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Appendix F1
Local air quality and greenhouse gas

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Report

WESTERN SYDNEY AIRPORT EIS – LOCAL AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

DEPARTMENT OF INFRASTRUCTURE AND REGIONAL DEVELOPMENT

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EXECUTIVE SUMMARY

Pacific Environment was engaged by GHD to prepare an Air Quality and Greenhouse Gas Assessment for the proposed Western Sydney Airport ('the airport') as part of an Environmental Impact Statement (EIS) required under the *Environment Protection and Biodiversity Conservation Act 1999.*

The assessment quantified the potential local air quality impacts and greenhouse gas emissions that may arise due to the operation of the Stage 1 airport development and long-term airport development as well as the Stage 1 construction phase. For the purposes of the assessment, the local air quality study was defined as being within a 5 km radius of the airport site. The regional air quality impacts were addressed separately in *Western Sydney Airport EIS – Regional Air Quality Assessment* **(Environ, 2015)**.

The assessment followed the procedures outlined in the NSW Environment Protection Authority (EPA) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**).

The air quality assessment for the Draft EIS was completed in October 2015. The assessment was updated in May 2016 to reflect revised traffic modelling for the airport and the publication of the new *National Environment Protection (Ambient Air Quality) Measure* (NEPM-AAQ) in February 2016.

DESCRIPTION OF OPERATIONS

The airport would service both domestic and international air traffic, with development staged in response to passenger demand. The initial development of the airport would include a single, 3,700 metre runway coupled with landside and airside facilities such as passenger terminals, cargo and maintenance areas, car parks and navigational instrumentation capable of facilitating the safe and efficient movement of up to 10 million domestic and international passengers per year.

In the long-term, approximately 40 years after the airport has been constructed and in accordance with relevant planning processes, the airport development could include parallel runways and additional passenger and rail transport facilities for around 82 million passenger movements per year. To maximise the potential of the site, the airport is proposed to operate on a curfew-free basis. Consistent with the practice at all federally leased airports, non-aeronautical commercial uses could also be permitted on the site.

OPERATIONS ASSESSMENT METHODOLOGY

The contribution of airport operations to local air pollution was calculated using the United States (US) Federal Aviation Administration (FAA) Emissions and Dispersion Modelling System (EDMS) (Version 5.1.4, June 2013). EDMS performs dispersion analyses using the USEPA's AERMOD **(USEPA, 2004a)** dispersion model. AERMOD has been accepted in Australia for use in a variety of regulatory applications, including several other recent airport assessments such as those for Sydney (Kingsford Smith) Airport (KSA) and Adelaide Airport.

The air quality metrics currently included in EDMS for dispersion analysis are carbon monoxide (CO), total hydrocarbons (THC), non-methane hydrocarbons (NMHC), volatile organic compounds (VOC), total organic gases (TOG), oxides of nitrogen (NO_X), oxides of sulfur (SO_X) and (primary) particulate matter less than 10 micrometres and 2.5 micrometres in aerodynamic diameter (PM_{10} and $PM_{2.5}$ respectively).

Two assessment scenarios were investigated:

- Stage 1 development
- Long-term development

STAGE 1 OPERATIONAL IMPACTS

For the Stage 1 development, the following pollutants were assessed: NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2, air toxics, odour from exhaust emissions and from the waste water treatment plant.

There were no predicted exceedances of the NSW EPA criteria or NEPM Ambient Air Quality (NEPM-AAQ) standards at the residential receptors investigated for Stage 1 operations.

With the exception of roadways external to the airport site, aircraft movements were the largest source of PM_{10}, $PM_{2.5}$, NO_X and SO_2 within the study area. The operation of auxiliary power units (APUs) and ground support equipment (GSE) also had an influence on the predicted pollutant concentrations. Aircraft and stationary sources, in particular evaporative losses from the jet fuel tanks, were shown to be a significant contributor to VOC emissions and corresponding predicted ground-level concentrations.

The highest off-site concentrations were generally predicted to occur at the receptors located to the north and northeast of the airport. This was a function of the location of the runway, prevalence of south-westerly winds and the proximity of these receptors to airport activities.

The external road infrastructure was shown to be a significant contributor to predicted off-site ground level concentrations, particularly for those receptors located close to existing or proposed new roadways.

There were almost no predicted exceedances of the NSW EPA criteria or the current NEPM-AAQ standards at the residential or on-site receptors investigated for the proposed Stage 1 operations. The exception was the 99.9th percentile 1-hour maximum for formaldehyde, with an exceedance predicted at the on-site receptors R24 and R25 when assessed against the NSW EPA assessment criterion.

The predicted $PM_{2.5}$ concentrations demonstrated compliance with the NEPM-AAQ 24-hour goal for 2025 of 20 µg/m^3 and current annual goal of 8 µg/m^3.

All receptors will exceed the annual NEPM-AAQ goal for 2025 of 7 µg/m^3, as the background contribution is in excess of this value. Incremental contributions associated with the airport are predicted to range between 0.1 µg/m^3 and 0.8 µg/m^3 for the residential receptors. It is anticipated that there would need to be a region wide emission reduction program, addressing multiple and diverse potential emission sources, to meet this goal.

Predicted off-site odour concentrations were below odour detection limits for both aircraft exhaust emissions and odours from the waste water treatment plant.

LONG-TERM OPERATIONAL IMPACTS

A key assumption in the assessment of the long-term development was that there would be no improvement in aircraft emissions, either due to improvements in fuel or in engine emission-control. This was based on the inability to predict the effect of future policies or technological developments which would be expected to occur and which would be likely to result in reductions in predicted concentrations. This assumption will have led to a degree of conservatism in the assessment for the long-term development scenario.

Given the uncertainty in emissions from a future aircraft fleet, combined with an expected improvement in aircraft emissions over time, the long-term development was evaluated only for the most important air quality metrics (NO_2, PM_{10} and $PM_{2.5}$).

The results indicated some exceedances of the 1-hour average NO_2 criterion of 246 µg/m^3 at six residential receptors. These exceedances were predicted to occur for between one and two hours per year.

With the exception of roadways external to the airport site, aircraft movements were again by far the largest source of PM_{10}, $PM_{2.5}$, NO_X and SO_2 within the study area, with operation of APUs and GSE also having an influence on predicted off-site impacts. Aircraft and stationary sources, in particular evaporative loss from the jet fuel tanks, were shown to be a significant contributor to VOC emissions and corresponding predicted ground level concentrations.

The results of the dispersion modelling indicated that, under the conservative emission assumptions adopted, there would be exceedances of the 1-hour average NO_2 objective of 320 µg/m^3 in the AEPR at five residential receptors. These exceedances were predicted to occur for between one and two hours per year.

Predicted (cumulative) 24-hour PM_{10} concentrations were anticipated to be below the NSW EPA impact assessment criterion of 50 µg/m^3 at all on-site and residential receptors.

At one on-site receptor (R24) and two off-site receptors (R14 and R18), cumulative $PM_{2.5}$ concentrations were predicted to be above the NEPM-AAQ standard of 8 µg/m^3 for the annual averaging period.

All receptors are predicted to exceed the annual NEPM-AAQ goal for 2025 of 7 µg/m^3, as the background contribution (i.e. in the absence of any airport development) is already in excess of this value. Increment from the airport ranges between 0.1 µg/m^3 and 0.8 µg/m^3 for the residential receptors. It is envisaged that, if the long-term development is undertaken at some point in the future, there would need to be a region wide emission reduction program to meet NEPM-AAQ goal.

CONSTRUCTION IMPACTS

Due to the transient and variable nature of construction activities, it is difficult to accurately quantify air quality impacts from construction activities. Any effects of construction on airborne particle concentrations would generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary mitigation measures are routinely employed on other construction sites. However, in view of the length of the construction period, a quantitative assessment of impacts was completed for the following:

- Bulk earthworks (particulate matter (PM) impacts only)
- Construction of aviation infrastructure
- Working crew (PM impacts)
- Concrete batching plant (PM impacts)
- Asphalt plant (odour impacts)

A risk-based approach was used to identify key construction air quality risks and to recommend appropriate mitigation measures based on the methodology described by the UK Institute of Air Quality Management (IAQM). Most of the recommended measures are routinely employed as 'good practice' on other construction sites. At the airport site particular attention should be paid to controlling PM generated by vehicles traveling on unsealed surfaces and transporting materials onto the road network (track-out) due to the overall level of risk and the potential close proximity of potential track-out PM emissions to sensitive receptors.

AIR QUALITY MANAGEMENT AND MITIGATION

The largest contributor of on-site emissions was aircraft taking off and landing, for both the proposed Stage 1 and long-term development scenarios. However, the regulation of aircraft engine emissions would be beyond the remit of the Western Sydney Airport developer or operator. Moreover, potential exceedances of air quality criteria (notably 1-hour NO_2 and 24-hour / annual $PM_{2.5}$) were predicted to occur due to activities associated with ground power units. Mitigation of such activities may include the connection of APUs to the mains power where practicable rather than the current conservative assumption that they are operated by dedicated internal combustion engines.

Community concern over potential health impacts of airport emissions can be addressed through the conduct of ambient air quality monitoring within or in the vicinity of the airport. Such monitoring will provide scientifically robust data to demonstrate that any changes in local air quality associated with the WSA development would be within regulatory guidelines.

The international literature was reviewed to identify mitigation and management measures for NO_x emissions during operations at airports. A number of mitigation measures have been adopted by other airports internationally and are suggested for managing air quality impacts from the airport. It is acknowledged some of the measures are up to the individual airlines and out of the control of the airport operator to implement directly. Nevertheless, these measures are useful as a guideline for potential NO_x reduction.

FUEL JETTISONING

Currently, fuel jettisoning (commonly referred to as fuel dumping) events are very rare and only occur during certain emergency situations where alternative methods to achieve a safe landing are not feasible. Aircraft do not jettison fuel as a standard procedure when landing. Any potential local effects of fuel jettisoning at the airport site will be limited due to the inability of many aircraft to perform fuel jettisons, the quick vaporisation and dispersion of aircraft (jet) fuel, the strict regulations on fuel jettisoning altitudes and locations, and the anticipated reduction in fuel jettisoning events and volumes in the future. For these reasons, fuel jettisoning is not considered likely to have an impact on local air quality.

GREENHOUSE GASES

An assessment was conducted of greenhouse gas emissions from the construction, Stage 1 and long-term development phases of the proposed airport. Direct (scope 1) and indirect (scope 2) emissions from the Stage 1 development of the airport were 0.13 Mt CO_2-e/annum, with the majority of emissions being associated with purchased electricity. The Stage 1 development Scope 1 & 2 emissions associated with the airport represented approximately 0.11% of Australia's projected 2030 transport-related greenhouse gas emission inventory. For this reason, it was concluded that greenhouse gas emissions from the airport were not material in terms of the national inventory. However, a number of mitigation measures were suggested to reduce emissions.

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1 INTRODUCTION

Pacific Environment was engaged by GHD to prepare a local air quality and greenhouse gas (GHG) assessment for the proposed Western Sydney Airport ('the airport') as part of an Environmental Impact Statement (EIS), required under *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The assessment quantified the potential local air quality impacts and GHG emissions that would arise due to the operation of the proposed Stage 1 airport development and long-term development, as well as the Stage 1 construction phase.

This assessment followed the procedures outlined in the NSW Environment Protection Authority (EPA) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**) ('Approved Methods').

The air quality assessment for the Draft EIS was completed in October 2015. This assessment updates the previous report to reflect revised traffic modelling for the airport and the publication of the new *National Environment Protection (Ambient Air Quality) Measure* (NEPM-AAQ) in February 2016.

1.1 Background

Planning investigations to identify a site for a second Sydney airport first commenced in 1946, with a number of comprehensive studies—including two previous environmental impact statements for a site at Badgerys Creek—having been completed over the last 30 years.

More recently, the Joint Study on Aviation Capacity in the Sydney Region (**Department of Infrastructure and Transport, 2012**) and A Study of Wilton and RAAF Base Richmond for civil aviation operations (**Department of Infrastructure and Transport, 2013**) led to the Australian Government announcement on 15 April 2014 that Badgerys Creek will be the site of a new airport for Western Sydney. The airport is proposed to be developed on approximately 1,780 hectares of land acquired by the Commonwealth in the 1980s and 1990s. Airport operations are expected to commence in the mid-2020s.

The proposed airport would provide both domestic and international services, with development staged in response to demand. The initial development of the proposed airport (referred to as the Stage 1 development) would include a single, 3,700 metre runway coupled with landside and airside facilities such as passenger terminals, cargo and maintenance areas, car parks and navigational instrumentation capable of facilitating the safe and efficient movement of approximately 10 million passengers per year as well as freight operations. To maximise the potential of the site, the airport is proposed to operate on a 24 hour basis. Consistent with the practice at all federally leased airports, non-aeronautical commercial uses could be permitted on the airport site subject to relevant approvals.

While the proposed Stage 1 development does not currently include a rail service, planning for the proposed airport preserves flexibility for several possible rail alignments including a potential express service. A joint scoping study is being undertaken with the NSW Government to determine rail needs for Western Sydney and the airport. A potential final rail alignment will be determined through the joint scoping study with the New South Wales Government, with any significant enabling work required during Stage 1 expected to be subject to a separate approval and environmental assessment process.

As demand increases, additional aviation infrastructure and aviation support precincts are expected to be developed until the first runway reaches capacity at around 37 million passenger movements. At this time, expected to be around 2050, a second parallel runway is expected to be required. In the longer term, approximately 40 years after operations commence, the airport development is expected to fully occupy the airport site, with additional passenger and transport facilities for around 82 million passenger movements per year.

On 23 December 2014, the Australian Government Minister for the Environment determined that the construction and operation of the airport would require assessment in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act). Guidelines for the content of an environmental impact statement (EIS) were issued in January 2015.

Approval for the construction and operation of the proposed airport will be controlled by the Airports Act 1996 (Cth) (Airports Act). The Airports Act provides for the preparation of an Airport Plan, which will serve as the authorisation for the development of the proposed airport.

The Australian Government Department of Infrastructure and Regional Development is undertaking detailed planning and investigations for the proposed airport, including the development of an Airport Plan. A draft Airport Plan was exhibited for public comment with the draft EIS late in 2015.

Following receipt of public comments, a revised draft Airport Plan has been developed. The revised draft Airport Plan is the primary source of reference for, and companion document to, the EIS. The revised draft Airport Plan identifies a staged developpment of the proposed airport. It provides details of the initial development being authorised, as well as a long-term vision of the airport's development over a number of stages. This enables preliminary consideration of the implications of longer term airport operations. Any airport development beyond Stage 1, including the construction of additional terminal areas or supporting infrastructure to expand the capacity of the airport using the first runway or construction of a second runway, would be managed in accordance with the existing process in the Airports Act. This includes a requirement that, for major airport developments (defined in the Airports Act), a major development plan be approved by the Australian Government Minister for Infrastructure and Regional Development following a referral under the EPBC Act.

The Airport Plan will be required to include any conditions notified by the Environment Minister following this EIS. Any subsequent approvals for future stages of the development will form part of the airport lessee company's responsibilities in accordance with the relevant legislation.

1.2 Scope of work

The EIS Guidelines (Department of the Environment 2014) require the following to be addressed as part of the air quality assessment (Section 5g): "*changes to air quality during construction and operation (including consideration of seasonal and meteorological variations that influence local air quality)*".

This report has been prepared in accordance with the EIS Guidelines.

The scope of work of the local air quality assessment for the airport therefore included the following activities:

- Summarising the legislation, standards and goals that are relevant to air quality at the proposed airport.
- Characterising existing local air quality and meteorology in the vicinity of the airport site.
- Identifying the types and locations of sensitive receptors that are representative of residences and communities in the local area.
- Developing an airport model for estimating the operational emissions and associated ambient concentrations of regulated air pollutants.
- Assessing the operational impacts of the airport on emissions and air quality using a dispersion model.

- Developing emission inventories and conducting dispersion modelling for two assessment scenarios:
  - Stage 1 development
  - Long-term development
- Assessing construction impacts on air quality using a computer dispersion model.
- Quantifying and assessing GHG emissions in accordance with national and international framework.
- Providing mitigation and management measures to address identified issues.

1.3 Overview of airport construction and operations

The site for the Western Sydney Airport covers an area of approximately 1,780 hectares located at Badgerys Creek in Western Sydney. The airport site is located within the Liverpool local government area, around 50 kilometres west of Sydney's Central Business District and 15 to 20 kilometres from major population centres such as Liverpool, Fairfield, Campbelltown and Penrith.

The Northern Road transects the western end of the airport site and Elizabeth Drive borders the site to the north. Badgerys Creek flows in a north-easterly direction and forms the south eastern boundary of the airport site. The airport site is located on undulating topography that has been extensively cleared with the exception of stands of remnant vegetation located predominantly along Badgerys Creek and the south western portion of the site.

Based on the concept plans provided in Chapter 5 of Volume 1 of the EIS:

- The runways would be on an approximate 50/230 degree (magnetic) orientation, referred to as 05/23.
- The terminal complex including aircraft gates would be located approximately midway along the runway and in the middle of the site and ultimately between the two runways.
- Aircraft maintenance and cargo areas would be located at the south-western end of the site.
- The sewage treatment plant and main access road would be at the north-eastern end of the site.
- The jet fuel storage area would be along the north-western site boundary.

The proposed airport is expected to be developed over a number of stages.

The construction of the Stage 1 development would involve:

- Bulk earthworks.
- Aviation infrastructure and support facilities, including the use of on-site asphalt and concrete batching plants.
- Network infrastructure including utilities.
- Ground transport infrastructure.

Given the uncertainty of the timing of the long-term development, the construction impacts for this aspect have not been quantitatively assessed. Construction impacts for the Stage 1 development are therefore the focus of this assessment.

1.4 Structure of this report

The remainder of this report is structured as follows.

- Chapter 2 – outlines the relevant legislation and guidelines for the assessment as well as the modelling methodology and key modelling assumptions used.
- Chapter 3 – describes the methodology used to assess the operational, construction and GHG impacts.
- Chapter 4 – summarises the existing environmental conditions in and around the airport site at Badgerys Creek.
- Chapter 5 – presents the key stages and results of the airport operational assessment.
- Chapter 6 – presents a qualitative assessment of fuel dumping on the local area.
- Chapter 7 – presents the key stages and results of the construction assessment.
- Chapter 8 – presents the key stages and results of the GHG assessment.
- Chapter 9 – presents the summary and conclusions.

2 RELEVANT LEGISLATION AND STANDARDS

2.1 Background

The proposed airport has the potential to generate emissions in the form of nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), sulfur dioxide (SO_2), air toxics, odour and GHGs. These emissions have the ability to impact human health, amenity and contribute to climate change.

In an effort to reduce emissions, Australia's air navigation service provider, Airservices Australia, has implemented a range of measures to improve fuel efficiency such as flexible flight tracks, improved air traffic control sequencing, continuous descent approaches and better management of aircraft on the ground **(DIRD, 2014a)**.

Airservices Australia is also working with the Asia and Pacific Initiative to Reduce Emissions (ASPIRE), that includes air navigation service providers from the United States, New Zealand, Japan, Singapore and Thailand. One of the key goals of ASPIRE is to reduce aviation's environmental footprint. During 2014, Airservices focussed on improving the Oceanic and en-route phase of flight with network and surface movement optimisation, reduced airborne holding and runway efficiency **(ASPIRE, 2014)**.

The introduction of newer, more fuel efficient aircraft into their fleets such as the A380, A320neo, B787 and B737-800 aircraft is also being undertaken by airlines in Australia. For example, the phasing out of the B737 in favour of the B737-800 is now common to many domestic routes. The B737-800 is approximately 20% more fuel efficient than the earlier B737 models. Other actions by airlines include the refinement of operational procedures to minimise fuel use, including the reduction in weight of cabin items and the reduction of engine ground running time **(DIRD, 2014a)**.

There are also a number of other measures being undertaken by Australian airports that primarily focus on reducing GHG emissions and include green star rated commercial developments on airports, energy and water audits, recycling and the creation of biodiversity zones **(DIRD, 2014a)**.

2.2 Gaseous pollutants and particulate matter performance criteria

Legislation, guidelines and standards governing air pollutant emissions and ambient air quality have been introduced at the Commonwealth and State levels in Australia. The legislation that is relevant to the airport is summarised in **Table 2-1**.

The criteria for specific pollutants that are set out in the legislation summarised in **Table 2-1** have been considered in the assessment for this report.

Regulated air pollutants are 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 with characteristics. The health effects and main sources of pollutants investigated in this assessment are summarised in **Appendix B**.

The *Airports (Environment Protection) Regulations 1997* (Cth) (AEPR) include ambient air quality assessment criteria for some pollutants. However, more extensive guidelines and criteria for assessing the air quality impacts of developments are contained in the NSW EPA's *Approved Methods* document, which takes criteria and averaging periods from several sources, including NEPM-AAQ.

Table 2-1: Emissions and air quality legislation

Legislating body	Legislation/measures	Summary
Ambient air quality		
Australian Government	*Airports Act (1996)*	Contains an obligation on airport lessee companies to develop a master plan every 5 years including a detailed environmental strategy which is required to address (amongst other things) continuous improvement in the environmental consequences of activities at the airport; progressive reduction in extant pollution at the airport and development and adoption of a comprehensive environmental management system for the airport that maintains consistency with relevant Australian and international standards.
		An Airport Plan is required to authorise the construction and operation of Stage 1 of the proposed Western Sydney Airport, address the long-term operation of the proposed airport, and provide planning and land use controls for the proposed airport.
	Airports (Environment Protection) Regulations 1997	Includes provisions setting out definitions, acceptable limits and objectives for air quality, as well as monitoring and reporting requirements.
	Air Navigation (Aircraft Engine Emissions) Regulations /Chicago Convention Annex 16	The regulations make it an offence to fly certain aircraft if they do not meet relevant emissions standards including the standards set out in Annex 16 to the Chicago Convention.
	National Environment Protection (Ambient Air Quality) Measure (NEPM-AAQ)	Sets the national health-based air quality standards for six air pollutants (CO, NO_2, SO_2, Pb, O_3, PM_{10} and $PM_{2.5}$.
	National Environment Protection (Air Toxics) Measure (Air Toxics NEPM)	Sets a nationally consistent approach to monitoring (by reference to 'investigation levels') for five air toxics: benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons). These are not compliance standards but are for use in assessing the significance of the monitored levels of air toxics with respect to the protection of human health.
NSW Government	*Protection of the Environment Operations Act 1997* (POEO Act), and the *Protection of the Environment Operations (Clean Air) Regulation 2010*	The POEO Act provides a range of controls with regard to air quality including a requirement to maintain plant and equipment in a proper and efficient condition and to operate plant and equipment in a proper and efficient manner. This includes the means of processing, handling, moving, storage and disposal of materials.
Emissions of air quality criteria pollutants		
Australian Government	*National Environment Protection (National Pollutant Inventory) Measure*	The primary goals are to: (a) collect a broad base of information on emissions and transfers of substances and (b) disseminate information to all sectors of the community.
NSW Government	*Protection of the Environment Operations Act 2007* (POEO Act *and Protection of the Environment Operations (Clean Air) Regulation (2010)*(Clean Air Regulation)	The object of the POEO Act is to achieve the protection, restoration and enhancement of the quality of the NSW environment having regard to the need to maintain ecologically sustainable development. The Clean Air Regulations prescribe standards for certain groups of plant and premises to regulate industry's air emissions and impose requirements on the control, storage and transport of volatile organic liquids.
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW	This policy document lists the statutory methods that are to be used to model and assess emissions of air pollutants from stationary sources in NSW. It is referred to in Part 5: Air impurities from emitted activities and plant of the Clean Air Regulation. It also prescribes the air pollutants and averaging periods that an airport's emissions are to be assessed against.
Emissions of greenhouse gases		
Australian Government	*National Greenhouse and Energy Reporting Act 2007*	A corporation will be required to register and report its GHG emissions and energy use attributable to the facilities over which it has operational control where those emissions and energy use exceed relevant thresholds.
Ozone-depleting substances		
Australian Government	*Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and the *Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995*	This Act and Regulations impose controls on the manufacture, import, export and management of substances that deplete ozone in the atmosphere including CFCs 11, 12, 113, 114 and halons 1211, 1301 and 2402.
NSW Government	*Ozone Protection Act 1989*	This Act regulates or prohibits the manufacture, sale, distribution, conveyance, storage, possession and use of ozone-depleting substances in NSW.

The assessment criteria from the AEPR, Approved Methods and NEPM-AAQ are listed in **Table 2-2**. The AEPR includes ambient objectives for NO_2, CO, SO_2, lead, ozone (O_3), total suspended particulates (TSP) and sulphates. One criteria pollutant from the Approved Methods, hydrogen fluoride (HF), has been excluded from this Table as HF relates to sensitive vegetation rather than human health, and HF is not a pollutant that is relevant to airport operations. Three other pollutants/metrics in the AEPR and the Approved Methods have not been assessed here: O_3, TSP and lead. Ozone, because of its secondary and regional nature, cannot practicably be considered in a local air quality assessment. Ozone has been addressed in a separate EIS technical study pertaining to regional air quality **(Environ, 2015)**. Sulphates have also not been assessed as impacts are associated with regional air quality rather than local air quality. For the types of particulate matter (PM) sources at an airport (mainly combustion-related), it can be assumed that TSP is equivalent to PM_{10}, and therefore the standard for PM_{10} is the controlling one. Following its removal as a petrol additive, lead is no longer considered to be an air quality problem except in relation to specific industrial activities such as smelting.

Table 2-2: Air quality criteria considered in this assessment

Pollutant		Criterion(a)	Averaging period	Source(b)
Carbon monoxide (CO)		87 ppm or 100 mg/m³	15 minutes	NSW EPA
		25 ppm or 30 mg/m³	1 hour	NSW EPA
		9 ppm or 10 mg/m³	8 hours	AEPR, NSW EPA(b)
Nitrogen dioxide (NO_2)		16 pphm or 320 µg/m³	1 hour	AEPR
		12 pphm or 246 µg/m³	1 hour	NSW EPA
		3 pphm or 62 µg/m³	1 year	NSW EPA
Total suspended particulate matter (TSP)		90 µg/m³	1 year	AEPR, NSW EPA
Particulate matter<10 µm (PM_{10})		50 µg/m³	24 hours(c)	NSW EPA, NEPM-AAQ
		25 µg/m³	1 year	NEPM-AAQ
Particulate matter <2.5 µm ($PM_{2.5}$)		25 µg/m³, 20 µg/m³	24 hours	NEPM-AAQ NEPM-AAQ aim by 2025
		8 µg/m³ 7 µg/m³	1 year	NEPM-AAQ NEPM-AAQ aim by 2025
Deposited dust	Incremental	2 g/m²/month	Annual	NERDDC
	Cumulative	4 g/m²/month	Annual	
Lead (Pb)		1.5 ppm	3 months	AEPR
		0.5 µg/m³	1 year	NSW EPA
Photochemical oxidants (as ozone (O_3))		0.10 ppm or 210 µg/m³	1 hour	AEPR , NSW EPA(d)
		0.08 ppm or 170 µg/m³	4 hours	AEPR, NSW EPA(e)
Sulfur dioxide (SO_2)		25 pphm or 710 µg/m³	10 minutes	AEPR, NSW EPA(f)
		20 pphm or 570 µg/m³	1 hour	AEPR, NSW EPA
		8 pphm or 228 µg/m³	1 day	NSW EPA
		2 pphm or 60 µg/m³	1 year	AEPR, NSW EPA
Benzene		0.009 ppm or 29 µg/m³	99.9th 1-hour max	NSW EPA
Toluene		0.09 ppm or 360 µg/m³	99.9th 1-hour max	NSW EPA
Xylene		0.004 ppm or 180 µg/m³	99.9th 1-hour max	NSW EPA
Formaldehyde		0.18 ppm or 20 µg/m³	99.9th 1-hour max	NSW EPA
Benzo[a]pyrene		0.4 µg/m³	99.9th 1-hour max	NSW EPA

(a) ppm = parts per million; pphm = parts per hundred million; µg/m³ = micrograms per cubic metre; mg/m³ = milligrams per cubic metre
(b) NSW EPA = NSW EPA 'Approved Methods'; AEPR = *Airports (Environment Protection) Regulations 1997*
(c) Up to 5 exceedances allowed per year in NEPM-AAQ
(d) Given as 214 µg/m³ in Approved Methods
(e) Given as 171 µg/m³ in Approved Methods
(f) Given as 712 µg/m³ in Approved Methods

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. The variation includes new or revised standard for $PM_{2.5}$ and PM_{10}. Whilst the Approved Methods have not yet been updated to reflect the changes in the NEPM-AAQ, the new PM standards have been adopted in this report.

In recognition of the potential health problems arising from the exposure to air toxics, Australia has set 'investigation levels' for five priority pollutants in ambient air: benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons). These are not compliance standards but are for use in assessing the significance of the monitored levels of air toxics with respect to protection of human health. These investigation levels are given in **Table 2-3.**

Table 2-3: Advisory standard air toxic investigation levels applicable to the airport

Pollutant	Criterion[a]		Averaging period	Source
Benzene	0.003	ppm	1 year[d]	Air Toxics NEPM, investigation levels
PAHs[b] (as B[a]P)[c]	0.3	ng/m³	1 year[d]	
Formaldehyde	0.04	ppm	24 hours	
Toluene	1.0	ppm	24 hours	
	0.1	ppm	1 year[d]	
Xylenes	0.25	ppm	24 hours	
	0.20	ppm	1 year[d]	

(a) ng/m³ – nanograms per cubic metre
(b) PAH – polycyclic aromatic hydrocarbons
(c) B[a]P – benzo[a]pyrene, the most widely studied PAH and used as an indicator compound
(d) Arithmetic mean of concentrations of 24-hour monitoring results

2.3 Odour performance criteria

The Approved Methods also include ground-level concentration (GLC) criteria for complex mixtures of odorous air pollutants, taking account of population density in a given area. **Table 2-4** lists the odour criteria to be exceeded not more than one per cent of the time, for different population densities.

The differences between odour criteria are based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour concentration, there will be a wide range of responses in the exposed population. 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.

The project location falls within the Sydney contiguous urban area, and thus an odour criterion of 2 OU is anticipated to apply.

Table 2-4: Odour Performance Criteria for the Assessment of Odour

Population of affected community	Criterion for complex mixtures of odorous air pollutants 99th percentile (OU)
≤ ~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2

2.4 Fuel standards relevant to airports

The *Fuel Quality Standards Act 2000* (Cth) provides a legislative framework for setting national fuel quality and fuel quality information standards for Australia. It also regulates the quality of fuel supplied in Australia by requiring compliance with standards made under the Act. The Act aims to minimise the levels of pollutants and emissions arising from the use of fuel that may cause environmental and health problems, facilitate the adoption of better engine technology and emission control technology and allow the more effective operation of engines.

Under the *Fuel Quality Standards Act 2000*, the Australian Government announced a phase-out of leaded petrol in Australia. On 1 January 2002, that phase-out was completed. The sale of leaded petrol in Australia is now prohibited, except in cases specifically authorised by the Minister.

One exception to this relevant to airport operations is the allowance for lead within Aviation Gasoline, or Avgas. Avgas is used in small piston engine powered aircraft within the General Aviation community, predominantly in activities such as flights by private pilots, flight training, flying clubs and crop spraying. Piston engines operate using the same basic principles as spark ignition engines of cars, but they have a much higher performance requirement.

There are two main Avgas grades available in Australia - 100 and 100LL low lead. The former is permitted to contain lead up to 1.12 g/litre of fuel and the latter 0.56 g/litre. This is compared with 0.005 g/litre for all conventional grades of petrol.

Notwithstanding the above, the proportion of small piston aircraft servicing the proposed airport is anticipated to be low (less than 1% of total aircraft **(NSW EPA, 2012c)**). The resultant lead emission inventory associated with Avgas use at the airport is not considered significant and this air quality metric has been evaluated in a semi-quantitative manner.

2.5 Greenhouse gases

2.5.1 International framework

2.5.1.1 Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is a panel established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to provide independent scientific advice on climate change. The panel was originally asked to prepare a report, based on available scientific information, on all aspects relevant to climate change and its impacts and to formulate realistic response strategies. This first assessment report of the IPCC served as the basis for negotiating the United Nations Framework Convention on Climate Change (UNFCCC).

The IPCC also produce a variety of guidance documents and recommended methodologies for GHG emissions inventories, including (for example):

- 2006 IPCC Guidelines for National GHG Inventories; and
- Good Practice Guidance and Uncertainty Management in National GHG Inventories (2000).

Since the UNFCCC entered into force in 1994, the IPCC remains the pivotal source for scientific and technical information relevant to GHG emissions and climate change science.

The IPCC operates under the following mandate: *"to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate-related data or parameters. Its role is to assess on a* *comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide, relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. They should be of high scientific and technical standards, and aim to reflect a range of views, expertise and wide geographical coverage"* (**CCC, 2011**).

The stated aims of the IPCC are to assess scientific information relevant to:

- Human-induced climate change.
- The impacts of human-induced climate change.
- Options for adaptation and mitigation.

IPCC reports are widely cited within international literature, and are generally regarded as authoritative.

2.5.1.2 United Nations Framework Convention on Climate Change

The UNFCCC sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognises that the climate system is a shared resource, the stability of which can be affected by industrial and other emissions of CO_2 and other GHGs. The convention has near-universal membership, with 172 countries (parties) having ratified the treaty, the Kyoto Protocol.

Under the UNFCCC, governments:

- Gather and share information on GHG emissions, national policies and best practices.
- Launch national strategies for addressing GHG emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries.
- Cooperate in preparing for adaptation to the impacts of climate change.

2.5.1.3 International Civil Aviation Organisation

The International Civil Aviation Organisation (ICAO) studies policy options to limit or reduce the environmental impact of aircraft engine emissions and to develop proposals and advice to the UNFCCC. ICAO is working to promote and develop capacity building programs to provide further assistance to States and facilitate the development and implementation of State Action Plans.

In 2015 the ICAO and United Nations Development Programme formed a partnership to contribute to the global agenda of addressing climate change by signing an agreement to implement a project. ICAO is supporting Developing States and Small Island Developing States in their efforts to reduce CO_2 emissions from international aviation. This is facilitated through ICAO's "Transforming the global aviation sector: emissions reductions from international aviation" initiative.

2.5.1.4 Kyoto Protocol

The Kyoto Protocol entered into force on 16 February 2005. The Kyoto Protocol built upon the UNFCCC by committing to individual, legally binding targets to limit or reduce GHG emissions. Annex I Parties are countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition such as Russia. The GHGs included in the Kyoto Protocol were:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF_6)

The emission reduction targets were calculated based on a party's domestic GHG emission inventories (which included land use change and forestry clearing, transportation and stationary energy sectors). Domestic inventories required approval by the Kyoto Enforcement Branch. The Kyoto Protocol required developed countries to meet national targets for GHG emissions over a five year period between 2008 and 2012.

To achieve their targets, Annex I Parties had to implement domestic policies and measures. The Kyoto Protocol provided an indicative list of policies and measures that might help mitigate climate change and promote sustainable development.

Under the Kyoto Protocol, developed countries could use a number of flexible mechanisms to assist in meeting their targets. These market-based mechanisms include:

- Joint Implementation – where developed countries invest in GHG emission reduction projects in other developed countries.
- Clean Development Mechanism – where developed countries invest in GHG emission reduction projects in developing countries.

Annex I countries that failed to meet their emissions reduction targets during the 2008-2012 period were liable for a 30 per cent penalty (additional to the level of exceedance). A second commitment period was agreed on in 2012 that spans from 2013 to 2020, whereby 37 countries, including Australia, were bound to emissions targets (**DFAT, 2015**).

