

Williamtown Special Activation Precinct

Air Quality and Odour Report

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7 February 2022

Williamtown Special Activation Precinct

Air Quality and Odour Report

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EXECUTIVE SUMMARY

This report presents the Air Quality and Odour Assessment for the Williamtown Special Activation Precinct (Williamtown SAP). This report provides an investigation of the Williamtown SAP, agreed during the Final Enquiry by Design workshop, as they relate to air quality and odour.

The existing RAAF base/Newcastle Airport is considered within the SAP boundary and is the main existing emission source. This assessment has considered the proposed expansion of the airport taking into account additional aircraft movements and larger aircraft for the year 2036.

There are potential air emission sources in the western catchment of the Williamtown SAP. The potential land uses in this area may include: brewery/distillery, ceramics and glass industries, chemical industries and works, petroleum works, and contaminated soil treatment works. This assessment has considered a proposed stack source located in the western catchment. This stack source has been tested for different flow rates, temperatures, stack diameters and height.

Dispersion modelling has been undertaken for the existing and proposed emission sources. The modelling has focused on the following pollutants; particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides/nitrogen dioxide (NO_x/NO_2) and Volatile Organic Compounds (VOCs). The results have been compared with the current NSW Environment Protection Authority's (EPA) impact assessment criteria and National Environmental Protection (Ambient Air Quality) Measure (NEPM AAQ) standards.

The modelling of the proposed airport expansion showed that any proposed exceedances of the NSW EPA impact assessment criterion or NEPM AAQ standards was due to a high background concentration. For $PM_{2.5}$ exceedances, these were mostly contained with the airport site boundary. For maximum 1-hour NO_2 exceedances, these were for the NEPM AAQ standards and were again due to the high background concentrations. In addition, as this is a 1-hour averaging period it would only occur when high background and maximum concentrations occur at the same time.

For the proposed point source, there were no predicted exceedances of the NSW impact assessment criteria for any of the scenarios for annual average and 24-hour average $PM_{2.5}$, annual average and 24-hour average PM_{10}, annual average NO_2, and the maximum 1-hour for benzene, which was selected for VOCs.

For annual average and maximum 24-hour average $PM_{2.5}$ concentrations, it was noted that results were slightly higher when considering emission rates for the kiln activity, when compared with the crushing activity across heights and flow rates. The predicted cumulative concentrations were dominated by background concentrations. The largest extent of the contours was noted for the 20 m stack with a high flow rate. The modelled concentrations represent stack / point sources emitting at their regulatory limits. It is likely that these emissions will be lower but conservative assumptions have been used. In addition, the modelling has assumed that $PM_{2.5}$ is 100% of total dust, which is a conservative approach.

For the maximum 1-hour NO_2 concentration, the results were again highest for the 20 m stack with the highest flow rate. It should be noted that the NSW EPA impact assessment criterion was not exceeded at any modelled height. For the high flow rate 20 m stack, there were exceedances of the NEPM AAQ standards but this was contained within the Williamtown SAP boundary. There is a significant reduction in the NEPM AAQ standard compared to the NSW EPA impact assessment criterion. In addition, as this is a 1-hour averaging period it could occur only when high background and maximum concentrations occur in the same hour.

For plume rise, the results show that inferred Obstacle Limitation Surface (OLS) incursions are not predicted for the nominal industry stack sources assessed, with plume velocities predicted to reduce below 4.3 m/s prior to reaching the inferred OLS. These results indicate that appropriately scaled industrial sources would be unlikely to adversely impact upon the RAAF Williamtown airspace.

The recommendations, based on air quality are:

- Given the proximity to RAAF Williamtown, any proposed developments should be assessed to compliance with the relevant planning controls for the management of airspace in and surrounding RAAF Williamtown;
- For possible odour/air emissions sources from a proposed brewery or contaminated soil treatment works, it is considered that these industries could be located within the Williamtown SAP with the appropriate controls considered at the design stage so that there is no offensive odour beyond the boundary of the facility;
- The industries proposed are considered suitable for the Williamtown SAP and it is recommended that these are located in the western catchment;
- A single point source (stack) for the industries assessed could be located within the western catchment based on the height, flow rate and other stack parameters modelled; and
- Further air quality modelling and plume rise modelling should be conducted when the exact size and nature of the proposed industry is confirmed. Further modelling is recommended if more than one stack sources is considered within the western catchment.
- The airport has been considered holistically as part of the Williamtown SAP but an upgrade to the airport is subject to a separate assessment and approval process to the Williamtown SAP;

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Acronyms, Abbreviations and Defined Terms

Name	Description
APU	Auxiliary Power Unit
AQMS	Air Quality Monitoring Station
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CASA	Civil Aviation Safety Authority
CPV	Critical plume velocity
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EDMS	Emissions and Dispersion Modelling System
EPA	(NSW) Environment Protection Authority
FAA	Federal Aviation Administration
g/s	Grams per second
GSE	Ground Support Equipment
mg/m^3	milligrams per cubic metre
m/s	Metres per second
NEPM AAQ	National Environment Protection (Ambient Air Quality) Measure
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
OLS	Obstacle Limitation Surface
PM	(airborne) particulate matter
PM_{10}	airborne particulate matter with an aerodynamic diameter of less than 10 µm
$PM_{2.5}$	airborne particulate matter with an aerodynamic diameter of less than 2.5 µm
RAAF	Royal Australian Air Force
SAP	Special Activation Precinct
TAPM	The Air Pollution Model
VOCs	Volatile Organic Compounds
$\mu g/m^3$	micrograms per cubic metre

1. INTRODUCTION

ERM Australia Pacific Pty Ltd (ERM) have prepared an Air Quality and Odour Assessment for the Williamtown Special Activation Precinct (SAP). This report provides an assessment for the Williamtown SAP, as it relates to air quality and odour for the master plan. The report will set out the following:

- A summary of the Williamtown SAP and potential land uses as it relates to air quality and odour;
- The legislative setting and air quality criteria;
- Local meteorological conditions and ambient air quality;
- Emissions calculations for existing and potential air quality sources;
- Dispersion modelling for existing and proposed emission sources;
- Analysis of dispersion modelling results and comparison with air quality and odour criteria; and
- Analysis of plume rise results.

The objective of this report is to assess the land uses in the Williamtown SAP, compare air quality and odour criteria, and recommend performance measures.

1.1 Project background

Funded by the Snowy Hydro Legacy Fund, a Special Activation Precinct is a dedicated area in regional NSW identified by the NSW Government as places where business will thrive. They will create jobs, attract investors and fuel development. The precincts will support industries in line with the competitive advantages and economic strengths of each area.

The new Williamtown precinct will help to create a defence and aerospace hub, boost the local economy and generate thousands of new jobs for the region. It will build on the Hunter region's history of supporting Australia's defence industry and emerging aerospace industry around the Royal Australian Air Force (RAAF) base as well as its proximity to air, road, rail and sea transport.

It aims to build on the NSW Government's existing investment into the Astra Aerolab and create highly-skilled, long-term job opportunities that will attract investors, and strengthen the region's economy. The Special Activation Precinct planning process will deliver coordinated and precinct-wide approach to addressing historical land constraints including flooding and drainage, which have acted as a barrier to development in the past.

The new State Environmental Planning Policy – Activation Precincts SEPP and the master plan will replace existing planning instruments. It will provide for environmental protection and performance, land uses and planning pathways. The goal is to undertake upfront assessment at a strategic level so industry and the community have certainty and clarity about what types of land uses and development can occur where. The draft master plan is expected to go on public exhibition for comments and feedback in the second half of 2021.

1.2 Existing industries/sources

From an air quality perspective, the main existing emission source is Newcastle Airport/Williamtown RAAF Base which is located in the north eastern area of the Williamtown SAP. The Williamtown RAAF Base is Australia's primary fighter pilot training base. For Newcastle Airport, it is considered that all current aircraft movements are for Code C aircraft which are commonly used for domestic flights.

The assessment will include the proposed expansion of Newcastle Airport and will model estimated aircraft movements for 2036.

It is anticipated that by 2036 there will be international flights from Newcastle Airport and therefore this assessment has considered larger aircraft (Code D and Code E) along with an increased number of aircraft movements. For the RAAF base, it is anticipated that the number of military aircraft movements will remain unchanged through to 2036.

This report will present the aircraft movements for 2019 and 2036 and will provide modelling results for 2036. Full details on airport emissions and modelling is detailed in Section 6.1.

1.3 Proposed industries/sources

In the Williamtown SAP there are seven precinct/land uses, some of which include activities that are relevant to air quality planning considerations. Table 1-1 provides a list of these precincts, with detail of activities that potentially include air emission sources, and corresponding key pollutants for these activities.

Table 1-1: Proposed land uses and activities relating to air quality and odour

Land use	Activity with air emission sources	Key pollutants
Freight and Logistics	None	N/A
Defence and Aerospace/Airside		
Environmental Protection		
Light Industrial	- Breweries and distilleries - Ceramic and glass industries - Chemical industries and works - Petroleum works - Contaminated soil treatment works	- Particulate matter (PM_{10} and $PM_{2.5}$) - Nitrogen oxides/nitrogen dioxide (NO_x/NO_2) - Air toxics/volatile organic compounds (VOCs) - Odour
Advanced Manufacturing	None	N/A
Mixed Use/Commercial		
Research and Development (R&D)		

As shown in Table 1-1, activities that are of potential interest to this study are limited to the western catchment. ERM have been requested to consider the viability of a ‘complying development’ pathway for these facilities, whereby the generic emission risks for specific activities can be assessed in a local context, with identification of appropriate mitigation strategies, as suitable to ensure acceptable environmental outcomes from the performing of a given activity.

Table 1-2 outlines the activities and intensities for consideration in the western catchment. The intensities are derived directly from relevant Designated Development triggers listed in Schedule 3 of the *Environmental Planning and Assessment Regulation 2000*, thus representing activities of a scale and intensity for which a complying development pathway would be of relevance.

Table 1-2 Industries for consideration within the western catchment

Activity	Intensity Metric	Value (t/year)[1]
Breweries or distilleries producing alcohol or alcoholic products	Intended production capacity	> 30 tonnes/day; or > 10,000 tonnes/year
Ceramic or glass industries (being industries that manufacture bricks, tiles, pipes, pottery, ceramics, refractories or glass by means of a firing process)	Intended production capacity	> 150 tonnes/day; or > 30,000 tonnes/year
Paint manufacture	Manufactured quantity	> 5,000
Paint solvent manufacture		
Pigments, dyes and/or printing ink manufacture		
Industrial polish manufacture		
Adhesives or sealant manufacture		
Battery industries	Use or recovery	> 30
Petrochemical manufacture	Manufactured quantity	> 2,000
Pesticide, rodenticide, miticide, or nematocide, fumigant or related manufacture	Manufacture of products (excluding simple blending)	> 2,000
	Usage or production of 'poisonous' materials as per ADG code definition.	Any
Herbicide manufacture	Manufactured products (excluding simple blending)	> 2,000
	Use or production of 'poisonous' materials as per ADG code definition.	Any
Fungicide manufacture	Manufacture of products (excluding simple blending)	> 2,000
	Use or production of 'poisonous' materials as per ADG code definition.	Any
Pharmaceutical or veterinary products industries	Use or production of 'poisonous' materials as per ADG code definition.	Any
Synthetic plastic resin manufacture	Manufactured quantity	2,000
Plastics industries	Reprocessing of plastics otherwise than by a simple melting and reforming process	> 5,000
Rubber industries or works	Manufacture of synthetic rubber	> 2,000
	Manufacture, retreading or recycling of rubber products or rubber tyres	> 5,000
	Dump or store used rubber tyres (otherwise than in a building)	> 10 tonnes[2]

Activity	Intensity Metric	Value (t/year)[1]
Soap or detergent industries that manufacture soap or detergent (including domestic, institutional or industrial soap or detergent	Production of materials containing 'poisonous' substances as per ADG code definition.	> 100[3]
	Production of products (excluding simple blending)	> 5,000
Petroleum works	Intended storage capacity of petroleum and natural gas products	> 2000 tonnes liquefied gases > 2,000 tonnes of petroleum products
Contaminated soil treatment (for the purpose of storage only)	Within 100 metres of a natural waterbody or wetland	Any
	In an area of high water table or highly permeable soils	
	Within a drinking water catchment	
	On land that slopes at more than 6 degrees to the horizontal,	
	On a floodplain	
	Within 100 metres of a dwelling not associated with the development.	

Notes:

- [1] Units of t/year unless stated otherwise.
- [2] Defined as an absolute quantity.
- [3] Threshold applies to tonnage of materials containing the poisonous substances.
- 'ADG Code' – Australian Dangerous Goods Code.
- Intensities are based on designated development thresholds articulated in Schedule 3 of the Environmental Planning and Assessment Regulation 2000, and should be consulted directly where clarification is sought.

The range of air potential air emissions from these activities is diverse in nature, and in the context of prospective air emissions, will likely be unique for any given facility. These emissions will depend on a range of factors, which include:

- The manufacturing operation undertaken, inclusive of:
  - operations performed and processes used;
  - materials handled;
  - intensity of production; and
  - scale of the facility.
- The type of emission controls and management techniques employed.

The Protection of the Environment Operations (Clean Air) Regulation 2021 provides emission limits for a range of industries which conduct activities at thresholds for which the activity is deemed a 'scheduled activity'. In addition, generic emission limits are provided for non-scheduled activities. In many cases, it is likely that emission controls will either need to perform at a level below that specified by generic emission limits in order to attain compliance with ambient air quality criteria, or alternatively, there may be no regulatory emission limit for the key pollutants of interest.

In this respect, for the range of facilities outlined in Table 1-2, the ability to comply with relevant ambient air quality standards is not able to be readily definable by criteria such as emission limits and / or generic management measures.

In this respect, it is identified that for proposed facilities of a scale that would constitute designated development, a detailed air quality impact assessment would be required, incorporating an air emission inventory that is specific to the manufacturing processes undertaken, and the capabilities of the emission controls that are proposed.

Noting these limitations, within this assessment, a broad consideration of potential air quality risks has been made based on a refined understanding of prospective activities that may be undertaken within the western catchment.

For breweries and distilleries and contaminated soil treatment works, the key pollutant is expected to be odour (NPI, 2007). For ceramic and glass industries the key pollutants are expected to be PM_{10}, $PM_{2.5}$ and NOx/NO_2 (NPI, 1998). For chemical industries and works and petroleum works the key pollutants are expected to be VOCs (NPI, 1999a and NPI, 1999b).

The land use area with proposed air emission sources is the western catchment of the Williamtown SAP and furthest from the airport runway.

Schedule 1 of the *Protection of the Environment Operations Act 1997* has been reviewed for relevant activity thresholds for activities listed in **Error! Reference source not found.**. Operations that trigger these thresholds would require an Environmental Protection Licence EPL, and where point sources are included within the design, would be required to meet relevant emission limits detailed within Schedule 3 and Schedule 4 of the *Protection of the Environment Operations (Clean Air) Regulation 2021* at a minimum.

The masterplan has assessed a single stack source located in the western catchment. This stack source has been tested for different flow rates, temperatures, stack diameters and height, with the assumption that pollutant emissions are present at the relevant regulatory limits. Further details of emissions sources is provided in Section 6.

Error! Reference source not found. notes that odour is a potential key pollutant. There are potential odour sources from the brewery/distillery and contaminated soil treatment works. It is considered that with appropriate design controls these industries will be able to control odour emissions and therefore odour modelling has not been conducted within this report. In Section 7 it is noted that there are potential emissions of VOCs from the ceramics industry which can potentially be odorous. These have been included in the point source modelling detailed in Section 6.2 and Section 7.3.

1.4 Data gaps and limitations

For this assessment, there are a range of proposed activities that could be located in the western catchment. It is not currently confirmed whether any or all or a combination of these activities would proceed in this area. On that basis, this assessment has considered a range of pollutants that may be emitted through a point source to address these activities.

With regard to the proposed airport expansion, proposed aircraft movements for 2036 could not be provided within the timescale of the assessment. On that basis, an estimate of an increase in flights has been calculated. Further details are provided in Section 6.

Based on the above, the main assumptions for this assessment are as follows:

- Point source modelling:
  - The main pollutants from the proposed activities/industries are: $PM_{2.5}$, PM_{10}, NO_2, and Volatile Organic Compounds (VOCs);
  - Only one stack will be located within the western catchment;

  - Emission rates have been calculated based on the in-stack concentration limits taken from the Protection of the Environment Operations (Clean Air) Regulation 2021;
  - Stack parameters have been selected that are suitable for the proposed industries and a range of stack heights, diameters, temperatures and flow rates have been assessed; and
  - The proposed stack height would not exceed 20 m.
- Williamtown RAAF base/Newcastle Airport:
  - Military aircraft movements will remain unchanged from 2019 to 2036;
  - There will be an increase in commercial aircraft movements at Newcastle Airport. The increase in aircraft movements has been calculated based on the proposed increase in passenger numbers taken from the 2036 Newcastle Airport vision; and
  - The additional commercial aircraft movements in 2036 will include international flights and therefore larger Code D and Code E aircraft.

2. LEGISLATIVE SETTING AND AIR QUALITY CRITERIA

There are a number of different activities in the western catchment of the Williamtown SAP that can contribute emissions of various pollutants. The main pollutants that will be considered in this analysis are:

- Particulate matter - $PM_{2.5}$: particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres (μm);
- Particulate matter – PM_{10}: particulate matter with an equivalent aerodynamic diameter of 10 micrometres (μm);
- Nitrogen oxides (NO_x)/Nitrogen dioxide (NO_2); and
- Air toxics/volatile organic compounds (VOCs).

2.1 Air quality issues and effects

2.1.1 Particulate matter

Particulate matter has the capacity to affect health and to cause nuisance effects and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges of interest for this report are commonly described as:

- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10 μm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10 μm and with a unit density. PM_{10} are a sub-component of TSP.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 μm diameter (a subset of PM_{10}). These are often referred to as the fine particles and are a sub-component of PM_{10}.

No safe threshold has been identified for the human health effects of particles (NSW DECCW, 2010) and, for $PM_{2.5}$, there is substantial evidence of health associations down to very low concentrations. $PM_{2.5}$ may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

2.1.2 Oxides of nitrogen (NOx)/nitrogen dioxide (NO_2)

By convention, NO_X is the sum of NO and NO_2. NO_2 is predominantly a secondary pollutant, being produced by the oxidation of NO in atmospheric photochemical reactions.

Some atmospheric pollutants have slow chemical reaction rates, and for air quality modelling on a local scale they can essentially be treated as inert. This is not the case for NO_2 since it is rapidly formed through the atmospheric reaction of NO with O_3, and is destroyed by sunlight during the day. This is one reason why air pollution models are generally configured to predict NO_X concentrations, with the spread of NO_X being simulated as though it were a non-reactive gas. However, as air quality criteria address NO_2 rather than NO_X, it is necessary to estimate NO_2 concentrations from the modelled NO_X concentrations.

Nitrogen dioxide (NO_2) is an irritant and oxidant which has been linked to a range of adverse health effects, with the most consistent associations found with respiratory outcomes (COMEAP, 2009).

2.1.3 Air toxics/Volatile Organic Compounds (VOCs)

Air pollutants are often divided into 'criteria' pollutants and 'air toxics'. Criteria pollutants tend to be ubiquitous and emitted in relatively large quantities, and their health effects have been studied in some detail.

Air toxics are gaseous or particulate organic pollutants that are present in the air in low concentrations, but are defined on the basis that they are, for example, highly toxic, carcinogenic or highly persistent in the environment, so as to be a hazard to humans, flora or fauna.

For this assessment, benzene has been adopted as a surrogate for VOCs on the basis of its prevalence in a range of industrial emissions and the relative stringency of the benzene impact assessment criterion. The combined influence of these two factors support the use of benzene as a conservative surrogate for the assessment of VOCs where the speciation is unknown. As additional context, it is also noted that within Victoria (which shares the same benzene criterion), benzene commonly forms the sole pollutant considered in assessment of VOCs from fuel terminals and storage facilities.

2.2 Ambient air quality standards and criteria

An ambient air quality standard defines a metric relating to the concentration of an air pollutant in the ambient air. Standards are usually designed to protect human health, including sensitive populations such as children, the elderly, and individuals suffering from respiratory disease, but may relate to other adverse effects such as damage to buildings and vegetation. The form of an air quality standard is typically a concentration limit for a given averaging period (e.g. annual mean, 24-hour mean), which may be stated as a 'not-to-be-exceeded' value or with some exceedances permitted. Several different averaging periods may be used for the same pollutant to address long-term and short-term exposure. Each metric is often combined with a goal, such as a requirement for the limit to be achieved by a specified date.

