering 50%, Minimise drop height 30%	10.3	4.9	0.7
Excavation for cutting	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	60,631	t	Watering 50%	40.2	19.0	2.9
Unloading cut materials	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	60,631	t	Watering 50%, Minimise drop height 30%	28.1	13.3	2.0
Unloading imported fill	AP-42 - Batch drop - Section 13.2.4.3	1.3E-03	6.3E-04	9.5E-05	$kg \cdot t^{-1}$	75,425	t	Watering 50%, Minimise drop height 30%	35.0	16.6	2.5
Grading	AP-42 - Grading - Table 11.9-2	5.3E-02	3.0E-02	1.6E-03	$kg \cdot VKT^{-1}$	81	VKT	Watering 50%	2.1	1.2	0.1
Topsoil export haulage	AP-42 Unpaved roads - Section 13.2.2	3.9E+00	1.1E+00	1.1E-01	$kg \cdot VKT^{-1}$	244	VKT	Watering 75%, Speed reduction 85%	36.0	10.3	1.0
Import fill haulage	AP-42 Unpaved roads - Section 13.2.2	3.9E+00	1.1E+00	1.1E-01	$kg \cdot VKT^{-1}$	829	VKT	Watering 75%, Speed reduction 85%	122.6	35.0	3.5
Total site exposed	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	8.5E+02	4.3E+02	6.4E+01	$kg \cdot ha^{-1} \cdot yr^{-1}$	8.1	ha	Watering 50%	3,435.1	1,717.5	257.6

APPENDIX E

Additional Emissions Control Methods

A number of emissions control methods that may be considered as part of the Trigger Action Response Plan (TARP) to be developed under the Construction Air Quality Management Plan (CAQMP) are outlined below in Table E1. *Guidance on the assessment of dust from demolition and construction* as published by the Institute of Air Quality Management (IAQM, 2024) has been reviewed to identify appropriate control methods.

It is noted that the control methods outlined in Table E1 would be employed at the Proposal site at defined triggers in addition to the control methods already expected to be applied during the construction phase of the Proposal as summarised in Section 5.1.2. Furthermore, Table E1 is not intended to comprise a complete list of emissions control methods to be considered under the TARP and correspondingly, additional or alternative control methods may be outlined within the CAQMP.

Table E1 Emissions control methods to be considered within a TARP

ID	Emissions control method
AQ1	Erect solid screens or barriers around dusty activities or the site boundary that they are at least as high as any stockpiles on site.
AQ2	Keep site fencing, barriers and scaffolding clean using wet methods.
AQ3	Avoid site runoff of water or mud.
AQ4	Cover, seed or fence stockpiles to prevent wind erosion
AQ5	Ensure all vehicles switch off engines when stationary - no idling vehicles
AQ6	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/ mitigation, using non-potable water where possible and appropriate
AQ7	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate
AQ8	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.
AQ9	Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).
AQ10	Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition, high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground.
AQ11	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.
AQ12	Only remove the cover in small areas during work and not all at once
AQ13	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place
AQ14	Use water-assisted dust sweeper(s) on the access and local roads to remove, as necessary, any material tracked out of the site.
AQ15	Avoid dry sweeping of large areas.
AQ16	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.
AQ17	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.

ID	Emissions control method
AQ18	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).
AQ19	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.

air quality | environment | sustainability

air quality	Northstar specialises in all aspects of air quality, dust, and odour management, covering monitoring, modelling and assessment, due diligence and process specification, licencing and regulatory advice, peer review and expert witness.
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