2.5.1.5 Paris Agreement

In 2015, an historic global climate agreement was reached under the UNFCCC at the 21st Conference of the Parties (COP21) in Paris (known as the Paris Agreement). The Paris Agreement sets in place a durable and dynamic framework for all countries to take action on climate change from 2020 (that is, after the Kyoto period), building on existing efforts in the period up to 2020. Key outcomes of the Paris Agreement include:

- A global goal to hold average temperature increase to well below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels.
- All countries to set mitigation targets from 2020 and review targets every five years to build ambition over time, informed by a global stocktake.
- Robust transparency and accountability rules to provide confidence in countries' actions and track progress towards targets.
- Promoting action to adapt and build resilience to climate change.

- Financial, technological and capacity building support to help developing countries implement the Paris Agreement.

Australia has signed the Paris Agreement and is committed to ratifying it by the end of 2016. Australia's target under the Paris Agreement is to reduce emissions by 26-28 per cent below 2005 levels by 2030, furthering the 2020 target of reducing emissions by five per cent below 2000 levels.

2.5.2 Australian context

2.5.2.1 Australia's GHG Inventory

According to the Department of Environment and Energy (DoEE), Australia's GHG emissions increased by 2.4% between 1990 and 2012. The energy sector was the largest source of GHG emissions in 2012 having contributed 76% (413.4Mt CO_2-e) of total net emissions (excluding the Land Use, Land Use Change and Forestry (LULUCF) sector) and increased 44.2% between 1990 and 2012. Within the energy sector, 'transport' emissions accounted for 16.6% of total net emissions (excluding LULUCF) in 2012 and increased by 49.7% between 1990 and 2012. The proposed airport is considered a part of the 'transport' subsector of the energy sector emissions.

The relatively small change in Australia's GHG emissions from 1990 to 2012 is largely attributable to a significant reduction in GHG emissions associated with land use change, which has decreased by over 88% between 1990 and 2012 (**DoE, 2014**).

2.5.2.2 National Inventory

Australia's National Inventory Report 2012 from the DoEE shows that 2012 emissions were 102.4% of the 1990 baseline (**Table 2-5**). Having come in below the target by 5.6%, Australia has 131 million tonnes of CO_2-e that can be transferred over to Australia's new Kyoto target to cut emissions by 5% below 2000 levels by 2020.

Table 2-5: Australian's Net GHG Emissions 1990 to 2012 by Sector

Sector and Subsector	Emissions (Mt CO_2-e)		Percentage Change
	1990	2012	1990 to 2012
All Energy (Combustion + Fugitive)	286.7	413.4	44.2%
Stationary Energy	194.6	283.2	45.5%
Transport	60.3	90.2	49.7%
Fugitive Emissions from Fuel	31.9	39.9	25.2%
Industrial Processes	24.7	31.2	26.5%
Agriculture	86.5	87.4	1.0%
Waste	17	11.7	-31.4%
Land Use, Land Use Change and Forestry	130.5	15.2	-88.4%
Australia's Net Emissions	545.5	558.8	2.4%

Source: (**DoE, 2014**).

2.5.2.3 National Greenhouse and Energy Reporting Framework

The *National Greenhouse and Energy Reporting Act 2007* (Cth) (the NGER Act) establishes a mandatory obligation on corporations which exceed defined thresholds to report GHG emissions, energy consumption, energy production and other related information.

Corporate and facility reporting thresholds for GHG emissions and energy consumption or energy production are provided in **Table 2-6**. Emissions are measured in terms of tonnes of CO_2-e. Emissions are normalised to their equivalent Global Warming Potential (GWP) of CO_2.

Table 2-6: NGER reporting thresholds

Corporate Threshold		Facility Threshold	
GHG Emissions (Scope 1&2) (kt CO_2-e)	Energy Usage (TJ)	GHG Emissions (Scope 1&2) (kt CO_2-e)	Energy Usage (TJ)
50	200	25	100

Source: **DCCEE, 2007**

If a corporation has operational control over facilities whose GHG emissions or energy use in a given reporting year:

- Individually exceed the relevant facilities threshold.
- When combined with other facilities under the corporation's operational control, exceed the relevant corporate thresholds,

That corporation must report the relevant GHG emissions or energy use (as the case may be) for that year under the NGER Act.

This may include the airport lessee-company, construction or other contractors, and airlines, for example. A preliminary assessment of GHG emissions and energy use for Stage 1 of the airport is set out in chapter 8 of this report.

It is anticipated that during construction, there will be multiple parties with operational control over different aspects of the site development. For this reason, while it is anticipated that there is likely to be some reporting requirement under the NGER scheme, this is likely to be apportioned across the NGER reporting corresponding to several corporations. Once operational, the airport is anticipated to have relevant GHG emissions greater than 25,000 tonnes CO_2-e in a financial year (see **Section 8.2.1**). Because of this, the reporting of emissions is expected to be required under the NGER scheme.

3 METHODOLOGY

3.1 Operations

3.1.1 Overview

This Chapter describes the modelling of emissions and air pollution associated with the airport using the EDMS model. EDMS is a combined emissions and dispersion model which permits the factors affecting emissions and air quality to be considered in some detail.

Two assessment scenarios were investigated:

- Stage 1 development - The initial stage in the development of the airport, including a single runway and handling approximately 10 million passengers annually. The EIS assumes 10 million passengers is reached around 2030 for assessment purposes.

- Long-term development - A future stage in the development of the proposed airport, where the airport is assumed to comprise parallel runways and handling approximately 82 million passengers annually. The EIS assumes this occurs around 2063 for assessment purposes.

The methodology for this assessment is comprehensive, and rather than presenting all the technical elements in the body of the report, these have been provided in **Appendix C** and **Appendix D**. The following Sections provide a brief description of the inputs for the air quality modelling. **Table 3-1** provides a summary of the data sources used for the air quality scenario assessment.

Table 3-1: Summary of data sources for the air quality assessment

Activity	Data source
Aircraft	Synthetic schedule developed based on worst case day and projected ATMs
GSE	GSE operations based on aircraft schedule
APUs	APU operations based on aircraft schedule
Parking facilities	Projected traffic numbers
External roadways	Projected traffic numbers
Terminal traffic	Projected traffic numbers
Stationary sources	
Boilers	Fuel throughput
Engine tests	SACL (2012)
Fuel tanks	SACL (2012)
Generators	Fuel throughput
Solvent	SACL (2012)
Surface coating/painting	SACL (2012)
Training Fires	SACL (2012)

3.1.2 Modelling overview

3.1.2.1 Selection of model

The contribution of operations at the airport to emissions and resultant local air quality were calculated using the US Federal Aviation Administration (FAA) Emissions and Dispersion Modelling System (EDMS) (Version 5.1.4 from June 2013). EDMS has been used for several recent airport assessments in Australia including Sydney (Kingsford Smith) Airport (KSA) and Adelaide Airport. The overall modelling approach is summarised in **Figure 3-1.**

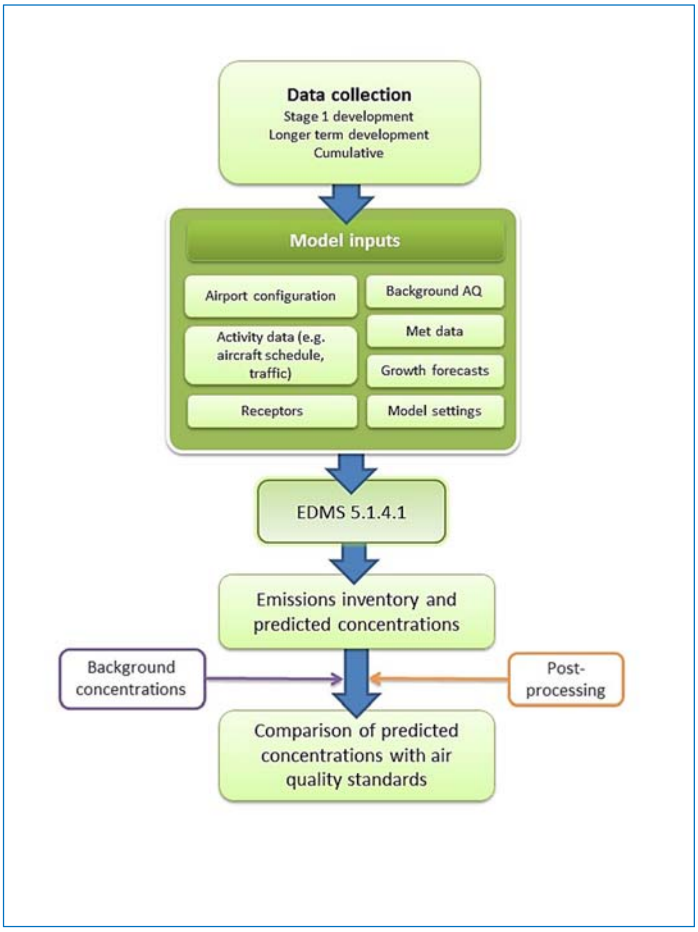


Figure 3-1: Summary of air quality assessment methodology

Emissions inventories and dispersion model predictions for the two assessment scenarios (Stage 1 and long-term development) were obtained using EDMS based on activity data and growth projections provided by GHD for all emission sources. These include aircraft fleet types, engine tests, vehicle emissions, and stationary sources such as fuel tanks.

For dispersion modelling, detailed spatial information on aircraft movements, spatial information on the other emission sources (e.g. engine testing, APUs, etc.), the airport layout, and meteorological data were employed within EDMS to determine the airport's contribution to concentrations of criteria pollutants at discrete receptor locations and across the model domain. The results from the dispersion modelling were then used in combination with the data on existing air quality (used to define background concentrations) to determine the likely impact of operations at the airport.

The operational air quality assessment takes into consideration the Approved Methods, along with other relevant legislation and guidelines (see **Section 2**).

3.1.2.2 Dispersion modelling

The EDMS dispersion analysis undertaken in this assessment uses the USEPA's AERMOD **(USEPA, 2004a)** dispersion model. AERMOD has USEPA preferred model status, and has been accepted in Australia for use in a variety of regulatory applications. The air quality metrics currently included in EDMS for dispersion analysis are CO, THC, NMHC, VOC, TOG, NO_X, SO_X, (primary) $PM_{2.5}$ and (primary) PM_{10} **(CSSI, 2013)**.

AERMOD is designed to handle a variety of source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the United States in December 2006 as it provides more realistic results compared to the conservative ISC model. Ausplume, a steady-state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications, is largely based on the ISC model. Compared with ISC and Ausplume, AERMOD represents an advanced next-generation model which requires additional meteorological and land-use inputs to provide more refined predictions.

All of the inputs necessary for the emissions inventory are also necessary for dispersion modelling. However, the amount of data required to perform a dispersion analysis is significantly greater than the amount required for an emissions inventory alone, as spatial and temporal information is important. Additional requirements in AERMOD include:

- Locations of receptors.
- Hourly local meteorological data.
- Accurate operational profiles to describe how activities, and hence emissions, vary with time.
- An annual schedule of aircraft operations, including gate and runway allocations.
- Aircraft performance modelling.
- Aircraft delay and sequencing modelling.

The location of sensitive receptors and site-specific meteorological data was made available for this study. Information on aircraft operations was available for a worst case day only. To develop the schedule for a full year of aircraft movements daily and monthly operational profiles from KSA were adopted. In the absence of highly detailed information, such as aircraft performance and aircraft delay and sequence modelling, default parameters were adopted. A technical description of the dispersion model inputs is provided in **Appendix D**.

3.1.2.3 Emissions inventory

The types of activity which result in atmospheric emissions at airports are identified in the relevant NPI emission estimation technique manual **(DEWHA, 2008)**. These activities (which generate emissions through either combustion or evaporation) are listed in **Table 3-2**.

Table 3-2: Summary of activities generating atmospheric emissions at the airport

NPI Source type		Description
Emissions directly from aircraft	Aircraft main engine	Main engines of aircraft ranging from start-up to shut-down.
	APU	APU located on-board aircraft providing electricity and pre-conditioned air during ground times and bleed air for main engine start.
Aircraft handling emissions	Ground support equipment (GSE)	GSE necessary to handle the aircraft during the turnaround at the stand, including ground power units, air climate units, aircraft tugs, conveyor belts, passenger stairs, fork lifts, tractors, cargo loaders, etc.
	Airside traffic	Service vehicle and machinery traffic, including sweepers, trucks (catering, fuel, sewage), cars, vans, buses etc. that circulate on service roads within the airport perimeter (typically restricted area).
	Aircraft refuelling	Evaporation through aircraft fuel tanks (vents) and from fuel trucks or pipeline systems during fuelling operations.
Stationary/ infrastructure sources	Power/heat generating plant	Facilities that produce energy for the airport infrastructure, namely boiler houses, heating/cooling plants, co-generators.
	Emergency power generator	Diesel or other generators for emergency operations (e.g. for buildings or for runway lights).
	Aircraft maintenance	All activities and facilities for maintenance of aircraft, i.e. washing, cleaning, paint shop, engine test beds, etc.
	Airport maintenance	All maintenance of airport facilities, including cleaning operations.
	Fuel	Fuel storage, distribution and handling.
	Construction and demolition activities	All construction and demolition activities in airport operation and development, including the resurfacing of roads and runways.
	Fire training	Activities for fire training with different fuel (e.g. kerosene, butane, propane, wood).
	Waste water treatment	All activities and facilities for the collection, storage and treatment of waste water on-site.
Landside traffic	Vehicle traffic	Cars, vans, trucks, buses, motorbikes etc. associated with the airport on access roads, drop-off areas and on- or off-site parking lots. Emissions include tailpipe and evaporative releases).

EDMS incorporates a comprehensive database of emission factors for aircraft engines, GSE, APUs, vehicles and stationary sources. The emission factors are taken from a range of sources, including the International Civil Aviation Organisation (ICAO), the FAA and the USEPA. The pollutants currently included in the EDMS emission calculations are:

- Carbon dioxide (CO_2)
- CO
- NO_x
- SO_x
- $PM_{2.5}$
- PM_{10}
- Total hydrocarbons (THC)
- Non-methane hydrocarbons (NMHC)
- Volatile organic compounds (VOC)
- Total organic gases (TOG)
- 394 speciated organic gases (including benzene, toluene, xylenes and formaldehyde)

CO_2 is calculated only for aircraft, and THC is calculated only for aircraft and APUs. EDMS includes information that is not included in the public ICAO database, such as PM emission factors. It also contains more up-to-date emission factors than those given in the NPI manuals.

The emission categories which are used in EDMS, along with their relevance to the airport are summarised in **Table 3-3**. Any default values in EDMS were replaced with these site-specific values where possible. More detailed descriptions of the different elements of the emissions calculation method are provided in **Appendix C**.

Table 3-3: EDMS categories and relevance to the airport

EDMS category		Relevant
Aircraft main engines and APUs		Yes
Ground support equipment		Yes
Parking facilities		Yes
Roads		Yes
Buildings		Yes
Stationary sources	Engine tests	Yes
	Boilers	Yes
	Generators	Yes
	Incinerators	No
	Fuel tanks	Yes
	Surface coating/painting	Yes
	Solvents	Yes
	De-icing area	No
	Sand/salt piles	No
Training fires		Yes

In May 2015, the EDMS model was replaced with the Aviation Environmental Design Tool (AEDT) as the FAA's preferred model. At the time of writing the original assessment, the full release version of the model was not available and therefore the use of AEDT for modelling purposes was not considered. For this updated assessment EDMS was still considered an appropriate dispersion model=. The emissions data for EDMS and AEDT both reference the ICAO database and therefore the aircraft based emissions are expected to be the same. Key differences between EDMS and the AEDT models include the transition of roadway emissions from the US EPA's MOBILE emission estimation tool to Motor Vehicle Emissions Simulator (MOVES) in 2013. This upgrade is of no consequence for this assessment as roadways have been based on the Australian traffic emission data developed by **PIARC (2012)**.

3.1.2.4 Airport layout

The airport layout for each development scenario assessed is provided in **Appendix C**.

Aircraft movements are calculated in EDMS using the schedule, gate locations, runway locations and the taxi paths between the gates and runways. Whilst EDMS allows each gate to be specified individually, this would have been impractical in this study given this detail is not yet available. Gates were therefore allocated in groups. More than 30 different taxiway sections were entered utilising the proposed runways, and these were used in different sequences to define a total of 72 taxi paths once the airport is fully operational as part of the long-term development.

3.1.2.5 Roadways

In EDMS it is assumed that roadways generate emissions due to on-road vehicle operations and vehicle idling and travelling within and outside of the airport site. These have been termed 'terminal traffic' and 'external roadways', respectively.

The terminal traffic comprises traffic that will be travelling to and from the airport and accounts for movements such as the use of the parking facilities and the drop off and collection of passengers.

The traffic emissions from the external roadways include all roads outside of the airport study boundary, extending as far north as the M4 and as far east as the M7. Future emissions from the proposed M12 roadways were also included.

A detailed description of the roadway emission calculations for each development scenario assessed is provided in **Appendix C**.

3.2 Sensitive receptors

It is standard practice in air quality assessments to estimate pollutant concentrations at discrete locations which are considered to be broadly representative of exposure in the area of interest. The concentrations at these locations are then compared with the relevant air quality assessment criteria. The locations are known as 'receptors'. As a general rule, receptors should reflect locations where the general public is likely to have access on a regular basis. In addition, it is important that any sensitive locations are identified. These include where people are likely to work or reside as well as schools, day care centres, hospitals, etc., as defined in the *Approved Methods.*

The airport site is located in an area where there is a high density of sensitive receptors. To assess each individual receptor is not practicable given the extent of the project. For this reason, a series of receptors have been selected, representative of residential suburbs and individual residences in close proximity to the proposed development. In addition, a number of community receptors that comprise schools, churches, shopping centres and recreational areas were also identified within the local area. On-site receptors were nominated within the airport site boundary to evaluate the potential exposures of airport staff and passengers at the facility, noting that airport terminal staff are likely to have a much longer exposure. The on-site receptors have been assessed during operations only as during construction the respective uses will not yet exist.

For the EIS, a total of 152 sensitive receptors were identified. The approach taken for this assessment was to identify a sub-set of receptors to represent individual residences and clusters of residences located within approximately 5km of the airport site. This subset includes 18 residential receptors, two on-site receptors and 75 community receptors which are listed in **Appendix E** for reference. The locations of the receptors are shown in **Figure 3-2**.

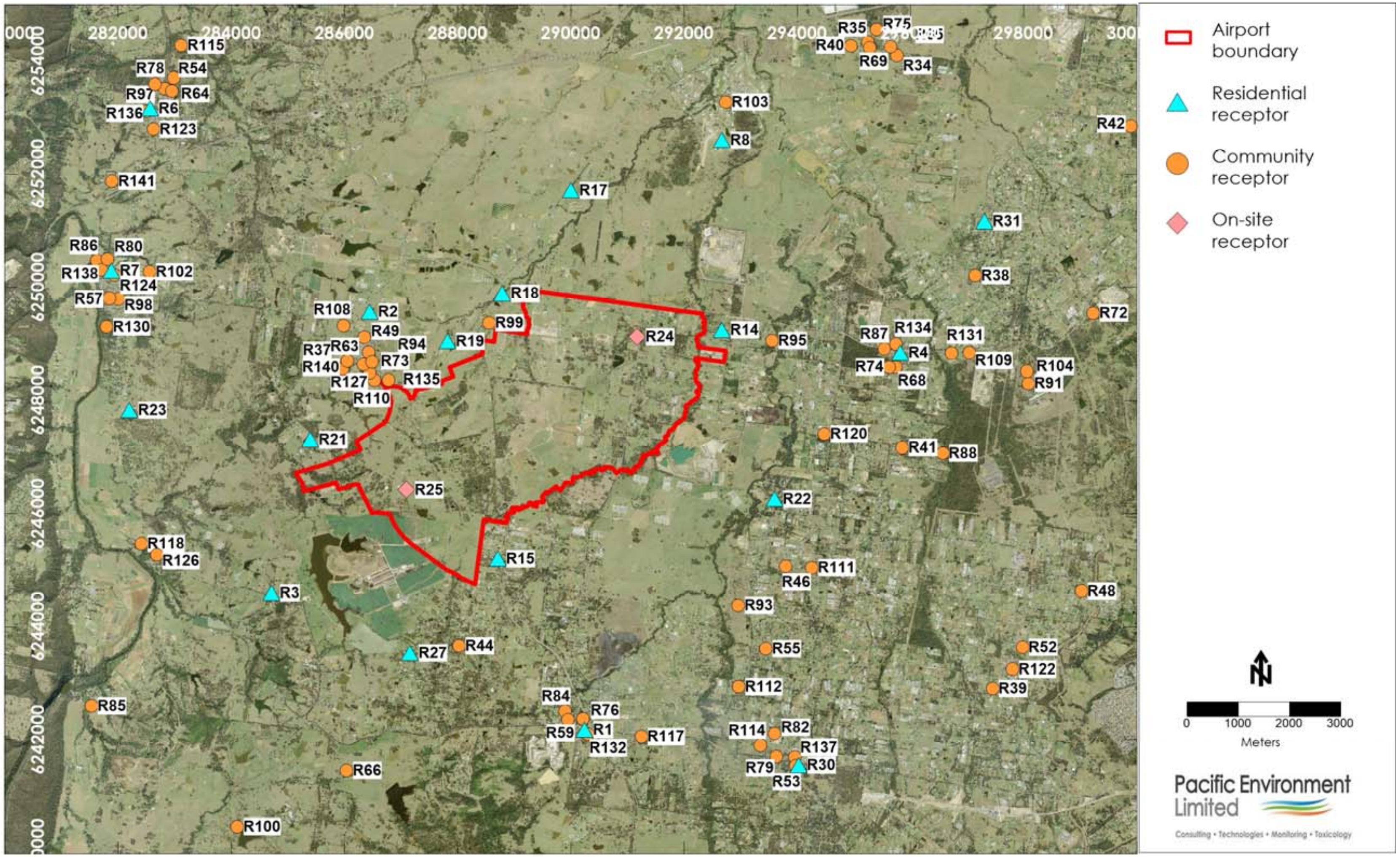


Figure 3-2: Location of sensitive receptors

3.3 Cumulative impacts

There is potential for cumulative impacts to occur during the operation of the airport. Cumulative impacts, for the purpose of this assessment, are defined as 'existing' (background) air quality, combined with the airport activities within the airport site (incremental) for each development stage. For the Stage 1 development, cumulative impacts include the emissions from the airport operating with the single runway and the external roadways combined with background pollutant measurements that represent other sources. For the long-term development, airport emissions will be generated by both runways at full capacity.

Within the Western Sydney air shed, there are a number of other industrial emitters in the area with the potential to affect local air quality and these include:

- Major roadways (e.g. M4, M7 and future emissions from the proposed M12)
- Camden Airport
- Bankstown Airport
- Elizabeth Drive landfill facility
- Boral Bricks Bringelly
- Erskine Park Quarry
- Western Sydney Service Centre (metal manufacturing)
- Western Sydney Employment Area (WSEA)

With the exception of the major roadways, the above listed sources are all located at a sufficient distance from the airport site that potential cumulative impacts at the local scale are considered negligible. Furthermore, the adopted background air quality values will effectively account for potential emissions from these sources.

To address the potential cumulative impacts of the airport in combination with the major roadways, emissions from both sources have been included in the modelling. Sources that are specifically included in dispersion modelling are detailed in **Appendix D**.

It is also noted that there is potential for cumulative emissions from the operation of Stage 1 of the airport in combination with the construction activities pertaining to the long-term development. It is anticipated that the dust emissions generated during construction of the second runway would be effectively managed. This assumption is supported by the fact that there are significant safety issues associated with dust generation in the vicinity of an operational airport that would be of much greater risk (and thus receive much greater management) than conventional nuisance dust issues from other construction activities. The additional combustion emissions from onsite equipment during long-term development construction activities are also assumed to be insignificant in comparison to the emissions from the airport in isolation and on that basis, have not been considered further.

3.4 Model post-processing

3.4.1 Modelling of NO_X chemistry

One of the most common atmospheric chemistry issues is the estimation of NO_2 from modelled NO_x concentrations. The amount of NO_2 in the exhaust stream as it is released from combustion sources is typically in the order of 5-10% of total NO_X (expressed as NO_2 equivalents), but can be much higher for some sources, such as modern diesel vehicles equipped with catalytically regenerating particle filters. However, following release, the NO_2 proportion also changes through complex photochemical reactions of atmospheric ozone and NO_x.

Several approaches are available for estimating the transformation of NO to NO_2 that occurs after the exhaust gases are discharged. For this project, the 'ozone limiting method' (OLM) was used. The OLM is based on the assumption that approximately 10% of the NO_x emissions are generated as NO_2 **(Alberta Environment, 2003)**. The majority of the NO_X emission is in the form of NO, which reacts with ambient levels of ozone to form additional NO_2. If the ozone concentration is greater than 90% of the predicted NO_x concentration, all the NO_x is assumed to be converted to NO_2, otherwise NO_2 concentrations are calculated using the equation below, which assumes total conversion of the ozone and adds the 10% of the NOx that was emitted as NO_2:

$$NO_2 = O_3 + 0.1 \times NO_X$$

The predicted NO_2 concentration is then added to the background NO_2 concentration.

For this assessment, a modified version of the OLM Level 2 assessment methodology equation was adopted to reflect the NSW EPA requirement outlined in a recent submission by NSW EPA for the NorthConnex major road project EIS **(AECOM, 2012)**. The modified equation is as follows:

$$[NO_2]_{total} = \{0.16 \times [NO_X]\} + MIN\ \{(0.84) \times [NO_X] \text{ or } (46/48) \times [O_3]_{background}\} + [NO_2]_{background}$$

To apply the OLM, hourly background concentrations of ozone and NO_2 in 2014 were obtained for the NSW EPA monitoring station at Bringelly. The NO_2 concentration at each receptor was calculated using the above equation for each hour of the year, and then added to the corresponding hourly background value from the Bringelly site. The maximum hourly NO_2 concentration and annual mean concentration were then determined from the results.

3.4.2 SO_2 estimation

As the vast majority of SO_X emissions are SO_2, it was assumed that all SO_X predicted by EDMS is released as, and remains, SO_2.

3.4.3 VOC speciation

Concentrations of specific air toxics were estimated from the total VOC concentrations predicted by EDMS in combination with speciation profiles for aircraft exhaust from the USEPA SPECIATE program **(US EPA, 2015b)** (**Table 3-4**).

Table 3-4: Air toxics as % of VOC emissions from aircraft engines (US EPA, 2015b)

Compound	% by weight of VOC emissions
Benzene	1.681
Benzo[a] pyrene	N/A [a]
Formaldehyde	12.31
Toluene	0.642
Xylenes	0.448

Note: (a) Benzo[a] pyrene is not specified as an aircraft exhaust emission **(US EPA, 2015b)**.

3.4.4 Lead

As already discussed in **Section 2.2**, since the removal of lead in petrol, lead is typically no longer considered to be a regional air quality issue. However, the allowance for leaded fuel (AvGas) to be used by a limited number of small piston engine powered aircraft means that there is potential for some additional lead to be released into the local air shed as a result of airport activities.

Lead emissions are not quantified by the EDMS airport emissions inventory tool. Therefore a semi-quantitative approach has been adopted to evaluate the potential for impact. This is based on projections of fuel consumption and references the EPA's GMR Atmospheric Emission Inventory documentation, specifically the *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales 2008 Calendar Year Off-Road Mobile Emissions: Results* **(NSW EPA, 2016c)**.

Total lead emissions were calculated based on the reported lead content of AvGas (0.8 g/L) and the assumption that 0.8% of aircraft will use a piston engine (based on figures for KSA **(NSW EPA, 2016c)**).

In view of the level of uncertainty in terms of both future fuel composition and aircraft types, lead emissions have been estimated for the Stage 1 scenario only.

3.5 Odour

3.5.1 Odour from aircraft exhaust

The assessment of potential odour effects on the local area is not straightforward. A qualitative method is to survey odour nuisances caused by aircraft activities and draw comparisons between aircraft operations and odour complaints. This method has a number of limitations as demonstrated by **BAA (2008)** in its survey of 14,000 residents in the vicinity of Stansted Airport. The survey was conducted between August and November 2005 with residents asked to report any incidents of odour annoyance. During the survey period, only 99 responses were received with the majority located some distance from the airport. This was considered a critical limitation to the study, with no causal factors related to odour occurrence from airport activities able to be deduced from the survey. Similar studies have also been completed for other major international airports including Hamburg, Amsterdam and Boston.

The current approach to the assessment of odour is to use the quantitative approach described in *Technical framework: Assessment and management of odour from stationary sources in NSW* **(DEC, 2006)**. As there are no instrument-based methods that can measure an odour response in the same way as the human nose, "dynamic olfactometry" is typically used as the basis of odour quantification 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 odour 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".

This method was adopted as part of the *Draft Environmental Impact Statement: Second Sydney Airport Proposal* **(PPK Environment and Infrastructure, 1997)**. The odour impacts of the airport were assessed by predicting the ground level total hydrocarbon concentrations and using an odour threshold (1 OU) of 34 mg/m^3. This relationship was based on odour measurements conducted by CSIRO in 1997 at Sydney Airport **(PPK Environment and Infrastructure, 1997)**.

More recent studies include those by **Winther et al (2005)** who established a factor of 57 OU per mg/m^3 of hydrocarbon emission. This approach has been used within other local air quality assessments recently published, such as London Luton Airport **(Air Quality Consultants, 2012)**.

This approach (mass emission of TOC multiplied by 57 to establish the OU emission rate) has been adopted within the current assessment. Hydrocarbon emissions were quantified from aircraft operations in start-up mode in combination with APU and GSE hydrocarbon emissions by EDMS, and scaled accordingly to represent odour emission rates in OU/s.

Due to significant uncertainties in future emission inventories, the predicted odour concentrations for the long-term development have not been assessed.

3.5.2 Odour from on-site waste water treatment plant

There is the potential for odour emissions to be released from the on-site waste water treatment plant (WWTP).

It has been assumed that the WWTP will treat sewage from the airport to produce high quality recycled water. Information provided by GHD indicates that the average daily demand for recycled water would be approximately 1.8 ML. As little information is currently available about the type of processing operations and population that would use the WWTP, odour emissions have been based on odour assessments that have been completed for WWTPs to be used for future residential development in the Sydney area, processing 1.5 ML per day **(Pacific Environment, 2015)**, assuming equivalent odour emissions.

To characterise the potential odour impacts of the proposed development, odour sampling was completed at two similar facilities located at Pitt Town and central Sydney (**Pacific Environment, 2015**). The purpose of the monitoring was to characterise the odour from the existing facility and use the data to derive odour emission rates (OERs) for use in the dispersion modelling. The odour emissions used in this assessment are provided in **Table 3-5**. A factor of 2.3 was added to the predictions to account for the peak to mean ratio as prescribed in the *Approved Methods*.

Due to significant uncertainties in future emission inventories, the predicted odour emissions have been assessed for the Stage 1 development only.

Table 3-5: Adopted WWTP odour monitoring inputs

Sample	Odour concentration (OU)	Specific odour emission rate (OU.m/s)[1]
MBR Tank – Membrane Chamber	1,970	0.68
MBR Tank – Aerobic Chamber	3,620	1.19
MBR Tank –Anoxic Chamber	4,310	1.42
Activated Carbon Filter outlet (treated air)	3,320	n/a

[1] Specific odour emission rate (SOER) is calculated from the sweep gas flow rate and area of flux hood. That is: SOER = odour concentration (ou) x sweep gas flow rate (Nm^3/s) x area (m^2). The SOER is only used when the source is represented as an area source. For the point source (FBT OCU vent), the measured odour concentration is multiplied by the volumetric flow rate to determine an estimated emission rate.

3.6 Construction

3.6.1 Overview

Due to the transient, variable nature of construction activities, it is difficult to accurately quantify air quality impacts from construction activities. Any effects of construction on airborne particle concentrations would generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary mitigation measures are routinely employed on construction sites. However, in view of the length of the construction period, a quantitative assessment of impacts has been completed using the same dispersion model used for the operational impact assessment, AERMOD (see **Section 3.1.2.2**). A detailed description of the model configuration and meteorological file is provided in **Appendix D**. Rather than relying on a central database such as EDMS, the emissions have been calculated based on established emission factors.

Construction of the Stage 1 activities for the proposed airport would involve two major components namely worksite preparation activities and development of aviation infrastructure. It is acknowledged that there are some components of construction that will overlap. So as to provide a conservative assessment, the adopted approach has been to identify the worst case emissions scenario for each of the worksite preparatory activities and development of aviation infrastructure and use that as the basis for the assessment. For example, PM emissions during construction of aviation infrastructure include the concurrent emissions from earthworks activities from the working crew, asphalt plant and concrete batch plant.

Dust emissions from each component are as follows:

- Bulk earthworks
- Dozers
- Scrapers
- Loading and unloading of material
- Hauling on paved and unpaved roads
- Wind erosion
- Grading
- Aviation infrastructure
- Working crew (similar to equipment used during bulk earthworks)
- Asphalt plant
- Concrete batching plant

In addition to the above, there would also be diesel particulate matter emissions (comprising $PM_{2.5}$ only) from the onsite equipment and odour emissions from the asphalt plant.

Construction emissions for the Long-term development have not been assessed. This is in part due to the uncertainty regarding the future construction activities and also due to the detailed information not being available.

3.6.2 Construction dust

A detailed description of the construction activities is presented in the Construction Planning Report **(GHD, 2015a)**. Construction activities during site preparation and aviation infrastructure activities have been analysed and estimates of dust emissions for the individual activities have been made based on a total area of approximately 21,800,000 m^3 of land to be sub-graded for the bulk earthworks and approximately 1,780,000 m^3 during the construction of aviation infrastructure. The construction schedule **(GHD, 2015a)** identifies that not all of this material would be handled at once, but rather in stages over the course of several years. So as to provide for a worst case scenario it has been assumed that all of the material would be handled within the space of one year. The individual dust generating activities and equipment numbers are based on those provided in the Construction Planning Report **(GHD, 2015a).** Emission factors developed both locally and by the US EPA **(US EPA, 1995)** have been applied to estimate the amount of dust produced by each activity. The emission factors applied are the most reliable and up-to-date for determining dust generation rates. Dust emissions calculated for site preparation and the aviation infrastructure activities are presented in **Table 3-6**.

Most activities and emissions are assumed to occur between 6am and 6pm six days per week, the exception being pavement materials that will be delivered 24 hour per day and also wind erosion.

Table 3-6: Estimated dust emissions during construction

Activity	TSP (kg/y)	PM_{10} (kg/y)	$PM_{2.5}$ (kg/y)
Bulk earthworks			
Dozers	54,126	17,648	5,683
Loading bulk spoil East (cut)	913	432	65
Loading bulk spoil East (fill)	913	432	65
Loading bulk spoil North (cut)	104	49	7
Loading bulk spoil North (fill)	104	49	7
Loading bulk spoil Northwest (cut)	130	62	9
Loading bulk spoil Northwest (fill)	221	105	16
Loading bulk spoil Southwest (cut)	115	54	8
Loading bulk spoil South (fill)	109	52	8
Hauling unpaved roads East	177,340	54,288	5,429
Hauling unpaved roads North	10,105	3,093	309
Hauling unpaved roads Northwest	21,473	6,573	657
Hauling unpaved roads Northwest	11,115	3,403	340
Scraper loading topsoil for rehabilitation	60,448	31,433	1,813
Scraper transporting topsoil for rehabilitation	31,157	9,538	954
Wind erosion (East)	124,849	62,425	9,364
Wind erosion (North)	846	423	63
Wind erosion (Northwest)	1,383	691	104
Wind erosion (southwest)	4,036	2,018	303
Grading roads	45,623	45,086	4,000
TOTAL	***545,111***	***237,854***	***29,207***
Construction of aviation infrastructure			
Dozers	23,197	7,564	2,436
Loading subgrade	96	45	7
Unloading subgrade	96	45	7

Activity	TSP (kg/y)	PM_{10} (kg/y)	$PM_{2.5}$ (kg/y)
Unloading unbound gravel	163	77	12
Hauling subgrade	37,220	11,394	1,139
Hauling gravel	150,370	46,032	4,603
Wind erosion of subgrade area	28,854	14,427	2,164
Grading roads	13,035	12,882	1143
TOTAL	***253,029***	***92,465***	***11,511***

3.6.3 Concrete batching plant

During the construction of aviation infrastructure, the concrete batch plant would have the potential to generate PM emissions. A total volume of approximately 458,100 m^3 of concrete is required over a period of 54 months during the aviation infrastructure works. An estimated daily average of 424 m^3 is provided in **GHD (2015)**, which equates to an annual throughput of 154,760 m^3 per year and has been used as the basis for the PM emission calculations. Further detail on the concrete batch plant is provided in **GHD (2015)**. As limited information is available on the configuration of the asphalt batch plant, the PM sources and emissions identified are based on a typical concrete batch plant operation in the Sydney region. The estimated PM emissions are based on emission factors developed both locally and by the US EPA **(US EPA, 1995).** The estimated annual PM emissions are presented in **Table 3-7**.