In 1998, Australia adopted a National Environmental Protection (Ambient Air Quality) Measure (NEPM AAQ) that established national standards for six criteria pollutants (NEPC, 1998). The AAQ NEPM was extended in 2003 to include advisory reporting standards for PM with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$) (NEPC, 2003). The standards for PM were further amended in February 2016 (NEPC, 2016).

In 2016 the National Environment Protection Council (NEPC) approved a variation to the NEPM AAQ for particles to reflect the latest scientific understanding of health risks. On 15 April 2021, the National Environment Protection Council (NEPC) agreed to vary the NEPM AAQ, approving an amending instrument to incorporate more stringent standards for NO_2 amongst others.

Table 2.1 presents NSW impact assessment criteria taken from the NSW Environment Protection Authority's (EPA) document titled *"Approved methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW"* (Approved Methods) (NSW EPA, 2016) and NEPM AAQ standards.

Table 2.1: NSW impact assessment criteria and NEPM AAQ standards

Pollutant or metric	Maximum concentration (µg/m³)		Averaging period
	Approved Methods	NEPM AAQ standards	
Particulate matter <2.5 µm ($PM_{2.5}$)	25	25	24 hour
	8	8	Annual
Particulate matter <10 µm (PM_{10})	50	50	24 hour
	25	25	Annual
Nitrogen dioxide (NO_2)	246	164	1 hour
	62	31	Annual

In addition to the above there are National Environment Protection goals. For particles as $PM_{2.5}$ from 1 January 2025 the goals are 20 µg/m^3 for maximum 24-hour average and 7 µg/m^3 for annual average. The modelling results have been discussed against these goals in Section 7.

For air toxics, the NSW Approved Methods specify air quality impact assessment criteria and odour assessment criteria for many other substances (mostly hydrocarbons), including air toxics.

Table 2.2 presents the NSW impact assessment criterion for air toxics. As previously mentioned, this assessment will focus on benzene as a surrogate for VOCs.

Table 2.2: NSW impact assessment criterion for benzene

Substance	99.9th Percentile Concentration (µg/m³)	Averaging period
Benzene	29	1 hour

2.3 Odour

2.3.1 *Measuring odour concentration*

There are no instrument-based methods that can measure an odour response in the same way as the human nose. Therefore, “dynamic olfactometry” is typically used as the basis of odour management by regulatory authorities.

Dynamic olfactometry is the measurement of odour by presenting a sample of odorous air to a panel of people with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. The correlations between the known dilution ratios and the panellists’ responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement using dynamic olfactometry are “odour units” (OU) which are dimensionless and are effectively “dilutions to threshold”.

As with all sensory methods of identification there is variability between individuals. Consequently the results of odour measurements depend on the way in which the panel is selected and the way in which the panel responses are interpreted.

2.3.2 *Odour performance criteria*

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably. There is still considerable debate in the scientific community about appropriate odour goals as determined by dispersion modelling.

The EPA has developed odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour.

There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW, and
2. how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are the so-called FIDOL factors:

- the Frequency of the exposure;
- the Intensity of the odour;
- the Duration of the odour episodes;
- the Offensiveness of the odour; and
- the Location of the source.

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant.

Some odours, for example the smell of sewage, hydrogen sulfide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The NSW EPA Approved Methods include ground-level concentration criteria for complex mixtures of odorous air pollutants. They have been refined by the NSW EPA to take account of population density in the area. Table 2.3 lists the odour thresholds, to be exceeded not more than 1% of the time, for different population densities.

The difference between odour goals is based on considerations of risk of odour impact and not differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. An important point to note is that the odour assessment criteria are not intended to achieve ‘no odour’. They are concerned with controlling odours to ensure offensive odour impacts will be effectively managed.

Table 2.3: Odour performance criteria

Population of affected community	Odour performance criteria (nose response odour units at the 99th percentile)
Single rural residence (≤ ~2)	7
~10	6
~ 30	5
~ 125	4
~ 500	3
Urban (~ 2000) and/or schools and hospitals	2

2.4 Summary

To summarise, this section has provided the NSW impact assessment criteria and the NEPM AAQ standards for air quality and odour performance criteria. For the purposes of this assessment report, the results from the air quality modelling will be compared with the NSW impact assessment criteria and NEPM AAQ standards. For any proposed facility emitting odour, there will be a requirement for no offensive odour beyond the boundary of the facility.

3. LOCAL METEOROLOGICAL CONDITIONS

This report section provides a summary of the local climate and meteorology. These factors are relevant to the consideration of atmospheric dispersion, as well as the existing condition of the airshed, which forms an important consideration in the prediction of total pollutant concentrations, for assessment against cumulative air quality criteria.

3.1 Climate and meteorology

The area has a humid sub-tropical climate with warm summers and mild winters. Precipitation is typically heaviest in the first half of the year when east coast lows can bring very heavy falls and damaging winds. The region is influenced by land and sea breeze flows, which have significant implications for air quality when extended anticyclonic conditions occur (PAE Holmes, 2011a). Within the Williamtown SAP is the Bureau of Meteorology (BoM) Williamtown RAAF Automatic Weather Station (AWS).

Table 3.1 presents a summary of compiled climate statistics for the BoM Williamtown RAAF Weather Station.

Table 3.1: Summary of climate statistics for BoM Williamtown RAAF

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6
Humidity	72	76	77	76	79	80	77	71	66	64	66	68	73
3pm Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8
Humidity	59	62	61	59	60	60	55	50	50	54	55	56	57
Daily Maximum Temperature (ºC)													
Mean	28.3	27.7	26.4	23.8	20.4	17.7	17.2	18.8	21.5	23.8	25.6	27.4	23.2
Daily Minimum Temperature (ºC)													
Mean	18.2	18.1	16.4	13.2	10.1	8.0	6.4	6.9	9.1	12.0	14.4	16.6	12.4
Rainfall (mm)													
Mean	98.3	118	121	110	109	125	72.6	72.8	60.1	75.9	81.9	77.5	1118
Rain days (Number)													
Mean	6.9	7.9	7.4	5.7	4.2	6.1	4.4	3.9	5.9	6.7	8.0	8.0	75.1

Source: BOM (2020) Climate averages for Station 061078; Commenced: 1942 – Last Record 05/11/2020 (2010 for 9 am and 3 pm conditions); Latitude: 32.79° S; Longitude: 151.84° E

The data show that January is the warmest month with an average maximum temperature of 28.3°C. July is the coolest month with an average minimum temperature of 6.4°C. February through April produces the highest average monthly rainfall, whilst the number of rain days is relatively consistent across all months of the year. Winters are generally drier with the highest prevalence of clear conditions.

Table 3.2 presents a summary of wind parameters from the BoM Williamtown RAAF AWS from 2015 to 2020.

Table 3.2: Wind data – summary statistics (BoM Williamtown RAAF AWS)

Year	Average Wind Speed (m/s)	Calm Periods (%)	Data capture rate (%)
2015	4.2	6.6	99.2
2016	4.5	2.8	98.1
2017	4.2	4.6	99.1
2018	4.3	4.3	99.3
2019	4.3	4.9	97.1
2020	4.3	4.5	99.9
All years (2015-2020)	**4.3**	**4.6**	**98.8**

Figure 3.1 to Figure 3.6 provide annual and seasonal wind roses for the BoM Williamtown RAAF AWS across this period.

As shown in these figures and Table 3.2, winds are generally consistent between years, with an average wind speed of 4.3 m/s and calm conditions generally occurring less than 5% of the time. Dominant winds from west-north-west in winter are consistent with those seen near to the Hunter River, and show the influence of the Hunter Valley topography. East-north-easterly and south-easterly winds are dominant during summer, whilst north-westerly winds are dominant during autumn. Winds in spring are blended around the valley axis, with strong north-westerly winds present during early spring.

Based on the data provided, the year 2018 is considered to be a representative year for modelling with a high data capture and average wind speed and calm periods consistent with the five year average.

There are nearby Department of Planning and Environment (DPE) monitoring stations that monitor meteorological parameters, but these are located outside of the Williamtown SAP. The closest DPE monitoring station is located at Beresfield. The wind roses for Beresfield and BoM Williamtown RAAF have been compared for 2018.

Figure 3.7 wind roses for 2018 for Beresfield. It can be seen that the same trends are apparent at Beresfield and Williamtown RAAF. This provides further assurance that the meteorological data used for Williamtown RAAF is representative of the area.

Discussion of air quality monitoring conducted at the DPE monitoring stations is detailed in the following section.

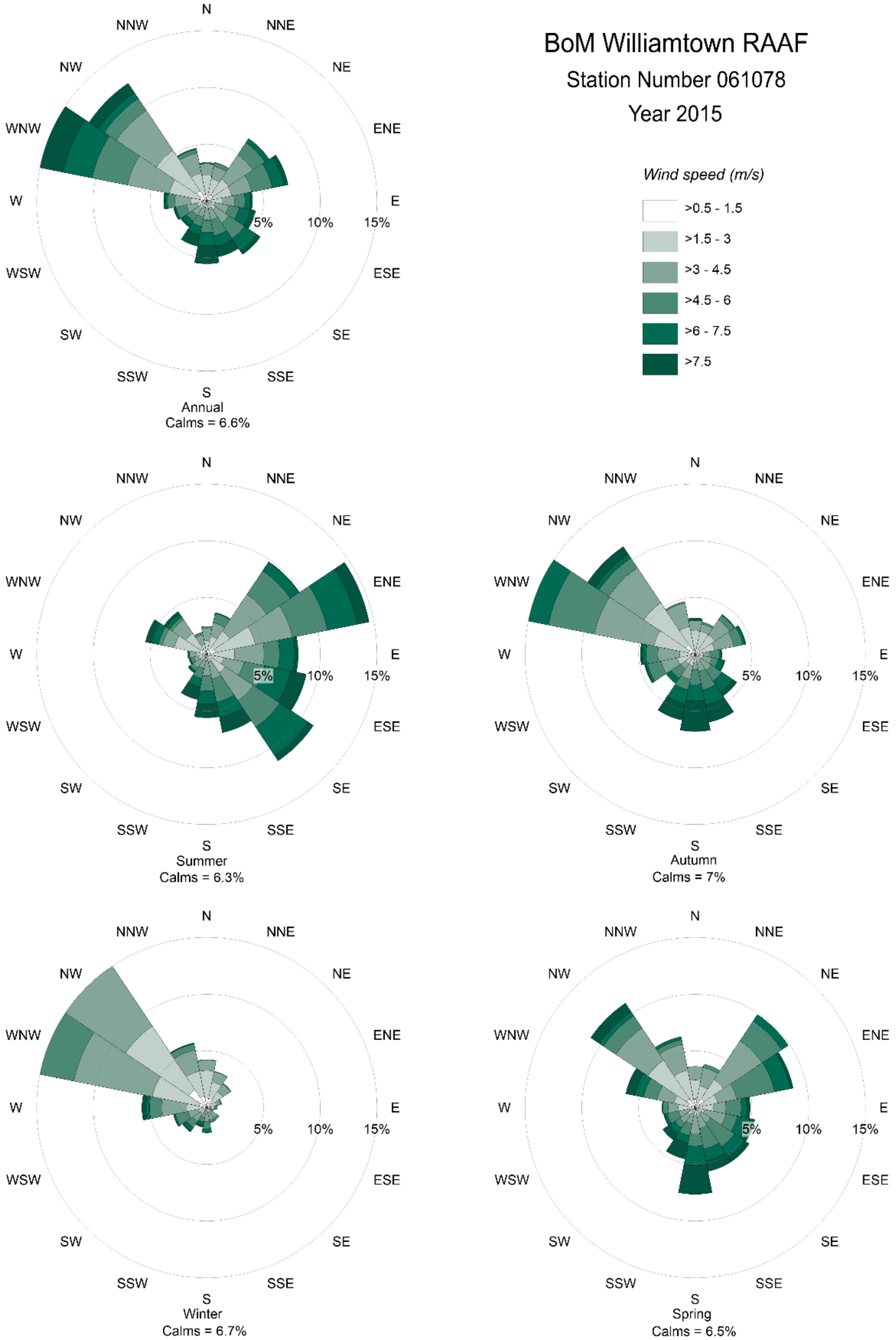


Figure 3.1: Annual and seasonal windroses - BoM Williamtown RAAF, 2015

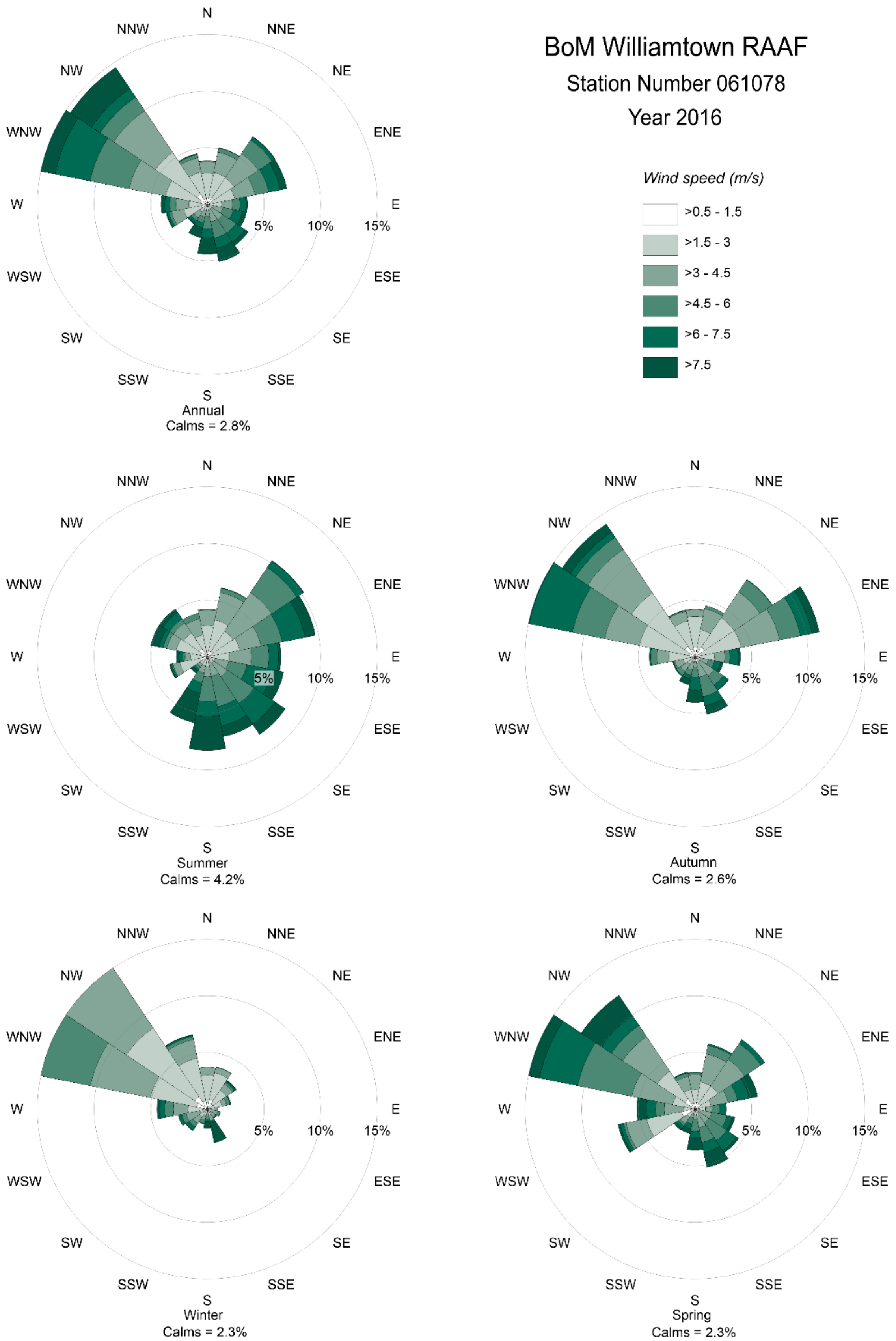


Figure 3.2: Annual and seasonal windroses - BoM Williamtown RAAF, 2016

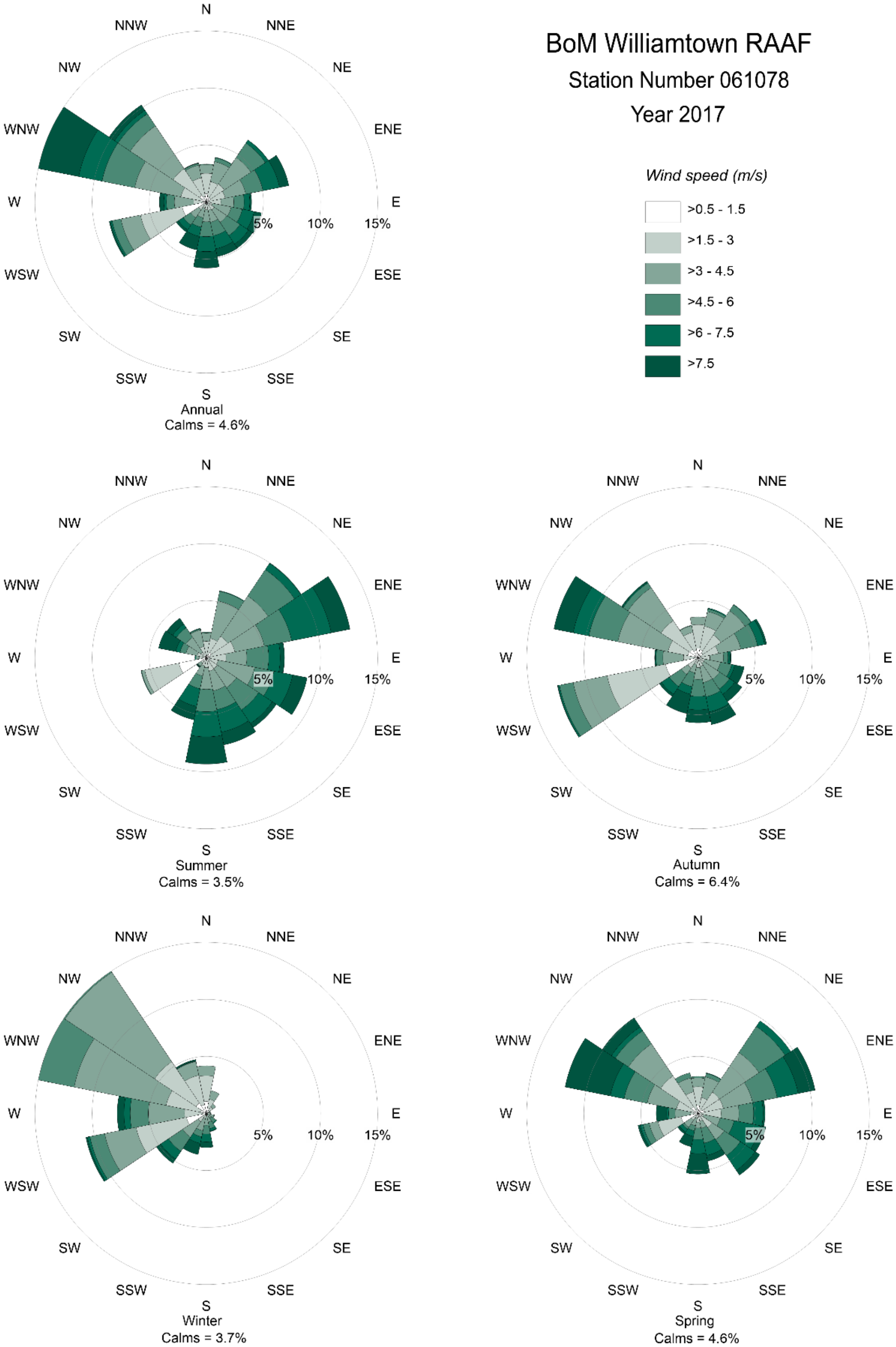


Figure 3.3: Annual and seasonal windroses - BoM Williamtown RAAF, 2017

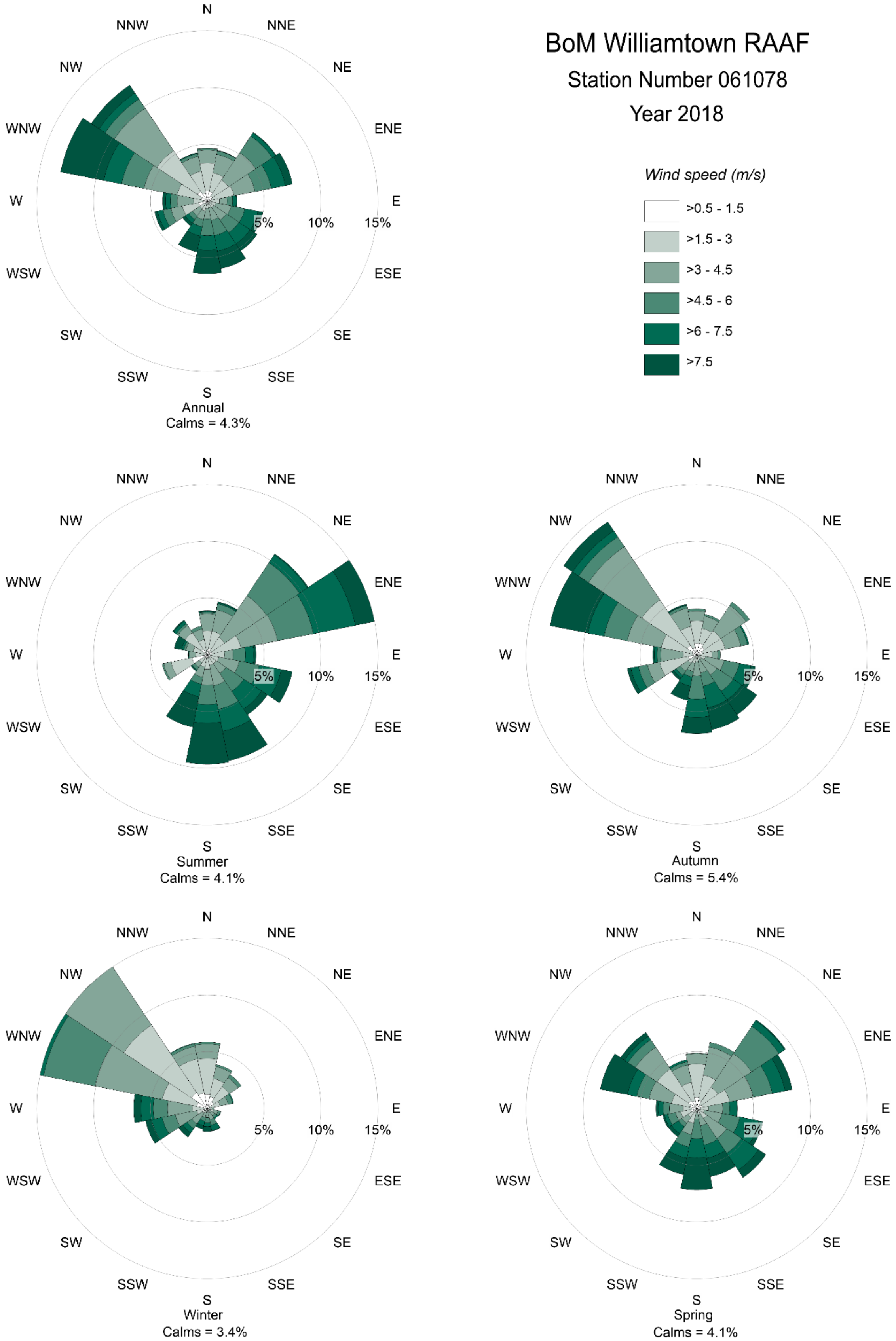


Figure 3.4: Annual and seasonal windroses - BoM Williamtown RAAF, 2018

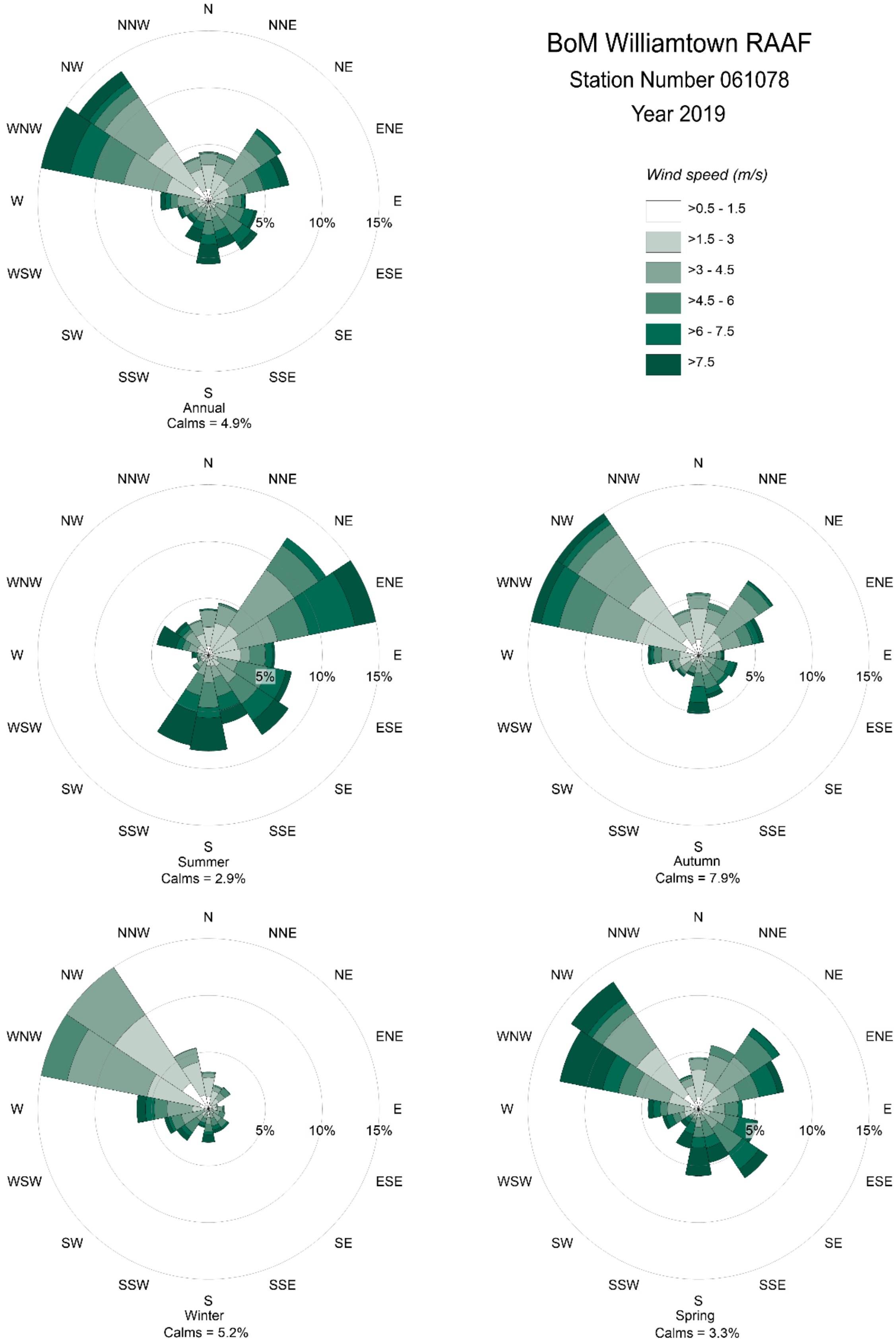


Figure 3.5: Annual and seasonal windroses - BoM Williamtown RAAF, 2019

Figure 3.6: Annual and seasonal windroses - BoM Williamtown RAAF, 2020

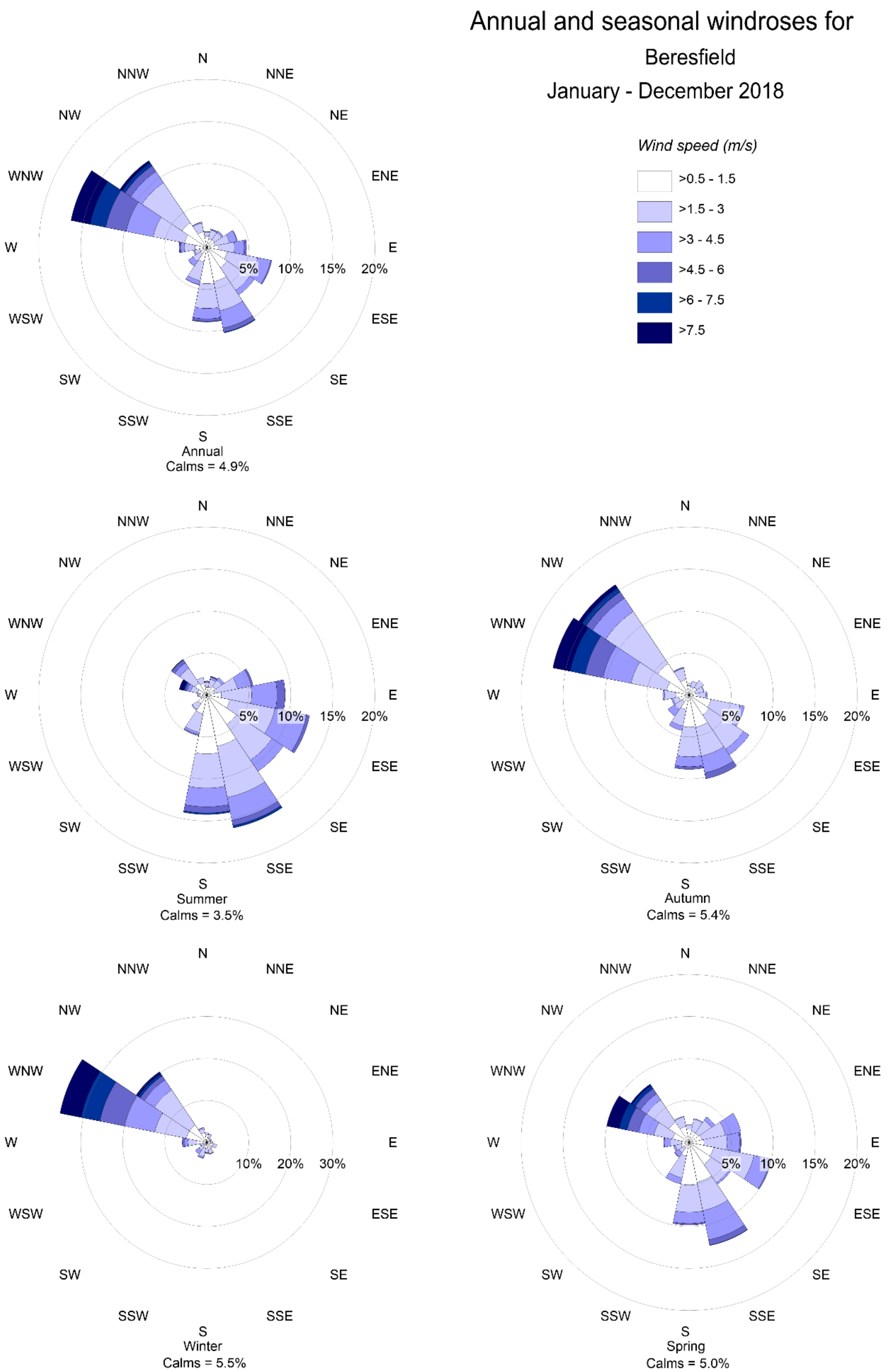


Figure 3.7: Annual and seasonal windroses - Beresfield (2018)

4. LOCAL AMBIENT AIR QUALITY

The NSW DPE operate six air quality monitoring stations (AQMS) within the Newcastle region. These AQMS collect both meteorological and ambient air quality data. Table 4.1 presents a summary of nearby AQMS locations, with proximity to the Proposal.

Monitoring data from 2015 through to 2020 has been summarised in the following sections.

Table 4.1: Summary of nearby AQMS and weather stations with proximity to the nearest boundary of the Williamtown SAP

AQMS location	Easting (kmE, MGA94)	Northing (kmE, MGA94)	Distance from Williamtown SAP/ Bearing
Beresfield	374.627	6370.449	15 km W
Stockton	386.306	6358.923	9 km SW
Wallsend	375.623	6359.638	15 km SW
Newcastle	384.038	6355.662	13 km S
Mayfield	381.057	6360.752	11 km SW
Carrington	384.350	6358.050	10 km S

As presented in Table 4.1, there are six air quality monitoring stations that are located within 15 km of the Williamtown SAP. This is a significant dataset in close proximity to the region. It is considered beneficial to this assessment to have multiple monitoring stations within close proximity to the Williamtown SAP. These monitoring stations show air quality varies across this region, the effect from local industry and representative background concentrations. The site at Beresfield is able to provide representative background concentrations for the area and is located within 15 km of the Williamtown SAP. Due to the project timelines, there is insufficient time to conduct site specific monitoring and any data gathering would not provide the depth of data that is available from the DPE monitoring stations. Data would need to be collected for a minimum of 12 months, likely longer, to be of any benefit to this project. Further, even if these data were collected, they would be unlikely to add anything further to the discussion already presented. It has been demonstrated that the air quality in the Williamtown SAP is unlikely to be significantly different to that already presented in the surrounding area, in particular Beresfield.

4.1 PM_{10}

Continuous hourly average ambient PM_{10} concentrations are measured at all six locations. Figure 4.1 presents the annual average concentration of PM_{10} for the period 2015 to 2020.

Trends are varied with annual average concentrations over the six-year period highest at Stockton (44 µg/m³), followed by Carrington (31 µg/m³) and Mayfield (31 µg/m³). The six-year average at Beresfield (26 µg/m³) is near to that at Newcastle (28 µg/m³), and higher than Wallsend (23 µg/m³). Inter-annual variability in peak statistics is primarily driven by the influence of exceptional events such as dust storms, hazard reduction burning and bushfire activity. In 2019, extensive bushfires were the major influences on elevated PM_{10} concentrations throughout NSW. During 2020 the extensive bushfires continued for the first few months of the year.

Figure 4.2 shows the 24-hour average PM_{10} concentrations from 2015 to 2020 at each site. It shows the significant variations throughout the year with peaks in the warmer months, and highly elevated levels during the bushfire periods of November 2018, later 2019 and start of 2020. For the majority of the time, concentrations remain below the 24-hour criterion of 50 µg/m³.

From the review of local monitoring and background concentrations it is considered that Beresfield is the most representative monitoring station for background concentrations. For annual average PM_{10} at Beresfield, it can be seen that concentrations are steadily increasing from 2015 through to 2017 before greater increases in 2018 and 2019. During 2019 there were some significant bushfire events which have affected the PM_{10} concentrations. During 2020, the concentrations at Beresfield were the lowest recorded across the six-year period. With much greater concentrations being experienced during 2019, these have not been considered for a period average. The five-year period average across the years 2015, 2016, 2017, 2018 and 2020 is 19.5 µg/m^3. This value exceeds the annual average for 2015, 2016 and 2020 and is similar to the annual average in 2017 (19.6 µg/m^3). The background value of 19.5 µg/m^3 is considered appropriate for the background PM_{10} concentration.

To determine a maximum 24-hour average PM_{10} concentration at Beresfield, the 98th percentile has been considered. Similar to the above, the concentrations for 2019 are excluded. The 98th percentile for Beresfield covering the years 2015-2018 and 2020 is 39.2 µg/m^3.

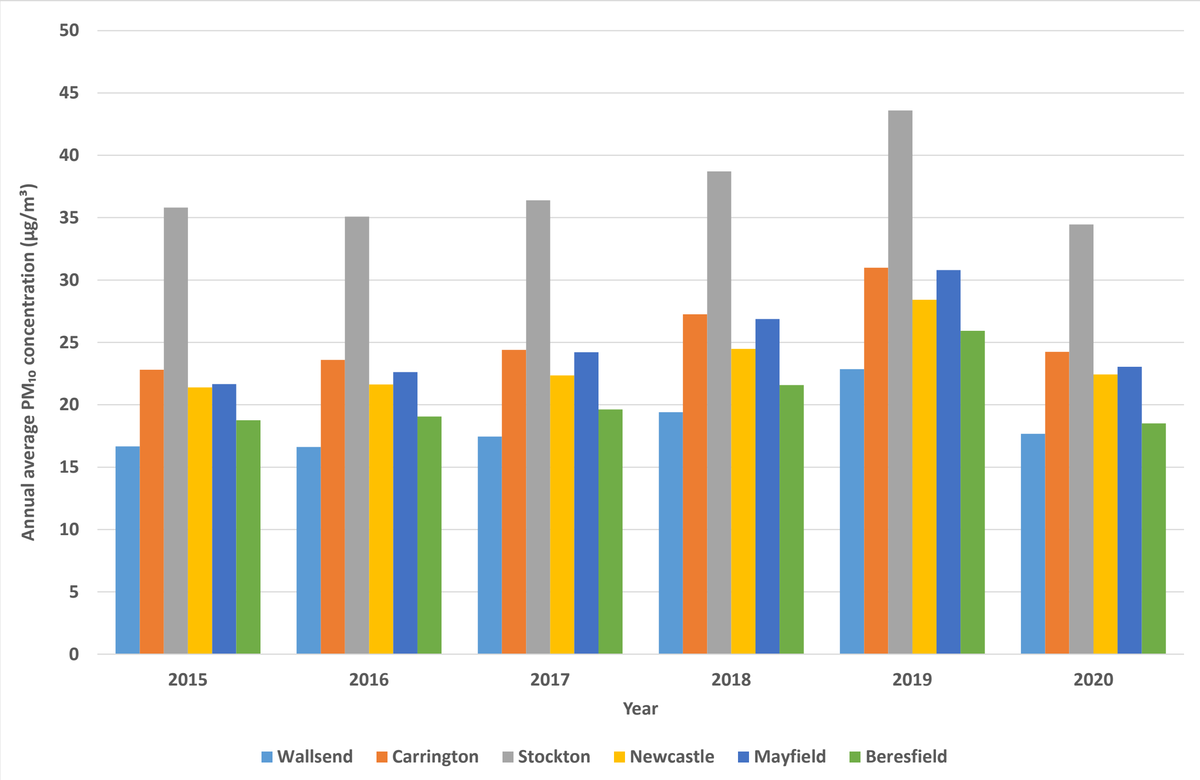


Figure 4.1: Annual average PM_{10} concentrations measured in the Newcastle region (2015-2020)

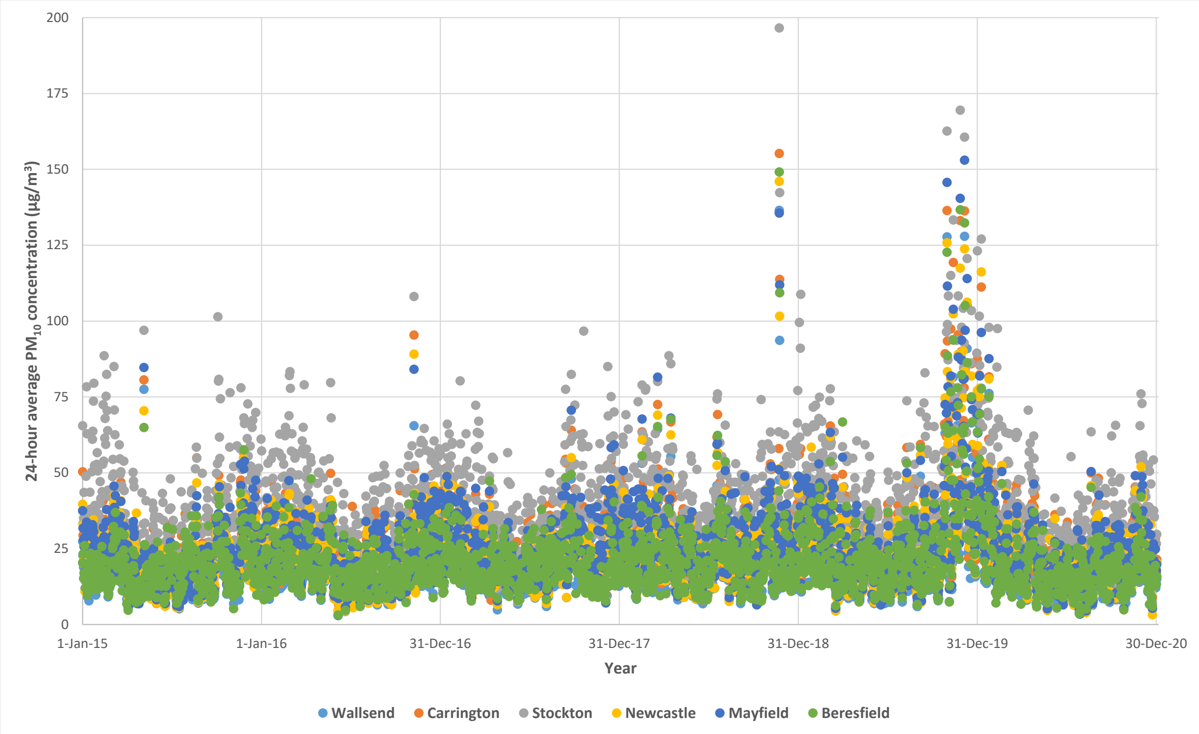


Figure 4.2: Varying 24-hour average PM_{10} concentrations measured in the Newcastle region (2015-2020)

4.2 $PM_{2.5}$

Continuous hourly average ambient $PM_{2.5}$ concentrations are measured at all six locations within the Newcastle region. Figure 4.3 presents the annual average concentration of $PM_{2.5}$ for the period 2015 to 2020.