Table 3-7: Estimated PM emissions from concrete batching plant

Activity	TSP (kg/y)	PM_{10} (kg/y)	$PM_{2.5}$ (kg/y)
Movement of delivery trucks onsite	6,641	1,275	308
Movement cement trucks onsite	53,294	10,230	2,475
Vehicle exhaust	0 [a]	156	131
Unloading to aggregate storage bins	399	203	52
Residual from de-dusted air loading cement and fly-ash	0 [a]	540	30
Wind erosion	88	45	11
Total	***60,421***	***12,448***	***3,007***

Notes: (a) Emissions limited to PM_{10} and $PM_{2.5}$.

3.6.4 Asphalt batching plant

During the construction of aviation infrastructure, the onsite asphalt batch plant would have the potential to release both PM and odour emissions. The asphalt batch plant would produce approximately 712,000 tonnes of asphalt over a 48 month period during the aviation infrastructure works. Further detail on the asphalt batch plant is provided in **GHD (2015)**. As limited information is available on the configuration of the asphalt batch plant, the odour sources and emissions identified are based on a typical asphalt batch plant operation in the Sydney region with a similar production capacity. The estimated annual PM and odour emissions from the asphalt plant are presented in **Table 3-8** and **Table** 3-9, respectively.

Table 3-8: Estimated PM emissions from asphalt batch plant

Activity	TSP (kg/y)	PM_{10} (kg/y)	$PM_{2.5}$ (kg/y)
Wind erosion from raw material stockpiles	175	88	13.14
Loading aggregate to material stockpiles	275	130	19.68
Loading aggregate to conveyors using FEL	275	130	19.68
Conveying / aggregate transfer	275	130	19.68
Oil-fired dryer	5,874	4,094	176.22
Mixer and sorting in mixer	7,476	4,806	224.28
Product load out	275	130	19.68
Delivery trucks	4,165	800	193.43
Asphalt trucks	26,671	5,119	1238.59
Total	***45,461***	***15,427***	***1,924***

Table 3-9: Estimated odour emissions from asphalt plant

Activity	Assumed odour emission rate (OU.m³/s)
Trucks waiting to be tarped	1,080
Loading truck with product	11,407
Plant stack exhaust	2,167

3.6.5 Diesel particulate matter emissions

Diesel particulate matter emissions are required to be assessed as part of the Community Health Assessment **(Pacific Environment, 2015)**. Details of the diesel emissions and predicted concentrations are provided in **Appendix H.**

3.7 Greenhouse gases

3.7.1 Assessment approach

Quantification of GHG emissions (in tonnes of CO_2-equivalent (tCO_2-e)) associated with each GHG source has been made in accordance with the GHG Protocol (**WRI & WBCSD, 2004**), IPCC and Australian Government GHG accounting/classification systems.

The GHG assessment is guided by the *National Greenhouse and Energy Reporting Regulations 2008* (NGER Regulations). These describe the detailed requirements for reporting under the NGER Act.

Calculation is consistent with the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (the "NGER Measurement Determination").

Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (NGER Technical Guidelines) support reporting under the NGER Act. They have been designed to assist corporations in understanding and applying the NGER Measurement Determination.

The NGER Technical Guidelines are reporting year specific, and outline calculation methods and criteria for determining GHG emissions, energy production, energy consumption and potential GHG emissions embodied in natural gas. The latest published NGER Technical Guidelines at the time of writing has been referenced.

It is acknowledged that as the NGER Technical Guidelines are derived from the NGER Measurement Determination, where there is a perceived contradiction between the NGER Technical Guidelines and NGER Measurement Determination, the NGER Measurement Determination takes precedence.

To streamline the quantification process, GHG emissions were calculated within the EDMS model used for the local air quality assessment. Any deviations in the calculation approaches between the NGER Technical Guidelines and the EDMS model are acknowledged and their material impact quantified.

GHG emission calculations are generally of the form:

$$Emission_i = Activity\ data \times EF_i$$

Where:

$Emission_i$	=	Estimated emissions of GHG i	(t CO_2-e)
$Activity\ data$	=	Basis of emission estimate (for example, amount of fuel combusted for energy generation)	(generally in the units of GJ for fuel combustion)
EF_i	=	Emission factor for GHG i	(t CO_2-e/Activity)

The activity data used to determine GHG emissions for this assessment were provided by GHD.

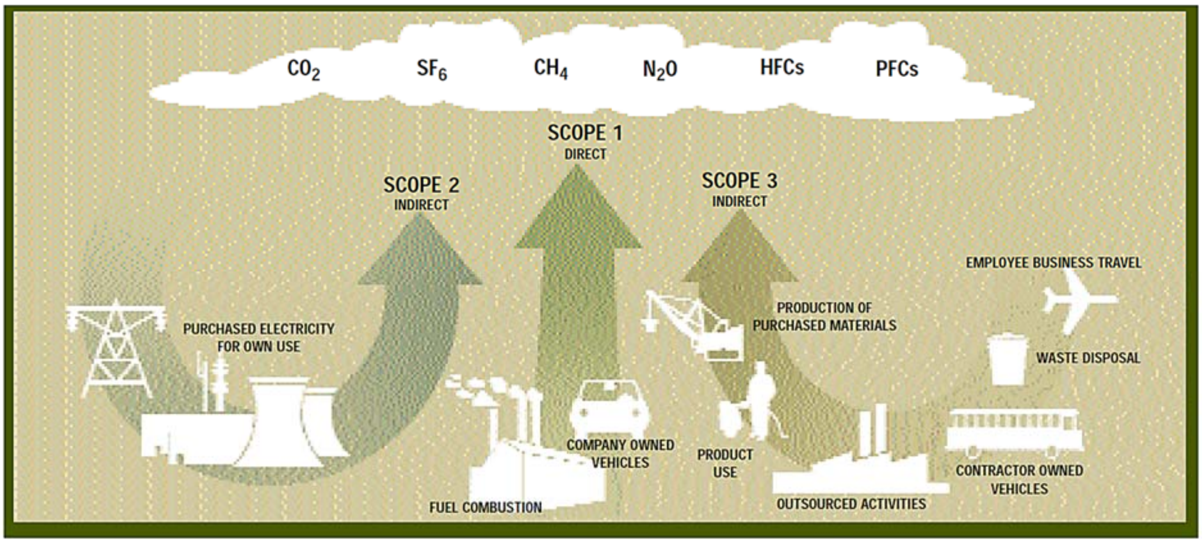
GHG emissions have been estimated based upon the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development GHG Protocol (**WRI & WBCSD, 2004**).
- The National Greenhouse and Energy Reporting (Measurement) Amendment Determination 2015 (No.2) (**DoE, 2015b**) produced from the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (**DCCEE, 2008**).
- Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (**DoE, 2014b**).

3.7.1.1 The GHG Protocol

The GHG Protocol (**WRI & WBCSD, 2004**) establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organization for Standardization, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Under this protocol, three "scopes" of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The definitions for scope 1, scope 2 and scope 3 emissions are provided in the following sections, with a visual representation provided in **Figure 3.3**.



Source: WRI & WBCSD 2004

Figure 3.3: Overview of Scopes and Emissions across a Reporting Entity

3.7.1.1.1 Scope 1: Direct Emissions

Direct GHG emissions are defined as emissions that occur from sources owned or controlled by the reporting entity. For the airport, direct GHG emissions primarily result from the following sources:

- Airport owned vehicles;
- Airport-owned ground support equipment (GSE);
- Airport-owned auxiliary power units (APU);
- Airport facilities (not including electricity);
- Boilers using natural gas;
- Back-up power generators using diesel oil;
- Fugitive emissions from airport-owned equipment;
- Jet fuel tanks;
- Gasoline and diesel fuel tanks;
- Contractor-owned vehicles used during the construction of the airport;
- Vegetation clearing;
- Emissions from operation of any waste water treatment plant; and
- Emissions from fire training.

It is highlighted that it is common practice for tenants such as airline companies to own and operate GSE and APU facilities. For the purposes of this inventory, this report considers all GSE and APU facilities to be within the operational control of the airport. Thus the projected scope 1 emissions for the airport may be conservative compared with the final GHG inventory for the operational airport, once contractual arrangements between the airport and its tenants are finalised. Similarly, the operation of the airport's waste water treatment plant may be the responsibility of a third party.

However, for the purposes of this exercise have been included within the total GHG inventory for the site.

In addition, it is noted that although the vehicles used throughout construction are not owned and operated by the airport operator, for the purposes of developing a construction phase GHG inventory, these activities have been incorporated.

It was assumed the waste water treatment plant was an 'extended aeration plant'. Data was drawn from **Haas & Lant (2009)** in order to find an approximate GHG emission. This treatment plant was assumed to have 100 per cent throughput of potable water (3.5 ML/day) and recycled water (1.8 ML/day).

3.7.1.1.2 Scope 2: Indirect Emissions

Scope 2 emissions are indirect GHG emissions from the generation of purchased energy by the airport. Scope 2 in relation to the airport covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the facility that generates the electricity, rather than the facility that uses the electricity. This is why they are often referred to as indirect GHG emissions.

3.7.1.1.3 Scope 3: Other Indirect Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. For the airport, other indirect GHG emissions primarily result from the following sources.

- Airline-owned aircraft movements;
- Airline-owned jet fuel;
- Private vehicles travelling to and from the airport site;
- Employee business travel;
- Taxis;
- Public transport serving the airport;
- Cargo trucks; and
- Off-site waste disposal.

The GHG Protocol allows optional reporting of scope 3 emissions. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2 emissions. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult (because reporting is voluntary). Double counting needs to be avoided when compiling national (country) inventories under international agreements such as the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e., direct emissions) and/or indirect emissions from the purchase of electricity.

In this regard, it is noted that the NGER scheme applies only to scope 1 and scope 2 emissions. An estimate of the Scope 3 emissions associated with the combustion of jet fuel from departing aircraft (anticipated to be the principal scope 3 emission source) has also been provided within this report.

4 EXISTING ENVIRONMENT

4.1 Meteorology

Air quality is influenced by meteorological conditions, primarily in the form of interactions with coastal influences, such as sea breezes, and by local conditions driven by topographical features and night time drainage flows. Wind speed, wind direction, temperature and relative humidity all affect the potential dispersion and transport of emissions and are basic input requirements for dispersion modelling. The local meteorology for the airport site has been reviewed and is described in the following sub-sections.

An on-site automatic weather station (AWS) was installed by the Bureau of Meteorology in 1995. Meteorological data measured over the past five years have been used to characterise the prevailing weather conditions at the airport site. As this weather station is located on-site and is compliant with the Australian Standards (AS 2923-1987 Guide for Measurement of Horizontal Wind for Air Quality Applications), it is considered representative of airport site specific meteorology.

As specified in the Approved Methods, five years of data are required to be reviewed so that a representative year of meteorological conditions can be selected. The following sections provide a review of the meteorological data measured at Badgerys Creek AWS between 2010 and 2014.

A detailed study of the meteorological measurements at Badgerys Creek AWS was completed by the Bureau of Meteorology in the *Western Sydney Airport Climatological Review* **(BoM, 2015).**

4.1.1 Wind speed and wind direction

The Badgerys Creek meteorological data have been reviewed for five consecutive years (2010 to 2014). Summary statistics for the wind data - including wind speed and percentage of 'calms' (winds less than 0.5 m/s) - are shown in **Table 4-1.**

Table 4-1: Wind data – summary statistics

Year	Completeness of data set (%)	Average wind speed (m/s)	Calm periods (%)
2010	98.2	2.9	12.5
2011	99.8	2.6	7.5
2012	100.0	2.4	9.0
2013	99.9	2.5	8.6
2014	99.4	2.5	7.4
Average	**n/a**	**2.6**	**9.0**

Figure 4-1 indicates that there is no strong relationship between the time of year and the monthly average wind speed. Generally speaking, the monthly average wind speeds are less during the months of autumn. The 2010 year was the highest average wind speed across the five years investigated at 2.9 m/s. The year with the lowest average wind speed was 2012 at 2.4 m/s.

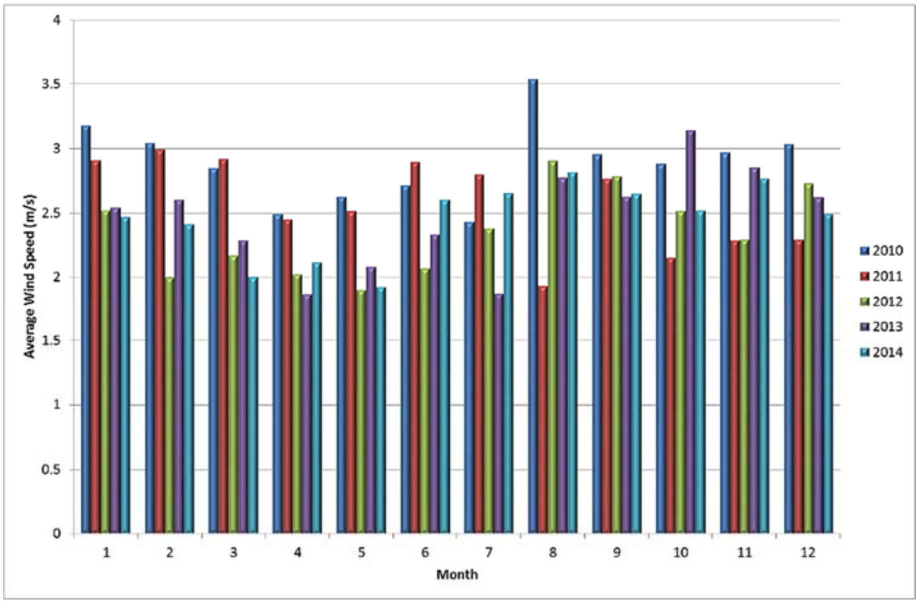


Figure 4-1 Monthly average wind speed at Badgerys Creek (2010-2014)

Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – north, north-northeast, north-east, etc. The bar at the top of each wind rose diagram represents winds blowing from the north (*i.e.* northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds.

The annual and seasonal wind roses for the years 2010 to 2014 are presented in **Figure 4-2** to **Figure 4-6.** The annual wind distribution patterns across the five years show a similar pattern. On an annual basis, the predominant winds at Badgerys Creek originate from the southwest, followed by the south-southwest and north. Very few winds originate from the north-western quadrant.

The prevailing winds vary across the seasons with the characteristic south-westerly wind less prominent during summer where winds from the north-eastern quadrant become more frequent. During winter, the majority of winds originate from the south-western quadrant. There is a consistent seasonal pattern across all years.

The wind distribution patterns are consistent with the findings described in **BoM (2015)**.

The wind data for 2014 were found to be generally representative of the larger data set in terms of average wind speed, percentage of calms and directional patterns, and were therefore chosen to represent the meteorology of the area within the analysis. This is also the most recent full year of meteorological data available. Further discussion on the selection of the year for dispersion modelling is provided in **Appendix D**.

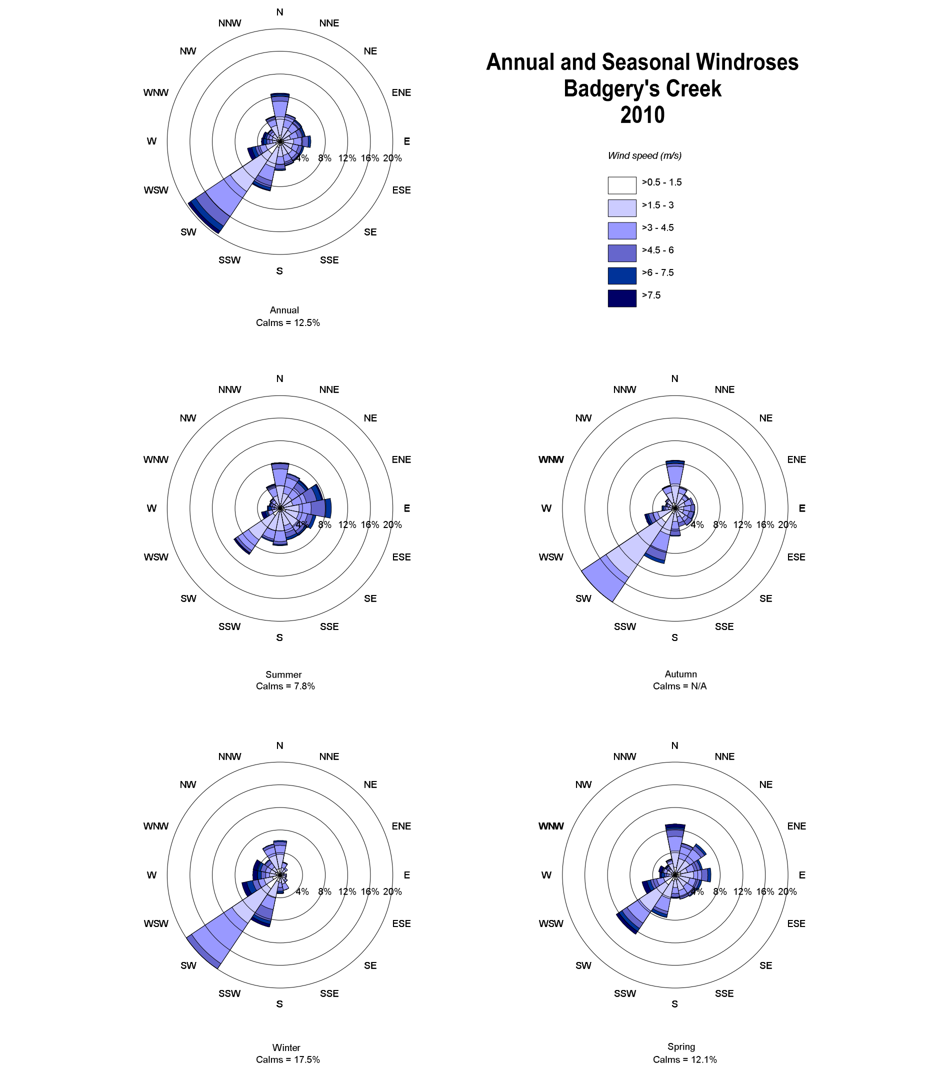


Figure 4-2: Annual and seasonal wind roses for Badgerys Creek (2010)

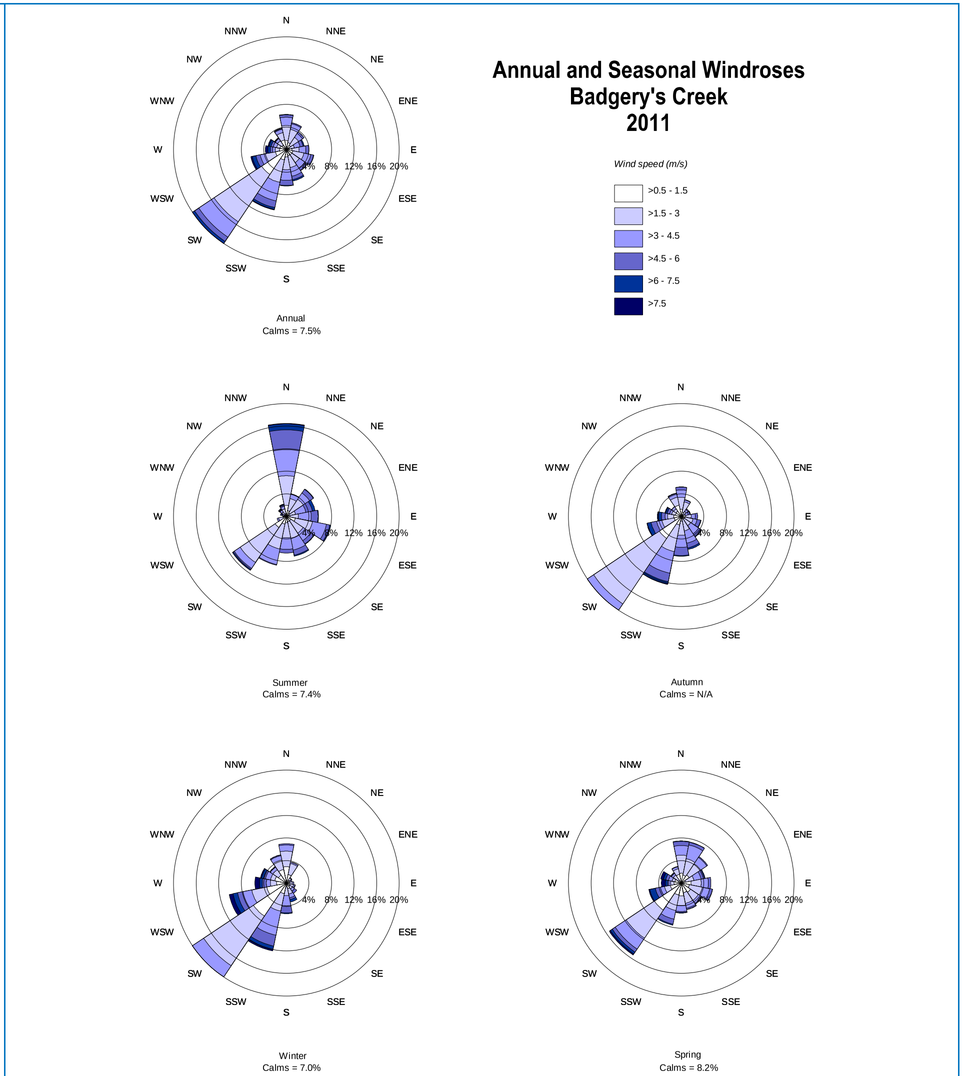


Figure 4-3: Annual and seasonal wind roses for Badgerys Creek (2011)

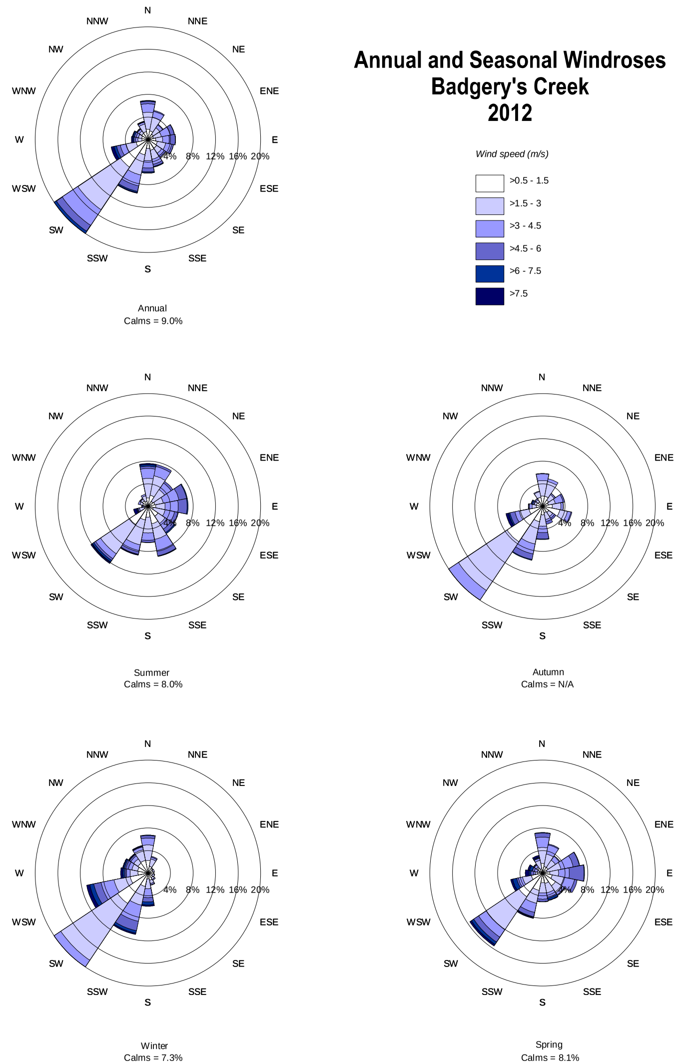


Figure 4-4: Annual and seasonal wind roses for Badgerys Creek (2012)

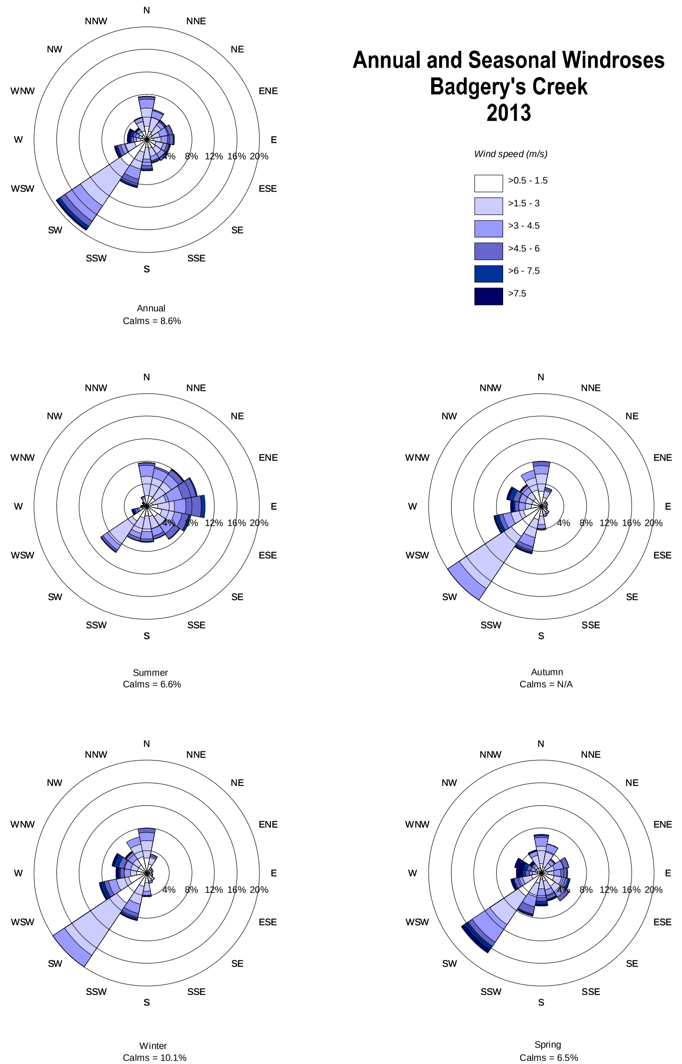


Figure 4-5: Annual and seasonal wind roses for Badgerys Creek (2013)

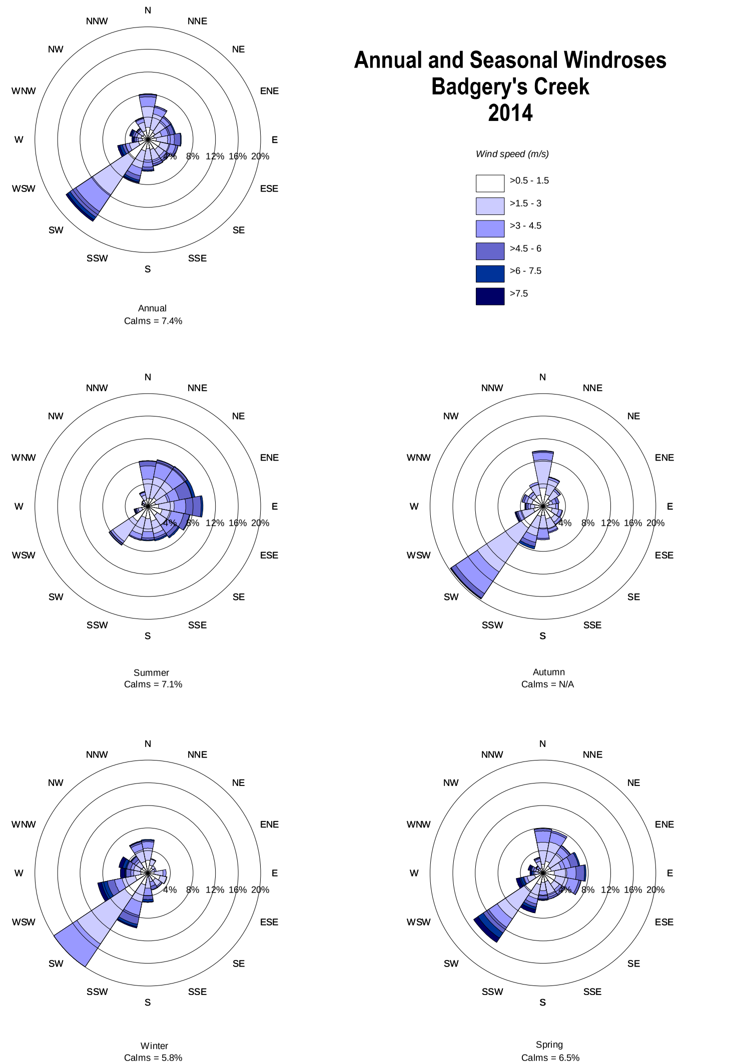


Figure 4-6: Annual and seasonal wind roses for Badgerys Creek (2014)

4.1.2 Temperature, rainfall and humidity

The measurements of temperature, rainfall and humidity at Badgerys Creek between 2010 and 2014 are summarised in **Table 4-2** (**BoM, 2014**). The temperature and humidity data consisted of monthly averages. Also presented are the monthly average maximum and minimum temperatures. The rainfall data consisted of mean monthly values.

Total annual rainfall data measured over the 2010 to 2014 period are shown in **Figure 4-7**. There appears to be a steady fluctuation around the annual average total rainfall (2010-2014) of 814 mm. The wettest year was 2013 with a total of 912 mm of rainfall. The driest year was 2014 with 693 mm of rainfall. The rainfall data collected at Badgerys Creek shown in **Figure 4-7** indicate that February is the wettest month, with an average rainfall of 114 mm. The average monthly rainfall for all years was 73 mm.

Figure 4-7 shows that there is a strong seasonal variation in temperature at Badgerys Creek. The annual average temperature at Badgerys Creek between 2010 and 2014 was 17°C. On average, January was the hottest month (see **Table 4-2** and **Figure 4-7**), with an average monthly temperature of 23°C and maximum of 45°C. June and July were the coldest months for the five year period, with average temperatures of 11°C and 10°C respectively. The minimum temperatures for these months were -2°C and -1°C respectively.

The annual average relative humidity reading at the Badgerys Creek site was 73%. The month with the highest relative humidity on average was June, with an average of 79%. The months with the lowest relative humidity were September and October (see **Table 4-2** and **Figure 4-7**).

The climate variables are consistent with the findings described in **BoM (2015)**.

Table 4-2: Temperature, rainfall and humidity statistics for Badgerys Creek (2010-2014)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean temperature (°C)	23	22	20	17	13	11	10	12	15	17	20	21	17
Minimum temperature (°C)	10	11	9	5	1	-2	-1	0	1	5	7	8	-2
Maximum temperature (°C)	45	41	35	30	27	21	24	28	33	36	41	40	45
Mean rainfall (mm)	76	114	106	62	37	80	30	42	35	47	101	85	68
Mean relative humidity (%)	71	76	76	77	76	79	76	69	67	67	73	71	73

Source: **BoM (2014)**

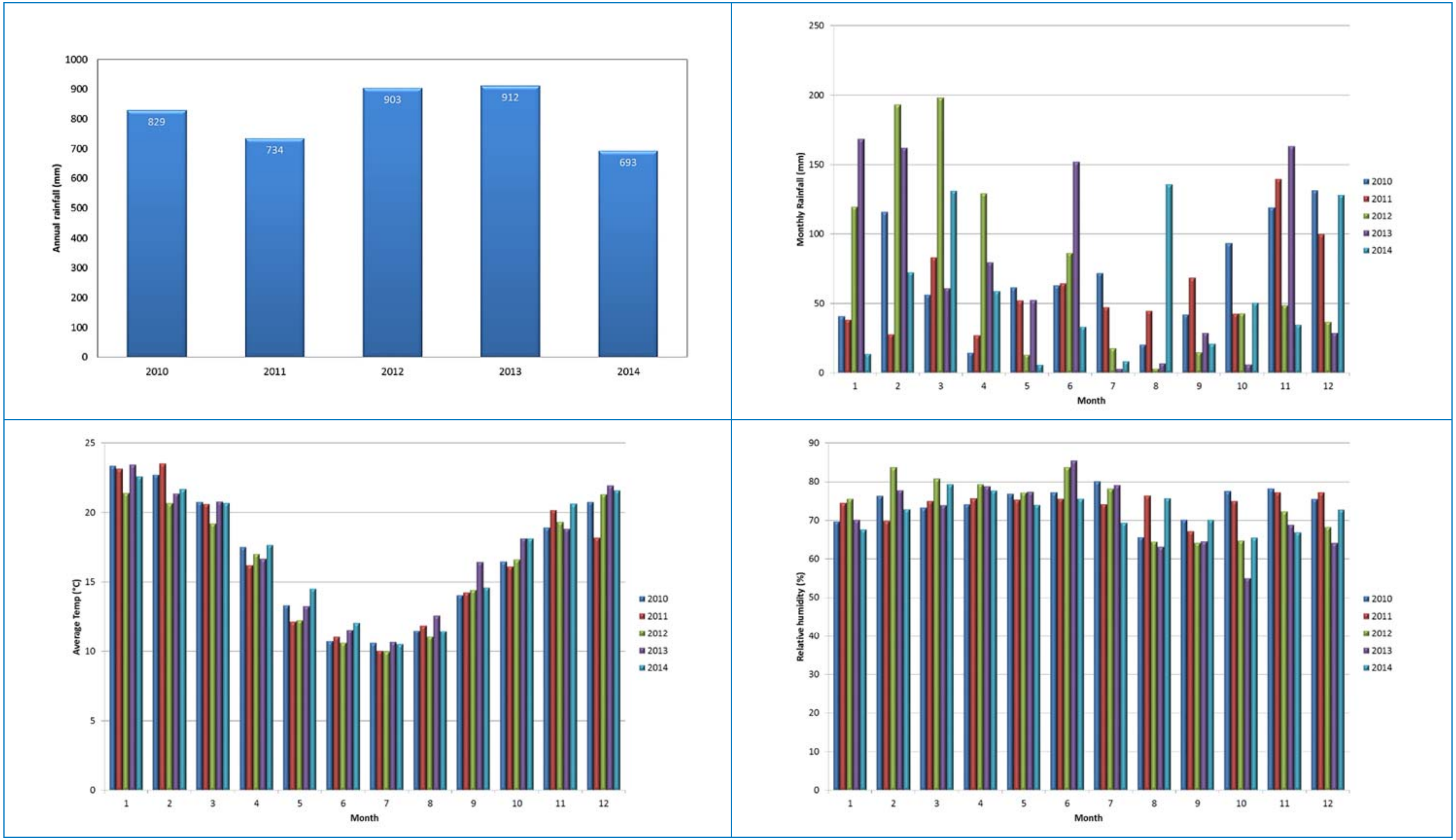


Figure 4-7 Annual and monthly average rainfall, temperature and relative humidity at Badgerys Creek (2010-2014)

4.1.3 Vertical profile

Measurements of the vertical profile of the lower atmosphere are made at Sydney (Kingsford Smith) Airport up to four times each day and are published as part of the NOAA/ESRL Radiosonde database. No other regular measurements of this kind are made within the Sydney region. The measurements are made using a radiosonde that measures wind speed and wind direction, typically up to 7,000 m above ground level. The vertical profile measurements of wind speed between 2010 and 2014 are shown in **Figure 4-8**.