As shown in Figure 4.3, trends are varied within the six year period. It has been identified that the highest concentrations for each year are at Stockton and the highest annual average concentrations occur during 2019 with Stockton experiencing (13 µg/m³ and Beresfield experiencing 12 µg/m³. It can be seen that concentrations at Beresfield are fairly similar consistent for 2015, 2016, 2017 and 2020.

Inter-annual variability in peak statistics is primarily driven by the influence of exceptional events such as dust storms, hazard reduction burning and bushfire activity. In 2019, extensive bushfires were the major influences on elevated $PM_{2.5}$ concentrations throughout NSW and is also shown here with elevated levels at every monitoring station. During 2020 the extensive bushfires continued for the first few months of the year.

Figure 4.4 shows the 24-hour average $PM_{2.5}$ concentrations from 2015 to 2020 at each site. As with PM_{10}, there is significant variation throughout the year, and highly elevated levels during the bushfire period in late 2019 and beginning of 2020. There was another peak for a single day in November 2016, but the November 2018 bushfires did not show a spike in $PM_{2.5}$ like they did for PM_{10}. For the majority of the time, concentrations remain below the NSW EPA impact assessment criterion 24-hour criterion of 25 µg/m³ and the NEPM AAQ standards of 20 µg/m³.

As mentioned in Section 4.1, it is considered that Beresfield is the most representative monitoring station for background concentrations. For annual average $PM_{2.5}$ at Beresfield, it can be seen that concentrations are steadily increasing from 2015 through to 2017 before greater increases in 2018 and 2019. During 2019 there were some significant bushfire events which have affected the PM_{10} concentrations. During 2020, the concentrations at Beresfield were the lower than 2018 and 2019 but marginally higher than 2015-2017. With much greater concentrations being experienced during 2019, these have not been considered for a period average. The five-year period average across the years 2015, 2016, 2017, 2018 and 2020 is 7.7 µg/m^3. This value exceeds the annual average for 2015, 2016 and 2017 and matches the annual average for 2020. The background value of 7.7 µg/m^3 is considered appropriate for the background $PM_{2.5}$ concentrations.

To determine a maximum 24-hour average PM_{10} concentration at Beresfield, the 98th percentile has been considered. Similar to the above, the concentrations for 2019 have been excluded. The 98th percentile for Beresfield covering the years 2015-2018 and 2020 is 16.9 µg/m^3.

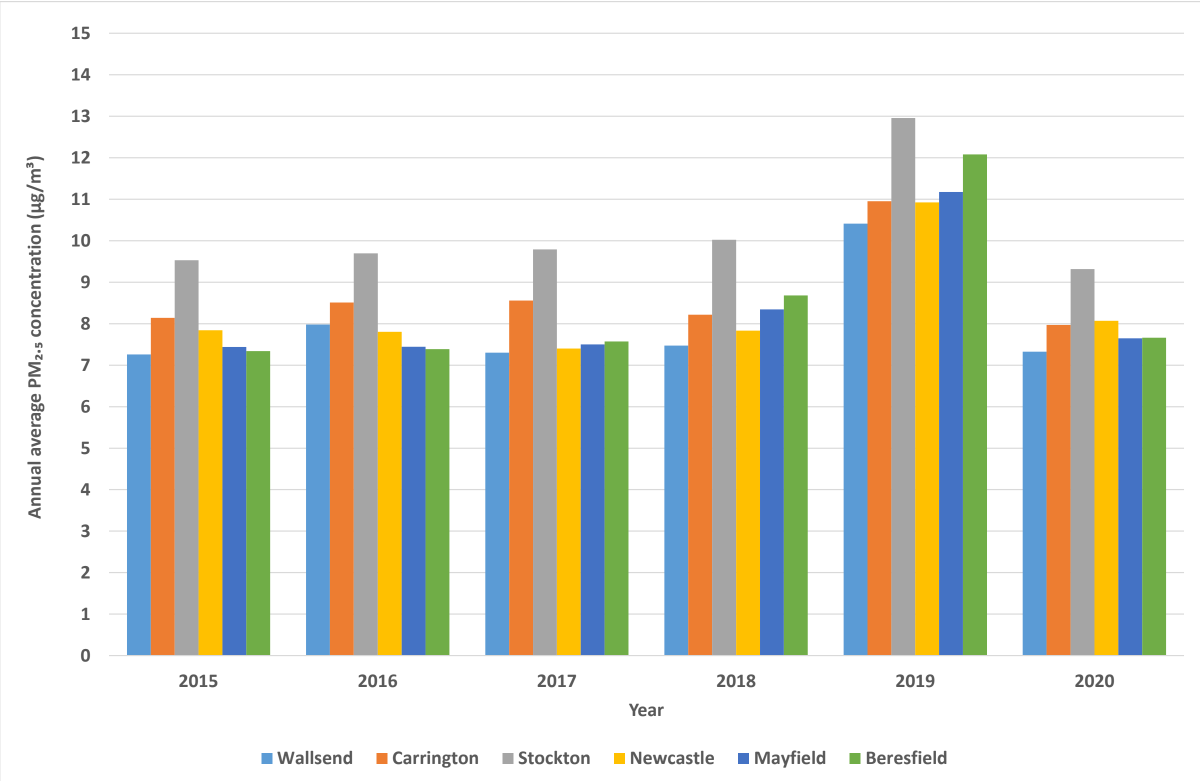


Figure 4.3: Annual average $PM_{2.5}$ concentrations measured in the Newcastle region (2015-2020)

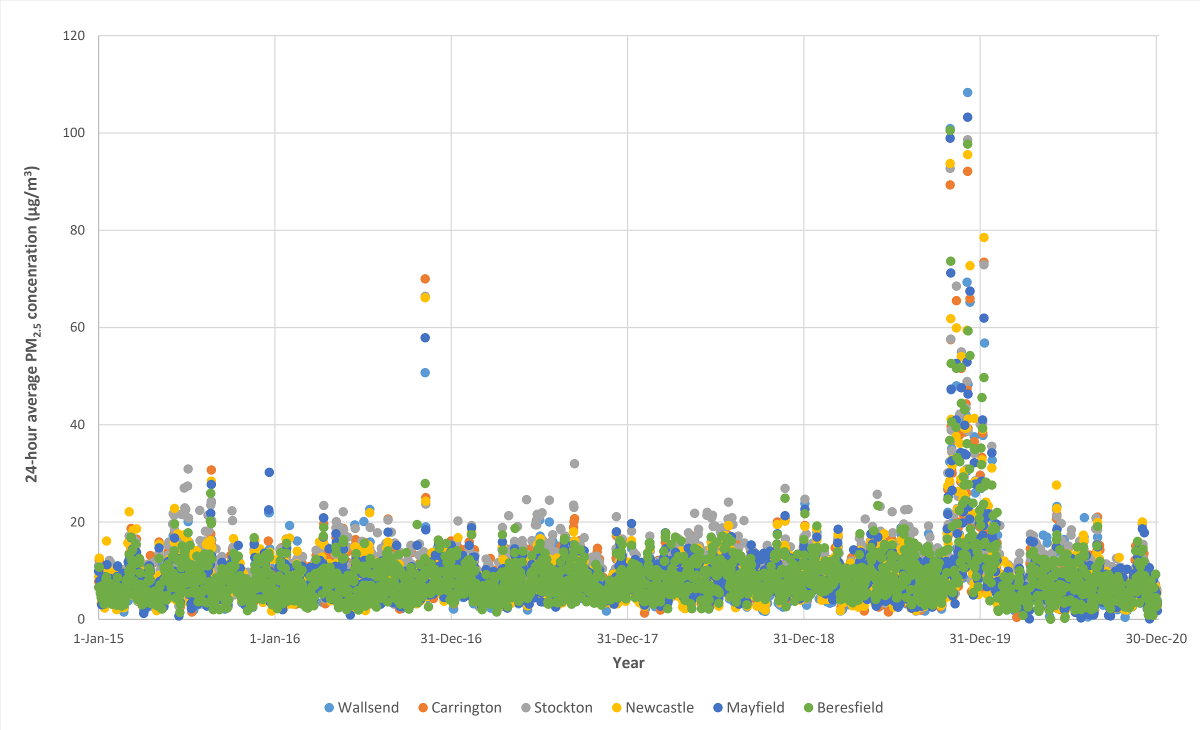


Figure 4.4: Varying 24-hour average $PM_{2.5}$ concentrations measured in the Newcastle region (2015-2020)

4.3 NO_2

NO_2 concentrations have been measured at all six monitoring locations in the Newcastle area, and the annual averages are presented in Figure 4.5. Measured concentrations at all sites are well below the annual average criterion of 62 µg/m³ and below the NEPM AAQ standards of 31 µg/m³. The maximum 1-hour average concentrations are also well below their criterion of 246 µg/m³ and below the NEPM AAQ standards of 164 µg/m³, as shown in Figure 4.6.

As mentioned briefly in Section 2.1.2, while NO_2 is emitted directly, it is predominantly a secondary pollutant, formed when nitric oxide is oxidised in the atmosphere in the presence of ozone. Therefore, the level of NO_x in the ambient air is also important as it will determine the rate at which any new NO_x is converted to NO_2, which is more relevant when considering human health. The rate of conversion of NO_x to NO_2 is proportional to the amount of existing NO_x. Any new sources of NO_x need to be converted to NO_2 and then added to the existing concentrations of NO_2 in the ambient air. The higher the total NO_x, the lower the conversion rate to NO_2, as shown in Figure 4.7.

For establishing background concentrations, the annual average and 98th percentile for 1 hour concentrations have been calculated across the entire dataset (2015-2020). Unlike particulate matter, NO_x/NO_2 is not affected as much by the bushfire episodes. On that basis, 2019 has been included in the calculations. The background annual average NO_x concentration is considered to be 28.1 µg/m³. The background 1 hour NO_x concentration is considered to be 121.3 µg/m³.

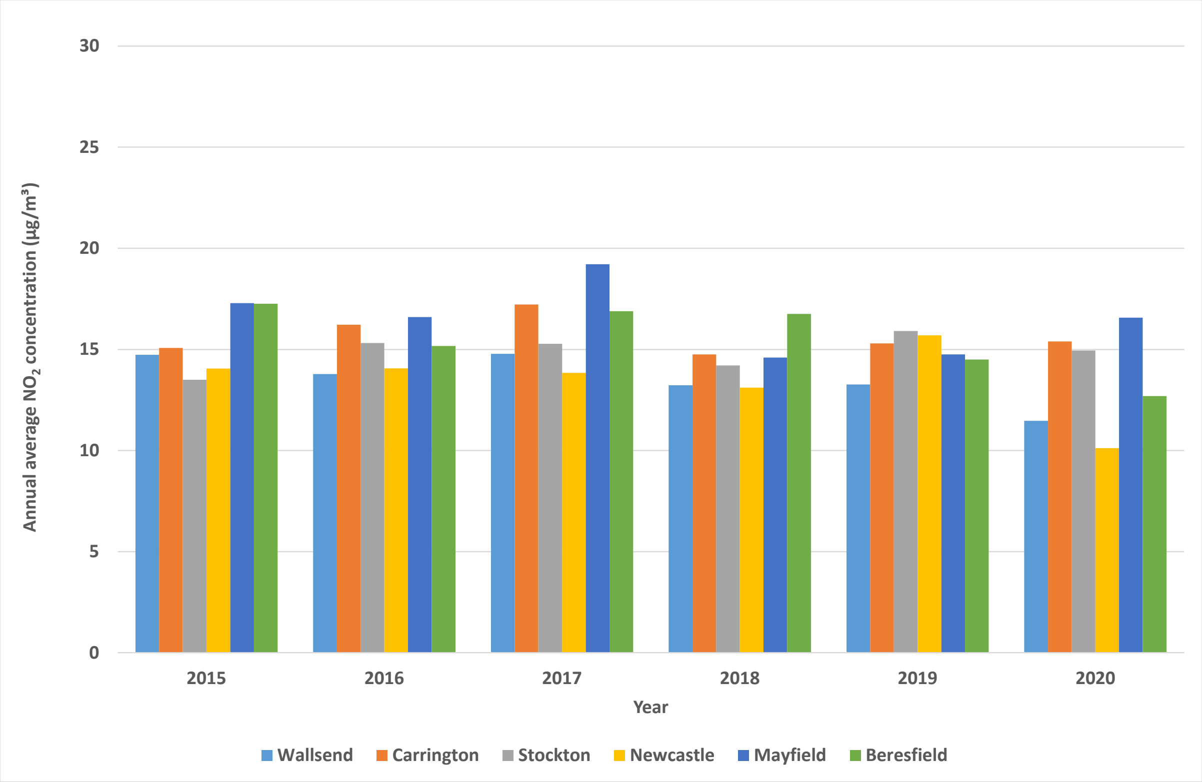


Figure 4.5: Annual average NO_2 concentrations measured in the Newcastle region (2015-2020)

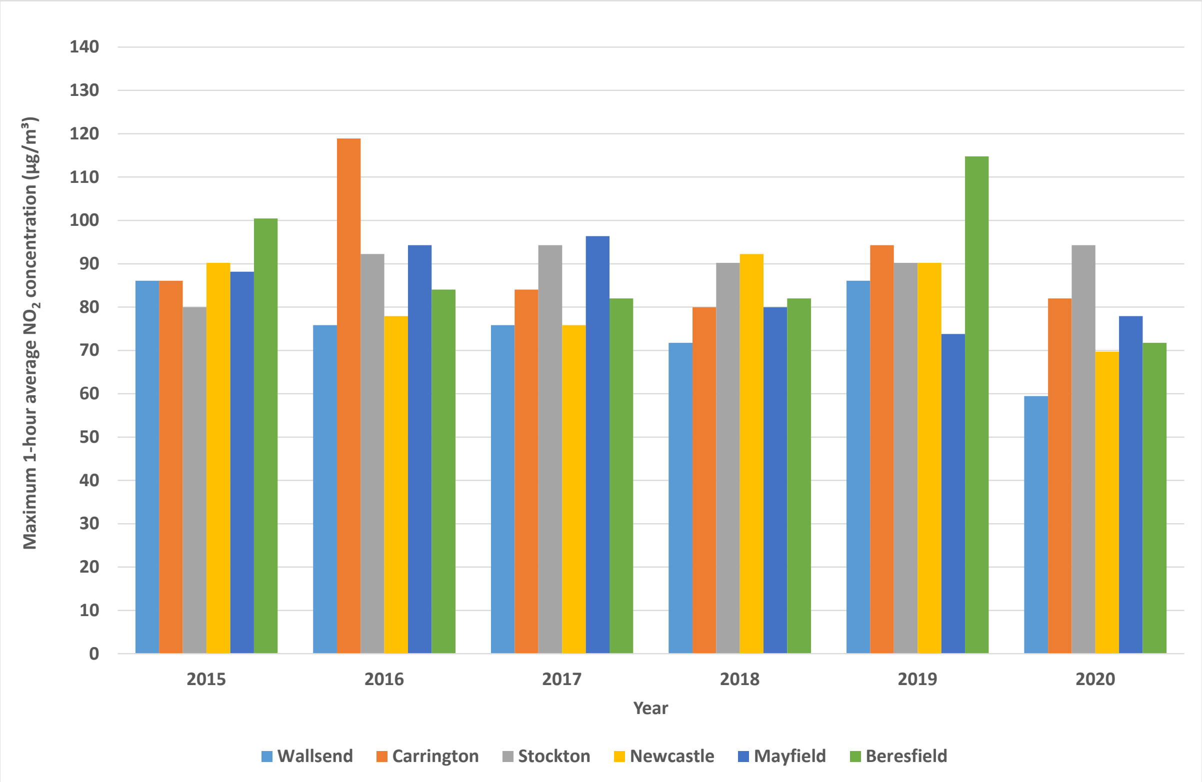


Figure 4.6: Maximum 1-hour average NO_2 concentrations measured in the Newcastle region (2015-2020)

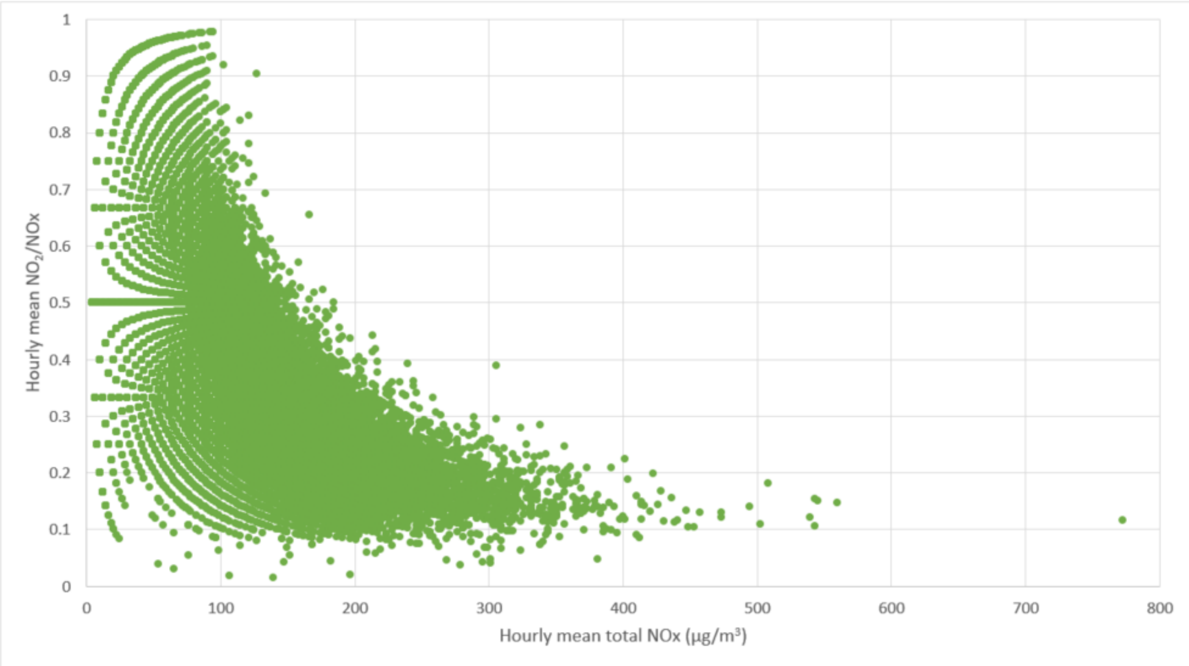


Figure 4.7: Hourly mean NO_2/NOx vs NOx at all sites from 2015 to 2020

4.4 Summary

From the review of local monitoring and background concentrations it is considered that Beresfield is the most representative monitoring station for background concentrations. To summarise, the following background concentrations will be used in the assessment and these have been derived from the Beresfield monitoring station.

- PM_{10}:
  - Annual average = 19.5 µg/m^3 (five-year period average covering 2015-2018 and 2020)
  - 24-hour average = 39.2 µg/m^3 (taken from 98th percentile covering 2015-2018 and 2020)
- $PM_{2.5}$:
  - Annual average = 7.7 µg/m^3 (five-year period average covering 2015-2018 and 2020)
  - 24-hour average = 16.9 µg/m^3 (taken from 98th percentile covering 2015-2018 and 2020)
- NO_x
  - Annual average = 28.1 µg/m^3 (six-year period average covering 2015-2020)
  - 1-hour average = 121.3 µg/m^3 (taken from 98th percentile covering 2015-2020)

It is noted that background concentrations for VOCs have not been referenced given their assessment on an incremental basis (project emissions considered in isolation) within the Approved Methods.