The in-situ measurements of wind speed indicate that generally in the lower few hundred metres of the atmosphere the wind speeds are relatively low, recording up to 8 m/s. Layers of high wind speeds are observed between 800 m and 1,000 m and again between 3,500 m and 4,500 m. The highest observed wind speed was 116 m/s.

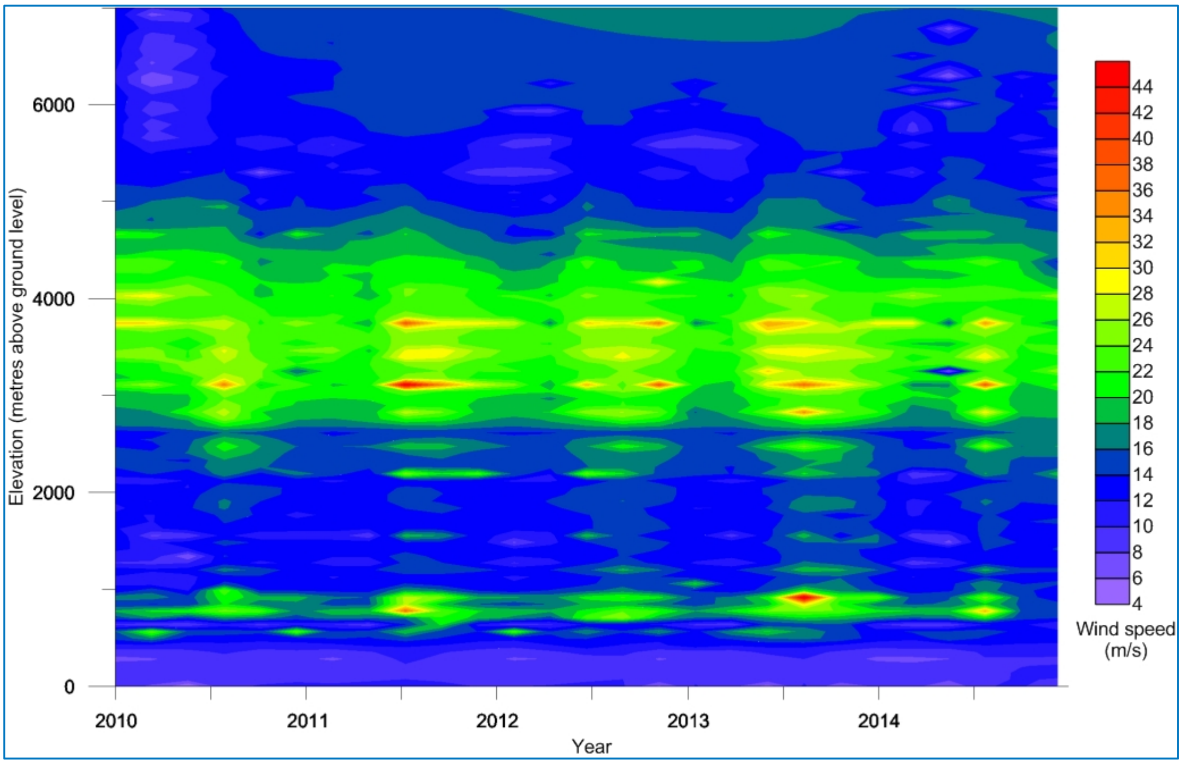


Figure 4-8: Vertical profile of wind speed at Sydney (Kingsford Smith) Airport 2010 – 2014

4.2 Ambient air quality

To assess the potential impacts of the proposal against the relevant air quality criteria in **Section 2**, it is necessary to have information on existing concentrations of these same pollutants for the study area such that the 'cumulative' (ambient conditions plus project incremental emissions) impact may be evaluated.

The NSW Office of Environment and Heritage (OEH) monitoring station at Bringelly was commissioned in 1992 and collects air quality data for air quality parameters including PM_{10}, NO_2 and SO_2. The Bringelly monitoring station is located to the south of the Hawkesbury basin in a semi-rural environment and 3.9 km southeast of the airport site. It is understood through communications with OEH that the SO_2 dataset between January and May 2014 was subject to minor calibration issues.

The Bringelly monitoring station does not measure all air quality parameters investigated as part of this assessment. For this reason, data from OEH air quality monitoring stations located further afield in

Western Sydney have also been used. For example, the next closest site is Campbelltown West and is considered a suitable and conservative (as it is located in a more urban area) source for CO measurements and an alternative for the SO_2 data. The only stations in Western Sydney to measure $PM_{2.5}$ are Liverpool and Richmond.

Table 4-3 summarises the available air quality parameters measured at each site. The highlighted cells indicate which sites have been referenced within the assessment of cumulative impacts. **Figure 4-9** shows the location of each of the stations with respect to the airport.

A summary of the available air quality data is provided in the subsequent sections. Generally, air quality for the local area can be described as good, with the exception of isolated high pollution days or extreme events such as dust storms and bushfires. Uncontrolled combustion events such as bushfires will influence regional observations of PM_{10} and $PM_{2.5}$, and to a lesser extent, NO_x.

Table 4-3: Pollutants monitored

Monitoring station	O_3	CO	NO_2/NO_x	PM_{10}	$PM_{2.5}$	SO_2
Bringelly	✓	-	✓	✓	-	✓
Campbelltown West	✓	✓	✓	✓	-	✓
Liverpool	✓	✓	✓	✓	✓	-
Richmond	✓	-	✓	✓	✓	✓

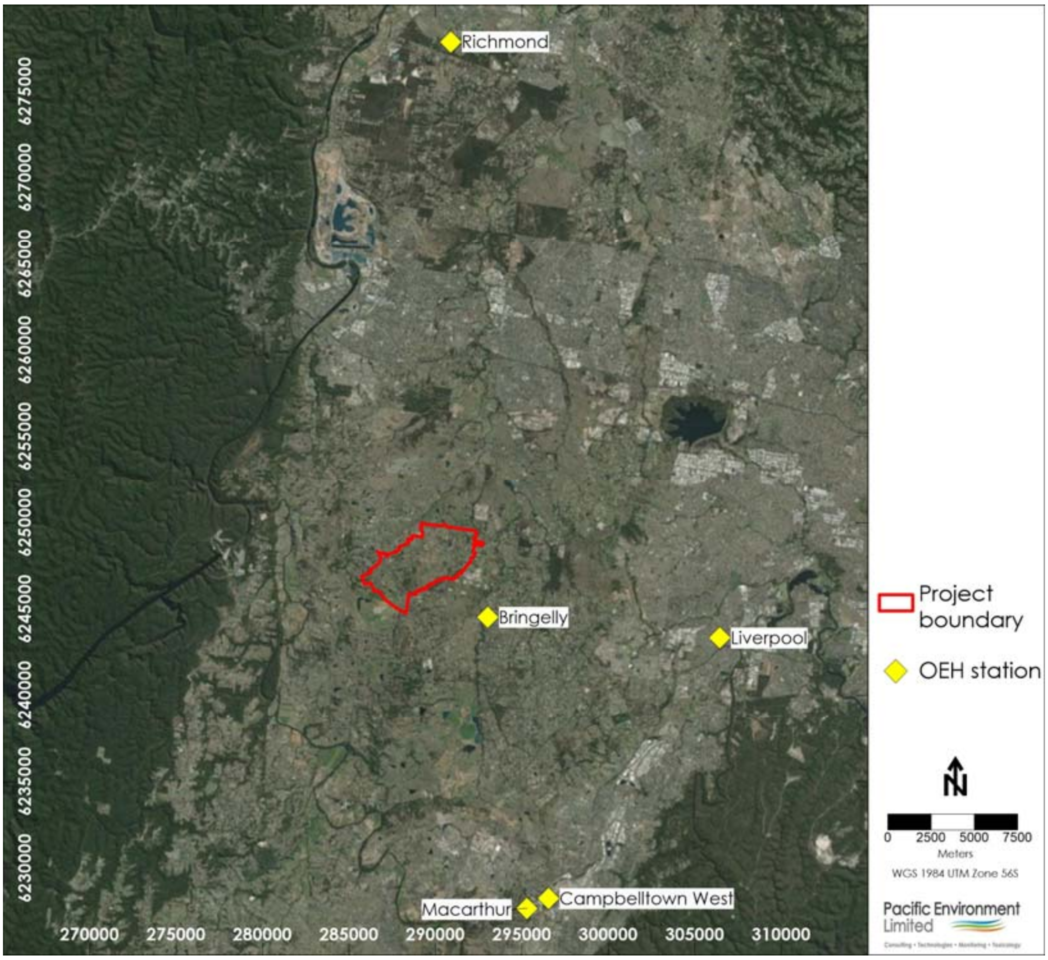


Figure 4-9: Air quality monitoring stations in proximity to the study area

4.2.1 Nitrogen dioxide

The maximum 1-hour, annual average and annual number of exceedances of the relevant criterion for NO_2 for the past ten years of measurements are shown in **Table 4-4**. The monthly mean concentrations are given in **Figure 4-10**.

Information in the table indicates that the NO_2 1-hour maximum concentration ranges between 51 µg/m^3 (2014) and 92 µg/m^3 (2005), both of which are well below the NSW criterion of 246 µg/m^3. The annual average concentrations show improvement over the past 10 years with long-term average concentrations decreasing by 30% over this period.

Table 4-4: Maximum 1-hour and annual average NO_2 concentrations at Bringelly

Year	1-Hour maximum (µg/m³)	Annual average (µg/m³)	Exceedances of 1-hour standard (days per year)
EPA criterion	**246**	**62**	**n/a**
2005	92	13	No exceedances
2006	82	13	No exceedances
2007	90	12	No exceedances
2008	68	10	No exceedances
2009	70	9	No exceedances
2010	76	12	No exceedances
2011	60	10	No exceedances
2012	78	11	No exceedances
2013	76	10	No exceedances
2014	51	10	No exceedances

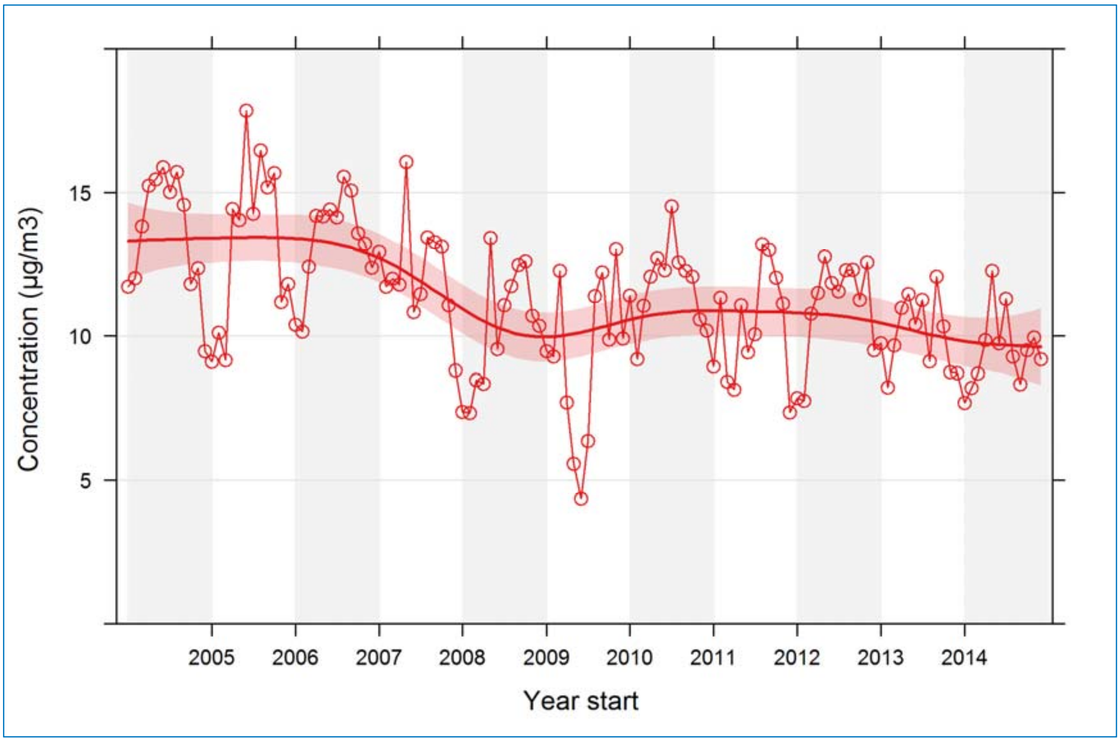


Figure 4-10: Monthly mean NO_2 concentrations at Bringelly

Monthly mean concentrations provide additional data on seasonal patterns in air quality. An example of the seasonal variation in NO_2 concentrations at the Bringelly monitoring site is provided in **Figure 4-10**. The Figure was produced using the 'smooth trend' function in the Openair software, and the shading around the trend line gives the 95% confidence intervals. The time series show a clear downward trend in the NO_2 concentrations most substantially between 2006 and 2009 and then again after 2012. There is a strong seasonal influence on the NO_2 concentrations, peaking during the winter months. This trend is attributed to a combination of more stable atmospheric conditions during this time of year that lead to reduced dispersion and the limited photochemical processes that react with NO_2 during the summer months.

Polar plots have been produced for the Bringelly monitoring data as these data provide a representation of the directional influences of existing emission sources in the vicinity of each monitoring station. Polar plots indicate how pollutant concentrations vary by wind speed and wind direction, with statistical smoothing techniques giving a continuous surface. The monitoring station is located at the centre of each plot. The axes show the directions from which the wind is coming, and the distance from the origin indicates the wind speed; the further from the centre that concentrations appear, the higher the wind speeds when they were measured. Calm conditions appear close to the centre. The polar plot for NO_2 concentrations measured between 2005 and 2014 is shown in **Figure 4-10**. The greatest concentrations originate from the east and are associated with the key local NO_x sources such as vehicle emissions from the M7 motorway that is located to the east of the Bringelly monitoring station.

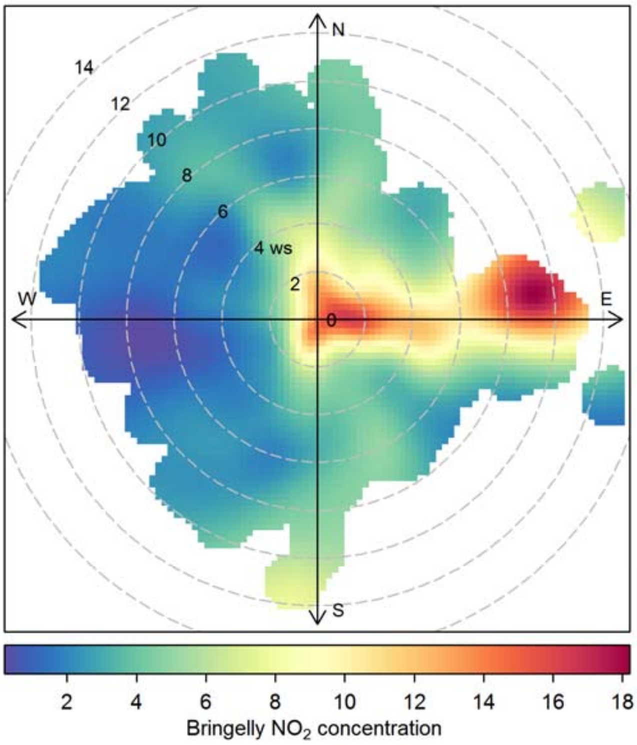


Figure 4-11: Polar plot of normalised NO_2 concentration at Bringelly

4.2.2 Ozone

Shown in **Table 4-5** are the maximum hourly and 4-hourly average O_3 concentrations over the past ten years at Bringelly. The data show that there have been multiple exceedances of one of the NSW EPA criteria (equivalent to the NEPM goal) in the region over the past ten years. The NEPM (Ambient Air) allows for one day of exceedance per year, and as such has been exceeded on several occasions.

The long term trend in the monthly mean O_3 concentrations are shown in **Figure 4-12** and clearly illustrate the seasonal variability in ozone concentrations. This variability is associated with the availability of sunlight, where during the summer months sunlight drives photochemical activity that generates ozone.

Table 4-5: Maximum 1-hour and 4-hour average O_3 concentrations at Bringelly

Year	1-Hour maximum (µg/m³)	4-Hour maximum (µg/m³)	Exceedances of 1-hour standard (days per year)	Exceedances of 4-hour standard (days per year)
EPA criterion (NEPM goal)	**214**	**171**	**(1)**	**(1)**
2005	261	235	8	5
2006	240	218	6	3
2007	255	219	10	5
2008	199	155	0	0
2009	257	232	7	3
2010	223	179	2	1
2011	268	226	5	2
2012	188	149	0	0
2013	231	207	3	1
2014	265	237	4	3

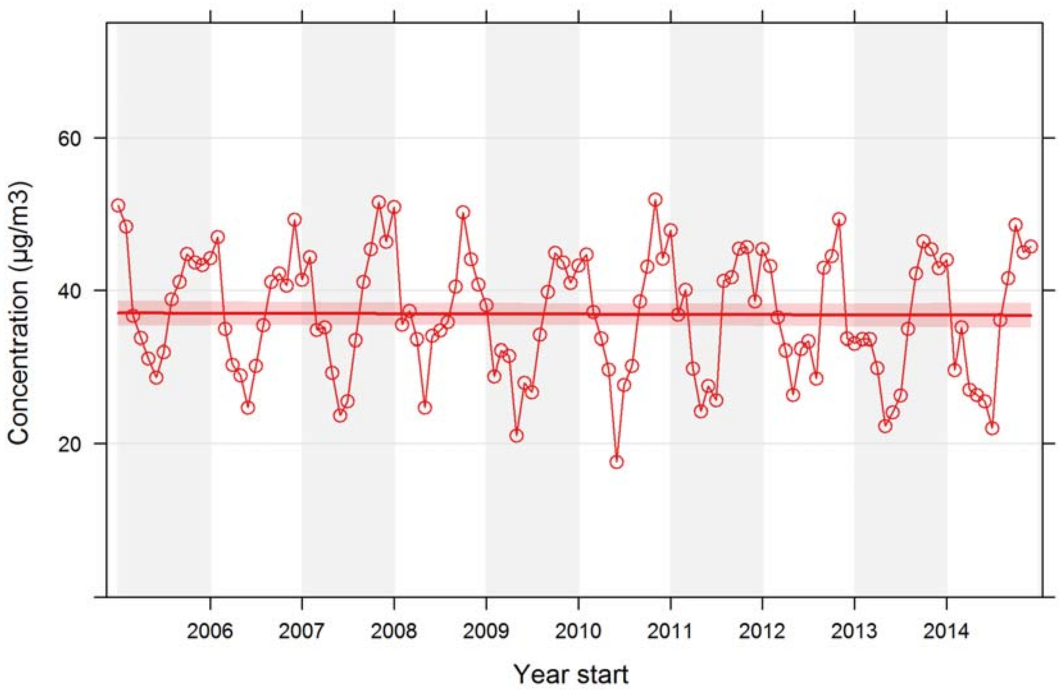


Figure 4-12: Monthly mean O_3 concentrations at Bringelly

4.2.3 Particulate matter

4.2.3.1 PM_{10}

Table 4-6 shows that maximum concentrations of 24-hour average PM_{10} have been fairly constant over the last 10 years, generally ranging between 40 µg/m³ and 97 µg/m³. The exception is 2009, where elevated 24-hour average PM_{10} concentrations were measured on a number of occasions as a result of a series of dust storms (recorded on 23/09/09, 26/09/09, 28/09/09, 29/09/09 and 22/11/09) that in some instances affected much of the state. Aside from 2009, the annual mean concentrations appear to generally be decreasing with no exceedances of the annual criterion (30µg/m³).This is supported by the mean monthly trend shown in **Figure 4-13**.

Table 4-6: Maximum 24-hour and annual average PM_{10} concentrations at Bringelly

Year	24-Hour maximum (µg/m³)	Annual average (µg/m³)	No. of exceedances of 24-hour standard
EPA criterion	**50**	**30**	**n/a**
2005	55	19	2
2006	72	20	3
2007	51	18	1
2008	63	16	1
2009	1684	25	6
2010	41	15	No exceedances
2011	86	16	2
2012	40	16	No exceedances
2013	97	17	3
2014	43	17	No exceedances

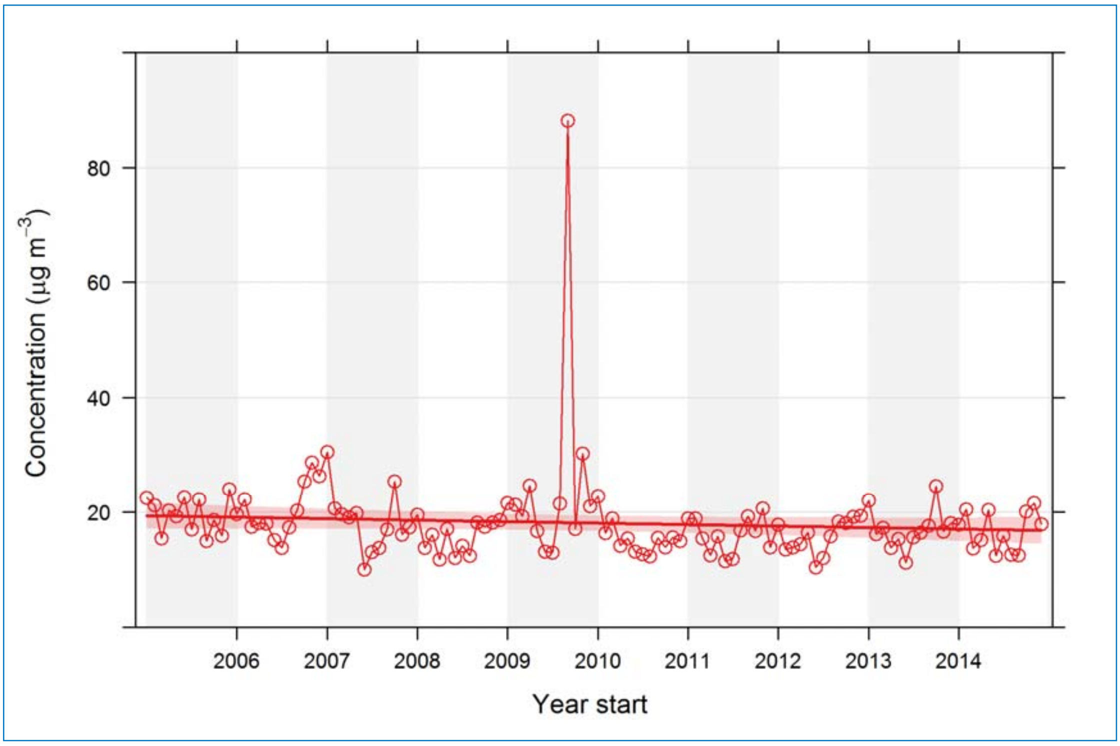


Figure 4-13: Monthly mean PM_{10} concentrations at Bringelly

A polar plot for the Bringelly PM_{10} monitoring data measured between 2005 and 2014 is shown in **Figure 4-14.** The greatest concentrations originate from the northwest, and to a lesser extent the east, west and southeast. The dominant northwest source is likely to be a function of natural events such as bushfires and dust storms that tend to be associated with hot dry prevailing winds originating from this direction. To the east and southwest are the densely populated precincts of Liverpool and Campbelltown which encompass a multitude of potential PM sources.

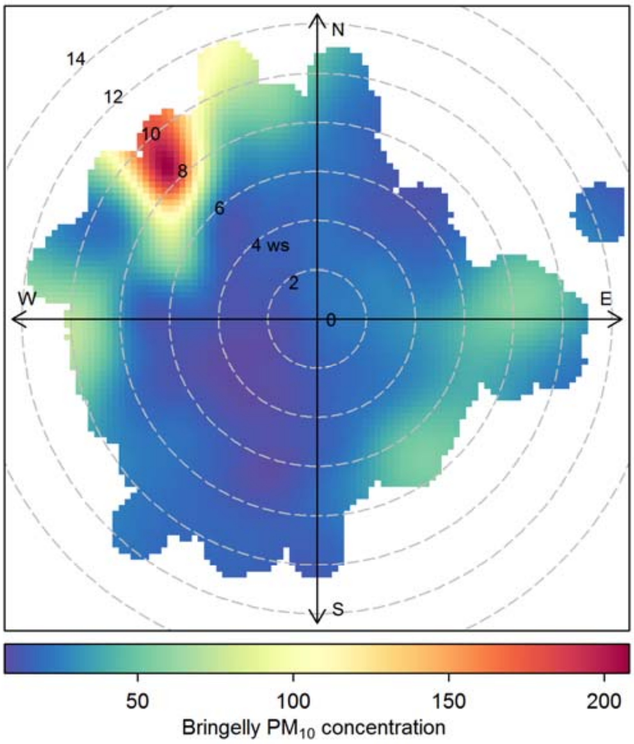


Figure 4-14: Polar plot of normalised PM_{10} concentration at Bringelly

4.2.3.2 $PM_{2.5}$

As $PM_{2.5}$ data are not measured at the Bringelly monitoring station, data from Liverpool and Richmond were selected to characterise the background (existing) concentrations of $PM_{2.5}$. Data is presented for the past ten years in **Table 4-7**. In general, data indicate that $PM_{2.5}$ concentrations are higher at Liverpool than Richmond, with combustion emissions from urbanisation anticipated to be a major source of the measured differences. There are a number of days across the monitoring period where the 24-hour average measurements are above the NEPM goal of 25 µg/m^3. As with the PM_{10} monitoring data (see **Section 4.2.3.1),** the dust storms from 2009 have also been captured in the data set, recording up to 268 µg/m^3 at Liverpool.

The long term trend in $PM_{2.5}$ concentrations in Western Sydney is shown in the monthly mean measurements in **Figure 4-15** and **Figure 4-16** for Liverpool and Richmond respectively. A clear upward trend in the data at both sites is observed from 2013 onwards. This timing corresponds with a change in monitoring techniques across the OEH monitoring network from the use of tapered element oscillating microbalances (TEOMs) to beta attenuation monitors (BAMs). Accordingly, this change is considered an artefact of the monitoring technique rather than an actual increase in $PM_{2.5}$ concentrations.

Table 4-7: Maximum 24-hour and annual average $PM_{2.5}$ concentrations at Liverpool and Richmond

Year	24-Hour max (µg/m³)		Annual average (µg/m³)		No. of exceedances of 24-hour standard	
	Liverpool	Richmond	Liverpool	Richmond	Liverpool	Richmond
NEPM standard	**25**		**8**		**n/a**	
2005	31	23	8	6	2	0
2006	48	78	9	6	3	1
2007	23	21 [(a)]	7	6 [(a)]	0	0
2008	32	18	6	7	1	0
2009	268	149	8	6	5	2
2010	22	21	6	4	0	0
2011	38	43	6	5	2	2
2012	25	117	9	5	0	2
2013	74	83	9	8	2	14
2014	24	25	9	7	0	0

Notes: (a) Less than 75% data retrieval for year

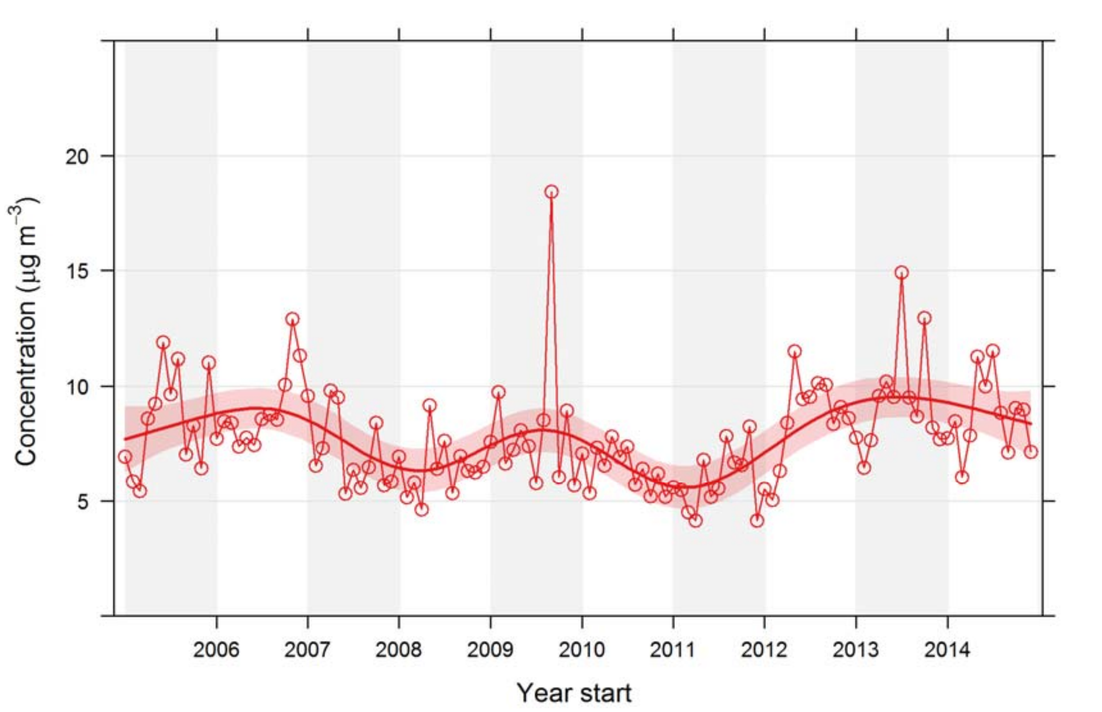


Figure 4-15: Monthly mean $PM_{2.5}$ concentrations at Liverpool

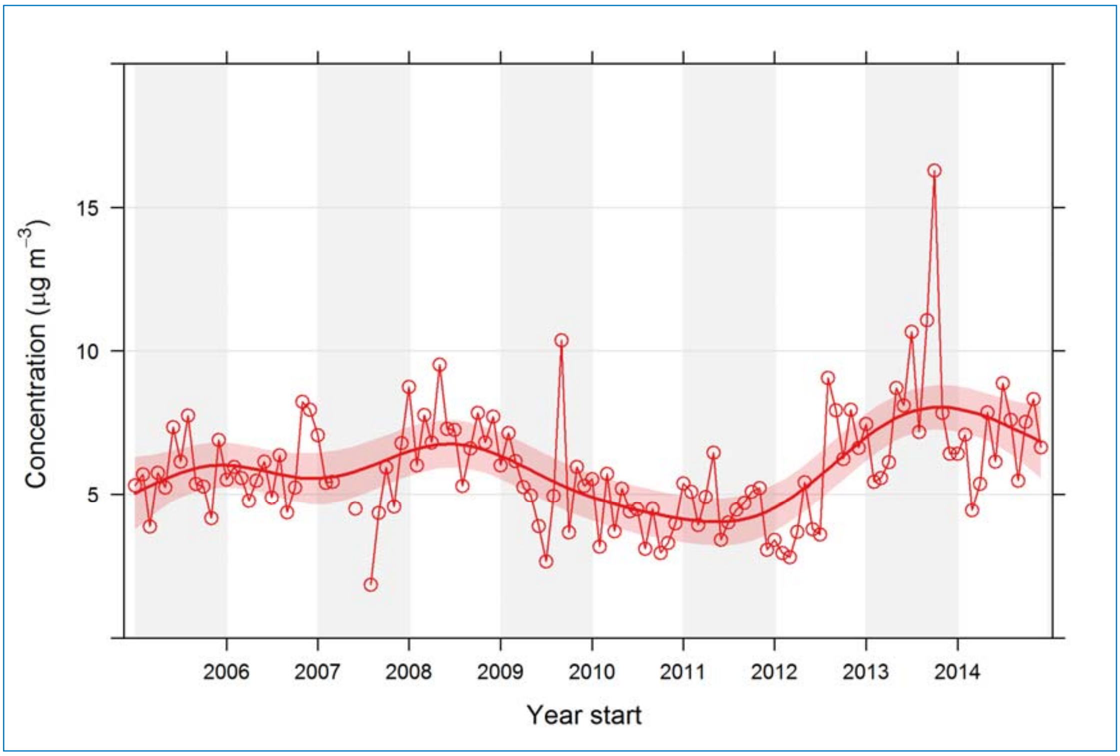


Figure 4-16: Monthly mean $PM_{2.5}$ concentrations at Richmond

4.2.3.3 Ultrafine particulate matter

A considerable amount of attention in recent years has focussed on ultrafine particles (UFPs). These are particles with a diameter of less than 0.1 µm. Whilst there is some evidence that particles in this size range are associated with adverse health effects (see **Appendix B**), it is not currently practical to incorporate them into an environmental impact assessment. There are several reasons for this, including the rapid transformation of such particles in the atmosphere, the need to treat UFPs in terms of number rather than mass, the lack of robust emission factors and concentration-response functions, the lack of ambient background measurements, and the absence of air quality standards.

In relation to concentration-response functions, the **WHO Regional Office for Europe (2013)** has stated the following:

> *'… the richest set of studies provides quantitative information for $PM_{2.5}$. For ultrafine particle numbers, no general risk functions have been published yet, and there are far fewer studies available. Therefore, at this time, a health impact assessment for ultrafine particles is not recommended.'*

For the purpose of this assessment, we have therefore assumed that the effects of UFPs on health are adequately represented through an evaluation of the impacts of $PM_{2.5}$.

4.2.3.4 Deposited dust

The measurement of deposited dust is typically undertaken to evaluate specific industries such as quarries and mining projects. Accordingly, publicly available data representative of existing local conditions are not available for this assessment. It is acknowledged that there are several quarries in the area, however, any such monitoring data are likely to be impacted by these operations and therefore provide an overly conservative estimate. On that basis, it was considered appropriate to adopt a (conservative) assumption of background dust loadings of 2 g/m^2/month. The adopted value thus allows for the construction of the airport to incrementally contribute an additional 2 g/m^2/month to meet the NSW EPA's cumulative criterion of 4 g/m^2/month.

4.2.4 Carbon monoxide

As CO data is unavailable at the OEH Bringelly weather station, data has been taken from Macarthur as it is the closest available site. **Table 4-8** shows CO concentrations at Macarthur for the past 10 years. 1-hour maximum concentrations of CO show a reasonably stable trend through the years with a slight decrease after 2006. The 8-hour maximum concentrations also show a slight decrease that occurred after 2007. There have been no exceedances of 1-hour or 8-hour CO health criteria at Macarthur.

The long term trend in CO concentrations is shown in the monthly mean measurements in **Figure** 4-17 for Macarthur. Only a short data set is available from the Campbelltown West monitoring station and therefore has limited value. There is a sharp decrease in the mean monthly CO concentrations measured at Macarthur in 2009, only to rise again and be relatively stable from 2010 onwards. The reason for this is not clear, and may be a function of the replacement of the monitoring instrumentation in 2008 rather than a regional trend.