5. MODELLING METHODOLOGY

This section provides an overview of the technical approaches applied within the assessment.

The air dispersion modelling conducted for this assessment is based on an advanced modelling system using the models TAPM and CALMET/CALPUFF. The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data based upon observed ground and upper level meteorological data, as well as observed or modelled upper air data generated for example by TAPM.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

Output from TAPM, plus local observational weather station data were entered into CALMET, a meteorological pre-processor endorsed by the US Environmental Protection Agency (US EPA) and recommended by the NSW EPA for use in complex terrain and non-steady state conditions (that is, conditions that change in time and space). From this, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled. An overview of the modelling system is presented in Figure 5.1, and details on the model configuration and data inputs are provided in the following sections.

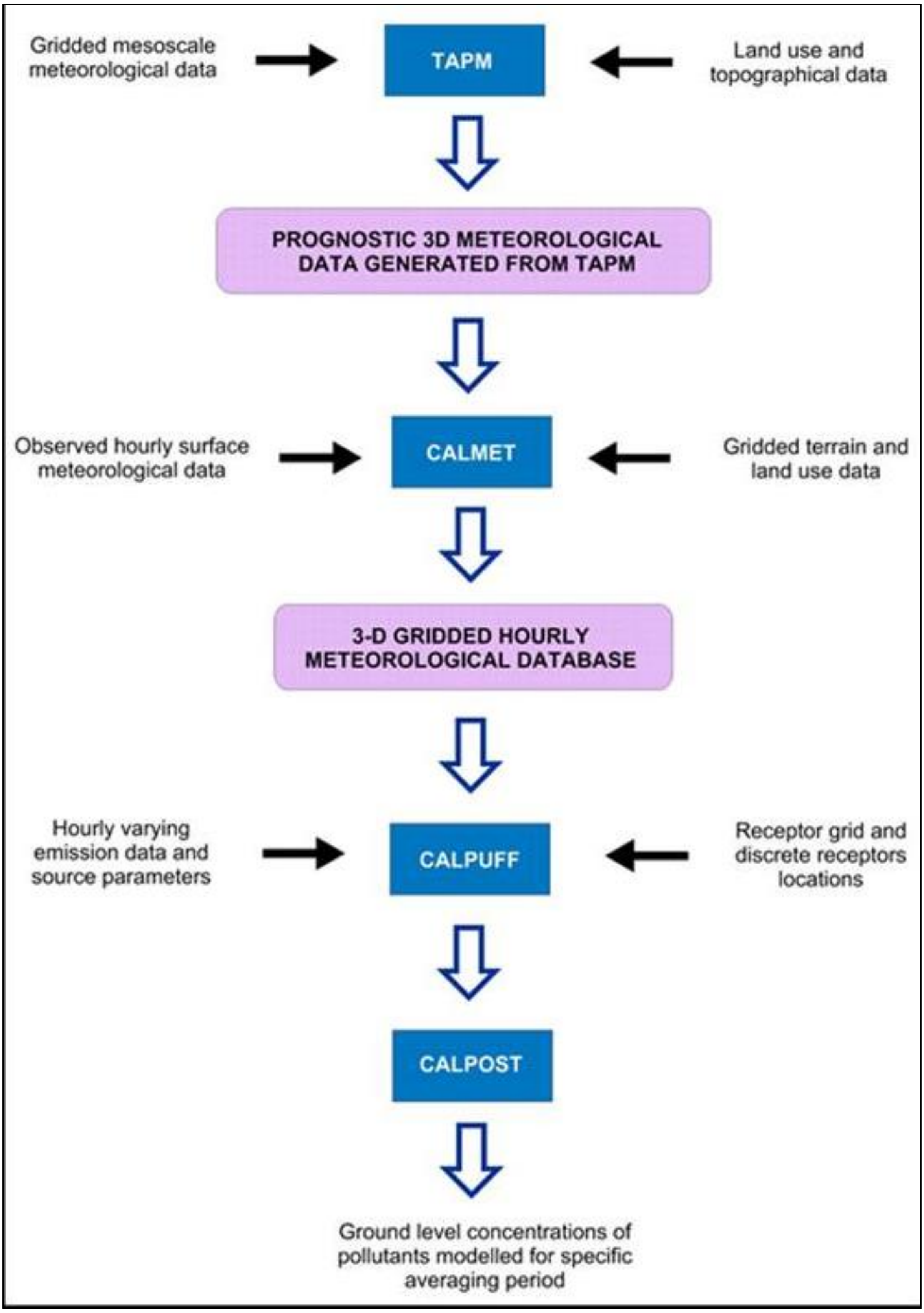


Figure 5.1: Overview of modelling methodology

5.1 TAPM

The Air Pollution Model, or TAPM, is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided in Hurley (2008) and Hurley et al. (2009).

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For this Modification, TAPM was set up with 4 domains, composed of 35 grids along both the x and the y axes, centred on -32˚11' Latitude and 150˚50' Longitude. Each nested domain had a grid resolution of 30 km, 10 km, 3 km and 1 km respectively.

5.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model (i.e. the CALPUFF dispersion model requires meteorological data in three dimensions). CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region.

A summary of the CALMET modelling is presented in Table 5.1.

5.3 CALPUFF

CALPUFF is the dispersion module of the CALMET/CALPUFF suite of models. It is a multi-layer, multi species, non-steady-state puff dispersion model that can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across released puffs and takes into account the complex arrangement of emissions from point, area, volume and line sources (Scire et al., 2000). In March 2011, generic guidance and optional settings for the CALPUFF modelling system were published for inclusion in the Approved Methods (TRC, 2011). The model set up for this study has been conducted in consideration of these guidelines.

As discussed in Section 2.1, the main pollutants considered in this analysis are: $PM_{2.5}$, PM_{10}, NO_2, and VOCs.

Table 5.1: CALMET meteorological model settings

TAPM (v 4.0.4)	
Number of grids (spacing)	30 km, 10 km, 3 km and 1 km
Number of grid points	35 x 35 x 35
Year of analysis	January 2018 – December 2018
Centre of domain	-32°47' S, 151°50' E
CALMET (v 6327)	
Meteorological grid domain	29 km x 19 km
Meteorological grid resolution	500 m
Surface meteorological stations	Inner and outer grid: BoM Williamtown RAAF ■ - Wind speed ■ - Wind direction ■ - Temperature ■ - Relative humidity ■ - Station level pressure TAPM ■ - Cloud height ■ - Cloud content
3D.dat	Data extracted from 1 km TAPM
Flag	**Value Used**
IEXTRP	-4
BIAS (NZ)	-1, 0, 0, 0, 0, 0, 0, 0
TERRAD	9
RMAX1 and RMAX2	5
R1 and R2	4.5

6. EMISSIONS

As mentioned in Section 1, there is one main existing emission source in the Williamtown SAP and a number of potential emission sources. The following sections outline the sources that have been modelled using CALPUFF.

6.1 Williamtown RAAF Base/Newcastle Airport

6.1.1 Existing (2019)

The airport is split into Newcastle Airport and Williamtown RAAF Base. Newcastle Airport has commercial flights that predominantly fly domestically. Williamtown RAAF Base is the Australia's primary fighter pilot training base. Aircraft movements at Williamtown RAAF Base/Newcastle Airport were sourced from the Department of Defence website for 2019 (Australian Government Department of Defence, 2020) for both military aircraft and commercial aircraft. It is identified that aircraft movements for 2020 are likely to be lower than a typical year due to the impact of the COVID-19 global pandemic. It is considered that 2019 provides a more representative and recent data sample.

In total there were 36,282 aircraft movements during 2019, covering both the military and civilian/commercial flights. The types of aircrafts, split into military, civilian jet and civilian propeller (known as prop), were as follows:

- Fokker 100 (civilian jet)
- Airbus A320-200 (civilian jet)
- Bombardier Dash 8 Q200 (civilian prop)
- Jetstream 32 (civilian prop)
- F/A 18A/B Hornet (military fast jet)[1]
- PC-9/A (military fast jet)

The annual aircraft movements and emissions have been presented below. As mentioned above, the total of 36,282 movements has been obtained from the Department of Defence website for 2019. The exact numbers of arrivals and departures for each aircraft type is not available and therefore assumptions have been made with movements for each type of aircraft (civilian jet, civilian prop and military fast jet) being equally split. Aircraft movements have been split equally for arrivals and departures.

Table 6.1 presents the aircraft types and annual movements that have been used for 2019.

Table 6.1: Aircraft type and annual aircraft movements for 2019

Aircraft type	Arrivals	Departures
Fokker 100	2,162	2,162
Airbus A320-200	2,162	2,162
Bombardier Dash 8 Q200	2,424	2,424
Jetstream 32	2,424	2,424
F/A 18A/B Hornet[1]	4,485	4,485
PC-9/A	4,485	4,485
Total	**18,141**	**18,141**
Combined total	**36,282**	

[1] The F-35 jet was not available in the emissions modelling database. The F/A 18A/B Hornet has been used in the absence of the F-35 jet.

6.1.2 Proposed expansion (2036)

By 2036, there is expected to be an expansion of Newcastle Airport, including widening of the runway to allow for more aircraft movements and larger aircrafts compatible with international flights.

It is anticipated that military aircraft movements will remain unchanged through to 2036. Data for commercial aircraft movements were not available within the timeframe of this assessment. Publically available information was reviewed to determine the likely increase in aircraft movements for 2036. The 2036 Newcastle Airport Vision (Newcastle Airport, 2018) provides an indication of the growth in passenger numbers from 2016 through to 2076 and includes 2036. It should be noted that these forecasts were made prior to the COVID-19 global pandemic. In addition, for modelling purposes it is aircraft movements rather than passenger numbers that are the critical input. That being said, in the absence of other information, passenger numbers have been used to scale aircraft movements to provide an estimate for 2036.

The 2036 Newcastle Airport Vision provides actual aircraft movements for 2016 and forecast aircraft movements for 2021. Passenger numbers for 2019 have been calculated based on the rate of growth from 2016 to 2021. It can be seen that from 2019 to 2036 there is just under a doubling of passenger numbers. On that basis, the modelling for 2036 will include a proposed doubling of aircraft movements.

Table 6.2 presents the actual, calculated and forecast passenger numbers for 2016, 2019, 2021 and 2036.

Table 6.2: Actual, calculated and forecast passenger numbers for 2016, 2019, 2021 and 2036

Year	2016 (actual*)	2019 (interpolated by ERM)	2021 (forecast*)	2036 (forecast*)
Passenger numbers	1,216,624	1,354,490	1,446,400	2,649,100

*Taken from 2036 Newcastle Airport Vision (Newcastle Airport, 2018).

It should be noted that for 2019, all aircraft from Newcastle Airport were considered to be the smaller Code C aircraft which are commonly used for domestic flights. With the expansion of the airport it is considered that the larger aircraft types - Code D and E - would become more frequent and have been included in the aircraft movements. The larger aircraft are able to carry additional passengers which in theory would reduce aircraft movements; however, to be conservative and as mentioned above, the modelling for 2036 will include a proposed doubling of aircraft movements.

Table 6.3 presents the aircraft types and annual movements that have been used in the modelling of 2036.

Table 6.3: Aircraft type and annual aircraft movements for 2036

Aircraft type	Arrivals	Departures
Fokker 100	2,162	2,162
Airbus A320-200	2,162	2,162
Bombardier Dash 8 Q200	2,424	2,424
Jetstream 32	2,424	2,424
F/A 18A/B Hornet[1]	4,485	4,485
PC-9/A	4,485	4,485
Airbus A-310	6,047	6,047
Airbus A330	6,047	6,047
Boeing 767	6,047	6,047
Total	**36,283**	**36,283**
Combined total	**72,566**	

[1]The F-35 jet was not available in the emissions modelling database. The F/A 18A/B Hornet has been used in the absence of the F-35 jet.

The aircraft movements were modelled using the US Federal Aviation Administration (FAA) Emissions and Dispersion Modelling System (EDMS). EDMS is a combined emissions and dispersion model which permits the factors affecting emissions and air quality to be considered in detail.

EDMS has been used for several airport assessments in Australia including Sydney (Kingsford Smith) Airport and Adelaide Airport. The emissions inventories included aircraft movements, ground support equipment (GSE) and auxiliary power units (APU). As this is for the screening study, default settings have been used for GSE. For APU timings, 32.5 minutes were applied for arrivals and departures.

The EDMS model was used to generate the NO_X and $PM_{2.5}$ emissions. The sources and emissions from Williamtown RAAF/Newcastle Airport were then entered into the CALPUFF model.

Table 6.4 presents the emissions for airport/aircraft sources for 2036 which have been entered into the model.

Table 6.4: Emissions from airport/aircraft sources for Williamtown RAAF/Newcastle Airport for 2036

Source summary	Sub category	NO_x emissions (g/s)	$PM_{2.5}$ emissions (g/s)
Aircraft	Takeoff	2.746	0.015
	Climb out	0.892	0.005
	Approach	0.393	0.004
Taxiway	Taxi in	0.188	0.007
	Taxi out	0.198	0.009
Gate	GSE	0.176	0.010
	APU	0.213	0.015
Total emissions		**4.806**	**0.065**

6.2 Proposed industrial point source

As outlined in Section **Error! Reference source not found.**, there are a number of proposed facilities/activities in the western catchment that would likely require a point source to control the release of emissions from its premises. At this stage, the types of facility are known but not the size of the facility and the exact emission rates. The types of development would be market-driven and details are not known.

The Protection of the Environment Operations (Clear Air) Regulation 2021, Schedule 3 (Standards of concentration for scheduled premises: activities and plant used for specific purposes) provides the in-stack concentration limits for a range of activities. Schedule 3 provides in-stack concentration limits for 'Ceramic works' and a number of other industrial processes, and these have been used to derive emission rates for the proposed point source for a range of pollutants.

This assessment has focused on two stack heights – 15 m and 20 m. These have been selected for a number of reasons:

- Proposed heights are likely for the type of proposed industrial activities in this area; and
- Proposed heights are likely to be below the required height to prevent plume rise impacts and meet the Obstacle Limitation Surface (OLS) (see Section 8.4 for further detail).

Along with height, this assessment has focused on 'high flow rate' stacks and 'low flow rate stacks'. In total, this assessment has modelled four individual stack options. The assessment has not considered multiple stacks in the same scenario.

Table 6.5 presents the stack parameters for high flow rate and low flow rate stacks that have been used in this assessment for point sources. These are all generic, as specific details for the individual industries have not been determined. The parameters used are considered representative for the type of industry that would be located in this sub-precinct land use. A review of publically available air quality assessments undertaken for breweries and ceramic manufacturing facilities was undertaken when selecting these parameters. The emissions are based on the in-stack concentration limits and therefore specific details of pollution control techniques/mitigation measures for individual pollutants or industries have not been outlined. These would be considered in the design phase. Some broad generic mitigation strategies are summarised in Section 9.

Table 6.5: Stack parameters for point sources

Parameter	Stack Type		Unit
	High flow rate	Low flow rate	
Stack height	15 or 20	15 or 20	m
Stack diameter	2	1	m
Exit velocity	10	10	m/s
Exit temperature	473	373	K
Flow rate	31.4	7.9	Am^3/s
	18.1	5.7	Nm^3/s (wet)
	15.1	4.8	Nm^3/s (dry)*
Stack area	3.14	0.79	m^2

Note: Am^3 - 1 cubic metre of gas at 'actual' in-stack conditions
Nm^3 - 1 cubic metre of gas at conditions of 273 K and 1 atmosphere.
*Assuming natural gas combustion to 3% dry excess oxygen.

Table 6.6 and Table 6.7 present the in-stack concentration limits and calculated emission rates for high flow rate and low flow rate stacks. As mentioned above, there are in-stack concentration limits for different pollutants which are set by the regulatory authorities. The tables show that there are different emission rates for PM depending on the type of activity (kiln and crushing). The modelling has considered both types of activity and this is discussed further in Section 7.

Table 6.6: In-stack concentration limits and calculated emission rates for high flow rate stacks

Parameter	Pollutant					Units/basis
	PM (Kiln)	PM (Crushing)	NO_x as NO_2	Cadmium (Cd)	VOCs (as Benzene)	
In-stack concentration limit (mg/m^3)	50	20	500	0.2	70.84	mg/m^3, dry 273K, 1 atm
Calculated emission rate (g/s)	0.76	0.30	7.6	0.0030	1.1	g/s

Table 6.7: In-stack concentration limits and calculated emission rates for low flow rate stacks

Parameter	Pollutant					Units/basis
	PM (Kiln)	PM (Crushing)	NO_x as NO_2	Cadmium (Cd)	VOCs (as Benzene)	
In-stack concentration limit (mg/m^3)	50	20	500	0.2	70.84	mg/m^3, dry 273K, 1 atm
Calculated emission rate (g/s)	0.24	0.1	2.4	0.0010	0.34	g/s

7. MODELLING RESULTS

The modelling predictions for existing and proposed emissions sources across the Williamtown SAP are presented in the sections below.

7.1 Odour

For this assessment, odour was not modelled. It is acknowledged that there are some existing odour sources outside of the SAP boundary which include chicken farms. Within the Williamtown SAP there are potential odour sources from the brewery and contaminated soil treatment works. It is considered that with appropriate design controls these industries will be able to control odour emissions and it is therefore not considered necessary to conduct odour modelling.

Odour performance criteria has been outlined in Table 2.3. For any proposed facility emitting odour, there will be a requirement for no offensive odour beyond the boundary of the facility. It is noted that there are potential emissions of VOCs from the ceramics industry which can potentially be odorous. These have been included in the point source modelling in Section 7.3.

7.2 Williamtown RAAF Base/Newcastle Airport

The major existing source of NO_x and $PM_{2.5}$ in the Williamtown SAP is from Williamtown RAAF/Newcastle Airport. Modelling of emissions from the airport for the proposed expansion in 2036 has been undertaken for NO_x and $PM_{2.5}$. After modelling NO_x, the background NO_x concentrations were added and this was subsequently converted to NO_2. For $PM_{2.5}$, the background concentrations have been added to the modelled $PM_{2.5}$ concentrations.

For annual average NO_2 concentrations, the NSW EPA impact assessment criterion of 62 µg/m^3 is not exceeded anywhere across the domain. For the NEPM AAQ standard of 31 µg/m^3, concentrations of this value are experienced within the boundary of airport activities.

Figure 7.1 presents the annual average NO_2 concentrations including background for the proposed airport expansion in 2036.

For maximum 1-hour NO_2 concentrations, concentrations equalling the NSW EPA impact assessment criterion of 246 µg/m^3 are experienced within the boundary of airport activities. The NEPM AAQ standard of 164 µg/m^3 is exceeded across the entire Williamtown SAP area. It should be noted that this is a significant reduction in standard compared to the NSW EPA impact assessment criterion. In addition, as this is a 1-hour averaging period it would only occur when high background and maximum concentrations occur at the same hour.

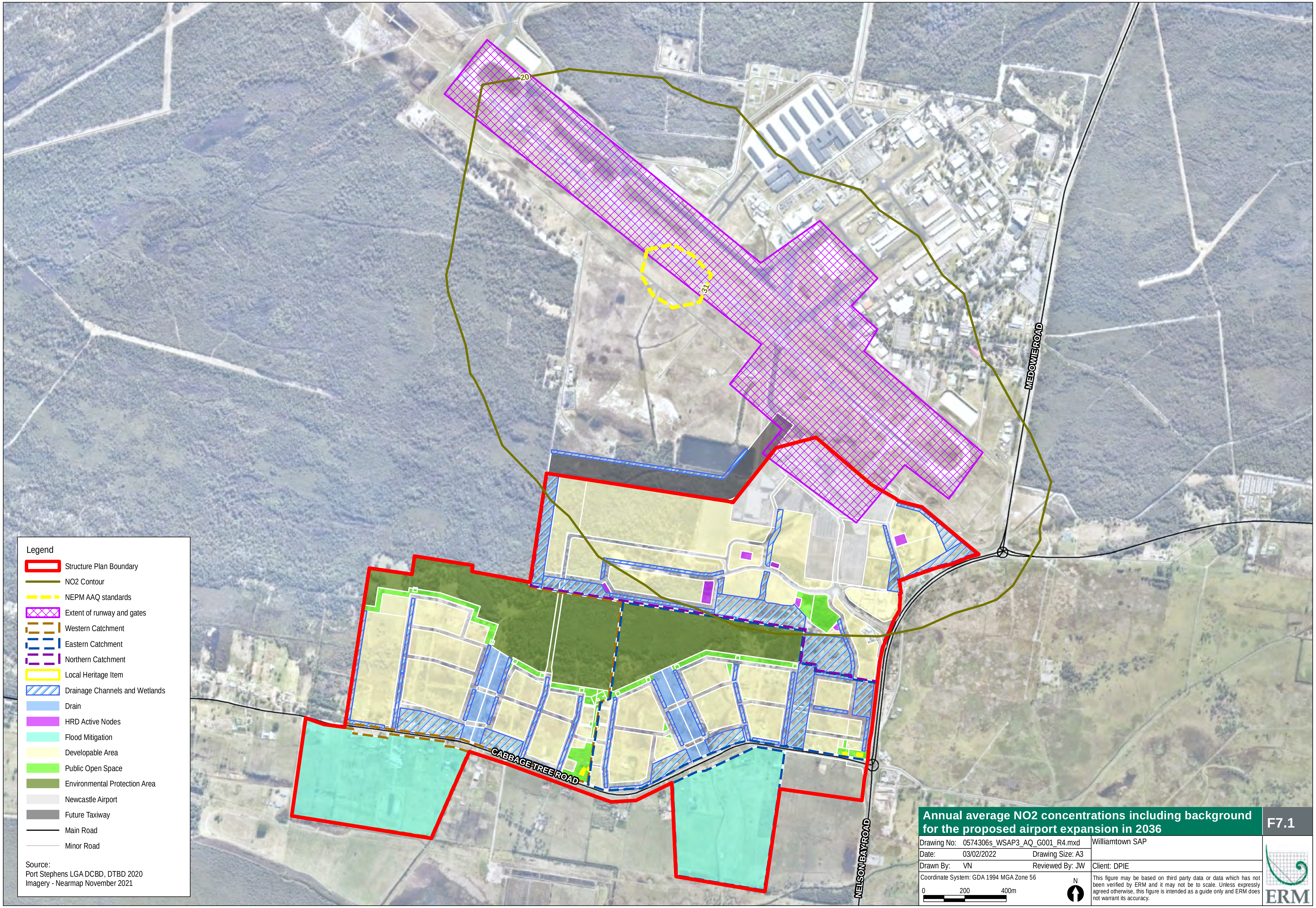
Figure 7.2 presents the maximum 1-hour NO_2 concentrations including background for the proposed airport expansion in 2036.

For annual average $PM_{2.5}$ concentrations, the contours show that the NSW EPA impact assessment criterion of 8 µg/m^3 extends slightly into the northern section of the Williamtown SAP. This is due to the high background concentration of 7.7 µg/m^3 which is dominating the cumulative concentrations. The National Environment Protection goal of 7 µg/m^3 is exceeded across the entire Williamtown SAP area which again is due to the high background concentrations.

Figure 7.3 presents the annual average $PM_{2.5}$ concentrations including background for the proposed airport expansion in 2036.

For maximum 24-hour average $PM_{2.5}$ concentrations, the NSW EPA impact assessment criterion of 25 µg/m^3 is not exceeded anywhere across the domain. The lower National Environment Protection goal of 20 µg/m^3 does protrude slightly into the northern section of the Williamtown SAP. Again it should be noted that the background concentration of 16.9 µg/m^3 is dominating the cumulative concentrations.

Figure 7.4 presents the maximum 24-hour average $PM_{2.5}$ concentrations including background for the proposed airport expansion in 2036.


20
31
MEDOWIE ROAD
CABBAGE TREE ROAD
NELSON BAY ROAD
Legend
Structure Plan Boundary
NO2 Contour
NEPM AAQ standards
Extent of runway and gates
Western Catchment
Eastern Catchment
Northern Catchment
Local Heritage Item
Drainage Channels and Wetlands
Drain
HRD Active Nodes
Flood Mitigation
Developable Area
Public Open Space
Environmental Protection Area
Newcastle Airport
Future Taxiway
Main Road
Minor Road
Source:
Port Stephens LGA DCBD, DTBD 2020
Imagery - Nearmap November 2021
Annual average NO2 concentrations including background for the proposed airport expansion in 2036
F7.1
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Date: 03/02/2022
Drawing Size: A3
Drawn By: VN
Reviewed By: JW
Williamtown SAP
Client: DPIE
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This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
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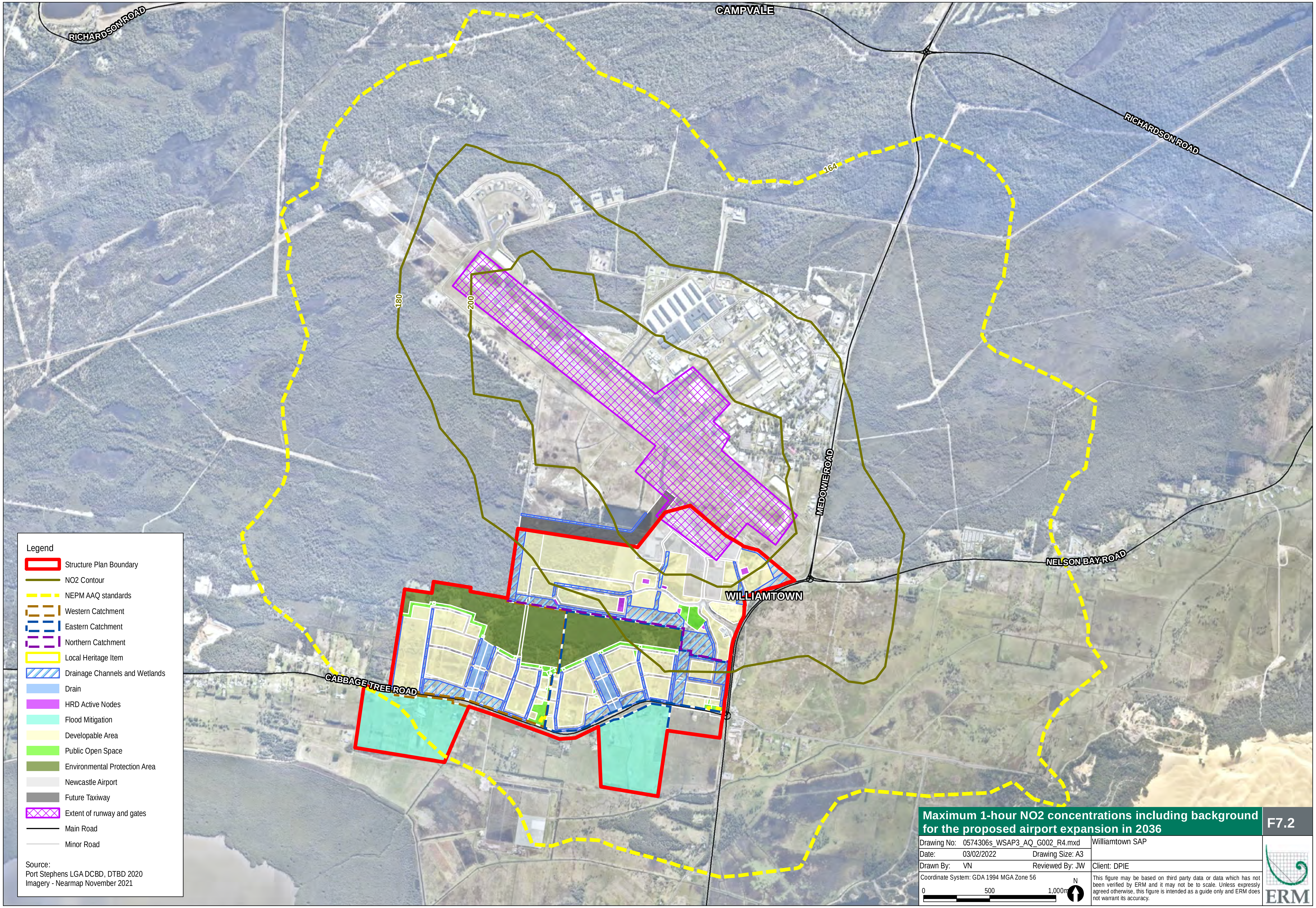
CAMPVALE
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RICHARDSON ROAD
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180
200
MEDOWIE ROAD
NELSON BAY ROAD
WILLIAMTOWN
CABBAGE TREE ROAD
Legend
Structure Plan Boundary
NO2 Contour
NEPM AAQ standards
Western Catchment
Eastern Catchment
Northern Catchment
Local Heritage Item
Drainage Channels and Wetlands
Drain
HRD Active Nodes
Flood Mitigation
Developable Area
Public Open Space
Environmental Protection Area
Newcastle Airport
Future Taxiway
Extent of runway and gates
Main Road
Minor Road
Source:
Port Stephens LGA DCBD, DTBD 2020
Imagery - Nearmap November 2021
Maximum 1-hour NO2 concentrations including background for the proposed airport expansion in 2036
F7.2
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Reviewed By: JW
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Williamtown SAP
Client: DPIE
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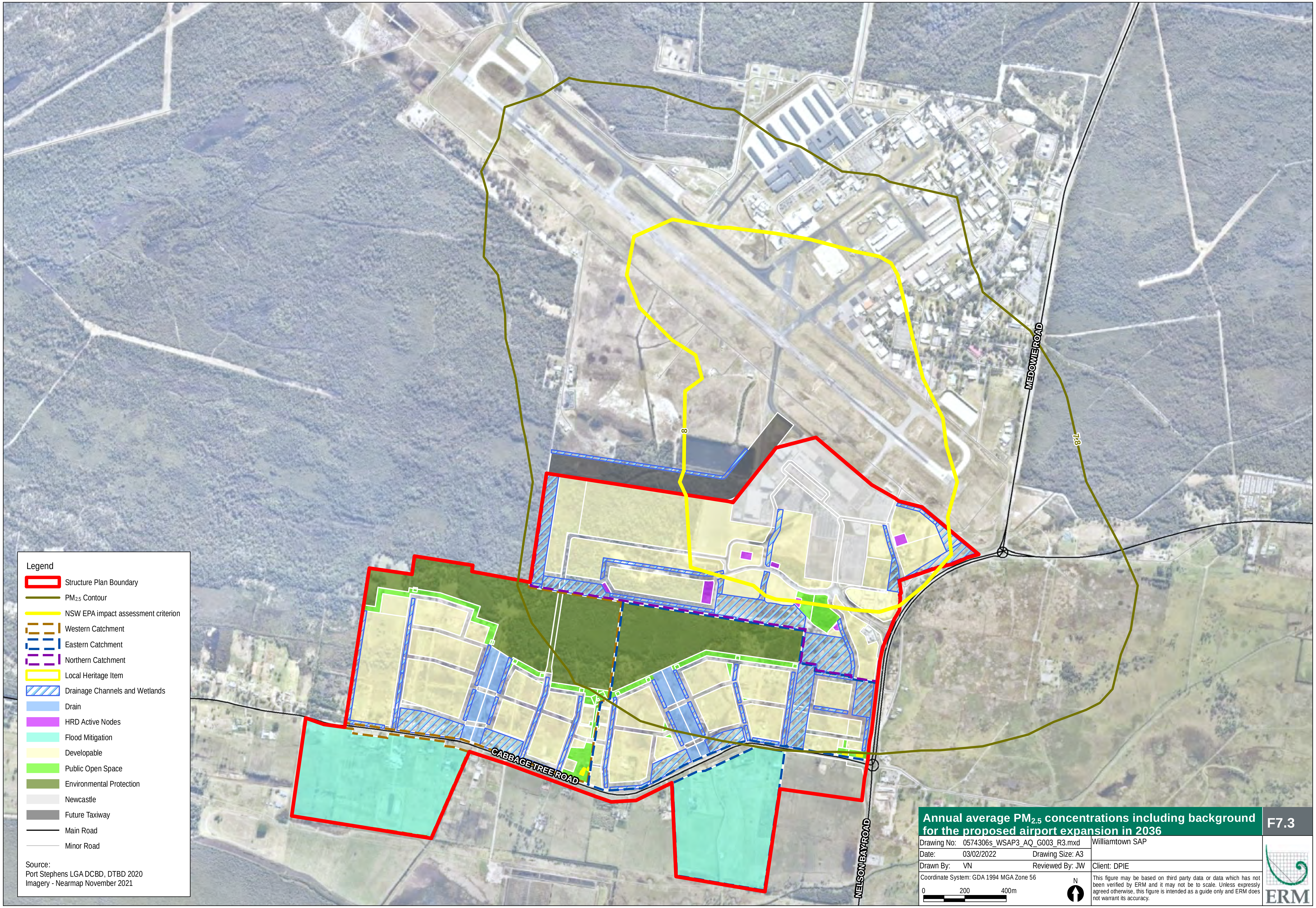
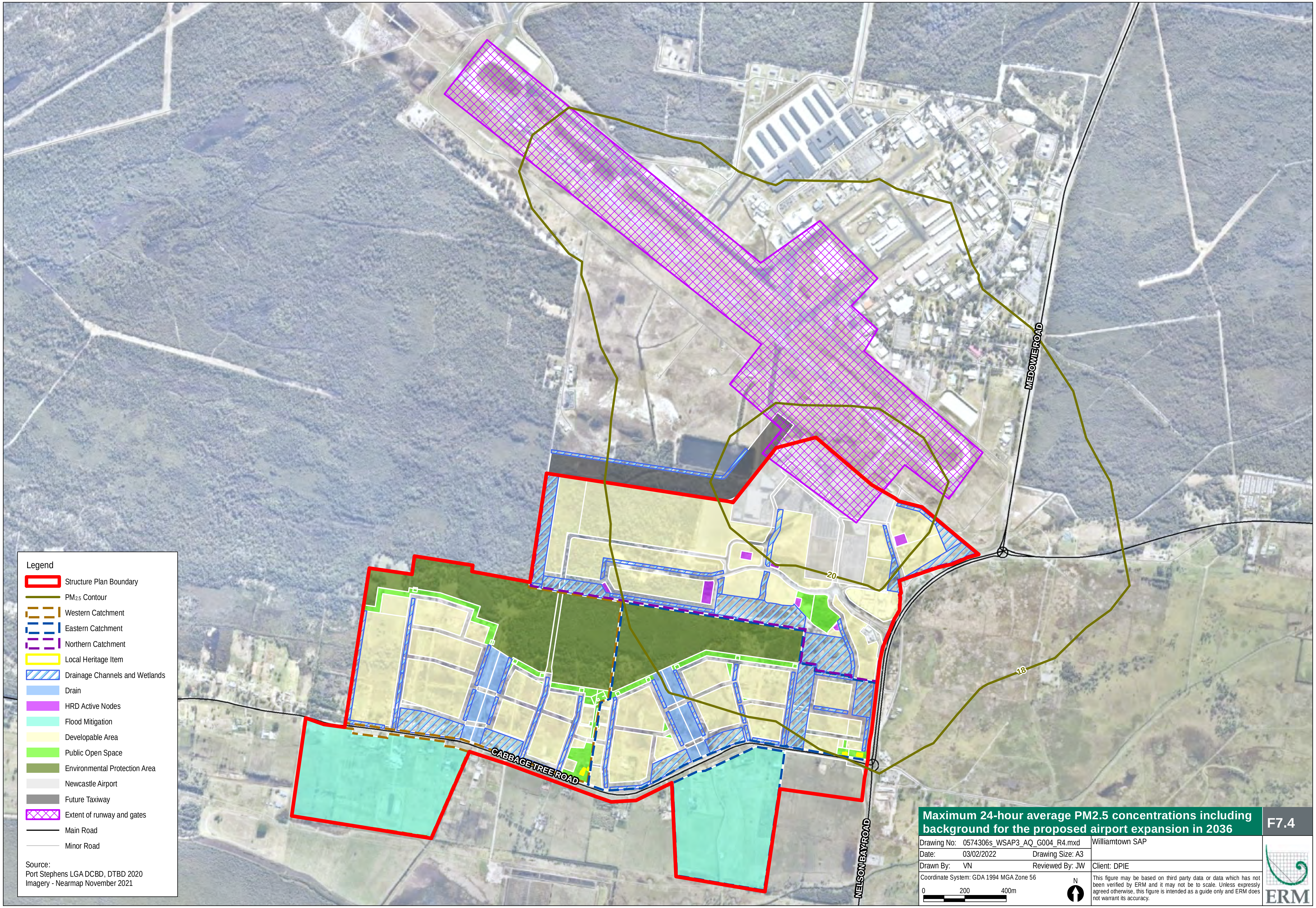


Annual average $PM_{2.5}$ concentrations including background for the proposed airport expansion in 2036



Maximum 24-hour average PM2.5 concentrations including background for the proposed airport expansion in 2036

F7.4

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Williamtown SAP

Client: DPIE

This figure may be based on third party data or data which has not been verified by ERM and it may not be scaled. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

ERM

7.3 Proposed industrial point source

As shown in **Error! Reference source not found.**, the western catchment could contain proposed air emission sources such as breweries and distilleries, ceramic and glass industries, chemical industries and works, petroleum works and contaminated soil treatment works. Many of these activities would likely require a point source (stack) to control the release of emissions.

Before proceeding with any point source modelling, the obstacle limitation surface (OLS) was considered and this is presented in more detail in Section 8. The remaining allowable height, which considers proposed stack height and proposed release height of emissions, was calculated as 46.5 m. For this assessment, a single proposed stack source has been considered for the western catchment and on the basis of the above, a stack of 15 m or 20 m could be pursued as an option. This stack source has been tested for different flow rates, temperatures, stack diameters and height. The results are presented for 'high flow rate' stacks and 'low flow rate stacks' at two heights, 15 m and 20 m. The modelling has been conducted with the stack source emitting at the in-stack concentration limit for PM_{10}[2], $PM_{2.5}$[3], NO_x and VOCs. The background concentrations have also been added to the stack increments.

There were no predicted exceedances of the NSW impact assessment criteria for any of the scenarios for annual average and 24-hour average $PM_{2.5}$, annual average and 24-hour average PM_{10}, and the maximum 1-hour for benzene. On that basis, these pollutants have not been considered any further in this analysis.

When considering the annual average NO_2 concentrations, there are also no predicted exceedances of the NSW impact assessment criterion.

As mentioned in Section 6.2, there are different emission rates for PM depending on the type of activity (kiln and crushing). The results for PM have considered the emission rates for kiln and crushing activities.

For annual average $PM_{2.5}$ concentrations, the results were similar across all four modelled scenarios. It was noted that results were slightly higher for the kiln activity, when compared with the crushing activity. The largest extent of the contour was noted in the 20 m stack with a high flow rate. The National Environment Protection goal of 7 $\mu g/m^3$ is exceeded across the entire Williamtown SAP area which again is due to the high background concentration of 7.7 $\mu g/m^3$.

Figure 7.5 presents the annual average $PM_{2.5}$ concentration including background for a 20 m high flow rate stack for kiln activity.

For the maximum 24-hour average $PM_{2.5}$ concentrations, the results for the kiln activity were higher than crushing activity when compared across heights and flow rates. The predicted concentrations did not exceed the NSW EPA impact assessment criterion or the National Environment Protection goal of 20 $\mu g/m^3$. As noted earlier, the modelled concentrations represent stack / point sources emitting at their regulatory limits. It is likely that these emissions will be lower but conservative assumptions have been used here. In addition, the modelling has assumed that $PM_{2.5}$ is 100% of total dust which is a conservative approach. The largest extent of the contour was noted in the 20 m stack with a high flow rate.