Table 4-8: Maximum 15-minute, 1-hour and 8-hour average CO concentrations at Macarthur and Campbelltown West

Year	15-minute maximum (mg/m^3)		1-hour maximum (mg/m^3)		8-hour maximum (mg/m^3)	
	Macarthur	C' West	Macarthur	C' West	Macarthur	C' West
EPA criterion	**100**	**100**	**30**	**30**	**10**	**10**
2005	-	-	2.3 (a)	-	1.2 (a)	-
2006	-	-	2.5	-	2.3	-
2007	-	-	2.4	-	2.2	-
2008	-	-	1.5	-	1.1	-
2009	-	-	1.6	-	0.9	-
2010	-	-	2.0	-	1.1	-
2011	-	-	2.1	-	1.3	-
2012	-	-	1.1 (a)	1.1 (a)	0.8 (a)	0.8 (a)
2013	-	-	-	10.5	-	8.6
2014	-	2.1	-	1.5	-	1.2

Notes: (a) Less than 75% data retrieval for year

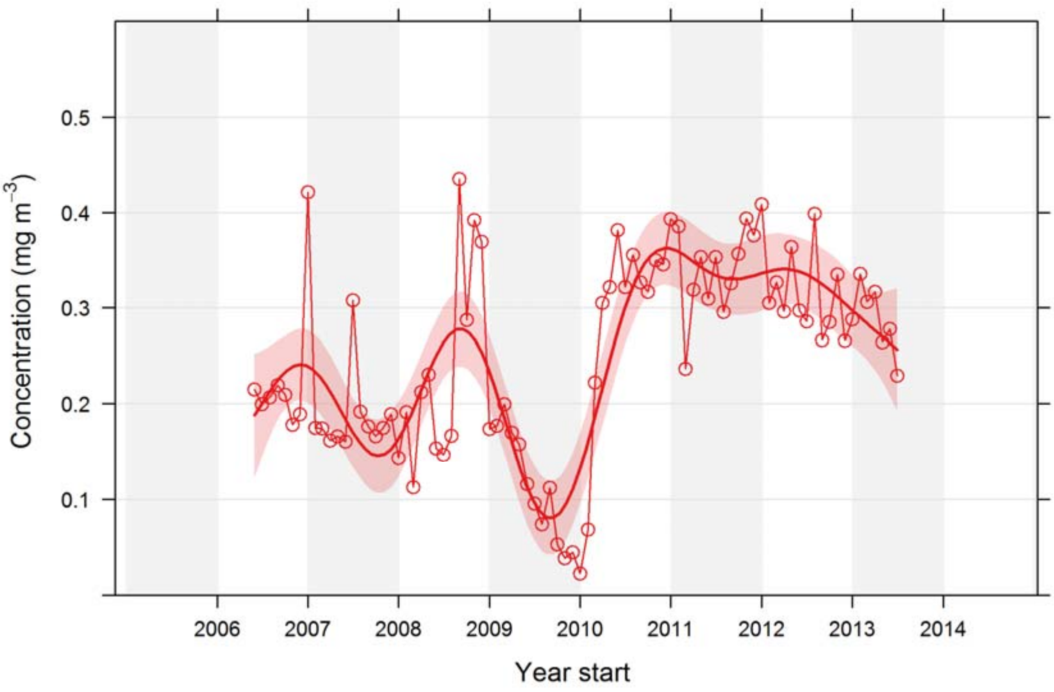


Figure 4-17: Monthly mean CO concentrations at Macarthur

4.2.5 Sulfur dioxide

To establish baseline SO_2 concentrations for the study area, data has been reviewed from multiple monitoring stations. This is because between January and May 2014 the Bringelly SO_2 instrument was subject to calibration issues and the data may was considered unreliable during this period. Data from the next closest site at Campbelltown West was therefore also reviewed. **Table 4-9** provides a summary of the SO_2 measurements over the past 10 years.

SO_2 also shows fluctuating 1-hour maximum concentrations at Macarthur. In 2007 and 2008, 1-hour maximum concentrations of SO_2 rose by 50% from the 2006 level. Concentrations decreased during 2010 and 2011 and subsequently rose again in 2011. 24-hour concentrations follow a similar trend to the 1-hour maximums with a significant drop in 2010 and subsequent increase in 2011. Annual average SO_2 concentrations appear to have decreased from 2010 to 2011. No exceedances of the OEH impact assessment criterion were observed for any of the required averaging periods for the time period reviewed.

The long term trend in SO_2 concentrations at Bringelly is shown in the monthly mean measurements in **Figure 4-17**. Only a short dataset is available from the Campbelltown West monitoring station and therefore it has limited value. There is a decrease in the mean monthly SO_2 concentrations measured in 2009, only to rise again and be relatively stable from 2010 onwards.

A polar plot for the Bringelly SO_2 monitoring data measured between 2005 and 2014 is shown in **Figure 4-19**. The greatest concentrations originate from the east, and are most likely associated with vehicle emissions and industry located in this direction.

Table 4-9: Maximum 15-minute, 1-hour, 8-hour and annual average SO_2 concentrations at Bringelly, and Campbelltown West

Year	10-minute maximum (µg/m³)	1-hour maximum (µg/m³)		24-hour maximum (µg/m³)		Annual average (µg/m³)	
	C' West	Bringelly	C' West	Bringelly	C' West	Bringelly	C' West
EPA criterion							
2004	-	43	-	6.8	-	0.6	-
2005	-	26	-	7.5	-	0.7	-
2006	-	26	-	6.3	-	1.0	-
2007	-	49	-	8.2	-	1.2	-
2008	-	54	-	7.5	-	0.3	-
2009	-	34	-	9.2	-	-0.8	-
2010	-	23	-	5.7	-	0.7	-
2011	-	31	-	5.2	-	0.3	-
2012	-	43	23 (a)	5.1	5.7 (a)	0.5	1.4 (a)
2013	-	31	26	7.0	6.8	0.7	1.3
2014 (b)	80 (c)	26	34	8.5	9.9	0.7	1.2

Notes: (a) Less than 75% data retrieval for year.
(b) Calibration issue with instrument between January and May 2014. The data have been included for completeness.
(c) Hi resolution data was available for Campbelltown West only.

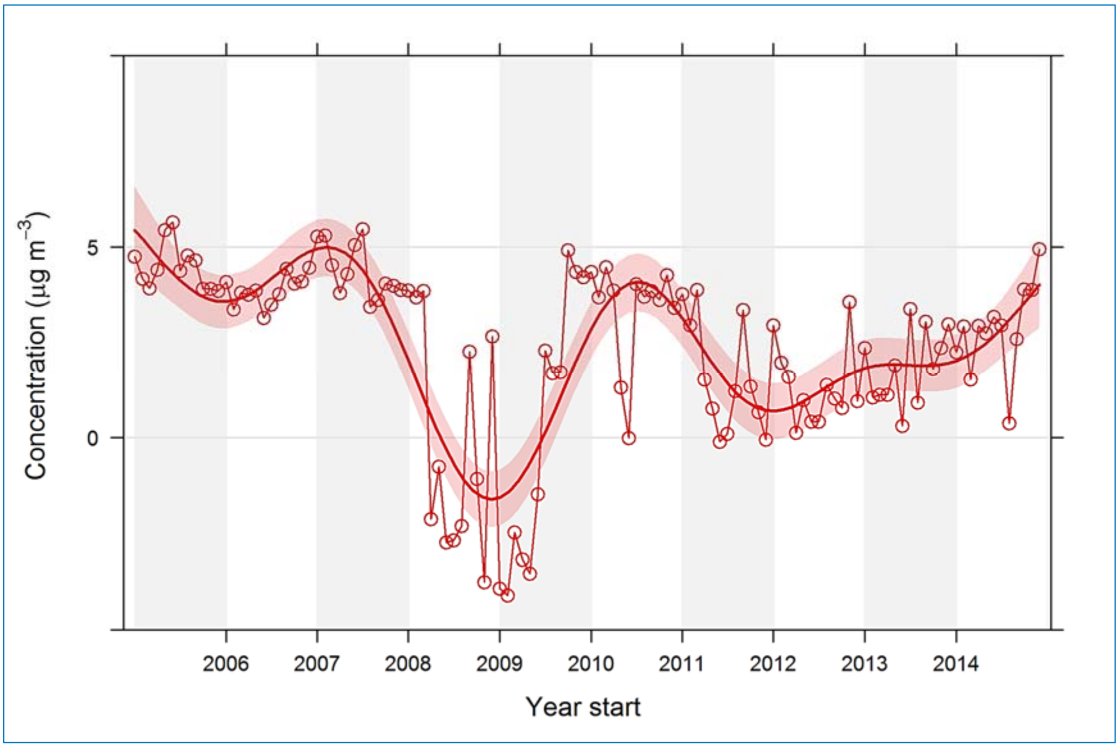


Figure 4-18: Monthly mean SO_2 concentrations at Bringelly

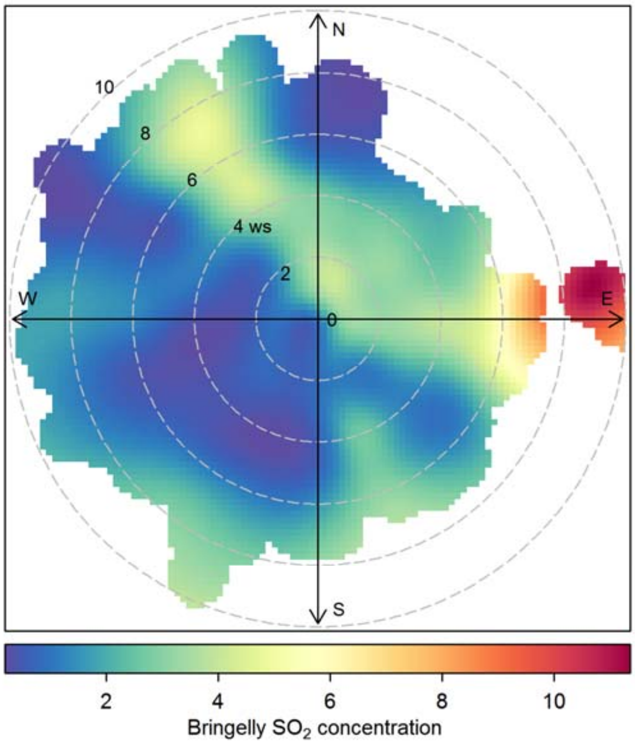


Figure 4-19: Polar plot of normalised SO_2 concentration at Bringelly

4.2.6 Air toxics

Continuous monitoring of air toxics is not measured as part of the OEH air quality monitoring network or under any other program at present. It is understood that some of air toxics monitoring is currently underway, however no details of any study or results are available. To establish baseline air toxic concentrations, it is therefore necessary to reference a historical measurement campaign.

Between 1996 and 2001, the EPA (then Department of Environment and Conservation (DEC)) conducted the Air Toxics Monitoring Project (ATMP) which investigated concentrations of the NEPM air toxics (benzene, toluene, xylene and PAHs such as benzo[a]pyrene) for 24-hour periods at numerous locations across Sydney and NSW **(DEC 2004a, DEC 2004b)**.

The Ambient Air Quality Monitoring and Fuel Quality Testing Project (AAQMFQTP) collected 24-hour concentrations of formaldehyde at Rozelle and Turrella for a one-year period from October 2008 to October 2009. The full report is not in the public domain, however results have been published as part of the NSW EPA's *Current Air Quality in New South Wales* technical paper **(DECCW, 2010)**.

The ATMP found ambient concentrations of most tested substances were well below international ambient air quality goals at the time. The AAQMFQTP also found low concentrations of all chemical pollutants, with many observations below the detection limit of the method. Concentrations of the five air toxics noted in the Air Toxics NEPM were low compared to the relevant measurement investigation level (see **Table 2-3**).

Table 4-10: Historical air toxics monitoring data

Study	Location	Averaging period	Benzene	Toluene	Xylene (m +p)	Xylene (o)	Form-aldehyde	PAH	B[a]P
		Unit	ppm	ppm	ppm	ppm	µg/m³	ng/m³	ng/m³
ATMP (1996 – 2001)	Sydney CBD	Annual	8.0	17.3	3.8	10.4	n/a	7.2	0.8
		24-hr	18.1	41.1	12.8	29.4	n/a	14.3	1.7
	Rozelle	Annual	3.8	9.0	1.9	4.7	n/a	2.4	0.2
		24-hr	21.3	65.8	11.4	31.3	n/a	11.4	1.4
	St Marys	Annual	1.4	3.3	0.5	1.9	n/a	n/a	n/a
		24-hr	4.2	13.6	3.3	7.6	n/a	n/a	n/a
	Blacktown	Annual	n/a	n/a	n/a	n/a	n/a	2.5	0.2
		24-hr	n/a	n/a	n/a	n/a	n/a	14.3	1.9
AAQMFQTP (2008 – 2009)	Turella	Annual	1.4	7.4	3.3	1.4	1.9	n/a	n/a
		24-hr	n/a	n/a	n/a	n/a	5.9	n/a	n/a
	Rozelle	Annual	1.0	3.7	2.4	0.9	1.8	n/a	n/a
		24-hr	n/a	n/a	n/a	n/a	4.3	n/a	n/a

4.3 Odour

The airport site is relatively isolated from other industries that have the potential to be odorous. The exception is the poultry industry with a number of broiler and egg-laying farms in the vicinity, particularly to the east of the airport site. Multiple sources of odour are typically only treated cumulatively when similar in character, and as such consideration of background odour has not been included as part of this assessment.

4.4 Adopted background concentrations

Various time periods are used in the air quality criteria (**Table 2-2**) and the availability of data for different air quality metrics is variable. Therefore, three different approaches were used to determine background concentrations for assessment purposes.

- For annual averages, the highest concentrations from the OEH monitoring sites (for 2014) were taken to represent the background concentration at the airport for the Stage 1 and long-term development scenarios.
- For short-term maxima where monitoring data exists, the maximum value was adopted.
- The exception to this was for NO_2, PM_{10} and $PM_{2.5}$, for which time-varying background data was used (see **Section 3.4.1**).

The adopted background concentrations are presented in **Table 4-11**.

Table 4-11: Summary of assumed background concentrations

Pollutant	Averaging period	Year	Value used for background		Location
CO	15 min.	2014	2.1	mg/m³	Campbelltown West
	1 hour	2014	1.5	mg/m³	
	8 hours	2014	1.2	mg/m³	
NO_2	1 hour	2014	Varying		Bringelly
	1 year	2014	10	µg/m³	
PM_{10}	24 hours	2014	Varying		Bringelly
	1 year	2014	17	µg/m³	
$PM_{2.5}$	24 hours	2014	Varying		Bringelly [(b)]
	1 year	2014	7	µg/m³	
Deposited dust	1 year	n/a	2	g/m²/month	n/a
SO_2	10 min.	2014	80	µg/m³	Campbelltown West
	1 hour	2014	34	µg/m³	
	24 hours	2014	9.9	µg/m³	
	1 year	2014	1.2	µg/m³	
Benzene	1 year	2008-09	1.0	µg/m³	Rozelle
Toluene[(a)]	24 hours	2008-09	15.3	µg/m³	Rozelle
	1 year	2008-09	3.7	µg/m³	
Xylenes [(a)]	24 hours	2008-09	16.6	µg/m³	Rozelle
	1 year	2008-09	2.4	µg/m³	
Formaldehyde	24 hours	2008-09	4.3	µg/m³	Rozelle
B[a]p	1 year	2008-09	0.2	ng/m³	Blacktown

Notes: (a) 24-hour average value has been pro-rated based on the 1996-2001 data from **Table 4-10**.
(b) Based on 2014 $PM_{2.5}$ / PM_{10} ratio of 0.31 at Liverpool and Richmond.

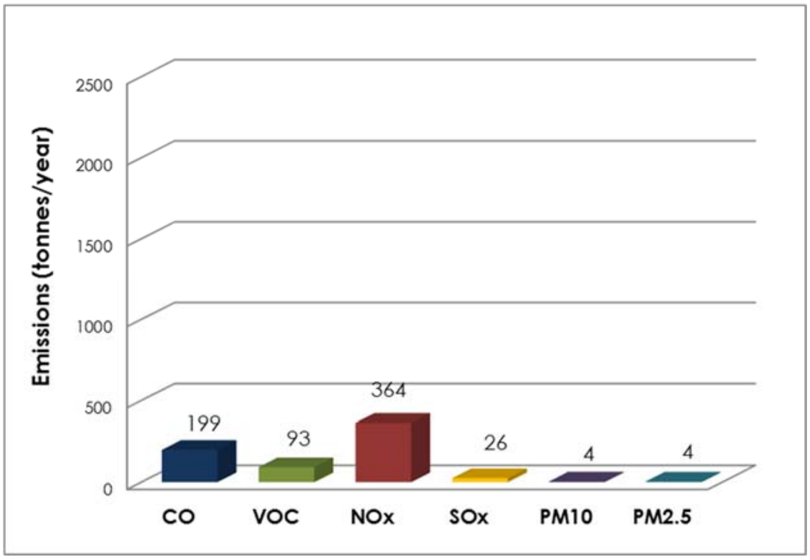
5 OPERATIONAL IMPACT ASSESSMENT

This Chapter describes the results of the emission calculations and air dispersion modelling. Emission inventories were compiled using activity data for the Stage 1 development and long-term development.

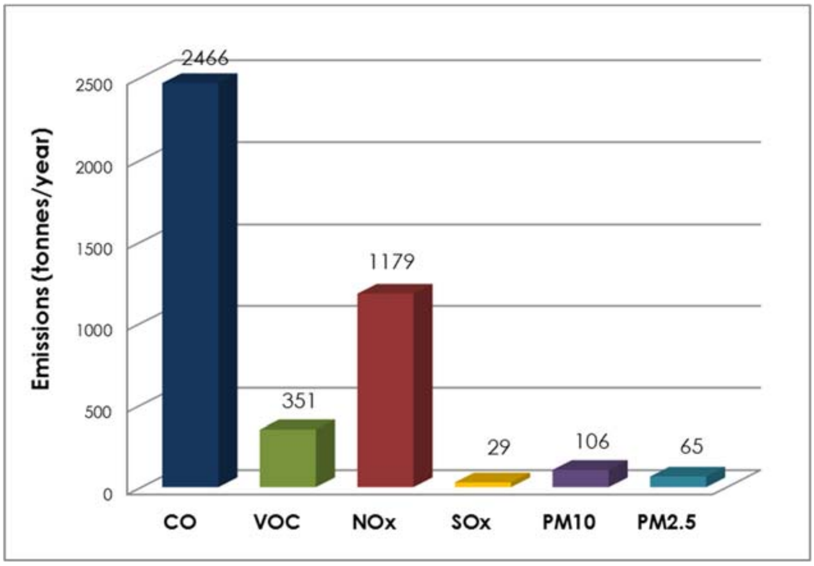
5.1 Emissions

5.1.1 Stage 1 development

The emissions of criteria pollutants from the airport operations during Stage 1 are presented in **Figure 5-1**. The incremental emissions comprise aircraft, APUs, GSE, parking facilities, terminal traffic, stationary sources, and training fires. Cumulative emissions include the respective airport sources and in addition emissions from the external roadways, including airport related traffic.



Airport emissions (incremental)



Airport and external road emissions (cumulative)

Figure 5-1: Total estimated emissions for criteria pollutants during Stage 1 development

The marked difference between the airport emission inventory in isolation compared with that of the external road emissions shown in **Figure 5-1** is further illustrated in **Figure 5-2**. **Figure 5-2** shows the airport emissions and external road emissions as a percentage of the total emissions modelled, by pollutant for the Stage 1 development. For almost all pollutants assessed, traffic using external roadways would be the most prominent source of emissions. Airport related traffic using the external roadways provides a relatively minor contribution to the overall emissions profile. During Stage 1 this contribution is anticipated to be 4% or less, depending upon the pollutant.

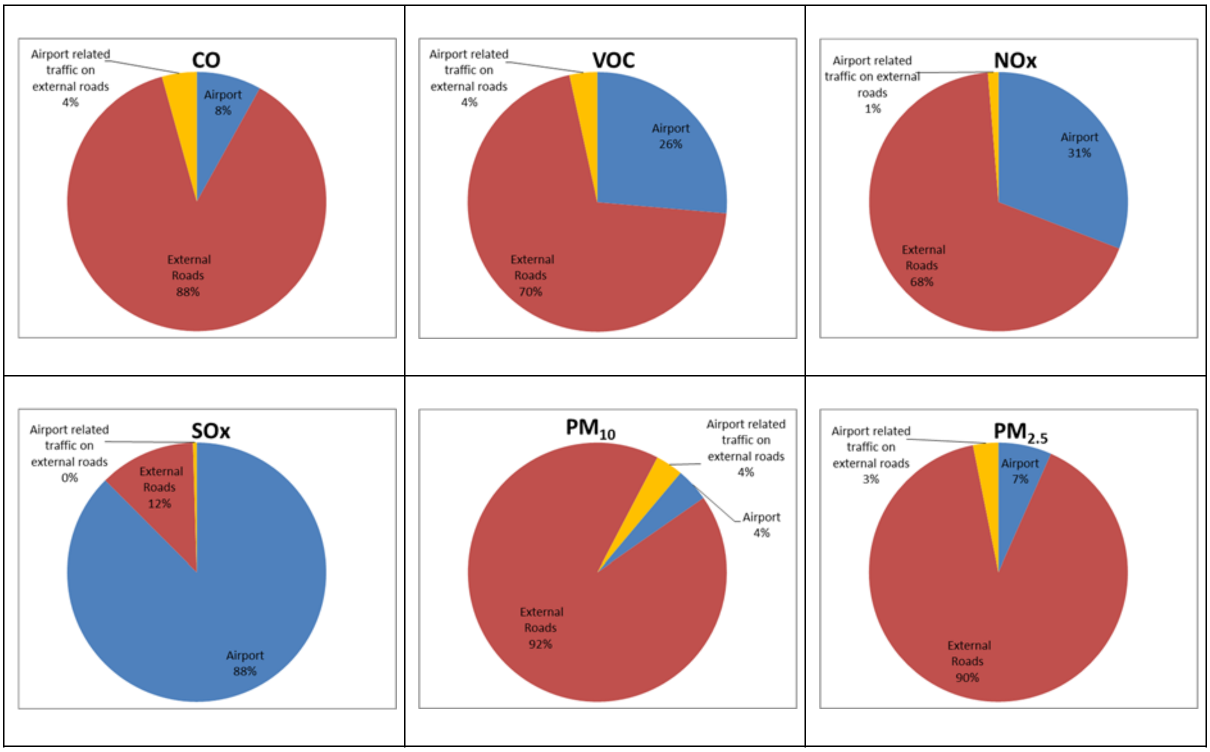


Figure 5-2: Estimated airport and external roads emissions as a percentage of total modelled for criteria pollutants during Stage 1 development

The emissions inventory for a future scenario in the absence of the airport (i.e. additional emissions are solely due to expansion of the external roadways) was calculated for Stage 1. Compared to the "with airport" Stage 1 scenario, total emissions are anticipated to be reduced by less than one third for the majority of pollutants investigated in this study. The exception being SO_2 where emissions are anticipated to be reduced by almost 90%, reflective of the reduction of aviation fuel use (and associated sulfur content) under this scenario.

The emission inventory for the Stage 1 airport development is presented by source type in **Table** 5-1. In each table, the percentage contribution of each source category is shown alongside the emission value. Emission totals have been provided with and without the cumulative contributions from external roadways.

The external roadways are estimated to contribute by far the largest source of emissions for this modelling scenario. This is attributed to the extent of the road network, the number of vehicles using the road network and the associated emissions that have been included in the modelling (see **Appendix C**) and should be considered in context.

Review of the incremental emissions (i.e. those emissions from within the airport site only) show that the emissions from aircraft engines are the most significant source.

Emissions from APUs, GSE, parking facilities and terminal traffic were also established as significant emission sources. In the case of CO, the largest single source was GSE (24%), while for NO_x, APUs were the next largest source (5%). Stationary sources, in particular fuel tanks, are a significant contributor to VOC emissions. Of the on-site fuel storage facility, evaporative losses from jet fuel at the fuel farm is calculated to account for over 99% of losses compared with those from diesel and petroleum, reflecting this fuel source's volatility. Emissions from aircraft engines are the single largest source of SO_2 emissions, contributing 91% of total emissions.

When the cumulative contributions from the external roadways are considered, they account for an estimated 92% of PM_{10}, 90% of $PM_{2.5}$ and 68% of NO_x total emissions with the remaining emissions comprising those from the airport.

Table 5-1: Airport emission inventory for criteria pollutants – Stage 1 development

Category	Emissions (tonnes per year)											
	CO		VOC		NO_x		SO_2		PM_{10}		$PM_{2.5}$	
Aircraft engines	127	63%	27	29%	336	92%	23	91%	2	41%	2	42%
GSE	48.6	24%	2.0	2%	4.5	1%	0.5	2%	0.3	7%	0.3	7%
APUs	4.7	2%	0.5	1%	17.3	5%	1.6	6%	1.1	24%	1.1	25%
Parking Facilities	9.4	5%	1.0	1%	0.4	0%	0.0	0%	0.0	1%	0.0	0%
Terminal traffic	4.9	2%	0.5	1%	1.2	0%	0.0	0%	0.2	4%	0.1	2%
Stationary Sources	2.4	1%	62.0	67%	4.4	1%	0.1	1%	0.3	7%	0.3	7%
Boilers	1.9	1%	0.1	0%	2.4	1%	0.0	0%	0.2	4%	0.2	4%
Engine tests	-	0%	0.0	0%	-	0%	-	0%	-	0%	-	0%
Fuel tanks	-	0%	54.5	59%	-	0%	-	0%	-	0%	-	0%
Generators	0.4	0%	0.1	0%	2.0	1%	0.1	1%	0.1	3%	0.1	3%
Paint and Solvent	-	0%	7.2	8%	-	0%	-	0%	-	0%	-	0%
Training Fires	3.1	2%	0.1	0%	0.0	0%	0.0	0%	0.7	16%	0.7	16%
Total (airport)	**199**	**100%**	**93**	**100%**	**364**	**100%**	**26**	**100%**	**4**	**100%**	**4**	**100%**
External roadways	2,159	88%	246	70%	800	68%	4	12%	98	92%	58	90%
Airport related traffic on external roads	107	4%	12	3%	16	1%	0	0%	4	3%	2	3%
Airport	199	8%	93	26%	364	31%	26	88%	4	4%	4	7%
Total including external roadways	**2,466**	**100%**	**351**	**100%**	**1,179**	**100%**	**29**	**100%**	**106**	**100%**	**65**	**100%**

Notes: (a) Includes contribution from airport traffic on roadways outside the airport site.

The emissions from lead (associated with the use of AvGas) have been estimated to be 934 kg/year under the Stage 1 scenario. This equates to less than 2% of the NSW GMR Inventory **(NSW EPA, 2012a)**. It is highlighted that the release of these emissions would be highly dispursed spatially, given their release will be a function of gradual fuel consumption of aircraft fuelled from the airport. Thus this potential for lead emission should be seen as a regional issue rather than a local issue. It is further considered that this contribution is unlikely to be additive compared to the status quo, as much of this contribution would be associated with existing aircraft movements, now being serviced by WSA rather than other existing airfields in the region.

Forecast emissions from the proposed airport have also been considered in the context of the Sydney airshed. Projected emissions data for the Sydney airshed were prepared by **EPA (2012a)** for the years 2016, 2021, 2026, 2031 and 2036. The projected emissions for 2031 have been compared with the total emissions from the proposed airport and shown in **Table 5-2**. As the Sydney airshed forecast emissions are not available for 2030, it has been assumed that they will be the same as 2031. The emissions from the airport represent up to 0.7% (NO_x) of the total anthropogenic emissions within the Sydney airshed.

Table 5-2: Forecast Sydney airshed emissions compared with forecast airport emissions during Stage 1

Pollutant	Forecast Sydney airshed emissions in 2031 (tonnes/year)	Forecast airport emissions in 2030 (tonnes/year)	Forecast airport emissions compared with Sydney airshed in 2030 (%)
CO	166,802	199	0.1%
VOC	98,369	93	0.1%
NO_x	51,452	364	0.7%
SO_2	18,522	29	0.2%
PM_{10}	10,446	4	<0.1%
$PM_{2.5}$	12,834	4	<0.1%

Source: Forecast 2031 Sydney Airshed emissions from EPA 2012a.
Note: Forecast airport emissions does not include contributions from external roadways

Given the contribution of aircraft engine emissions to local air quality, a split of emissions by operational mode is provided in **Figure 5-3** for the Stage 1 development.

The relative contributions of the different modes are a function of both the efficiency of fuel combustion and the rate of fuel consumption. For CO and VOC, the main source of aircraft emissions was taxiing in and out, and also start-up in the case of VOCs. For NO_X, the main sources were take-off and climb-out. All modes of operation contributed significantly to SO_2, PM_{10} and $PM_{2.5}$ emissions, with the largest single source being take-off.

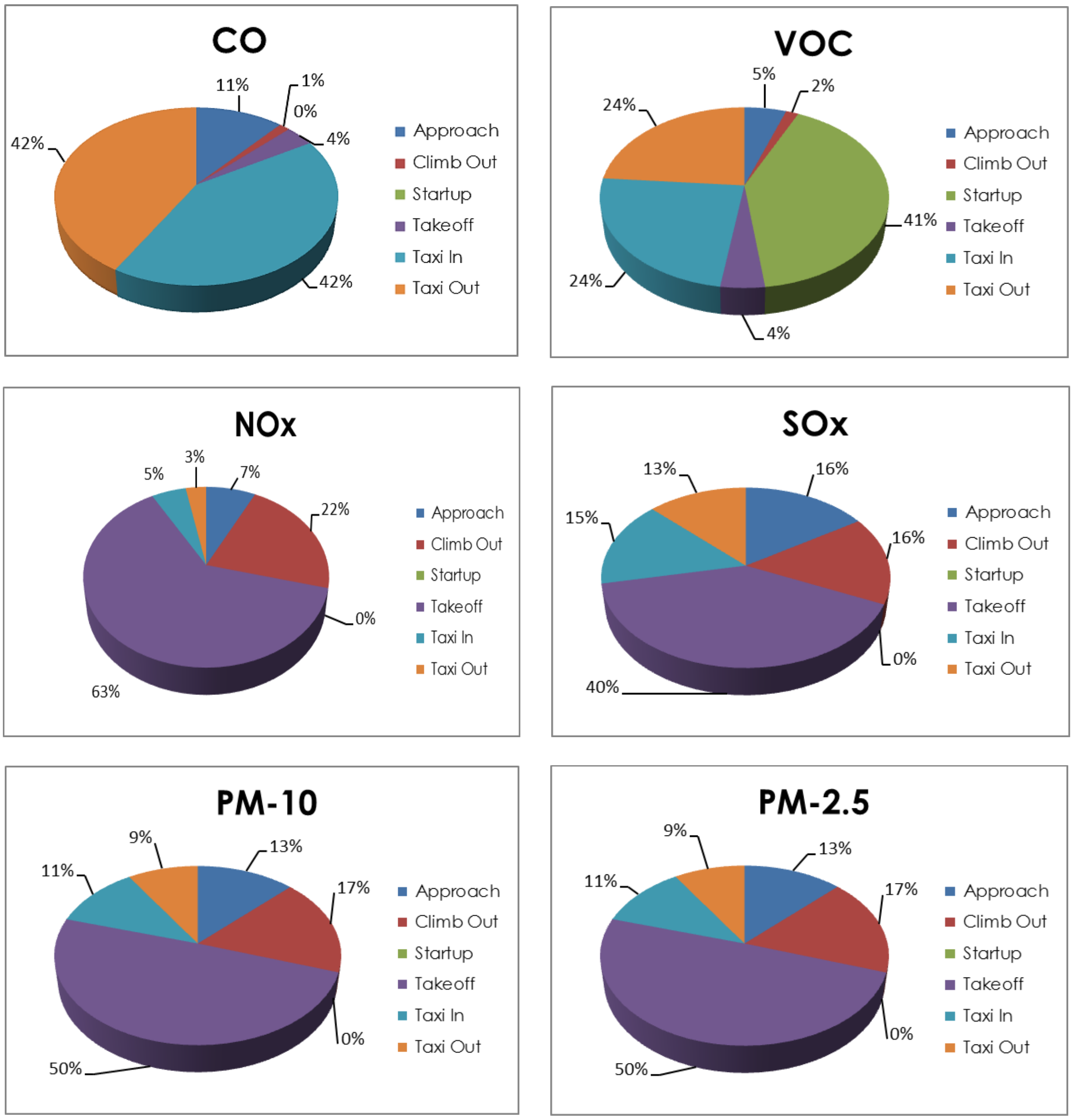
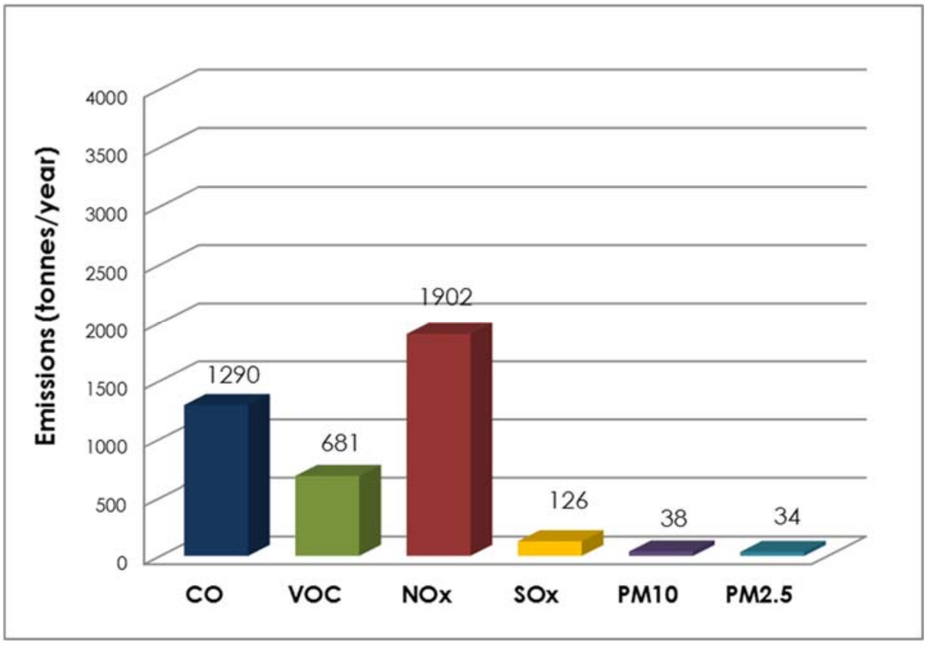


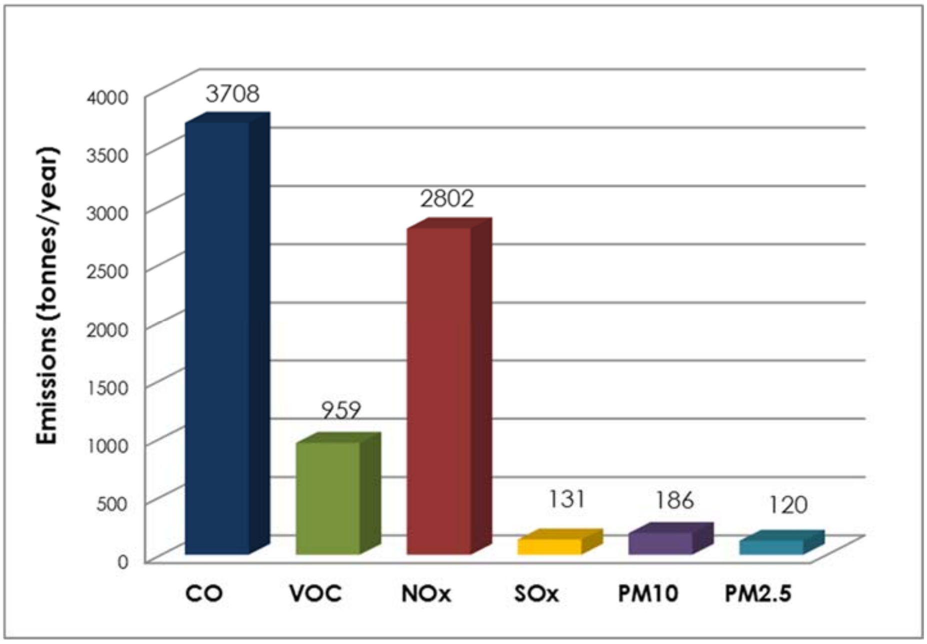
Figure 5-3: Estimated aircraft emissions by operational mode for Stage 1 development

5.1.2 Long-term development

Total emissions of criteria pollutants from the airport operations during the long-term development are presented in **Figure 5-4**. The incremental emissions comprise aircraft, APUs, GSE, parking facilities, terminal traffic, stationary sources, and training fires. Cumulative emissions include the respective airport sources and in addition emissions from the external roadways.



Airport emissions (incremental)



Airport and external road emissions (cumulative)

Figure 5-4: Total estimated emissions for criteria pollutants for long-term development

Again, the marked difference between the airport emission inventory in isolation compared with that of the external road emissions shown in **Figure 5-4** is further illustrated in **Figure 5-5**. **Figure 5-5** shows the airport emissions and external road emissions as a percentage of the total emissions modelled, by pollutant for the long-term development. Airport related traffic using the external roadways provides a relatively minor contribution to the overall emissions profile. This contribution is anticipated to be 14% or less, depending upon the pollutant.

The emission inventory results for the long-term development are presented by source type in **Table** 5-3. In each table, the percentage contribution of each source category is shown alongside the emission value. Emission totals have been provided with and without the cumulative contributions from external roadways.

The incremental emissions from the airport show that the emissions from aircraft engines are the most significant source.

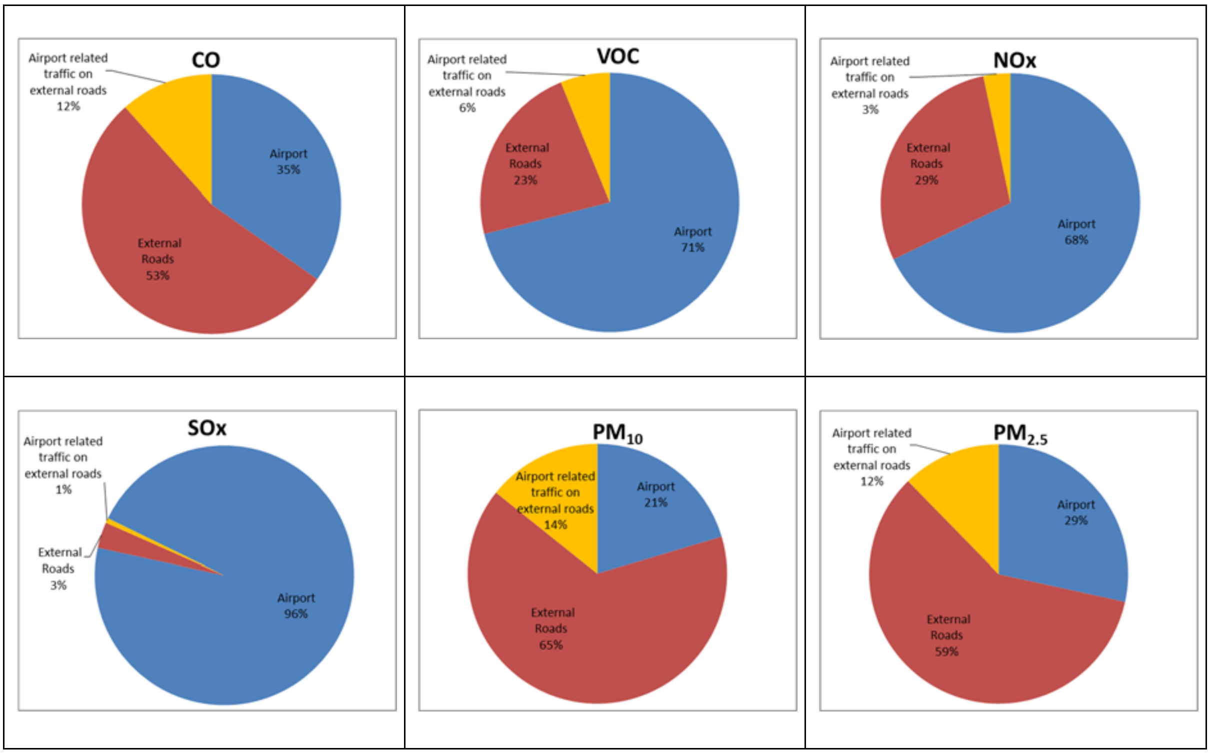


Figure 5-5: Estimated airport and external roads emissions as a percentage of total modelled for criteria pollutants during long-term development

Table 5-3: Airport emission inventory for criteria pollutants – long-term development

Category	Emissions (tonnes per year)											
	CO		VOC		NO_x		SO_2		PM_{10}		$PM_{2.5}$	
Aircraft	729	56%	132	19%	1,756	92%	116	93%	8	21%	8	23%
GSE	159.2	12%	7.2	1%	15.0	1%	1.7	1%	1.0	3%	1.0	3%
APUs	17.8	1%	1.8	0%	64.4	3%	6.6	5%	3.9	10%	3.9	12%
Parking Facilities	126.8	10%	13.7	2%	5.7	0%	0.1	0%	0.3	1%	0.2	0%
Terminal traffic	181.6	14%	17.8	3%	38.1	2%	0.4	0%	8.3	22%	4.7	14%
Stationary Sources	15.3	1%	507.0	74%	21.6	1%	0.4	0%	1.6	4%	1.6	5%
Boilers	14.5	1%	1.0	0%	17.8	1%	0.1	0%	1.3	4%	1.3	4%
Engine tests	-	0%	1.2	0%	-	0%	-	0%	-	0%	-	0%
Fuel tanks	-	0%	441.4	65%	-	0%	-	0%	-	0%	-	0%
Generators	0.8	0%	0.2	0%	3.8	0%	0.3	0%	0.3	1%	0.3	1%
Paint and Solvent	-	0%	63.2	9%	-	0%	-	0%	-	0%	-	0%
Training Fires	61.1	5%	2.0	0%	0.5	0%	0.1	0%	14.9	39%	14.9	44%
Total (airport)	**1,290**	**100%**	**681**	**100%**	**1,902**	**100%**	**126**	**100%**	**38**	**100%**	**34**	**100%**
External roadways	1,987	54%	218	23%	807	29%	4	3%	122	65%	71	59%
Airport related traffic on external roads	430	12%	59	6%	94	3%	1	1%	27	14%	15	12%
Airport	1,290	35%	681	71%	1,902	68%	126	96%	38	20%	34	28%
Total including external roadways	**3,708**	**100%**	**959**	**100%**	**2,802**	**100%**	**131**	**100%**	**186**	**100%**	**120**	**100%**

Emissions from APUs, GSE, parking facilities and terminal traffic were also important. In the case of CO, the largest single source after aircraft was terminal traffic (14%), while for NO_x, APUs were the next largest source (3%).

When the cumulative contributions are considered, external roadways account for an estimated 65% of PM_{10}, 59% of $PM_{2.5}$ and 29% of NO_x emissions with the remaining emissions comprising those from the airport. Emissions from aircraft engines are the single largest source of SO_2 emissions, contributing 93% of total emissions.

5.2 Dispersion modelling results

5.2.1 Overview

The concentrations of the criteria pollutants (CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and VOCs) were determined for residential, on-site and community receptors located in the local area (see **Section 3.2**). As the residential receptors are generally located in similar areas as the community receptors, only the residential and on-site receptors have been discussed in the following section.

Contour plots have also been prepared to show the spatial distribution of NO_2, PM_{10}, and $PM_{2.5}$, and these are provided in **Appendix F**. Contour plots of pollutant concentrations show the areas that are predicted to be affected by dust at different levels. It is important to note that the contour figures are presented to provide a visual representation of the predicted impacts. To produce the contours it is necessary to make interpolations, and as a result the contours will not always match exactly with predicted impacts at any specific location. The actual predicted pollutant concentrations at nearby receivers are presented in tabular form.

The incremental emissions comprise aircraft, APUs, GSE, parking facilities, terminal traffic, stationary sources, and training fires. Cumulative predictions include the respective airport sources and emissions from the external roadways and background contributions.

5.2.2 Stage 1 development

5.2.2.1 Nitrogen dioxide

The dispersion modelling results for maximum 1-hour and annual average NO_2 are presented in **Table** 5-4**.** As discussed in **Section 3.4.1**, the OLM Level 2 method has been applied for the prediction of NO_2 concentrations surrounding the airport site. This takes account of the 1-hour and annual NO_2 and O_3 monitoring data combined with the hourly predicted NO_x concentration at each sensitive receptor location for each of the respective averaging periods.

The results of the dispersion modelling demonstrate compliance at all residential receptors for the maximum 1-hour and annual average NO_2 concentrations when considering the airport in isolation (incremental) and combined with the external roadways and background sources (cumulative).

The maximum cumulative 1-hour NO_2 concentration is predicted to occur at receptor R25, located to the southwest of the airport site (see **Figure 3-2**). The incremental and cumulative contributions are predicted to be 60% and 70% of the AEPR ambient objective of 320 µg/m³ and 70% and 80% of the NSW impact assessment criterion of 246 µg/m³. The contribution from external roadways is shown to be negligible in the evaluation of cumulative impacts for some receptors, such as at R2 located at Luddenham. The contribution of external roads to the total predicted cumulative concentration is more pronounced at other receptors such as R22 at Rossmore.

The annual average results are less than 50% of the NSW EPA criterion of 62 µg/m³. The increase in the predicted GLCs for NO_2 from the external roadways is between 1% and 117%.

Table 5-4: Predicted cumulative NO_2 concentrations during Stage 1 development

Receptor ID	Receptor description	Airport increment (µg/m³)		Cumulative - airport + external roads + existing background (µg/m³)	
		1-hour	Annual	1-hour	Annual
Ambient objective / Assessment criterion		*320*	*62*	*320*	*62*
R1	Bringelly	84	11	145	19
R2	Luddenham	91	13	92	15
R3	Greendale, Greendale Road	194	12	213	13
R4	Kemps Creek	76	11	109	17
R6	Mulgoa	84	12	85	13
R7	Wallacia	90	11	92	13
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	86	13	91	17
R14	Lawson Road, Badgerys Creek	147	13	153	18
R15	Mersey Rd, Greendale	130	13	135	16
R17	Luddenham Road	96	13	103	17
R18	Cnr Adams & Elizabeth Drive	107	17	108	21

Receptor ID	Receptor description	Airport increment (µg/m³)		Cumulative - airport + external roads + existing background (µg/m³)	
		1-hour	Annual	1-hour	Annual
Ambient objective / Assessment criterion		*320*	*62*	*320*	*62*
R19	Cnr Adams & Anton Road	111	19	112	23
R21	Cnr Willowdene Ave and Vicar Park Lane	171	13	177	15
R22	Rossmore, Victor Ave	68	11	104	15
R23	Wallacia, Greendale Rd	87	11	101	12
R24	Badgerys Creek 1 NE	166	18	169	26
R25	Badgerys Creek 2 SW	104	12	215	26
R27	Greendale, Dwyer Rd	80	11	108	12
R30	Rossmore residential	66	11	126	18
R31	Mt Vernon residential	142	12	142	16

5.2.2.2 Particulate matter (PM_{10})

Table 5-5 presents a summary of the maximum 24-hour average and annual average PM_{10} concentrations from the airport in isolation (incremental) and combined with the external roadways and background sources (cumulative).

The results show that the predicted PM_{10} concentrations to be below the NEPM-AAQ 24-hour and annual mean standard of 50 µg/m³ and 25 µg/m³. There are no AEPR ambient objectives for PM_{10}. For both averaging periods, the background PM_{10} contributes more than half of the respective criterion.

The contour plots show the extent of the predicted impacts across the local area (**Appendix F**). It can be seen that in addition to the airport, the contribution from roadways plays a significant role in the ground level concentrations. For example, receptor R30 is well removed from the airport site in comparison to other residential receptors but is located in close proximity to a major roadway. By way of example, the contribution of emissions to the maximum 24-hour average PM_{10} concentrations predicted at receptor R30 are shown in **Figure 5-6**.

Table 5-5: Predicted incremental and cumulative PM_{10} concentrations during Stage 1 development

Receptor ID	Receptor description	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R1	Bringelly	0.5	<0.1	7.3	1.0	44	18
R2	Luddenham	0.5	<0.1	1.7	0.3	43	17
R3	Greendale, Greendale Road	1.0	<0.1	2.5	0.2	43	17
R4	Kemps Creek	0.6	<0.1	4.4	0.8	44	18
R6	Mulgoa	0.5	<0.1	1.5	0.2	43	17
R7	Wallacia	0.4	<0.1	1.4	0.2	43	17
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.6	<0.1	2.6	0.5	44	18
R14	Lawson Road, Badgerys Creek	1.5	0.1	6.0	0.8	44	18
R15	Mersey Rd, Greendale	1.1	0.1	2.1	0.5	44	17

Receptor ID	Receptor description	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R17	Luddenham Road	0.7	<0.1	2.9	0.5	43	18
R18	Cnr Adams & Elizabeth Drive	0.7	0.1	3.2	0.7	44	18
R19	Cnr Adams & Anton Road	2.0	0.2	3.1	0.7	44	18
R21	Cnr Willowdene Ave and Vicar Park Lane	0.9	<0.1	3.4	0.4	43	17
R22	Rossmore, Victor Ave	0.9	<0.1	3.4	0.5	44	18
R23	Wallacia, Greendale Rd	0.6	<0.1	2.0	0.2	43	17
R24	Badgerys Creek 1 NE	4.1	0.4	5.9	1.5	44	18
R25	Badgerys Creek 2 SW	0.6	<0.1	18.6	1.9	47	19
R27	Greendale, Dwyer Rd	0.1	<0.1	1.7	0.2	43	17
R30	Rossmore residential	0.3	<0.1	6.0	1.1	44	18
R31	Mt Vernon residential	0.9	<0.1	4.0	0.5	43	18

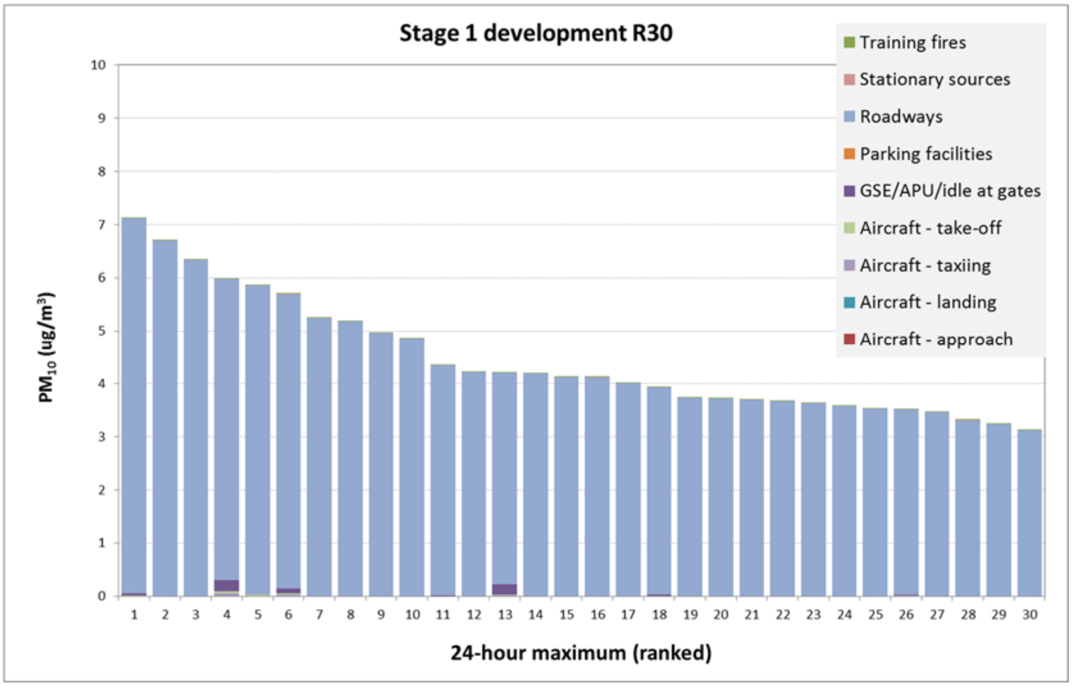


Figure 5-6: Contributions to PM_{10} concentrations at R30

5.2.2.3 Particulate matter ($PM_{2.5}$)

Table 5-6 presents a summary of the maximum 24-hour average and annual average $PM_{2.5}$ concentrations from the airport in isolation and combined with the external roadways and background sources (cumulative).

Table 5-6: Predicted incremental and cumulative $PM_{2.5}$ concentrations during Stage 1 development

		Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
Receptor ID	Receptor description	24-hour	Annual	24-hour	Annual	24-hour	Annual
NEPM standard		*n/a*	*n/a*	*n/a*	*n/a*	*25(20)*	*8 (7)*
R1	Bringelly	0.5	<0.1	4.3	0.6	14	8
R2	Luddenham	0.5	<0.1	1.1	0.2	14	7
R3	Greendale, Greendale Road	1.0	<0.1	1.9	0.1	13	7
R4	Kemps Creek	0.6	<0.1	2.6	0.5	14	7
R6	Mulgoa	0.5	<0.1	1.0	0.1	13	7
R7	Wallacia	0.4	<0.1	0.9	0.1	13	7
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.6	<0.1	1.5	0.3	14	7
R14	Lawson Road, Badgerys Creek	1.4	0.1	4.1	0.5	14	7
R15	Mersey Rd, Greendale	1.0	0.1	1.5	0.3	14	7
R17	Luddenham Road	0.7	<0.1	1.7	0.3	14	7
R18	Cnr Adams & Elizabeth Drive	0.7	0.1	2.0	0.4	14	7
R19	Cnr Adams & Anton Road	1.9	0.2	2.5	0.5	14	7
R21	Cnr Willowdene Ave and Vicar Park Lane	0.8	<0.1	2.1	0.2	14	7
R22	Rossmore, Victor Ave	0.9	<0.1	2.0	0.3	14	7
R23	Wallacia, Greendale Rd	0.6	<0.1	1.2	0.1	13	7
R24	Badgerys Creek 1 NE	3.9	0.3	4.3	0.9	14	8
R25	Badgerys Creek 2 SW	0.6	<0.1	11.1	1.1	18	8
R27	Greendale, Dwyer Rd	0.1	<0.1	1.0	0.1	13	7
R30	Rossmore residential	0.3	<0.1	3.5	0.6	14	8
R31	Mt Vernon residential	0.9	<0.1	2.4	0.3	14	7

The results show that the predicted $PM_{2.5}$ concentrations during the Stage 1 development do not exceed the current NEPM AAQ standards of 25 µg/m³ and 8 µg/m³ for the 24-hour and annual averaging periods respectively when emissions from the airport are combined with external roadways and background sources. There are no AEPR ambient objectives or NSW EPA criterion for $PM_{2.5}$. For both averaging periods, the background is anticipated to contribute more than half of the respective (cumulative) criterion.

No exceedances are predicted for the annual NEPM-AAQ goal of 20 µg/m³ for 2025. All receptors will exceed the annual NEPM-AAQ goal of 7 µg/m³ aimed after 2025 as the background concentration is 7 µg/m³. Further national / state based $PM_{2.5}$ emission reduction programs and initiatives will need to be implemented to reduce overall motor vehicle and airplane emissions to meet this goal

The predicted cumulative concentrations for the 24-hour averaging period account for between 53% and 74% of the NEPM standard. The adopted background of 7 µg/m³ is a significant contributor to the predicted annual average $PM_{2.5}$ concentrations.

The contour plots show the geographical pattern of dispersion across the local area (**Appendix F**). It can be seen that in addition to the airport, the contribution from external roadways plays a significant role in the ground level predictions.

5.2.2.4 Carbon monoxide

The predicted maximum 15-minute, 1-hour and 8-hour CO concentrations at each of the residential receptors were added to the emissions from external roadways and adopted background concentrations and presented in **Table 5-7**. At all receptors, for all averaging periods, the CO concentrations are predicted to be well below the corresponding AEPR ambient objective and NSW EPA impact assessment criteria.

Table 5-7: Predicted incremental and cumulative CO concentrations during Stage 1 development

Receptor ID	Receptor description	Airport (mg/m³)			Airport + external roadways (mg/m³)			Cumulative – airport + external roads + existing background (mg/m³)		
		15-minute	1-hour	8-hour	15-minute	1-hour	8-hour	15-minute	1-hour	8-hour
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*100*	*30*	*10*
R1	Bringelly	0.6	0.4	0.1	3.8	2.9	0.4	5.9	4.4	1.6
R2	Luddenham	0.5	0.4	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R3	Greendale, Greendale Road	0.9	0.7	0.1	1.4	1.0	0.2	3.5	2.5	1.4
R4	Kemps Creek	0.7	0.5	0.1	1.9	1.5	0.3	4.0	3.0	1.5
R6	Mulgoa	0.7	0.5	0.1	0.9	0.6	0.1	3.0	2.1	1.3
R7	Wallacia	0.3	0.2	0.0	0.9	0.7	0.1	3.0	2.2	1.3
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.9	0.7	0.1	1.2	0.9	0.1	3.3	2.4	1.3
R14	Lawson Road, Badgerys Creek	1.8	1.4	0.2	2.2	1.7	0.3	4.3	3.2	1.5
R15	Mersey Rd, Greendale	1.1	0.8	0.2	1.3	1.0	0.2	3.4	2.5	1.4
R17	Luddenham Road	0.5	0.4	0.1	1.0	0.7	0.1	3.1	2.2	1.3
R18	Cnr Adams & Elizabeth Drive	0.7	0.5	0.1	1.6	1.2	0.3	3.7	2.7	1.5
R19	Cnr Adams & Anton Road	2.3	1.7	0.3	2.4	1.8	0.3	4.5	3.3	1.5
R21	Cnr Willowdene Ave and Vicar Park Lane	1.1	0.8	0.2	1.7	1.3	0.2	3.8	2.8	1.4
R22	Rossmore, Victor Ave	1.0	0.8	0.1	1.1	0.8	0.2	3.2	2.3	1.4
R23	Wallacia, Greendale Rd	0.4	0.3	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R24	Badgerys Creek 1 NE	3.1	2.3	0.5	4.6	3.4	0.6	6.7	4.9	1.8
R25	Badgerys Creek 2 SW	0.5	0.4	0.1	4.8	3.6	0.9	6.9	5.1	2.1
R27	Greendale, Dwyer Rd	0.2	0.1	0.0	0.8	0.6	0.1	2.9	2.1	1.3
R30	Rossmore residential	0.4	0.3	0.1	3.1	2.3	0.3	5.2	3.8	1.5
R31	Mt Vernon residential	0.8	0.6	0.1	0.8	0.6	0.2	2.9	2.1	1.4

5.2.2.5 Sulfur dioxide

The predicted maximum 10-minute, 1-hour, 24-hour and annual average SO_2 concentrations at each of the residential receptors were added to the contributions from external roadways and adopted background concentrations and presented in **Table 5-8** (10-minute and 1-hour averaging periods) and **Table 5-9** (24-hour and annual averaging periods). At all receptors, for all averaging periods, the SO_2 concentrations are predicted to be well below the corresponding AEPR ambient objectives and NSW EPA impact assessment criteria.

Table 5-8: Predicted incremental and cumulative maximum 10-minute and 1-hour SO_2 concentrations during Stage 1 development

		Airport (µg/m³)		Airport + external roads (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
Receptor	**Receptor description**	**10-minute**	**1-hour**	**10-minute**	**1-hour**	**10-minute**	**1-hour**
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*700*	*570*
R1	Bringelly	28	19	29	19	109	53
R2	Luddenham	18	12	25	16	105	50
R3	Greendale, Greendale Road	63	42	83	55	163	89
R4	Kemps Creek	24	16	54	36	134	70
R6	Mulgoa	122	81	52	34	132	68
R7	Wallacia	66	44	32	21	112	55
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	64	42	64	43	144	77
R14	Lawson Road, Badgerys Creek	85	56	122	81	202	115
R15	Mersey Rd, Greendale	49	32	66	44	146	78
R17	Luddenham Road	133	88	54	35	134	69
R18	Cnr Adams & Elizabeth Drive	39	26	36	24	116	58
R19	Cnr Adams & Anton Road	102	67	102	68	182	102
R21	Cnr Willowdene Ave and Vicar Park Lane	51	34	86	57	166	91
R22	Rossmore, Victor Ave	25	16	49	32	129	66
R23	Wallacia, Greendale Rd	83	55	43	29	123	63
R24	Badgerys Creek 1 NE	87	57	133	88	213	122
R25	Badgerys Creek 2 SW	84	56	40	27	120	61
R27	Greendale, Dwyer Rd	16	11	16	11	96	45
R30	Rossmore residential	24	16	29	19	109	53
R31	Mt Vernon residential	90	59	90	59	170	93

Table 5-9: Predicted incremental and cumulative maximum 24-hour and annual average SO_2 concentrations during Stage 1 development

		Airport (µg/m³)		Airport + external roads (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
Receptor	Receptor description	24-hour	Annual	24-hour	Annual	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*228*	*60*
R1	Bringelly	1.8	0.1	2.0	0.1	11.9	1.3
R2	Luddenham	1.4	0.2	1.4	0.2	11.3	1.4
R3	Greendale, Greendale Road	4.6	0.2	4.6	0.2	14.5	1.4
R4	Kemps Creek	2.2	0.1	2.3	0.1	12.2	1.3
R6	Mulgoa	2.4	0.1	2.4	0.1	12.3	1.3
R7	Wallacia	1.5	0.1	1.5	0.1	11.4	1.3
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	2.2	0.2	2.2	0.2	12.1	1.4
R14	Lawson Road, Badgerys Creek	4.6	0.3	4.8	0.3	14.7	1.5
R15	Mersey Rd, Greendale	3.9	0.3	3.9	0.3	13.8	1.5
R17	Luddenham Road	2.7	0.2	2.8	0.2	12.7	1.4
R18	Cnr Adams & Elizabeth Drive	2.5	0.6	2.5	0.6	12.4	1.8
R19	Cnr Adams & Anton Road	4.4	0.8	4.4	0.8	14.3	2.0
R21	Cnr Willowdene Ave and Vicar Park Lane	3.8	0.2	3.8	0.2	13.7	1.4
R22	Rossmore, Victor Ave	2.4	0.1	2.5	0.1	12.4	1.3
R23	Wallacia, Greendale Rd	2.8	0.1	2.9	0.1	12.8	1.3
R24	Badgerys Creek 1 NE	7.4	0.7	7.4	0.7	17.3	1.9
R25	Badgerys Creek 2 SW	2.2	0.1	2.3	0.2	12.2	1.4
R27	Greendale, Dwyer Rd	0.6	0.1	0.7	0.1	10.6	1.3
R30	Rossmore residential	1.7	0.1	1.9	0.1	11.8	1.3
R31	Mt Vernon residential	4.2	0.1	4.3	0.2	14.2	1.4

5.2.2.6 Air toxics

The predicted concentrations of the four air toxics evaluated within the assessment are shown in **Table** 5-10 for the 99.9th percentile, **Table 5-11** for the 24-hour averaging period and **Table 5-12** for the annual averaging period**.** The 99.9th percentile results have been assessed against the NSW impact assessment criteria, which is evaluated as increment only (i.e. does not incorporate existing background concentrations). All predicted concentrations were below the relevant criteria.

The 99.9th percentile 1-hour average results demonstrate compliance with the NSW EPA impact assessment criteria, with the exception of formaldehyde with exceedance shown at the on-site receptor R24.

The 24-hour and annual average concentrations of benzene, toluene and xylenes were predicted to be orders of magnitude lower than the NEPM investigation levels. The concentration of formaldehyde was less than 18% of the investigation level.

Table 5-10: Predicted incremental 99.9th percentile 1-hour average air toxic concentrations during Stage 1 development

		Airport (µg/m³)				Airport + external roads (µg/m³)			
Rec. ID	**Receptor description**	**Benzene**	**Toluene**	**Xylene**	**Formaldehyde**	**Benzene**	**Toluene**	**Xylene**	**Formaldehyde**
NSW impact assessment criterion		*29*	*360*	*180*	*20*	*29*	*360*	*180*	*20*
R1	Bringelly	0.1	<0.1	<0.1	0.7	1.5	0.6	0.4	11.1
R2	Luddenham	0.2	0.1	0.1	1.5	1.3	0.5	0.3	9.2
R3	Greendale, Greendale Road	0.2	0.1	<0.1	1.2	1.0	0.4	0.3	7.4
R4	Kemps Creek	0.1	<0.1	<0.1	0.9	1.3	0.5	0.4	9.8
R6	Mulgoa	0.1	<0.1	<0.1	0.7	0.7	0.3	0.2	5.3
R7	Wallacia	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.2
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.1	<0.1	<0.1	0.8	0.9	0.3	0.2	6.3
R14	Lawson Road, Badgerys Creek	0.3	0.1	0.1	2.2	1.5	0.6	0.4	10.7
R15	Mersey Rd, Greendale	0.3	0.1	0.1	1.8	1.4	0.5	0.4	10.5
R17	Luddenham Road	0.1	0.1	<0.1	1.0	0.9	0.3	0.2	6.6
R18	Cnr Adams & Elizabeth Drive	0.2	0.1	<0.1	1.4	1.4	0.5	0.4	10.0
R19	Cnr Adams & Anton Road	0.4	0.1	0.1	2.6	2.1	0.8	0.6	15.6
R21	Cnr Willowdene Ave and Vicar Park Lane	0.2	0.1	0.1	1.5	1.3	0.5	0.4	9.7
R22	Rossmore, Victor Ave	0.2	0.1	<0.1	1.1	0.9	0.4	0.2	6.8
R23	Wallacia, Greendale Rd	0.1	<0.1	<0.1	0.9	0.6	0.2	0.2	4.3
R24	Badgerys Creek 1 NE	0.6	0.2	0.2	4.2	3.2	1.2	0.8	**23.2**
R25	Badgerys Creek 2 SW	0.3	0.1	0.1	2.0	2.6	1.0	0.7	18.8
R27	Greendale, Dwyer Rd	0.1	0.1	<0.1	1.0	1.1	0.4	0.3	7.9
R30	Rossmore residential	0.1	<0.1	<0.1	0.5	1.5	0.6	0.4	11.1
R31	Mt Vernon residential	0.2	0.1	0.1	1.4	1.1	0.4	0.3	8.3

Table 5-11: Predicted incremental and cumulative 24-hour average air toxic concentrations during Stage 1 development

Receptor ID	Receptor description	Airport (µg/m³)			Airport + external roads (µg/m³)			Cumulative – airport + external roads + existing background (µg/m³)		
		Toluene	Xylene	Formaldehyde	Toluene	Xylene	Formaldehyde	Toluene	Xylene	Formaldehyde
NEPM investigation level		*4,160*	*1,170*	*53*	*4,160*	*1,170*	*53*	*4,160*	*1,170*	*53*
R1	Bringelly	<0.1	<0.1	0.9	0.1	0.1	2.2	15.4	16.7	6.5
R2	Luddenham	0.1	0.1	1.6	0.1	0.1	1.5	15.4	16.7	5.8
R3	Greendale, Greendale Road	0.1	0.1	1.5	0.1	0.1	1.5	15.4	16.7	5.8
R4	Kemps Creek	0.1	<0.1	1.1	0.1	0.1	1.7	15.4	16.7	6.0
R6	Mulgoa	<0.1	<0.1	0.8	0.0	0.0	0.9	15.3	16.6	5.2
R7	Wallacia	<0.1	<0.1	0.8	0.0	0.0	0.9	15.3	16.6	5.2
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<0.1	<0.1	0.8	0.1	0.0	1.1	15.4	16.6	5.4
R14	Lawson Road, Badgerys Creek	0.1	0.1	2.4	0.1	0.1	2.6	15.4	16.7	6.9
R15	Mersey Rd, Greendale	0.1	0.1	2.0	0.1	0.1	1.7	15.4	16.7	6.0
R17	Luddenham Road	0.1	<0.1	1.1	0.1	0.0	1.1	15.4	16.6	5.4
R18	Cnr Adams & Elizabeth Drive	0.1	0.1	1.5	0.1	0.0	1.3	15.4	16.6	5.6
R19	Cnr Adams & Anton Road	0.1	0.1	2.7	0.2	0.1	3.0	15.5	16.7	7.3
R21	Cnr Willowdene Ave and Vicar Park Lane	0.1	0.1	1.7	0.1	0.1	1.4	15.4	16.7	5.7
R22	Rossmore, Victor Ave	0.1	<0.1	1.2	0.1	0.0	1.3	15.4	16.6	5.6
R23	Wallacia, Greendale Rd	0.1	<0.1	1.1	0.1	0.0	1.1	15.4	16.6	5.4
R24	Badgerys Creek 1 NE	0.2	0.2	4.6	0.3	0.2	4.9	15.6	16.8	9.2
R25	Badgerys Creek 2 SW	0.1	0.1	2.1	0.3	0.2	5.0	15.6	16.8	9.3
R27	Greendale, Dwyer Rd	0.1	<0.1	1.0	0.1	0.0	1.3	15.4	16.6	5.6
R30	Rossmore residential	<0.1	<0.1	0.5	0.1	0.1	1.9	15.4	16.7	6.2
R31	Mt Vernon residential	0.1	0.1	1.4	0.1	0.1	1.5	15.4	16.7	5.8

Table 5-12: Predicted incremental and cumulative annual average air toxic concentrations during Stage 1 development

Receptor ID	Receptor description	Airport (µg/m³)			Airport + external roads (µg/m³)			Cumulative – airport + external roads + existing background (µg/m³)		
		Benzene	Toluene	Xylene	Benzene	Toluene	Xylene	Benzene	Toluene	Xylene
NEPM investigation level		*10*	*406*	*935*	*10*	*406*	*935*	*10*	*406*	*935*
R1	Bringelly	0.01	<0.01	<0.01	0.05	0.02	0.01	1.1	3.7	2.4
R2	Luddenham	0.02	0.01	0.01	0.03	0.01	0.01	1.0	3.7	2.4
R3	Greendale, Greendale Road	0.01	<0.01	<0.01	0.02	0.01	<0.01	1.0	3.7	2.4
R4	Kemps Creek	0.01	<0.01	<0.01	0.04	0.02	0.01	1.0	3.7	2.4
R6	Mulgoa	0.01	<0.01	<0.01	0.02	0.01	<0.01	1.0	3.7	2.4
R7	Wallacia	0.01	<0.01	<0.01	0.01	0.01	<0.01	1.0	3.7	2.4
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.01	0.01	<0.01	0.04	0.01	0.01	1.0	3.7	2.4
R14	Lawson Road, Badgerys Creek	0.02	0.01	<0.01	0.05	0.02	0.01	1.1	3.7	2.4
R15	Mersey Rd, Greendale	0.01	0.01	<0.01	0.03	0.01	0.01	1.0	3.7	2.4
R17	Luddenham Road	0.01	0.01	<0.01	0.04	0.01	0.01	1.0	3.7	2.4
R18	Cnr Adams & Elizabeth Drive	0.03	0.01	0.01	0.06	0.02	0.01	1.1	3.7	2.4
R19	Cnr Adams & Anton Road	0.04	0.02	0.01	0.07	0.02	0.02	1.1	3.7	2.4
R21	Cnr Willowdene Ave and Vicar Park Lane	0.01	<0.01	<0.01	0.03	0.01	0.01	1.0	3.7	2.4
R22	Rossmore, Victor Ave	0.01	<0.01	<0.01	0.03	0.01	0.01	1.0	3.7	2.4
R23	Wallacia, Greendale Rd	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	1.0	3.7	2.4
R24	Badgerys Creek 1 NE	0.06	0.02	0.02	0.12	0.05	0.03	1.1	3.7	2.4
R25	Badgerys Creek 2 SW	0.02	0.01	<0.01	0.11	0.04	0.03	1.1	3.7	2.4
R27	Greendale, Dwyer Rd	0.01	<0.01	<0.01	0.02	0.01	<0.01	1.0	3.7	2.4
R30	Rossmore residential	<0.01	<0.01	<0.01	0.06	0.02	0.01	1.1	3.7	2.4
R31	Mt Vernon residential	0.01	<0.01	<0.01	0.03	0.01	0.01	1.0	3.7	2.4

5.2.2.7 Odour

5.2.2.7.1 Aircraft exhaust

The 99th percentile 1-second (nose response) predictions for emissions from aircraft exhaust during the Stage 1 development are presented in **Table 5-13**. Due to significant uncertainties in future emission inventories, the predicted odour concentrations for the long-term development have not been assessed.