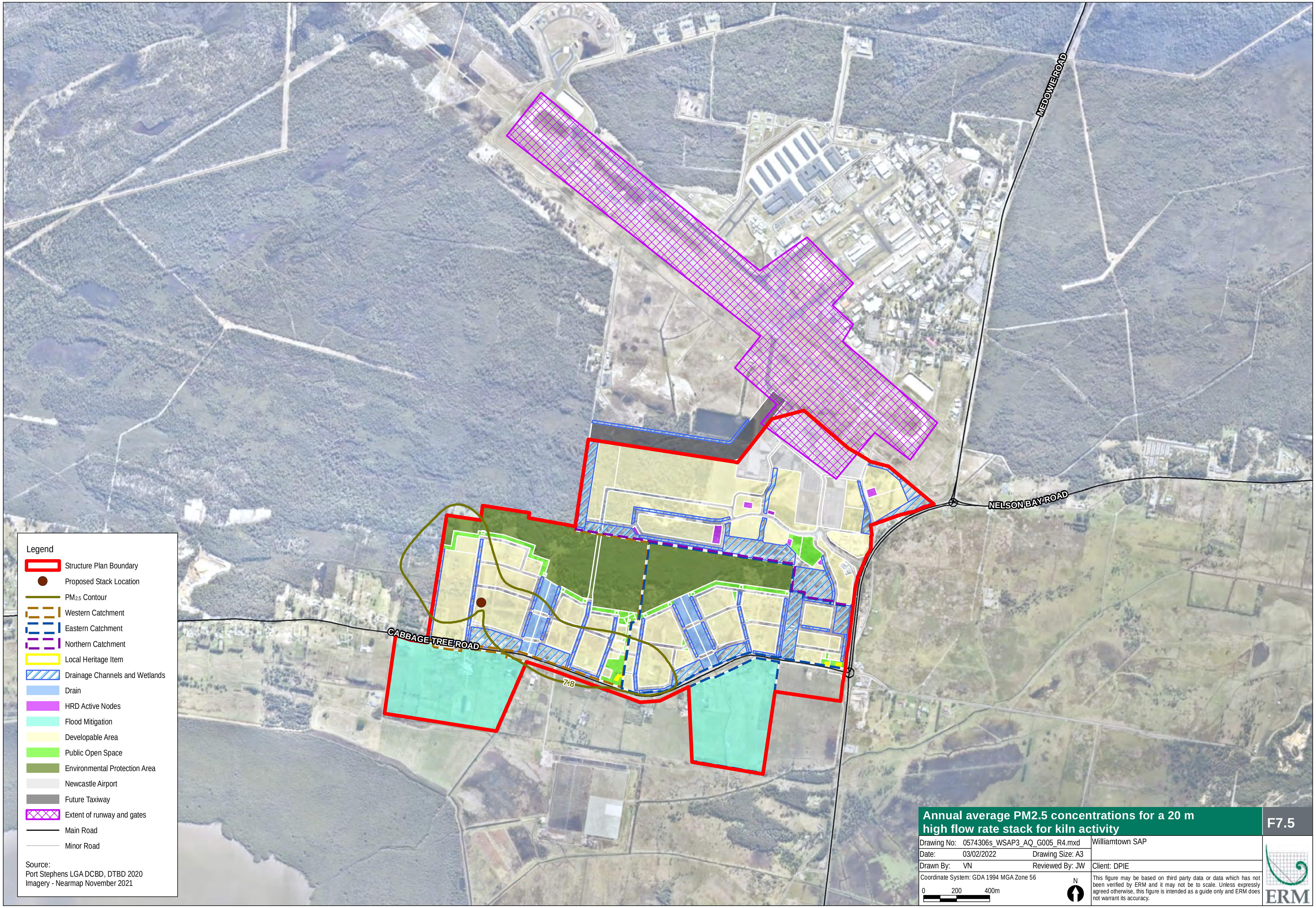
Figure 7.6 presents the maximum 24-hour average $PM_{2.5}$ concentration including background for a 20 m high flow rate stack for kiln activity.

[2] This limit actually applies to total dust as set out in the POEO Clean Air Regulation, but assuming that this could be 100% PM_{10} is a conservative approach.

[3] This limit actually applies to total dust as set out in the POEO Clean Air Regulation, but assuming that this could be 100% $PM_{2.5}$ is a conservative approach.

For the maximum 1-hour NO_2 concentration, the results were again highest for the 20 m stack with the higher flow rate. It is noted that the NSW EPA impact assessment criterion was not exceeded at any modelled height. For the high flow rate 20 m stack, there were exceedances of the NEPM AAQ standards but this was contained within the Williamtown SAP boundary. There is a significant reduction in the NEPM AAQ standard compared to the NSW EPA impact assessment criterion. In addition, as this is a 1-hour averaging period it could occur only once during the year and would occur when maximum NO_x and maximum concentrations occur on the same hour.

Figure 7.7 presents the maximum 1-hour NO_2 concentration including background for a 20 m high flow rate stack.



Annual average PM2.5 concentrations for a 20 m high flow rate stack for kiln activity

F7.5

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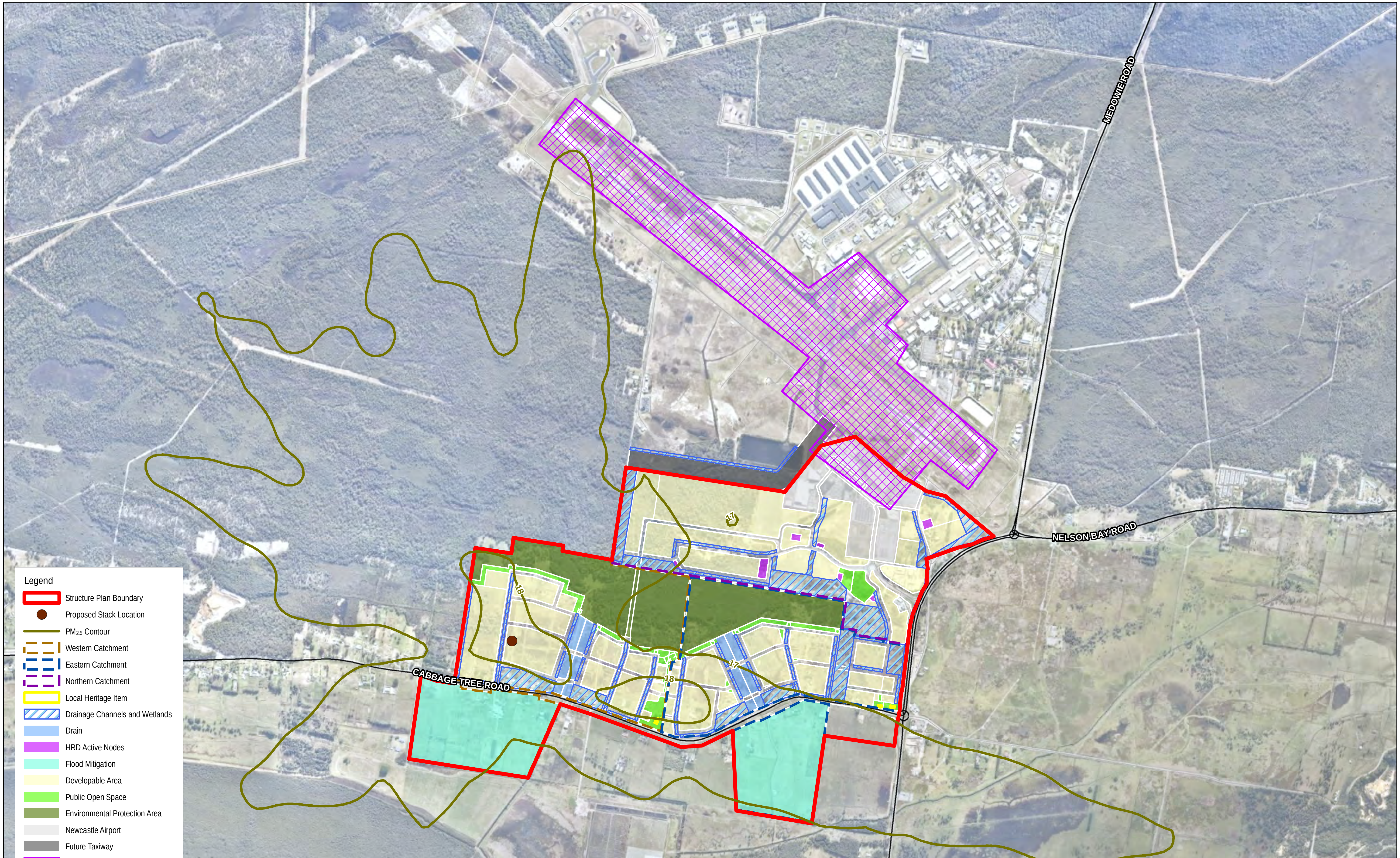

Maximum 24-hour average $PM_{2.5}$ concentrations for a 20 m high flow rate stack for kiln activity

F7.6

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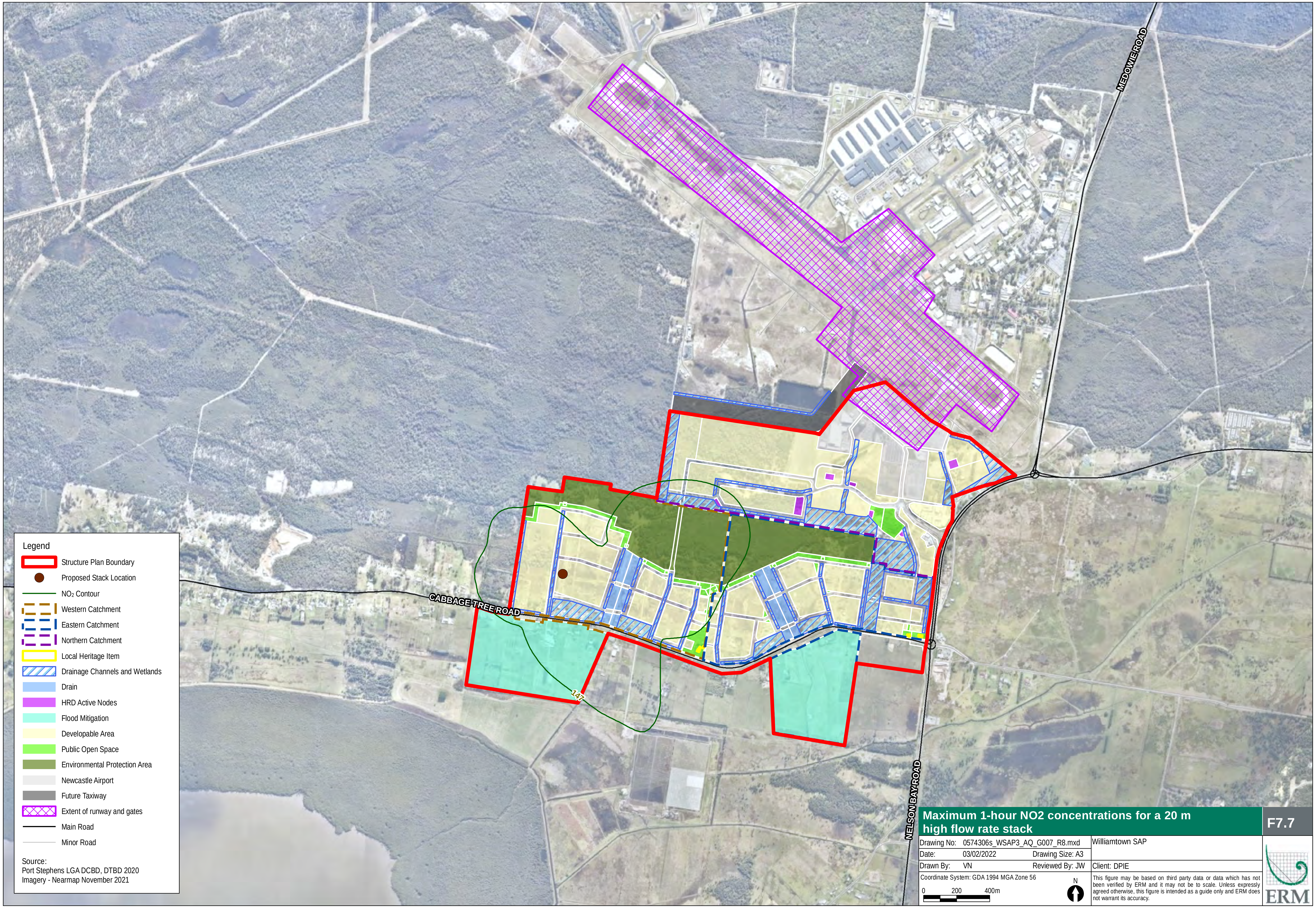
MEDOWIE ROAD
CABBAGE TREE ROAD
NELSON BAY ROAD
147
Legend
Structure Plan Boundary
Proposed Stack Location
NO_2 Contour
Western Catchment
Eastern Catchment
Northern Catchment
Local Heritage Item
Drainage Channels and Wetlands
Drain
HRD Active Nodes
Flood Mitigation
Developable Area
Public Open Space
Environmental Protection Area
Newcastle Airport
Future Taxiway
Extent of runway and gates
Main Road
Minor Road
Source:
Port Stephens LGA DCBD, DTBD 2020
Imagery - Nearmap November 2021
Maximum 1-hour NO2 concentrations for a 20 m high flow rate stack
F7.7
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Williamtown SAP
Date: 03/02/2022
Drawing Size: A3
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Reviewed By: JW
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This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
ERM

8. PLUME RISE SCREENING ANALYSIS

A screening level plume rise analysis has been undertaken in order to understand potential industrial point source constraints associated with the protection of airspace connected to the Royal Australian Air Force (RAAF) Base Williamtown.

These constraints relate to the impact of both physical structures (such as an exhaust stack), as well as thermal plume emissions, where the associated turbulence has the potential to affect the safety of aircraft operations, such as aircraft in critical stages of flight (periods of high pilot workload) and low-level flying operations. Part 139.370 of the Civil Aviation Safety Regulations 1988 (CASR) also provides that CASA may determine that a gaseous efflux having a velocity in excess of 4.3 m/s is, or will be, a hazard to aircraft operations because of the velocity or location of the efflux (CASA, 2019).

Aviation authorities have established that exhaust plumes with vertical velocities exceeding 4.3 m/s have the potential to cause damage to an aircraft airframe, or upset an aircraft flying at low altitudes. Light aircraft, including helicopters, are more likely to be affected by a plume than a heavier aircraft at the same altitude. The CASR provide that CASA may determine that a plume is a hazardous object if the vertical velocity of the exhaust exceeds 4.3 m/s. In addition, vertical wind gusts in excess of 10.6 m/s are noted as potentially resulting in severe turbulence and may cause momentary loss of aircraft control.

8.1 The Obstacle Limitation Surface

A key instrument for protection of airspace is the obstacle limitation surface (OLS). The OLS is an imaginary surface that represents the desirable limit to which objects may project into the airspace around an aerodrome so that aircraft operations may be conducted safely.

The geometry of an OLS is standardised by the International Civil Aviation Organisation (ICAO), with associated requirements specified within Chapter 7 of the Manual of Standards 139 – Aerodromes (CASA, 2020) based on aerodrome type. The OLS comprises a number of planar and conical surfaces. Figure 8.1 shows the generic structure of an OLS, as applied in Australia.

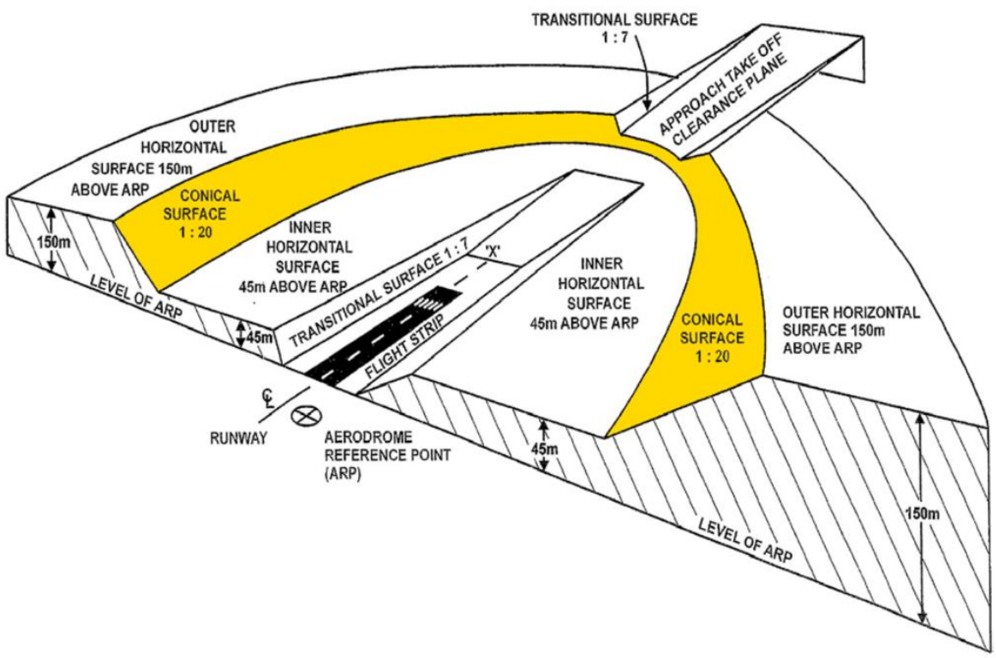


Figure 8.1: Generic structure of an OLS (ATSB, 2018)

Given the location of the industrial stack sources to the side of the RAAF Base Williamtown runway alignment, the surfaces of most relevance to this screening are:

- The inner horizontal surface;
- The conical surface; and
- The outer horizontal surface.

In a simplified sense, the inner horizontal surface extends 4000 m from a centreline that spans the extent of the runway (end to end), and at a height of 45 m above the (aerodrome specific) aerodrome reference point (ARP). Beyond this surface, a conical surface extends up to the outer horizontal surface at a gradient of 5%. The outer horizontal surface extends from the conical surface, to a distance 15000 m from the runway centreline at a height of 150 m above the ARP. Noting the height transition (105 m), and 5% gradient of the conical surface, the conical surface extends 6,100 m from the runway centreline, beyond which the horizontal surface is located. From ERM (2019a) an ARP reference height of 6.5 mAHD can be inferred, as evidenced by an outer horizontal surface height of 156.5 mAHD.

8.2 Assessment guidance

8.2.1 CASA Advisory Circular

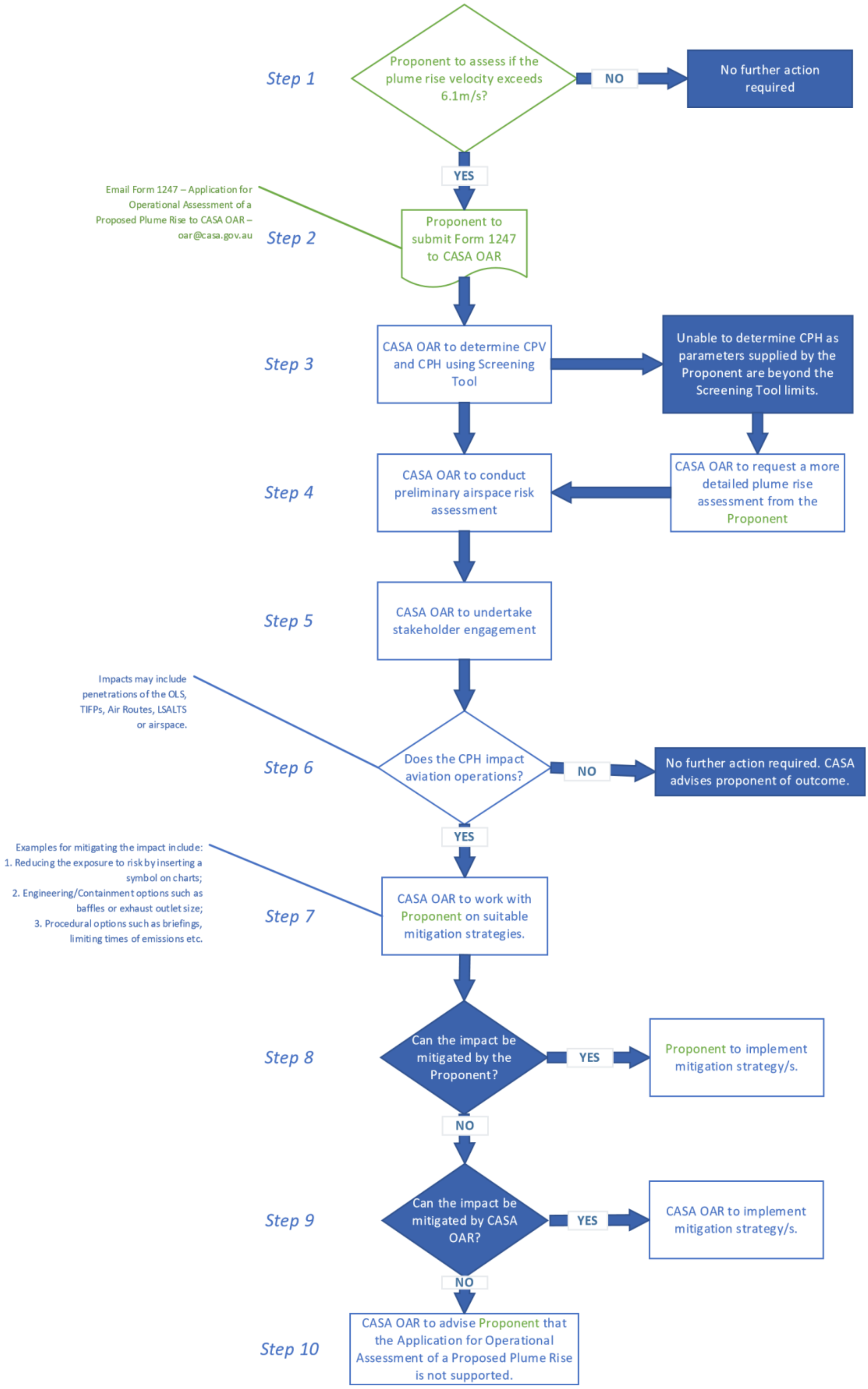
Guidance for plume rise assessments is provided in *Advisory Circular AC 139-05 v3.0, Guidelines for Conducting Plume Rise Assessments* (CASA, 2019). Plume rise assessment includes the assessment of the critical plume velocity (CPV) and critical plume height (CPH) and the subsequent assessment of potential plume impacts.