The odour concentrations for Stage 1 are predicted to be below the threshold detection level of 1 OU at all residential receptors. At R24, the predicted odour concentration is 1 OU, indicating when a receptor (i.e. a person) is located in this area, they may on occasion detect odour from aircraft exhausts. This is, however, less than the NSW EPA odour performance criterion of 2 OU.

Table 5-13: Predicted 99th percentile odour concentrations from aircraft exhaust

Receptor ID	Receptor description	OU, 1-second nose-response, 99th percentile
Criterion		*2*
R1	Bringelly	<1
R2	Luddenham	<1
R3	Greendale, Greendale Road	<1
R4	Kemps Creek	<1
R6	Mulgoa	<1
R7	Wallacia	<1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<1
R14	Lawson Road, Badgerys Creek	<1
R15	Mersey Rd, Greendale	<1
R17	Luddenham Road	<1
R18	Cnr Adams & Elizabeth Drive	1
R19	Cnr Adams & Anton Road	1
R21	Cnr Willowdene Ave and Vicar Park Lane	<1
R22	Rossmore, Victor Ave	<1
R23	Wallacia, Greendale Rd	<1
R24	Badgerys Creek 1 NE	1
R25	Badgerys Creek 2 SW	<1
R27	Greendale, Dwyer Rd	<1
R30	Rossmore residential	<1
R31	Mt Vernon residential	<1

5.2.2.7.2 Waste water treatment plant

The 99th percentile 1-second (nose-response) odour predictions for emissions from the on-site WWTP are presented in **Table 5-14**. The predicted odour concentrations for the long-term development have not been assessed, as this is anticipated to be beyond the design lifetime of the proposed WWTP.

The odour concentrations for Stage 1 are predicted to be below the threshold detection level of 1 OU at all residential receptors.

The spatial extent of the odour contours (see **Appendix G**) indicates that the highest odour concentrations would be largely limited to within the airport site.

Table 5-14: Predicted 99th percentile odour concentrations from WWTP

Receptor ID	Receptor description	OU, 1-second nose-response, 99th percentile
Criterion		*2*
R1	Bringelly	<1
R2	Luddenham	<1
R3	Greendale, Greendale Road	<1
R4	Kemps Creek	<1
R6	Mulgoa	<1
R7	Wallacia	<1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<1
R14	Lawson Road, Badgerys Creek	<1
R15	Mersey Rd, Greendale	<1
R17	Luddenham Road	<1
R18	Cnr Adams & Elizabeth Drive	<1
R19	Cnr Adams & Anton Road	<1
R21	Cnr Willowdene Ave and Vicar Park Lane	<1
R22	Rossmore, Victor Ave	<1
R23	Wallacia, Greendale Rd	<1
R24	Badgerys Creek 1 NE	<1
R25	Badgerys Creek 2 SW	<1
R27	Greendale, Dwyer Rd	<1
R30	Rossmore residential	<1
R31	Mt Vernon residential	<1

5.2.3 Long term development

Given the uncertainty regarding the future reduction in vehicular and aircraft engine emissions and the anticipated general reduction in background emissions over time, for the long-term development, ground level concentration predictions were assessed only for the key criteria pollutants comprising NO_2, PM_{10}, and $PM_{2.5}$.

5.2.3.1 Oxides of nitrogen

The dispersion modelling results for maximum 1-hour and annual average NO_2 are presented in **Table 5-15.** Exceedances are shown in bold. As discussed in **Section 3.4.1**, the OLM Level 2 method has been applied for the prediction of NO_2 concentrations surrounding the airport site. This takes account of the hourly 1-hour and annual NO_2 and O_3 monitoring data combined with the hourly predicted NO_x concentration at each sensitive receptor location for each of the respective averaging periods.

The results of the dispersion modelling demonstrate compliance with the NSW EPA criterion of 62 µg/m³ at all residential receptors for annual average NO_2 concentrations when considering the airport in isolation (incremental) and combined with the external roadways and background sources (cumulative). The increase in the predicted GLCs for NO_2 from the external roadways is between 1% and 15%.

The results of the dispersion modelling for the airport increment indicate that exceedances of the 1-hour average AEPR objective of 320 µg/m³ may be experienced at six of the 20 selected residential and at one on-site receptor. Cumulatively, there are seven residential receptors and one on-site receptor. These elevated concentrations are predicted to occur for between 1 and 2 hours per year. The maximum 1-hour NO_2 concentration is predicted to occur at receptor R14, located to the northwest of the airport site (see **Figure 3-2**). The exceedances of the 1-hour average NSW assessment criterion of 246 µg/m³ may be experienced at 10 of the 20 selected residential and at one on-site receptor.

Table 5-15: Predicted cumulative NO_2 concentrations during long-term development

		Airport increment (µg/m³)			Cumulative - airport + external roads + existing background (µg/m³)		
Receptor ID	Receptor description	1-hour		Annual	1-hour		Annual
Criterion		*320*	*Number of hours > 320*	*62*	*320*	*Number of hours > 320*	*62*
R1	Bringelly	237	0	17	243	0	23
R2	Luddenham	111	0	22	119	0	28
R3	Greendale, Greendale Road	**347**	1	22	**367**	1	24
R4	Kemps Creek	223	0	17	234	0	26
R6	Mulgoa	188	0	18	205	0	19
R7	Wallacia	241	0	17	247	0	18
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	155	0	21	178	0	27
R14	Lawson Road, Badgerys Creek	**517**	1	34	**538**	1	43
R15	Mersey Rd, Greendale	**343**	2	31	**350**	2	34
R17	Luddenham Road	310	0	22	312	0	27
R18	Cnr Adams & Elizabeth Drive	229	0	38	231	0	49
R19	Cnr Adams & Anton Road	211	0	47	212	0	51
R21	Cnr Willowdene Ave and Vicar Park Lane	**408**	1	24	**440**	1	30
R22	Rossmore, Victor Ave	242	0	18	253	0	23
R23	Wallacia, Greendale Rd	**342**	1	15	**347**	1	17
R24	Badgerys Creek 1 NE	**335**	1	55	**365**	2	52
R25	Badgerys Creek 2 SW	281	0	23	284	0	26
R27	Greendale, Dwyer Rd	116	0	14	118	0	16
R30	Rossmore residential	312	0	14	**326**	1	20
R31	Mt Vernon residential	**345**	1	22	**349**	1	27

5.2.3.2 Particulate matter (PM_{10})

Table 5-16 presents a summary of the maximum 24-hour average and annual average PM_{10} concentrations from the airport in isolation (incremental) and combined with the external roadways and background sources (cumulative). Exceedances are shown in bold. There are no AEPR ambient objectives for PM_{10}.

The results show that the predicted PM_{10} concentrations during the long-term development are anticipated to be below the NEPM-AAQ 24-hour standard of 50 µg/m³ at all receptors.

The predicted annual average PM_{10} concentrations also demonstrate compliance the current NEPM-AAQ annual standard of 25 µg/m³ at all receptors.

Table 5-16: Predicted incremental and cumulative PM_{10} concentrations during long-term development

		Airport (µg/m³)		Airport + external roads (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
Receptor ID	Receptor description	24-hour	Annual	24-hour	Annual	24-hour	Annual
Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R1	Bringelly	3.7	0.1	5.6	1.3	46	18
R2	Luddenham	1.7	0.3	6.0	1.4	45	18
R3	Greendale, Greendale Road	5.7	0.3	7.4	0.6	43	18
R4	Kemps Creek	2.6	0.2	8.8	1.6	46	19
R6	Mulgoa	1.8	0.1	3.5	0.4	43	17
R7	Wallacia	1.3	0.1	3.1	0.4	43	17
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	2.2	0.2	4.4	1.1	44	18
R14	Lawson Road, Badgerys Creek	9.6	0.7	13.6	2.4	46	19
R15	Mersey Rd, Greendale	6.1	0.5	11.7	1.3	46	18
R17	Luddenham Road	3.4	0.2	5.5	1.3	45	18
R18	Cnr Adams & Elizabeth Drive	5.3	0.6	11.2	2.8	46	20
R19	Cnr Adams & Anton Road	5.3	0.8	9.0	1.6	45	19
R21	Cnr Willowdene Ave and Vicar Park Lane	5.9	0.3	7.6	1.4	44	18
R22	Rossmore, Victor Ave	4.1	0.2	8.0	1.2	45	18
R23	Wallacia, Greendale Rd	2.3	0.1	3.8	0.4	43	17
R24	Badgerys Creek 1 NE	31.6	8.9	18.2	3.8	46	21
R25	Badgerys Creek 2 SW	3.6	0.5	4.9	1.1	44	18
R27	Greendale, Dwyer Rd	1.4	0.1	3.0	0.5	43	17
R30	Rossmore residential	1.7	0.1	4.8	1.3	45	18
R31	Mt Vernon residential	4.2	0.2	6.4	1.0	44	18

5.2.3.3 Particulate matter ($PM_{2.5}$)

Table 5-17 presents a summary of the maximum 24-hour average and annual average $PM_{2.5}$ concentrations for the airport separately and in combination with background sources. Exceedances are shown in bold. The predicted $PM_{2.5}$ impacts at the community receptors are provided in **Appendix G**. There are no AEPR ambient objectives for $PM_{2.5}$.

The results show that the predicted $PM_{2.5}$ concentrations during the long-term development are anticipated to be below the NEPM-AAQ 24-hour standard of 25 µg/m³ at all receptors. The annual $PM_{2.5}$ concentrations are predicted to be above the current annual NEPM-AAQ standard at two residential receptors and one on-site receptor.

All receptors will exceed the annual NEPM-AAQ for 2025 of 7 µg/m³, as the background contribution is in excess of this value. Increment from the airport ranges between 0.1 µg/m³ and 0.8 µg/m³ for the residential receptors. There would need to be a region wide emission reduction program that would address the largest future emissions sources which is likely to be vehicle emissions in order to meet this goal.

The contour plots show the geographical pattern of dispersion across the local area (**Appendix G**). It can be seen that in addition to the airport, the contribution from airport traffic on external roadways plays a significant role in the ground level predictions.

Table 5-17: Predicted incremental and cumulative $PM_{2.5}$ concentrations during long-term development

Receptor ID	Receptor description	Airport (µg/m³)		Airport + external roads (µg/m³)		Cumulative – airport + external roads + existing background (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
NEPM standard		*n/a*	*n/a*	*n/a*	*n/a*	*25/20*	*8/7*
R1	Bringelly	2.4	0.1	3.5	0.8	16	8
R2	Luddenham	1.5	0.2	3.5	0.9	15	8
R3	Greendale, Greendale Road	4.3	0.2	5.4	0.4	14	7
R4	Kemps Creek	2.0	0.1	5.6	1.0	16	8
R6	Mulgoa	1.6	0.1	2.5	0.3	14	7
R7	Wallacia	1.1	0.1	1.8	0.3	14	7
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	1.6	0.2	2.9	0.7	14	8
R14	Lawson Road, Badgerys Creek	6.8	0.6	9.0	1.5	18	**9**
R15	Mersey Rd, Greendale	4.6	0.5	8.1	0.9	16	8
R17	Luddenham Road	2.8	0.2	4.0	0.8	15	8
R18	Cnr Adams & Elizabeth Drive	3.8	0.5	7.2	1.7	16	**9**
R19	Cnr Adams & Anton Road	4.0	0.6	6.1	1.1	15	8
R21	Cnr Willowdene Ave and Vicar Park Lane	4.0	0.2	5.2	0.9	15	8
R22	Rossmore, Victor Ave	2.9	0.2	5.1	0.8	15	8
R23	Wallacia, Greendale Rd	1.7	0.1	2.6	0.3	14	7
R24	Badgerys Creek 1 NE	18.6	5.3	11.8	2.4	19	**9**
R25	Badgerys Creek 2 SW	2.3	0.4	3.2	0.8	14	8
R27	Greendale, Dwyer Rd	1.1	0.1	1.8	0.3	14	7
R30	Rossmore residential	1.2	0.1	3.2	0.7	15	8
R31	Mt Vernon residential	2.9	0.2	4.6	0.6	14	8

5.3 Summary of dispersion model results

For both scenarios, the highest off-site concentrations of the air quality metrics evaluated were generally predicted to occur at the receptors located to the north and north-east of the proposed airport. This is a function of the prevalence of south-westerly winds and the close proximity of these receptors to activities at the proposed airport.

The impacts of the proposed airport have been assessed against the AEPR ambient objectives, the NSW EPA air quality criteria and the NEPM-AAQ standards. A summary of the predicted impacts is provided below.

Stage 1 development

- There were no predicted exceedances of the AEPR ambient objectives, NSW EPA criteria or current NEPM-AAQ standards at the residential or on-site receptors investigated.
- The predicted $PM_{2.5}$ concentrations demonstrate compliance with the future NEPM-AAQ 24-hour goal for 2025 of 20 µg/m^3. The future NEPM-AAQ annual $PM_{2.5}$ goal for 2025 of 7 µg/m^3 will be exceeded at all receptors as the background concentration adopted is already in excess of this value. The airport contribution to this value is relatively small compared to that of the external roadway emissions source.

Long term development

- NO_2
  - *Annual average*: There were no exceedances of the annual average NSW EPA criterion at any of the receptors.
  - *One-hour average*: There were six residential receptors that were, on occasion, predicted to exceed the one-hour AEPR ambient criterion (up to two times during the modelling year). At the most impacted residential receptor, the maximum predicted concentration was 168% of the AEPR ambient objective (320 µg/m^3) and 218% of the NSW EPA criterion (246 µg/m^3). One on-site receptor was also predicted to exceed the AEPR ambient objective one time per year.

PM_{10}

- *Annual average*: There were no exceedances of the current NEPM-AAQ standard of 25 µg/m^3 at all receptors.
- *24-hour average*: There were no exceedances of the current NEPM-AAQ standard of 50 µg/m^3 at all receptors.

$PM_{2.5}$

- *Annual average*: The current NEPM-AAQ standard of 8 µg/m^3 was predicted to be exceeded at one on-site receptor and two residential receptors. The NEPM-AAQ goal for 2025 of 7 µg/m^3 was exceeded at all the identified receptors as the background concentration is already in excess of this value. The airport contribution to this value is relatively small compared to that of the external roadway emissions source.
- *24-hour average*: There were no exceedances of the current 24-hour NEPM-AAQ standard of 25 µg/m^3. Compliance was also demonstrated the future NEPM-AAQ goal for 2025 of 20 µg/m^3.

Based on the outcomes of the dispersion modelling it is recommended that the mitigation and management measures implemented by the airport operator for the Stage 1 development should focus on emissions of NO_x and, to lesser extent, particulate matter, as some exceedances of ambient air quality criteria were predicted for NO_2 and $PM_{2.5}$. It is also recommended that in order to meet the future NEPM-AAQ annual goal for $PM_{2.5}$ the relevant government agencies focus on mitigation measures on a regional scale, in particular on vehicular emissions and other background contributors.

The air quality assessment contains a number of conservative assumptions. For example, in the long-term scenario, emissions were projected approximately 50 years into the future, with the assumption that there will be no improvement to current aircraft emissions. The emission factors used in the assessment are therefore likely to be conservative. It was also assumed that there would be no improvement in background air quality during this period. Based on the recent trends in background air quality in the study area (i.e. at the Bringelly site), and notably the decrease in NO_2 and PM_{10} concentrations, it is reasonable to assume that background air quality could improve further in the future. However, Western Sydney is a focus for the development of future residential and industrial areas, and it is possible that emissions from these developments may, to some extent, offset the potential improvements in background air quality.

5.4 Mitigation and management measures

The outcomes of the dispersion modelling indicate that the airport emissions during the Stage 1 development would not result in exceedances of any of the air quality metrics investigated as part of this assessment. However, the predicted impacts for the long-term development show that the emissions from the airport will have the potential to result in some adverse air quality impacts. On that basis, the recommended mitigation and management measures have been separated into those that can be addressed now and those that can be considered in the future if a decision is made to proceed with development of the proposed airport beyond Stage 1.

Notwithstanding, the future annual average NEPM-AAQ goal of 7 $\mu g/m^3$ has shown to be in exceedance at all receptors for both cumulative scenarios. This is attributed to the adopted background levels already meeting this goal. The dispersion modelling identified that the external roadway emissions would also be a significant contributor relative to the incremental contributions from the airport.

5.4.1 Stage 1 development

As no adverse air quality impacts were predicted for the Stage 1 development when evaluated against current air quality goals. Concentrations of $PM_{2.5}$ were shown to be a focus area for future management when the NEPM-AAQ goal is reduced from 8 $\mu g/m^3$ to 7 $\mu g/m^3$. Nevertheless, the following mitigation and management measures are recommended as part of best practice measures for the airport operators.

It is recommended that an air quality monitoring station is installed. Ideally, the monitoring station would be co-located with the BoM weather station to the north-west of the airport site. The recommended pollutants to be monitored include; Oxides of nitrogen (NO_x, NO and NO_2), CO, O_3, PM_{10}, $PM_{2.5}$ and VOCs. Such monitoring will enable WSA to:

- Provide a valuable benchmark for current (baseline) performance, in the event potential mitigation measures are adopted in the future;
- Evaluate the relative benefit of any future mitigation or control measures adopted through comparison with baseline data; and
- Demonstrate to the regulator and community that the issue is being addressed.

Adequate strategic planning will be of high importance to reduce future cumulative sources of $PM_{2.5}$ emissions in order to meet the future NEPM-AAQ annual goal. It is recommended that the relevant government agencies focus on mitigation measures on a regional scale, particularly on vehicular emissions and other background contributors.

It is also recommended that fixed system APU and GSE are integrated (where practical) into the airport design. A best practice measure for on-site emissions management is the implementation of mains powered APU and GSE at the airport gates, typically comprising 400 Hz electric power and preconditioned air (PCA) is supplied to the aircraft.

A summary of the proposed air quality management measures for the operation phase of the stage 1 development is provided in **Table 5-18**.

Table 5-18: Mitigation specific to air quality management during operation phase

	Mitigation measure	Timing
Management of air quality and odour		
1	Develop and implement an operational air quality and odour management plan to be included as part of the operational management plan for the proposed airport.	Operation
Monitoring		
2	Install an air quality monitoring station at the airport site to monitor NOx, NO, NO_2, CO, O_3, PM_{10}, $PM_{2.5}$ and VOCs.	Pre-construction baseline, operation
Emissions		
3	Consider best available techniques to reduce emissions of ozone precursors, which may include: • replacing conventionally fuelled ground support equipment with electric or hydrogen powered belt loaders, pushback tractors, bag tugs, and cargo loaders; • using remote ground power for remote aircraft parking positions; • installing co-generation or tri-generation in-lieu of traditional gas fired boilers or solar hot water systems to replace gas fired boilers; • avoiding (where practicable) certain activities, such as training fires, maintenance (spray painting) during the ozone seasons; • using underground fuel hydrant systems and/or vapour recovery systems for refuelling and fuel storage; and • promoting the use of public transport to the airport.	Operation

5.4.2 Long term development

The dispersion modelling identified that NO_x emissions contributed 91% of the emissions from the airport and therefore mitigation and management measures focus on reducing NO_x emissions. It is noted that NO_x emissions from GSE and APUs also play an important role, so the mitigation measure proposed for the Stage 1 development (i.e. installation of fixed system APU and GSE) should reduce NO_x emissions for the long-term development as well.

The identified particulate matter impacts were restricted to the long-term development and also to those receptors located on-site or in close proximity to major external roadways. These impacts were also a function of a high background concentration, as in the case of $PM_{2.5}$.

The following literature was assessed for mitigation and management measures detailing relevant methods of reducing NO_x emissions during operations at the airport:

- Proposals for mitigation of pollutant emissions from aircraft at Lisbon Airport **(Ribeiro et al., 2011)**
- Heathrow Air Quality Strategy 2011-2020 **(Heathrow Airport Holdings, 2011)**
- Guidance Manual: Airport Greenhouse Gas Emissions Management **(ACI, 2009)**
- Aircraft Engine Emission Reduction Programme Zurich Airport **(Unique, 2005)**
- San Diego County Regional Airport Authority Air Quality Management Plan **(C&S Companies, KB Environmental, & Synergy Consultants, Inc., 2009)**
- Air Quality Management – London City Airport **(Moorcoft, 2010)**
- Calgary Airport Parallel Runway Project Air Quality Report **(AECOM, 2010)**
- Aviation and the Environment: Strategic Framework Needed to Address the Challenged Posed by Aircraft Emissions **(GAO, 2003)**

Based on these documents, a number of mitigation measures are suggested for managing air quality impacts from the airport. A number of these measures have been adopted by other airports internationally and are summarised in **Table 5-19**.

It is acknowledged some of the measures listed below are up to the individual airline and out of the control of the terminal operator. Nevertheless, these measures are useful as a guideline for potential NO_x reduction.

Table 5-19: Emissions mitigation measures adopted at various international airports

	Mitigation measure	Comments	Recommendation
1	Pushback by taxi to/from runway **(Ribeiro et al., 2011; Unique, 2005)**.	Aircraft would be towed between stands and runway with the aircraft engine switched off.	*This measure should be implemented where practical.*
2	Use of an automatic system for aircraft taxiing **(Ribeiro et al., 2011; Unique, 2005)**.	This could involve a fixed rail on the ground where an automatic towbar is moved. The towbar would move the aircraft to and from the runway.	*This measure should be evaluated for practical application during detailed design.*
3	Improve sequencing of aircraft **(Unique, 2005).**	Improving sequencing of aircraft will reduce the need for aircraft to queue. This would reduce unnecessary time spent with the engine on. This can be performed by virtual queueing and Collaborative Decision Making **(ACI, 2009)**.	*Highly recommended.*
4	Use market-based measures to manage demand for on-site car parking	Encourage passengers to use public transport when travelling to and from the airport.	*Highly recommended.*
5	Investigate provision of dedicated public transport at an early stage of airport development.	Providing dedicated and high capacity public transport e.g. express buses or a train line will encourage the use of public transport for passengers and staff, thereby reducing emissions from individual vehicles. A dedicated rail line is part of the long-term development. For Stage 1, the airport will be served by dedicated bus transit facilities.	*Highly recommended.*
6	Adopt a NOx charge for aircraft **(Heathrow Airport Holdings, 2011)**.	Varying charges dependent upon aircraft and/or fuel type can provide incentives for airlines to use clean aircraft and adopt new aircraft technologies more quickly.	*NO_2 impacts are anticipated as part of the long-term development and should be considered as a future measure.*

	Mitigation measure	Comments	Recommendation
7	Where possible, buildings (including commercial) should be equipped with cool roofs. **(C&S Companies, KB Environmental, & Synergy Consultants, Inc., 2009).**	Cool roofs utilise materials that store less heat, thereby minimising energy requirements for cooling during warmer seasons. Cool pavements have been successfully used in extremely hot climates **(Santamouris et al, 2012)** such as Sydney during summertime. It should be noted however that in areas of high or turbulent winds (i.e. parts of the airport that may create wind-tunnels) cool pavements would not be practical.	*This measure is recommended where practical.*
8	Implement an air quality monitoring strategy **(Moorcoft, 2010)**.	Air pollutants should be monitored on-site with an air quality report prepared annually to examine trends in pollutant concentrations and identify any criterion exceedances.	*Highly recommended.*
9	Aircraft equipped with two engines taxi with only one engine or aircraft equipped with four engines taxi with only two engines **(Ribeiro et al., 2011; Unique, 2005; GAO, 2003)**.	The achievable taxi speed is the same when only half of the engines are used. This would reduce the amount of NO_x emissions when aircraft are on the ground. It is noted that for aircraft taking off more power will be needed for initial momentum.	*This measure is recommended where practical.*
10	Reduction of reverse thrust deployment when landing **(Unique, 2005; AECOM, 2010).**	Reverse thrust is used to help slow the aircraft after landing. Reducing the duration that this is applied can reduce emissions after landing.	*This measure is recommended where practical.*
11	APUs to be powered by mains electricity whenever possible	This will reduce air pollutant emissions, especially NO_2.	*Highly recommended.*
12	Active involvement with aircraft manufacturers and research bodies for improved emissions-related data **(Heathrow Airport Holdings, 2011)**.	Being involved with aircraft manufacturers and research bodies will improve understanding of aircraft emissions, and will assist in efforts to provide cleaner technologies.	*Encouraged to be undertaken by airport operator.*

6 FUEL JETTISONING

Contrary to public perception, fuel jettisoning (commonly referred to as fuel dumping) is extremely rare and generally only occurs during an emergency, as a safety precaution when a plane must land prematurely. Aircraft do not jettison fuel as a standard procedure when landing. At take-off, aircraft are heavier than they are at landing due to the unburned fuel that is to be burned during the flight. As aircraft can only safely land when the specified maximum landing weight is reached, prior to an emergency landing, weight must sometimes be removed from the plane during flight. This occurs in the form of an expulsion of fuel from the plane's wing tips, tail or fuselage **(Aerospaceweb, 2005).** Potential adverse effects from fuel jettisoning have been addressed with reference to the ***Air Navigation (Fuel Spillage) Regulations 1999*** **(Cth)** and the procedures for fuel jettisoning in Australia (Aeronautical Information Package (AIP) **(Air Services Australia, 2014).** The cause, frequency and volume of fuel jettisoned, as well as results from a prior scientific study on fuel dumping are outlined below.

Fuel jettisoning events are extremely rare worldwide. For example, All Nippon Airways (Japan's largest airline by revenues and passenger numbers in 2012) experienced only three cases of fuel jettisoning during 2013. All of these occurred off the east coast of Japan away from urban areas **(ANA Holdings, n.d)**. As fuel jettisoning is usually only a safety feature of long-range aircraft, most planes are forced to burn the fuel in their exhaust prior to landing by circling in the air as opposed to dumping unburnt fuel. In Australia, common aircraft such as the Airbus A320 and Boeing 737 are not even capable of fuel jettisoning. Instances of fuel jettisoning in Australian airspace, where there is mandatory reporting of fuel jettisoning, are also very rare with only 10 reported occurrences in 2014 from 698, 856 domestic air traffic movements and 31, 345 international movements **(GHD, 2015b)**. Worldwide it is estimated that up to 6,800 tonnes of fuel was released over oceans in the 1990s **(Aerospaceweb, 2005).** The significant cost of fuel means that fuel dumps only occur when necessary. It is in the airlines' best interest to conserve fuel and consider alternate options prior to fuel dumping.

There are specific protocols in place to regulate fuel jettisoning in Australian airspace in accordance with the ***Air Navigation (Fuel Spillage) Regulations 1999***. The Aeronautical Information Package (AIP) **(Air Services Australia, 2014)** indicates that where possible, the pilot should obtain authority from Air Traffic Control (ATC) before commencing a fuel jettison and receive instruction on where the fuel dump is to be performed. Fuel dumps are required to occur in clear air at an altitude above 6,000 ft. (approximately 1.8 km) above ground level, and in an area nominated by the ATC to ensure that all fuel is vaporised before reaching the ground. The AIP also requires that reasonable precautions must be taken to ensure the safety of persons and property in the air and on the ground.

Civilian aircraft generally use Jet-A1 grade fuel which contains up to approximately 20% by volume aromatic hydrocarbons (including benzene) and approximately 2% by volume of naphthalene's (including Polycyclic Aromatic Hydrocarbons) **(IARC, 1989)**. This aircraft fuel is a source of volatile organic compounds (VOCs) and carbon dioxide (CO_2) when unburnt fuel droplets are released. The jettisoning of this unburnt fuel may therefore have an impact on local air quality. This is particularly significant for pollutants with long residence times. For example, VOCs such as benzene can occur in a predominantly vapour phase with a residence time of between 1 day and 2 weeks depending on climate and other pollutant concentrations **(Harrison et al, 2010)**. This may cause concern due to the known carcinogenic effect of benzene over long-term exposure **(Harrison et al, 2010)**. However, since fuel jettisoning is a very rare event and protocols are in place to ensure fuel-jettisons do not occur over sensitive areas, fuel jettisoning is not likely to have impacts on local air quality.

Investigations by **Clewell (1983)** indicate that fuel released at 1,500 metres elevation and at a ground temperature of 0 degrees Celsius, approximately 70 percent of fuel will evaporate prior to reaching the ground. This increases to around 95 percent at 20 degrees Celsius. While increasing the release altitude above 1,500 metres does not significantly decrease the fraction of fuel reaching the ground, it does allow considerably more time for atmospheric processes to disperse the fuel.

The findings indicate that that fuel jettisoning is very unlikely to have a significant impact at ground level due to the rarity of such events, the inability of many aircraft to perform fuel dumps, and the strict guidelines on fuel dumping altitudes and locations. In addition, in the very unlikely event that fuel is required to be jettisoned over land, research indicates that vaporisation and dispersion of fuel occurs rapidly.

Due to improvements in fuel efficiency and lightweight aircraft material, the amount of fuel jettisoned from aircraft under emergency situations has decreased substantially, with this trend anticipated to continue. As fuel efficiency, technology and airspace management continue to improve, volumes of fuel required to be carried on planes will steadily decline in the future. Major Australian airlines already have goals in place to implement these improvements. Qantas, for example, is currently aiming to improve its fuel efficiency by 1.5% per year until 2020 **(Department of Resources, Energy and Tourism, 2013)**. The Qantas Group Fuel Optimisation Program also has strategies in place to reduce travel distance and unnecessary aircraft weight. These strategies will help to reduce the volume of fuel carried by aircraft and reduce the amount of fuel jettisoned in event of an emergency.

Local effects of fuel jettisoning will be limited due to the inability of many aircraft to perform fuel jettisons, the rapid vaporisation and wide dispersion of jettisoned fuel, the strict regulations on fuel jettisoning altitudes and locations, and the anticipated reduction in fuel jettisoning events and volumes in the future. For these reasons, fuel jettisoning is not considered likely to have an immediate or future impact on local air quality.

7 CONSTRUCTION IMPACT ASSESSMENT

7.1 Dispersion modelling results

7.1.1 Overview

The concentrations of PM_{10}, $PM_{2.5}$, dust deposition and odour were determined for 18 residential receptors and 75 community receptors located in the local area (see **Section 3.2**). As the residential receptors are generally located in the similar areas as the community receptors, only the residential receptors have been discussed in the following results. Note that the two on-site receptors have not been considered in the construction assessment as the purpose of the on-site receptors was to evaluate the potential exposures of airport staff and passengers at the facility, noting that airport terminal staff are likely to have a much longer exposure. During construction these uses will not yet exist. The tabulated results for all receptors are provided in **Appendix G**.

Contour plots for each of the pollutants and relevant averaging periods are also provided in **Appendix G**. It should be noted that contour plots for maximum 24-hour average PM_{10} and $PM_{2.5}$ (with background contributions) could not be produced. This is because in determining the maximum 24 hour average PM_{10} and $PM_{2.5}$, daily contemporaneous background contributions were used.

7.1.2 Bulk earthworks

Table 7-1 summarises the maximum 24-hour average and annual average concentrations due to on-site construction activities. **Table 7-2** summarises the cumulative results including other sources/background predictions. The predicted dust impacts at the community receptors are provided in **Appendix G**.

Table 7-1: Predicted incremental PM and dust deposition results during bulk earthworks

		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Dust depos. (g/m²/month)
Receptor	Receptor description	24-hour	Annual	24-hour	Annual	Annual
Criterion		*50*	*30*	*25*	*8*	*2*
R1	Bringelly	1.0	0.1	0.4	<0.1	<0.1
R2	Luddenham	2.1	0.3	0.5	0.1	0.1
R3	Greendale, Greendale Road	2.7	0.1	1.4	0.1	<0.1
R4	Kemps Creek	1.3	0.1	0.8	<0.1	<0.1
R6	Mulgoa	0.4	0.1	0.2	<0.1	<0.1
R7	Wallacia	0.6	0.1	0.3	<0.1	<0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	2.0	0.3	0.7	0.1	<0.1
R14	Lawson Road, Badgerys Creek	4.8	0.6	2.0	0.2	0.1
R15	Mersey Rd, Greendale	3.3	0.4	1.2	0.1	0.1
R17	Luddenham Road	2.2	0.3	0.6	0.1	0.1
R18	Cnr Adams & Elizabeth Drive	6.5	1.0	1.8	0.2	0.2
R19	Cnr Adams & Anton Road	7.2	0.9	2.1	0.2	0.2
R21	Cnr Willowdene Ave and Vicar Park Lane	2.9	0.5	0.7	0.1	0.1
R22	Rossmore, Victor Ave	1.4	0.1	0.7	<0.1	<0.1
R23	Wallacia, Greendale Rd	0.8	0.1	0.3	<0.1	<0.1
R27	Greendale, Dwyer Rd	1.2	0.2	0.4	<0.1	<0.1
R30	Rossmore residential	0.7	0.1	0.3	<0.1	<0.1
R31	Mt Vernon residential	1.8	0.1	1.0	<0.1	<0.1

Table 7-2: Predicted cumulative PM and dust deposition results during bulk earthworks

Receptor	Receptor description	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Dust depos. (g/m²/ month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*50*	*30*	*25*	*8*	*4*
R1	Bringelly	43.0	17.1	13.5	7.0	2.0
R2	Luddenham	42.7	17.3	13.3	7.1	2.1
R3	Greendale, Greendale Road	42.7	17.1	13.3	7.1	2.0
R4	Kemps Creek	42.6	17.1	13.3	7.0	2.0
R6	Mulgoa	42.6	17.1	13.3	7.0	2.0
R7	Wallacia	42.6	17.1	13.3	7.0	2.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	43.4	17.3	13.5	7.1	2.0
R14	Lawson Road, Badgerys Creek	43.0	17.6	13.4	7.2	2.1
R15	Mersey Rd, Greendale	44.6	17.4	14.0	7.1	2.1
R17	Luddenham Road	44.2	17.3	13.7	7.1	2.1
R18	Cnr Adams & Elizabeth Drive	44.2	18.0	13.7	7.2	2.2
R19	Cnr Adams & Anton Road	43.9	17.9	13.6	7.2	2.2
R21	Cnr Willowdene Ave and Vicar Park Lane	42.9	17.5	13.4	7.1	2.1
R22	Rossmore, Victor Ave	42.7	17.1	13.3	7.0	2.0
R23	Wallacia, Greendale Rd	42.6	17.1	13.3	7.0	2.0
R27	Greendale, Dwyer Rd	43.0	17.2	13.4	7.0	3.1
R30	Rossmore residential	42.7	17.1	13.4	7.0	2.8
R31	Mt Vernon residential	42.6	17.1	13.3	7.0	2.0

The results show that the predicted dust impacts during the site establishment works are predicted to be below the NEPM AAQ standard and NSW impact assessment criteria for each of the reported air quality parameters.

The contour plots show the spatial extent of PM predicted concentrations across the local area. While the predicted concentrations remain low at all off-site residential receptors, the nature of the plume spread for the 24-hour and annual averaging periods is highest to the northeast and southwest of the airport site, consistent with the prevailing winds measured at Badgerys Creek AWS (**Section 4.1.1**).

7.1.3 Aviation infrastructure

Table 7-3 presents a summary of the maximum 24-hour average and annual average concentrations at each of the 20 residential receptors, due to the construction of aviation infrastructure and include PM emissions from the asphalt plant and concrete batching plant. **Table 7-4** summarises the results cumulatively with other sources/background predictions. The predicted dust impacts at the community receptors are provided in **Appendix G**.

The results show that the predicted dust impacts during the site establishment works are predicted to be below the NEPM AAQ standard and NSW impact assessment criteria for each of the reported air quality parameters.

The contour plots show a similar trend to that described for the bulk earthworks, with maximum off-site concentrations predicted to the northeast and southwest of the airport site.