Released in January 2019, CASA (2019) introduced a CPV of 6.1 m/s as a default value for analysis of these impacts. Within this report, performance against CPVs of 4.3, 6.1 has been presented. These CPVs are provided in CASA (2019) as thresholds against which potential plume rise impacts may be assessed in accordance with the following classifications:

1. **Light** (1.5 - 6.1 m/s) which can cause momentary changes in altitude and attitude.
2. **Moderate** (> 6.1 - 10.6 m/s) which can cause appreciable changes in altitude and attitude.
3. **Severe** (>10.6 m/s - 15.2 m/s) which can cause large abrupt changes in altitude and attitude and momentary loss of control
4. **Extreme** (> 15.2 m/s) where it can be practically impossible to control the aircraft, and which can cause structural damage.

CASA (2019) considers an exhaust plume of moderate or higher turbulence intensity has the potential to affect the safety of aircraft operations, such as aircraft in critical stages of flight (periods of high pilot workload) and low-level flying operations. A generalised outline of the default plume rise assessment process is outlined in Figure 8.2.

Given the hypothetical nature of this screening, this application process has not been applied, but is provided as being instructive of the assessment process for proposed developments.



Source: CASA, 2019

Figure 8.2: Overview of plume rise assessment process

8.2.2 CASA Technical Brief

Requirements for plume rise assessment are further detailed in CASA's *Plume Rise Assessment – Technical Brief* (Technical Brief) (CASA, 2013).

A summary of the requirements to determine the relevant CPH is as follows:

- Site-specific meteorology is to be used;
- A five-year period is to be assessed;
- CASA also specifies that TAPM Version 4 (or later) or CALPUFF Version 6.267 (or later) should be used;
- Where relevant, the methodology described in (Manins, P, 1992) should be used to account for the merging of multiple plumes;
- The 0.1% exceedance level for each year should be determined; and
- The maximum extent of the plume for each year should be determined.

8.3 Assessment methodology

8.3.1 Process overview

Plume rise modelling has been carried out using the CSIRO's TAPM model (V4.05) in accordance with CASA guidance (CASA 2019; 2013):

- The CSIRO's TAPM model was run to provide five years (43,824 hours) of hourly plume rise profiles for a single stack. These profiles were then processed to estimate the extent of plume buoyancy enhancement associated with the merging of plumes produced from the Project's multiple stacks.
- The plume rise profiles were processed to provide a spatial representation of the regions of airspace in which the plume exceeds the CASA defined critical plume velocities (CPVs). Model results were reviewed against the OLS.

8.3.2 Screening scenarios

In total, this assessment has modelled four individual stack options at a single indicative location as consistent with the dispersion modelling documented within Section 6.

Table 8.1 provides a summary of the industrial point source screening locations and inferred OLS heights at each locations.

Table 8.1: Summary of plume rise modelling scenarios

<table>
<tr><th>Scenario</th><th>Stack 1</th><th>Stack 2</th><th>Stack 3</th><th>Stack 4</th><th>Units</th></tr>
<tr><td>Easting</td><td colspan="4">389495</td><td rowspan="2">mE, MGA94</td></tr>
<tr><td>Northing</td><td colspan="4">6368806</td></tr>
<tr><td>Distance from Runway</td><td colspan="4">2.4</td><td>km</td></tr>
<tr><td>OLS - Surface Type</td><td colspan="4">Inner Horizontal</td><td>-</td></tr>
<tr><td>Inferred OLS Height</td><td colspan="4">51.5</td><td rowspan="2">mAHD</td></tr>
<tr><td>Base Elevation</td><td colspan="4">5.3</td></tr>
</table>

Notes: mAHD – metres elevation, referenced to the Australian Height Datum.
mAGL – metres above ground level

To provide additional spatial context, Figure 8.3 provides shows an example of common flight paths relative to the screening location, as sourced from the Department of Defence Noise and Flight Path Monitoring System for the month of December, 2019 (DoD, 2021). As shown in the figure, the point source location is in the direct vicinity of commonly used flight paths, as shown by the higher density of flight trace lines in the vicinity.

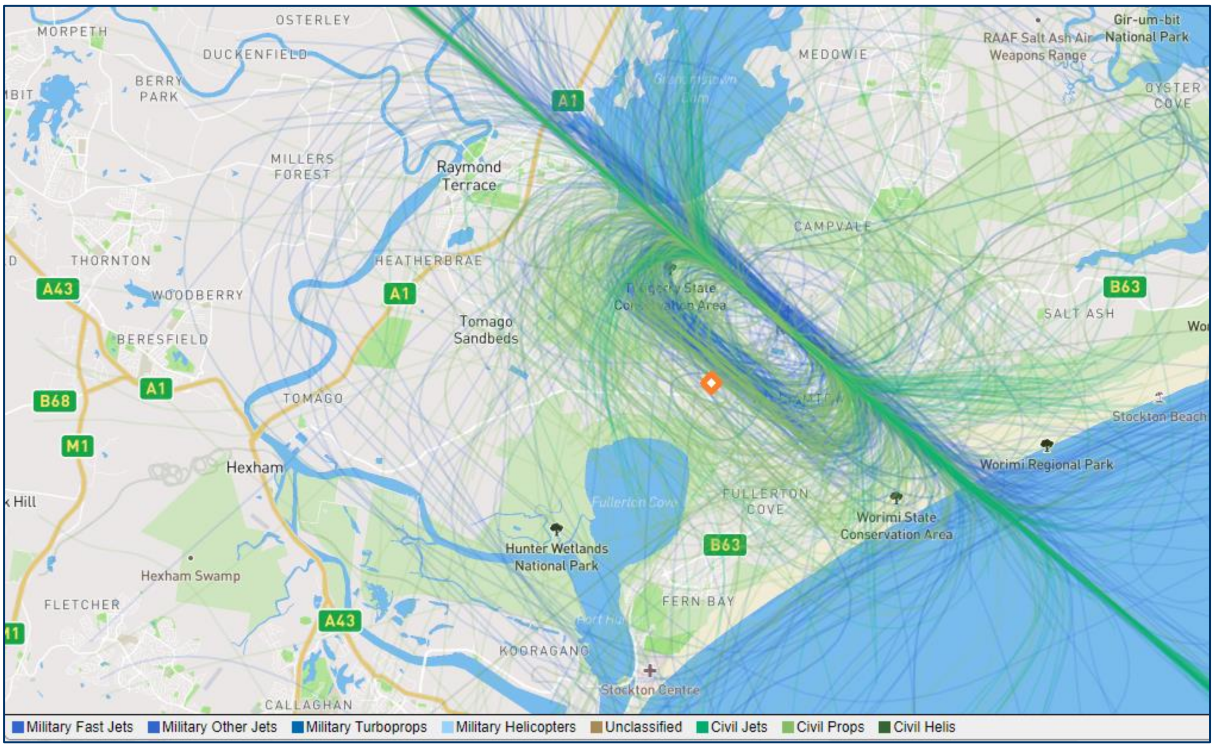


Image Source: (NFPMS, 2021)

Figure 8.3: Approximate point source screening location relative to common flight paths

8.3.3 Emission parameters

Nominal exhaust emission parameters for stack sources have been collated and are provided in Section 6.2.

Table 8.2: Summary of stack emission parameters

Scenario	Stack 1	Stack 2	Stack 3	Stack 4	Units
Stack Base Elevation	5.3				mAHD
Stack Height	15	20	15	20	mAGL
	20.3	25.3	20.3	25.3	mAHD
Diameter	2	2	1	1	m
Temperature	473	473	373	373	Kelvin
Exit velocity	10	10	10	10	m/s

8.3.4 TAPM model configuration

The Air Pollution Model, (TAPM) has been applied in this assessment as nominated for use within CASA (2013). TAPM is a three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research. TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution dispersion components, eliminating the need to have site-specific meteorological observations. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

TAPM incorporates the following databases for input to its computations:

- Gridded database of terrain heights on a latitude/longitude grid of 30 second grid spacing, (around one kilometre). This default dataset is supplemented by a finer resolution dataset at nine second spacing (around 270 metres) for this assessment.
- Australian vegetation and soil type data at three-minute grid spacing, (around five kilometres).
- Rand's global long term monthly mean sea-surface temperatures on a longitude/latitude grid at one-degree grid spacing (around 100 kilometres).
- Six-hourly synoptic scale analyses on a latitude/longitude grid at 0.75-degree grid spacing, (around 75 kilometres), derived from the local analysis and prediction system (LAPS) data from the Bureau of Meteorology.

TAPM (V4.0.5) was run for a five year modelling period as per the configuration outlined in Table 8.3.

Table 8.3: Summary of TAPM model configuration

Parameter	Value
Centre of TAPM Analysis	151°50’00’’ E, 32°47’00’’ °S
	390746 mE, 6372130 mN (MGA94, Zone 56H)
Number of grids	4
Grid spacing	30 km, 10 km, 3 km, 1km
Number of grid points	25 x 25 x 25
Years of analysis	2016 to 2020 (inclusive)
Terrain information	AUSLIG 9 second DEM data
Mode	Meteorology and Pollution - Lagrangian Particle Mode (Inner Grid)

8.3.5 Plume Rise Model

TAPM incorporates a detailed treatment of plume rise, based on a numerical implementation of Glendening (1984). This comprises the solution of a system of coupled differential equations for changes in bulk plume buoyancy, momentum and volume fluxes on a time step basis, with resolution of plume velocity and radius at each time step. For a given hour of the model run, these equations allow the estimation of the plume rise profile corresponding to the meteorological conditions predicted for that hour.

The TAPM outputs from the five-year simulation period include a file containing gradual plume rise data for every hour and from each emission source. This output includes data for plume averaged vertical velocity, plume height and plume dimensions from one second after release to the time that the final plume height is reached.

A sample gradual plume rise output file from TAPM is presented in Figure 8.4. This file shows plume rise parameters for the first 20 seconds (t(s)) after release, for the first hour of a model run. The outputs show the vertical velocity (w), height (z) and plume spread statistics (Ry, Rz, Dx and Dy).

```
DATE=20140101,HOUR= 1
src#,t(s),w(m/s),z(m),Ry(m),Rz(m),Dx(m),Dy(m)
  1,   1,10.06,  48.,   8.,   4.,    -1.,    -1.
  1,   2, 7.67,  56.,  11.,   6.,    -3.,    -3.
  1,   3, 6.56,  63.,  14.,   7.,    -4.,    -5.
  1,   4, 5.88,  69.,  17.,   8.,    -6.,    -6.
  1,   5, 5.40,  75.,  19.,  10.,    -7.,    -8.
  1,   6, 5.04,  80.,  21.,  11.,    -9.,   -10.
  1,   7, 4.76,  85.,  24.,  12.,   -11.,   -12.
  1,   8, 4.52,  90.,  26.,  13.,   -12.,   -14.
  1,   9, 4.32,  94.,  28.,  14.,   -14.,   -16.
  1,  10, 4.14,  98.,  30.,  15.,   -16.,   -19.
  1,  11, 3.99, 103.,  32.,  16.,   -18.,   -21.
  1,  12, 3.85, 106.,  33.,  17.,   -20.,   -23.
  1,  13, 3.73, 110.,  35.,  18.,   -21.,   -25.
  1,  14, 3.62, 114.,  37.,  19.,   -23.,   -28.
  1,  15, 3.53, 118.,  39.,  19.,   -25.,   -30.
  1,  16, 3.44, 121.,  41.,  20.,   -27.,   -32.
  1,  17, 3.35, 124.,  42.,  21.,   -29.,   -35.
  1,  18, 3.28, 128.,  44.,  22.,   -31.,   -37.
  1,  19, 3.21, 131.,  46.,  23.,   -33.,   -39.
  1,  20, 3.14, 134.,  47.,  24.,   -35.,   -42.
```

Figure 8.4: Excerpt from TAPM gradual plume rise file

The TAPM plume rise profiles are provided in regular time intervals from the point of release. Therefore, plume rise statistics for specific heights need to be generated via interpolation of the TAPM outputs. Each hourly prediction is then collated into statistical representations of plume rise extent across each 43,824-hour model run.

8.4 Results

Table 8.4 provides a summary of the plume rise results, as representative of the heights at which exhaust emissions are predicted to possess a plume-average velocity greater than or equal to the critical plume velocity (CPV) shown.

It is noted that in cases where five years of meteorology are modelled, the 99.9th percentile result is typically applied (CASA, 2013) and that a CPV of 6.1 m/s has been broadly endorsed in CASA (2019), but that CPV's of between 4.3 and 10.6 m/s may be applied depending on the assessment factors such as the phase of flight affected, with lower velocities used in more sensitive applications.

Table 8.4: Summary of Plume Rise Modelling Results

Scenario	Stack 1	Stack 2	Stack 3	Stack 4	Units
OLS	51.5*				mAHD
CPV = 4.3 m/s					
Maximum	32.8	37.8	24.6	29.6	mAHD
99.9th Percentile	28.4	33.2	24.4	29.4	
CPV = 6.1 m/s					
Maximum	25.0	30.0	23.2	28.2	mAHD
99.9th Percentile	24.7	29.7	23.1	28.1	

*Assumed OLS, should be confirmed for subsequent applications

These results show that inferred OLS incursions are not predicted for the nominal industry stack sources assessed, with plume velocities predicted to reduce below 4.3 m/s prior to reaching the inferred OLS. These results indicate that appropriately scaled industrial sources would be unlikely to adversely impact upon the RAAF Williamtown airspace.

Given the proximity to RAAF Williamtown, it is recommended that any proposed developments be assessed for compliance with relevant planning controls for the management of airspace in and surrounding RAAF Williamtown, and that CASA review the plume rise modelling for any proposed stack source.

9. MITIGATION STRATEGIES

When considering the modelled point source, there are predicted exceedances of the NEPM AAQ standards for maximum 1-hour NO_2 but these are contained within the Williamtown SAP boundary. The NEPM AAQ standards for NO_2 is considerably lower when compared with the NSW EPA impact assessment criteria. For maximum 1-hour NO_2, the background concentration is approaching the NEPM AAQ standard of 164 µg/m^3 and the contribution from the airport activities and the proposed industrial activity is considered to be small.

There are no predicted exceedances of the annual average $PM_{2.5}$ NSW EPA impact assessment criteria when considering the modelled point source. It should however be noted that the background concentration of 7.7 µg/m^3 is approaching the NSW EPA impact assessment criteria of 8 µg/m^3 and is already above the National Environment Protection goal of 7 µg/m^3. This assessment has shown that the contribution from the airport activities and the proposed industrial activity is considered to be minor.

While this study has shown that even with conservative assumptions regarding emissions there are unlikely to be air quality impacts caused by activities within the Williamtown SAP area, it is still necessary that best practice mitigation and management measures be considered for new industrial activities. In addition, due to the highly variable, and operation specific nature of air emission generation, a project specific air quality impact assessment should be undertaken for facilities that trigger the intensity thresholds outlined in Scheduled 3 of the Environmental Planning and Assessment Act 2000 (as reflected in Table 1-2 of this report), as required to demonstrate compliance with relevant regulatory impact assessment criteria, as specified within the Approved Methods. Emissions from most of the industries proposed as options can be relatively well controlled. General mitigation options for managing stack emissions can include such things as:

- Treatment of emissions prior to release into the atmosphere. This may include devices such as bag filters, activated carbon filters, wet or dry scrubbers etc;
- Improving plume dispersion (subject to aviation safety constraints):
  - Increasing thermal buoyancy of the emitted gas by increasing release temperatures;
  - Raising stack heights; and / or
  - Increasing exit velocity.
- Regular equipment maintenance to ensure proper and efficient operation.

10. SUMMARY AND CONCLUSIONS

This report presents the Air Quality and Odour Assessment for the Williamtown Special Activation Precinct (SAP). This report provides an investigation of the Williamtown SAP, agreed during the Final Enquiry by Design workshop, as they relate to air quality and odour.

The existing RAAF base/Newcastle Airport is considered within the SAP boundary and is the main existing emission source. This assessment has considered the proposed expansion of the airport taking into account additional aircraft movements and larger aircraft for the year 2036.

There are potential air emission sources in the western catchment of the Williamtown SAP. The potential land uses in this area may include: brewery/distillery, ceramics and glass industries, chemical industries and works, petroleum works, and contaminated soil treatment works. This assessment has considered a proposed stack source located in the light industrial area. This stack source has been tested for different flow rates, temperatures, stack diameters and height.

Dispersion modelling has been undertaken for the existing and proposed emission sources. The modelling has focused on the following pollutants; particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides/nitrogen dioxide (NO_x/NO_2) and Volatile Organic Compounds (VOCs). The results have been compared with the current NSW EPA impact assessment criteria and NEPM AAQ standards.

The modelling of the proposed airport expansion showed that any proposed exceedances of the NSW EPA impact assessment criterion or NEPM AAQ standards was due to a high background concentration. For $PM_{2.5}$ exceedances, these were mostly contained with the airport site boundary. For maximum 1-hour NO_2 exceedances, these were for the NEPM AAQ standards and were again due to the high background concentration. In addition, as this is a 1-hour averaging period it could occur only once during the year and would occur when maximum NO_x and maximum concentrations occur on the same hour.

For the proposed point source, there were no predicted exceedances of the NSW impact assessment criteria for any of the scenarios for annual average and 24-hour average $PM_{2.5}$, annual average and 24-hour average PM_{10}, annual average NO_2, and the maximum 1-hour for benzene, which was selected for VOCs.

For annual average and maximum 24-hour average $PM_{2.5}$ concentrations, it was noted that results were slightly higher when considering emission rates for the kiln activity, when compared with the crushing activity across heights and flow rates. The predicted cumulative concentrations were dominated by background concentrations. The largest extent of the contours was noted for the 20 m stack with a high flow rate. The modelled concentrations represent stack / point sources emitting at their regulatory limits. It is likely that these emissions will be lower but conservative assumptions have been used here. In addition, the modelling has assumed that $PM_{2.5}$ is 100% of total dust which is a conservative approach.

For the maximum 1-hour NO_2 concentration, the results were again highest for the 20 m stack with the highest flow rate. It should be noted that the NSW EPA impact assessment criterion was not exceeded at any modelled height. For the high flow rate 20 m stack, there were exceedances of the NEPM AAQ standards but this was contained within the Williamtown SAP boundary. There is a significant reduction in the NEPM AAQ standard compared to the NSW EPA impact assessment criterion. In addition, as this is a 1-hour averaging period it could occur only when high background and maximum concentrations occur in the same hour.

For plume rise, the results show that inferred OLS incursions are not predicted for the nominal industry stack sources assessed, with plume velocities predicted to reduce below 4.3 m/s prior to reaching the inferred OLS. These results indicate that appropriately scaled industrial sources would be unlikely to adversely impact upon the RAAF Williamtown airspace.

The recommendations, based on air quality are:

- Given the proximity to RAAF Williamtown, it is recommended that any proposed developments be assessed to compliance with relevant planning controls for the management of airspace in and surrounding RAAF Williamtown;
- For possible odour/air emissions sources from a proposed brewery or contaminated soil treatment works, it is considered that these industries could be located within the Williamtown SAP with the appropriate controls considered at the design stage so that there is no offensive odour beyond the boundary of the facility;
- The industries proposed are considered suitable for the Williamtown SAP and it is recommended that these are located in the western catchment;
- A single point source (stack) could be located within the western catchment based on the height, flow rate and other stack parameters modelled; and
- Further air quality modelling and plume rise modelling is conducted when the suitable detail of the proposed industry is available. Should two stack sources be considered within the western catchment then cumulative modelling is recommended.
- The airport has been considered holistically as part of the Williamtown SAP but an upgrade to the airport is subject to a separate assessment and approval process to the Williamtown SAP;

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