Table 7-3: Predicted incremental results during construction of aviation infrastructure

Receptor	Receptor description	PM10 (µg/m³) 24-hour	PM10 (µg/m³) Annual	PM2.5 (µg/m³) 24-hour	PM2.5 (µg/m³) Annual	Dust depos. (g/m²/month) Annual
Criterion		*50*	*30*	*25*	*8*	*2*
R1	Bringelly	0.8	0.0	0.5	0.0	<0.1
R2	Luddenham	0.7	0.1	0.2	0.0	<0.1
R3	Greendale, Greendale Road	1.2	0.1	0.7	0.0	<0.1
R4	Kemps Creek	1.0	0.1	2.2	0.0	<0.1
R6	Mulgoa	0.4	0.0	0.3	0.0	<0.1
R7	Wallacia	0.3	0.0	0.2	0.0	<0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	1.7	0.1	0.8	0.0	<0.1
R14	Lawson Road, Badgerys Creek	7.6	0.4	4.9	0.2	0.1
R15	Mersey Rd, Greendale	2.8	0.1	1.2	0.1	<0.1
R17	Luddenham Road	1.7	0.1	1.0	0.0	<0.1
R18	Cnr Adams & Elizabeth Drive	3.6	0.3	2.1	0.1	0.1
R19	Cnr Adams & Anton Road	2.3	0.3	0.9	0.1	0.1
R21	Cnr Willowdene Ave and Vicar Park Lane	1.1	0.2	0.3	0.0	0.1
R22	Rossmore, Victor Ave	1.4	0.1	1.3	0.0	<0.1
R23	Wallacia, Greendale Rd	0.5	0.0	0.3	0.0	<0.1
R27	Greendale, Dwyer Rd	0.6	0.1	0.2	0.0	<0.1
R30	Rossmore residential	0.6	0.0	0.5	0.0	<0.1
R31	Mt Vernon residential	1.6	0.1	0.6	0.0	<0.1

Table 7-4: Predicted cumulative results during construction of aviation infrastructure

Receptor	Receptor description	PM10 (µg/m³) 24-hour	PM10 (µg/m³) Annual	PM2.5 (µg/m³) 24-hour	PM2.5 (µg/m³) Annual	Dust depos. (g/m²/month) Annual
Criterion		*50*	*30*	*25*	*8*	*4*
R1	Bringelly	42.6	17.0	13.8	7.0	2.0
R2	Luddenham	42.6	17.1	13.3	7.0	2.0
R3	Greendale, Greendale Road	42.6	17.1	13.3	7.0	2.0
R4	Kemps Creek	42.6	17.1	13.3	7.0	2.0
R6	Mulgoa	42.6	17.0	13.3	7.0	2.0
R7	Wallacia	42.6	17.0	13.3	7.0	2.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	43.2	17.1	14.1	7.0	2.0
R14	Lawson Road, Badgerys Creek	42.6	17.4	13.7	7.2	2.1
R15	Mersey Rd, Greendale	43.4	17.1	13.5	7.1	2.0
R17	Luddenham Road	42.7	17.1	13.4	7.0	2.0
R18	Cnr Adams & Elizabeth Drive	42.6	17.3	13.4	7.1	2.1
R19	Cnr Adams & Anton Road	42.6	17.3	13.4	7.1	2.1
R21	Cnr Willowdene Ave and Vicar Park Lane	42.6	17.2	13.3	7.0	2.1
R22	Rossmore, Victor Ave	42.6	17.1	13.3	7.0	2.0
R23	Wallacia, Greendale Rd	42.9	17.0	13.3	7.0	2.0
R27	Greendale, Dwyer Rd	43.1	17.1	13.4	7.0	2.0
R30	Rossmore residential	42.6	17.0	13.5	7.0	2.0
R31	Mt Vernon residential	42.6	17.1	13.3	7.0	2.0

7.1.4 Asphalt plant

The 99th percentile 1-second (nose response) odour predictions for emissions from the asphalt plant are presented in **Table 7-5**. The extent of plume spread (see **Appendix G**) indicates that the highest odour concentrations would be largely limited to within the airport site. The 2 OU contour (the adopted impact assessment criterion) does spread outside of the airport site a relatively short distance to the north of the site boundary, however this area is currently unoccupied and therefore not considered to result in adverse odour impacts.

Table 7-5: Predicted 99th percentile odour concentration from asphalt plant

Receptor	Receptor ID	OU, 1-second nose-response, 99th percentile
Criterion		*2*
R1	Bringelly	<0.1
R2	Luddenham	<0.1
R3	Greendale, Greendale Road	<0.1
R4	Kemps Creek	0.1
R6	Mulgoa	<0.1
R7	Wallacia	<0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.3
R14	Lawson Road, Badgerys Creek	1.7
R15	Mersey Rd, Greendale	0.1
R17	Luddenham Road	0.4
R18	Cnr Adams & Elizabeth Drive	0.5
R19	Cnr Adams & Anton Road	0.1
R21	Cnr Willowdene Ave and Vicar Park Lane	<0.1
R22	Rossmore, Victor Ave	0.2
R23	Wallacia, Greendale Rd	<0.1
R27	Greendale, Dwyer Rd	<0.1
R30	Rossmore residential	<0.1
R31	Mt Vernon residential	0.2

7.2 Mitigation and management

While a quantitative approach has been adopted for the assessment of the potential impacts of construction activities at nearby residences, a risk based approach has been used to identify risks and to recommend appropriate mitigation measures. The approach used is based on that described by the IAQM methodology.

In accordance with the IAQM methodology**,** the bulk earthworks and construction of aviation infrastructure are associated with a high level of risk for demolition, earthworks, and construction and vehicles traveling on unsealed surfaces and transporting materials onto the road network (track-out) components. The risk category definitions are provided in **Table 7-6.** Sensitive receptors, including those of ecological significance, were also identified as being located within 350 m of construction activities. On that basis, the overall outcome was taken to be 'high risk'.

The results are shown in **Table 7-7** to **Table 7-12**, which detail the issue, proposed mitigation measure and the applicable timing in the development process. Most of the recommended measures are routinely employed as 'good practice' on construction sites. At the airport site, particular attention should be paid to controlling dust generated by track-out due to the overall level of risk and the potential proximity to sensitive receptors.

A Dust Management Plan (DMP) should be developed to address the construction of the proposed airport. This document would form part of the overarching Air Quality Construction Environmental Management Plan (CEMP). This should contain details of the site-specific mitigation measures to be applied. Additional guidance on the control of dust at construction sites is provided as part of the NSW EPA Local Government Air Quality Toolkit[b]. Detailed guidance is also available from the UK **(GLA, 2006)** and the United States **(Countess Environmental, 2006)**.

Table 7-6: Risk category definition for each stage of construction (IAQM, 2014)

Type of activity	Site category definitions		
	Large	Medium	Small
Demolition	Building volume >50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities >20 m above ground level.	Building volume 20,000–50,000m^3, potentially dusty construction material, demolition activities 10-20 m above ground level.	Building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding, timber), demolition activities <10 m above ground and during wetter months.
Earthworks	Site area >10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), >10 heavy earth-moving vehicles active at any one time, formation of bunds>8 m in height, total material moved >100,000 tonnes.	Site area 2,500-10,000 m^2, moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4-8 m in height, total material moved 20,000-100,000 tonnes.	Site area <2,500 m^2, soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <20,000 tonnes, earthworks during wetter months.
Construction	Total building volume >100,000 m^3, piling, on site concrete batching; sandblasting	Building volume 25,000-100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching.	Total building volume <25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).
Track-out	>50 HDV (>3.5t) OUTWARD movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100 m.	10-50 HDV (>3.5t) OUTWARD movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50–100 m.	<10 HDV (>3.5t) OUTWARD movements in any one day, surface material with low potential for dust release, unpaved road length <50 m.

Table 7-7: Mitigation specific to communications / community engagement

	Mitigation measure	Action for site risk
1	Develop and implement a stakeholder communications plan that specifically addresses construction and includes community engagement before work commences on-site.	Highly recommended
2	Display the name and contact details of person(s) accountable for environmental management at the airport site boundary.	Highly recommended
3	Display the head or regional office contact information	Highly recommended

[b] http://www.epa.nsw.gov.au/air/lgaqt.htm

Table 7-8: Mitigation specific to dust management

	Mitigation measure	Action for site risk
4	Develop and implement a dust management plan, which may include measures to control other emissions. The dust management plan should include standard measures such as watering of exposed surfaces and covering of stockpiled material. The dust management plan may also include monitoring of dust deposition, dust flux, real time PM10 continuous monitoring and/or visual inspections.	Highly recommended
Site management		
5	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	Highly recommended
6	Make the complaints log available to the relevant authority when asked.	Highly recommended
7	Record in a log book any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation.	Highly recommended
Monitoring		
8	Carry out regular site inspections to monitor compliance with the dust management plan, record inspection results, and make an inspection log available to the relevant authority when asked.	Highly recommended
9	Increase the frequency of site inspections by the person accountable for air quality and dust issues on-site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.	Highly recommended
10	Determine dust deposition, dust flux, or real-time PM10 continuous monitoring locations in consultation with the relevant authorities. Where possible commence baseline monitoring at least three months before work commences on site or before work on a phase commences.	Highly recommended
Preparing and maintaining the site		
11	Avoid site runoff of water or mud. This will reduce the potential for track-out dust emissions.	Highly recommended
Operating vehicle/machinery and sustainable travel		
12	Ensure all vehicles switch off engines when not in use.	Highly recommended
13	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.	Highly recommended
14	Appropriate vehicle speeds on unsealed roads would be considered as part of the dust management plan.	Highly recommended
15	Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Highly recommended
16	Implement a Travel Plan that supports and encourages sustainable travel for construction workers (public transport, cycling, walking, and car-sharing)	Highly recommended
Operations		
17	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays.	Highly recommended
18	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Highly recommended
19	Use enclosed chutes and conveyors and covered skips.	Highly recommended

	Mitigation measure	Action for site risk
20	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Highly recommended
21	Ensure equipment is readily available on-site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.	Highly recommended

Table 7-9: Mitigation specific to demolition

	Mitigation measure	Action for site risk
22	Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).	Highly recommended
23	Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground.	Highly recommended
24	Avoid use of explosive blasting in demolition works, using appropriate manual or mechanical alternatives.	Highly recommended
25	Bag and remove any biological debris or damp down such material before demolition.	Highly recommended

Table 7-10: Mitigation specific to earthworks

	Mitigation measure	Action for site risk S5
26	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	Highly recommended
27	Use hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Highly recommended
28	Minimise exposed areas as far as is practical.	Highly recommended

Table 7-11: Mitigation specific to construction

	Mitigation measure	Action for site risk
29	Avoid scrabbling (roughening of concrete surfaces) if possible.	Highly recommended
30	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	Highly recommended
31	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	Highly recommended
32	For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Desirable

Table 7-12: Mitigation specific to track-out

	Mitigation measure	Action for site risk
33	Use water-assisted dust sweeper(s) on the access and local roads to remove, as necessary, any material tracked out of the site. This may require the sweeper to be continuously in use.	Highly recommended
34	Avoid dry sweeping of large areas.	Highly recommended
35	Vehicles should be covered to prevent escape of material during transport.	Highly recommended
36	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Highly recommended
37	Record all inspections of haul routes and any subsequent action in a site log book.	Highly recommended
38	Ensure hard surfaced haul routes are regularly cleaned and damped down with fixed or mobile sprinkler systems or mobile water bowsers.	Highly recommended
39	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	Highly recommended
40	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	Highly recommended
41	Ensure access gates are located at least 10 m from receptors where possible.	Highly recommended

7.3 Significance of risks

For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be 'not significant' **(IAQM, 2014)**.

However, even with a rigorous Dust Management Plan in place, it is not possible to guarantee that the dust mitigation measures will be effective all the time. There is the risk that the on-site office buildings - in addition to a small number of residential properties, community facilities and businesses in the immediate vicinity of the airport site - might experience some occasional dust soiling impacts. This does not imply that impacts are likely, or that if they did occur, that they would be frequent or persistent. Given the distances between the construction sites and the receptors, overall construction dust is unlikely to represent a serious ongoing problem. Any effects would be temporary and relatively short-lived, and would only arise during dry weather with the wind blowing towards a receptor, at a time when dust is being generated and mitigation measures are not being fully effective. The likely scale of this would not normally be considered sufficient to change the conclusion that with mitigation, the effects will be 'not significant'. Nevertheless, particular attention should be paid to controlling dust generated by track-out as these emission have the potential to be in closer proximity to sensitive receptors.

8 GREENHOUSE GAS ASSESSMENT

8.1 Introduction

Climate change is the result of anthropogenic (man-made) activities, primarily through the burning of fossil fuels, which is resulting in increased atmospheric concentrations of greenhouse gases and contributing to increased global temperatures. As global temperatures rise it leads to a number of effects such as the increased occurrence and severity of weather events such as storms, floods, bushfires and droughts, and leads to ocean warming and sea level rise. These effects have an impact on both humans and ecosystems.

According to the National Greenhouse Gas Inventory **(DIRD, 2014a)**, Australia's civil aviation (both domestic and international) contributed a total of 17.7 mega tonnes of carbon dioxide equivalent (Mt CO2-e) in 2011. This corresponds to approximately 3.1 per cent of Australia's total emissions in that year. Of Australia's total aviation emissions in 2011, 60 per cent as due to international aircraft and the remainder was due to domestic operations.

A GHG assessment has been completed which quantifies the GHG emissions (in tonnes of CO_2-equivalent (tCO_2-e)) for the construction phase and the scope 1, scope 2 and scope 3 emissions associated with the proposed airport operations.

8.2 Assessment results

8.2.1 Operations

8.2.1.1 Stage 1 emission estimates

Table 8-1 outlines the GHG emissions that are forecasted to occur from sources shown in **Section 3.7.1.1.1** and **3.7.1.1.2** during Stage 1 in 2030. It is clear in **Figure 8.1** that Scope 2 GHG emissions (primarily electricity use) account for the vast majority (83%) of GHG emissions, with Scope 1 GHG emissions accounting for only 17% of total Scope 1 and Scope 2 GHG emissions. Within Scope 1 emissions, **Figure 8.1** shows that the GHG emissions from the APUs are greatest (8%) with the 'Other' sources (5%) including the following:

- Fugitive emissions
- Fire training
- Use of generators, a waste water treatment plant, GSE (diesel) and boilers

Table 8-1: Stage 1 – Summary of Estimated Annual Scope 1 & 2 GHG Emissions

Scope	Source	Fuel Type	Annual Quantity	Units	Annual emissions (t CO_2-e)
1	Ground Support Equipment	Transport Diesel Oil	0.85	ML	2,292
		Transport Gasoline	2	ML	4,776
1	APU	Stationary Gasoline (Jet Fuel)	5	ML	10,975
1	Boilers	Stationary Natural Gas	1,489,809	m^3	3,005
1	Generators	Stationary Diesel Oil	0.04	ML	113
1	Fire Training	Stationary Kerosene (Jet Fuel)	0.01	ML	14
1	Waste Water Treatment Plant	N/A	1,935	ML	1,204
1	Fugitive Emissions	Transport Gasoline (Jet Fuel)	985	ML	104
1	Fugitive Emissions	Transport Diesel Oil	0.85	ML	0.1
1	Fugitive Emissions	Transport Gasoline	2	ML	0.2
2	Electricity	N/A	124,392,000	kWh	106,977
				TOTAL	**129,462**

Note: Fuel Type reflects the categories in **DoE (2014)b**
Note: Assumptions made within the GHG calculations are provided within **Appendix C**.
Note: Emissions factor was not available for jet fuel, emissions have been assumed to be the same as Avgas.

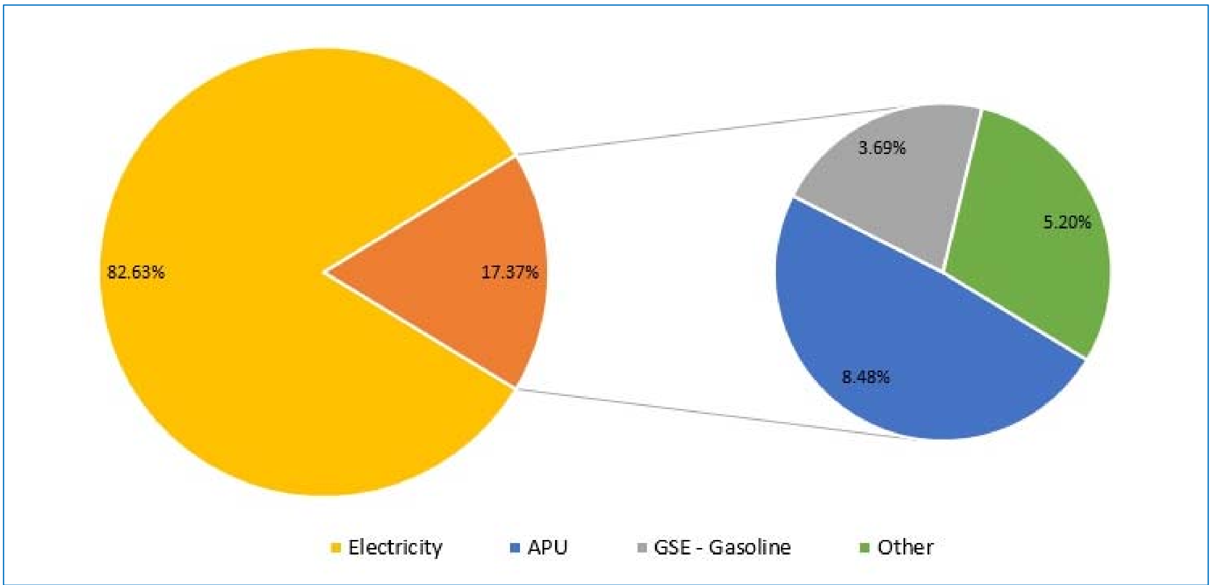


Figure 8.1: Percentage estimated Scope 1 & 2 GHG emissions from Stage 1 development

As mentioned in **Section 3.7.1.1.3**, it is not commonplace to report scope 3 emissions due to the potential of double counting GHG emissions between entities. Nevertheless, as they are considered significant for the airport, the most probable primary contributor, jet fuel, has been quantified in **Table 8-2**. It must be noted that this quantity involves only the emissions of departing planes. That is, due to limited information, this study only accounts for the GHG emissions being emitted during the whole flight of departing planes. This method assumes the arriving plane's emissions will be accounted for by the preceding airport. Furthermore, this method is common overseas and has been recommended by the Airport Cooperative Research Program (ACRP) **(ACRP 2009)**. In addition it assumes the anticipated demand (outlined in *Western Sydney Airport: Airport Land Use Master Plan Feasibility – Feasibility Design* (2015)) is equal to the actual demand of jet fuel from outgoing planes.

Table 8-2: Stage 1 – summary of estimated annual Scope 3 GHG emissions

Scope	Source	Fuel type	Annual quantity (ML)	Annual emissions (t CO_2-e)
3	In Flight Aviation Fuel	Transport Gasoline (Jet Fuel)	986	2,524,504

Notes: Emissions factor was not available for jet fuel, emissions have been assumed to be the same as Avgas.

8.2.1.2 Long-term development

Table 8-3 outlines the Scope 1 and Scope 2 GHG emissions that are estimated to occur from sources shown in **Section 3.7.1.1.1** and **Section 3.7.1.1.2** during the long-term development stage.

Figure 8.2 shows that Scope 2 GHG emissions are expected to account for the majority (80%) of Scope 1 and Scope 2 GHG emissions, with Scope 1 GHG emissions expected to comprise the remaining 20%. **Figure 8.2** shows that the GHG emissions from APU's are the largest Scope 1 source.

Table 8-3: Long-term development – summary of estimated annual Scope 1 & 2 GHG emissions

Scope	Source	Fuel Type	Annual Quantity	Units	Annual Emissions (t CO_2-e)
1	Ground Support Equipment	Transport Diesel Oil	6	ML	16,910
		Transport Gasoline	13	ML	30,728
1	APU	Stationary Gasoline (Jet Fuel)	33	ML	88,566
1	Boilers	Stationary Natural Gas	11,735,513	m^3	23,674
1	Generators	Stationary Diesel Oil	0.05	ML	143
1	Fire Training	Stationary Kerosene	0.03	ML	74
1	Waste Water Treatment Plant	N/A	9782	ML	6,092
1	Fugitive Emissions	Transport Gasoline (Jet Fuel)	8030	ML	846
1	Fugitive Emissions	Transport Diesel Oil	6	ML	0.7
1	Fugitive Emissions	Transport Gasoline	13	ML	1
2	Electricity	N/A	755,112,000	kWh	649,396
				TOTAL	**816,430**

Note: Fuel Type reflects the categories in **DoE (2014)b**
Note: Assumptions made within the GHG calculations are provided within **Appendix C**.
Note: Emissions factor was not available for jet fuel, emissions have been assumed to be the same as Avgas.

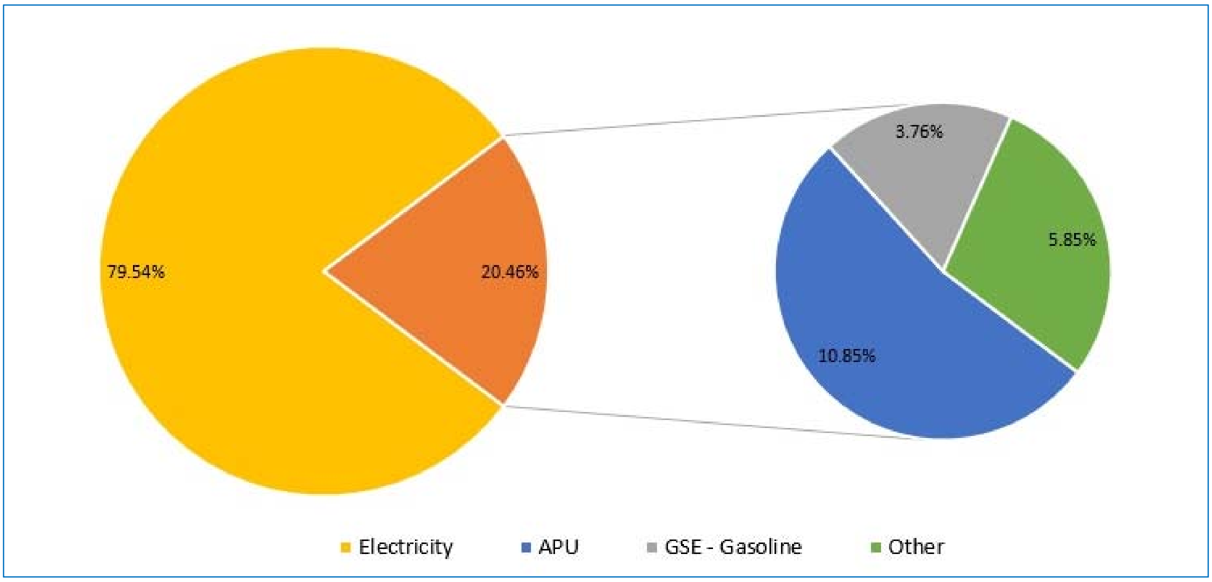


Figure 8.2: Percentage estimated Scope 1 & 2 GHG emissions from long-term development

The most probable primary contributor to Scope 3 emissions, jet fuel, has been quantified in **Table 8-2**.

Table 8-4: Long-term development stage – summary of estimated annual Scope 3 GHG emissions

Scope	Source	Fuel Type	Annual quantity	Units	Annual emissions (t CO_2-e)
3	In Flight Aviation Fuel	Transport Gasoline (Jet Fuel)	8,030	ML	20,570,033

8.2.2 Construction emissions

Table 8-5 outlines the GHG emissions from two primary sources during construction. In both cases, a conservative approach has been applied. When calculating the emissions from construction equipment, it was assumed the construction of aviation infrastructure used as much fuel as during bulk earthworks. Further, it was assumed that during the commissioning phase, no fuel was used from construction equipment. It was assumed during the construction period, equipment would be used for six working days a week and 6 days per month allocated for public holidays and bad weather where there would be no construction activity.

In addition, it was assumed that 50% of the vegetation cleared was carbon and 3.67 tonnes of CO_2-e is generated per tonne of carbon cleared **(AGO 1999, 2000, 2002 and 2003)**.

The quantity of to vegetation clearing during construction was revised to 73.5 kt, resultsing in an additional 63,308 t CO_2-e.

Table 8-5: Summary Table of GHG Emissions during Construction

Scope	Source	Fuel Type	Quantity	Units	Emissions (t CO_2-e)
1	Equipment	Transport Diesel Oil	162	ML	286,111
1	Vegetation Clearing	N/A	73.5	kt	134,873
				TOTAL	**420,983**

8.2.3 Context

Table 8-6 compares the airport's estimated Stage 1 GHG emissions to NSW's total anthropogenic emissions in 2011-12. It concludes that the airport will contribute to less than 0.09% of NSW total emissions for 2011-12.

Table 8-6: Comparison of greenhouse gas emissions

Location	Source coverage	Reference year	Emissions Mt CO_2-e
Western Sydney Airport Stage 1	Scope 1 and 2	2030	0.13
NSW	Total	2011-12	154.7

Source: **DoE (2014a)**.
Source: **CER (2015)**.

Table 8-7 summarises Australia's current and forecasted sectoral breakdown of GHG emissions. As aviation is considered a part of 'Transport' it can be concluded that the Stage 1 airport development would account for approximately 0.11% of the total 'Transport' GHG emissions throughout Australia.

Table 8-7: Australian sectoral breakdown of 2014-15 projection results to 2029-30

Sector	2013-14 Mt CO_2-e	2029-30 Mt CO_2-e
Electricity	180	224
Direct combustion	93	129
Transport	92	115
Fugitive emissions	41	68
Industrial processes	32	39
Agriculture	82	92
Waste	13	16
LULUCF	14	41
Total	548	724

Source: **DoE (2015a)**

8.3 Greenhouse gas and energy-reduction measures

Domestically and internationally, aviation is under pressure to address GHG emissions. With increasing energy costs, a focus on environmental policy and a growing public demand for protecting the environment, airports worldwide are implementing GHG emission reduction initiatives. The ICAO studies policy options to limit or reduce the environmental impact of aircraft engine emissions and to develop proposals and advice to the UNFCCC of whom's objective is to "stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" **(UN, 1992)**. Both organisations form a pivotal role in creating the underpinning framework that facilitates research into emission reduction procedures from groups such as Airports Council International **(ACI, 2009)** and the Airport Cooperative Research Program **(ACRP, 2014)**. The information below outlines examples of initiatives to reduce or offset direct and indirect GHG emissions from airport and aviation activities. It is noted that many of these measures are the same as those described earlier which would also reduce emissions and any lessening of local air quality conditions.

Table 8-8: Mitigation measures

Scope	Mitigation measure	Recommendation
1	Support alternatively fuelled and 'modernised' ground support equipment – including compressed natural gas, hydrogen, electric, compressed air and hybrid vehicles.	*This measure is recommended where practical.*
	Educate ground support equipment drivers in techniques to conserve fuel and implement a no-idling policy	*Highly recommended.*
	Design runways, taxiways, gates and terminals to minimise aircraft and ground support equipment travel distances where practical.	*Highly recommended.*
	Aircraft management procedures would consider the reduction of fuel use as far as practical.	*Highly recommended.*
	Reduce the use of auxiliary power units by using fixed electrical ground power and preconditioned air supply to aircraft where possible.	*This measure is recommended where practical.*
2	Specify high efficiency power, heating and cooling plants.	*Highly recommended.*
	Make use of renewable energy sources where practical for the generation, use or purchase of electricity, heating and cooling.	*Highly recommended.*
	Design energy efficient buildings to meet national / international benchmarking schemes (e.g. 5-star NABERS and Green Star ratings, Infrastructure Sustainability (IS) rating scheme, LEED or BREAM).	*Highly recommended.*
3	Consider the use of high speed, high capacity public transport to and from the proposed airport as part of the ground transport plan. Support the use of the low emission vehicles to and from the proposed airport, including the provision of recharging stations priority queuing and parking.	*Highly recommended.*
	Develop an integrated solid waste management plan to implement waste saving initiatives such as composting and recycling.	*Highly recommended.*
	Install tenant energy sub-metering systems.	*Highly recommended.*

9 SUMMARY AND CONCLUSIONS

Pacific Environment was engaged to prepare an Air Quality and Greenhouse Gas Assessment as part of an Environmental Impact Statement (EIS), required under *Environment Protection and Biodiversity Conservation Act 1999*.

The assessment quantified the potential local air quality impacts and GHG emissions that may arise during the construction and operation phases of the proposed airport. Both the Stage 1 development and long-term development were assessed. The assessment followed the procedures outlined in the NSW EPA's *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*.

The air quality assessment for the Draft EIS was completed in October 2015. The assessment was then updated to reflect revised traffic modelling for the airport and the publication of the new *National Environment Protection (Ambient Air Quality) Measure* (NEPM-AAQ) in February 2016..

9.1 Stage 1 operational impacts

For the proposed Stage 1 development the following pollutants were assessed: NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2, air toxics, odour from exhaust emissions and odour from the on-site waste water treatment plant.

With the exception of airport traffic on roadways external to the site, aircraft movements were by far the largest source of PM_{10}, $PM_{2.5}$, NO_X and SO_2 for both scenarios, with an associated contribution to the predicted concentrations at the receptors investigated. The operation of APUs and GSE would also have an influence on the predicted pollutant concentrations. Stationary sources, in particular evaporative losses from the Jet-A1 fuel tanks as well as aircraft, would be a significant contributor to VOC emissions and corresponding ground-level concentrations.

The highest off-site pollutant concentrations were generally predicted to occur at the receptors located to the north and north-east of the proposed airport. This was a function of the prevalence of south-westerly winds and the proximity of these receptors to activities at the proposed airport.

Airport traffic on surrounding road infrastructure was found to be a significant contributor to predicted off-site ground-level concentrations, particularly for those receptors close to proposed roadways.

There were almost no predicted exceedances of the current NSW EPA criteria or NEPM-AAQ standards at residential or on-site receptors for the proposed Stage 1 operations. The exception was the 99.9th percentile 1-hour maximum for formaldehyde, with an exceedance at the on-site receptor R24 when assessed against the NSW EPA assessment criterion.

The predicted 24-hour $PM_{2.5}$ concentrations demonstrate compliance with the future NEPM-AAQ goal for 2025 of 20 $\mu g/m^3$. For the annual average concentration of $PM_{2.5}$ the future NEPM-AAQ goal of 7 $\mu g/m^3$ in 2025 was exceeded at all receptors as the assumed background concentration was already 7 $\mu g/m^3$.

Predicted off-site odour concentrations were below odour detection limits for both aircraft exhaust emissions and odours from the on-site waste water treatment plant.

9.2 Long term operational impacts

No improvements in emission factors in the future could be incorporated into the model due to the lack of emission projections for the future aircraft fleet (nominal year 2063) or government policies which may act to reduce emissions in the future.

With the exception of roadways external to the airport site, aircraft movements were again predicted to be by far the largest source of PM_{10}, $PM_{2.5}$, NO_X and SO_2, with operation of APUs and GSE also having an influence on predicted off-site impacts. Stationary sources, in particular evaporative losses from the Jet-A1 fuel tanks as well as aircraft, were shown to be a significant contributor to VOC emissions and associated off-site impacts.

Given the uncertainties in the emission projections for the future aircraft fleet, combined with an expected improvement in aircraft emissions over time, the indicative long-term development was evaluated only for the most important air quality metrics (NO_2, PM_{10}, and $PM_{2.5}$).

The results of the dispersion modelling showed that, under the conservative assumptions adopted, the 1-hour average NO_2 ambient objective of 320 µg/m^3 in the AEPR was exceeded at six residential receptors. These exceedances were predicted to occur for between one and two hours per year.

Predicted (cumulative) 24-hour PM_{10} concentrations were predicted to be below the NEPM-AAQ 24-hour standard of 50 µg/m^3 at all on-site and residential receptors.

At one on-site receptor (R24) and two off-site receptors (R14 and R18), predicted (cumulative) $PM_{2.5}$ concentrations were above the NEPM-AAQ standard of 8 µg/m^3 for the annual averaging period.

The NEPM-AAQ goal of 7 µg/m^3 for 2025 was exceeded at all receptors as the assumed background concentration was already 7 µg/m^3. Should the decision be made to proceed with the long term development further $PM_{2.5}$ emission-reduction programs will need to be implemented to reduce overall motor vehicle and airplane emissions to meet this goal.

9.3 Air quality mitigation and management

The most important source of on-site emissions was aircraft taking off and landing, for both the proposed Stage 1 and the long-term development. However, the regulation of aircraft engine emissions would be beyond the remit of the operator of the proposed airport. Moreover, exceedances of air quality criteria (notably 1-hour NO_2 and 24-hour / annual $PM_{2.5}$) were predicted to occur due to activities in the vicinity of the airport gates as part of the long-term development. Mitigation of such activities may include the connection of APUs to mains power rather than the current assumption that they are operated by dedicated internal combustion engines.

Current community concern and associated regulatory pressure could be relieved through the provision of ambient air quality monitoring in the vicinity of the proposed airport. The implementation of such monitoring would provide scientifically robust data to demonstrate that any changes in local air quality associated with the airport development are within regulatory guidelines.

9.4 Construction impacts

Due to the transient, variable nature of construction activities, it is difficult to accurately quantify air quality impacts from the proposed construction activities. Any effects of the proposed construction on airborne particle concentrations would generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary mitigation measures are routinely employed on construction sites. However, in view of the length of the proposed construction period, a quantitative assessment of impacts was completed for the following:

- Bulk earthworks (particulate matter (PM) impacts only)
- Construction of aviation infrastructure
- Working crew (PM impacts)
- Concrete batching plant (PM impacts)
- Asphalt plant (odour impacts)

A risk-based approach has been used to identify key construction air quality risks and to recommend appropriate mitigation measures based on the methodology described by the IAQM methodology. Most of the recommended measures are routinely employed as 'good practice' on other construction sites.

A Dust Management Plan should be developed to address the construction of the proposed airport. This document would form part of the overarching Air Quality CEMP. At the airport site, particular attention should be paid to controlling PM generated by track-out due to the overall level of risk and the potential close proximity of potential track-out PM emissions to sensitive receptors.

9.5 Fuel jettisoning

Local effects of fuel jettisoning at the site would be limited due to the inability of many aircraft to perform fuel jettisons, the quick vaporisation and dispersion of aircraft fuel, the strict regulations on fuel jettisoning altitudes and locations, and the anticipated reduction in fuel jettisoning events and volumes in the future. For these reasons, fuel jettisoning is not considered likely to have an immediate or future impact on local air quality.

9.6 Greenhouse gases

An assessment was conducted of greenhouse gas emissions from the construction, Stage 1 and long-term development phases of the proposed airport. Direct (scope 1) and indirect (scope 2) emissions from the Stage 1 development of the airport were 0.13 Mt CO_2-e/annum, with the majority of emissions being associated with purchased electricity. The Stage 1 development Scope 1 & 2 emissions associated with the airport represented approximately 0.11% of Australia's projected 2030 transport-related greenhouse gas emission inventory. For this reason, it was concluded that greenhouse gas emissions from the airport were not material in terms of the national inventory. However, a number of mitigation measures were suggested to reduce emissions.

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Appendix A TERMS AND ABBREVIATIONS

Term	Description
μg/m^3	Micrograms per cubic metre
Air toxic	Air toxics include benzene, dioxins, lead and other metals. Major sources of these toxics include motor vehicle exhaust and some commercial and industrial processes.
Anthropogenic	Human sourced
AEPR	*Airports (Environment Protection) Regulations 1997* (Commonwealth)
APU	Auxiliary Power Unit
ATM	Aircraft traffic movement
AWS	Automatic Weather Station
BACT	Best available control technology
BMP	Best management practice
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CO	Carbon monoxide
Contemporaneous assessment	A method described in the *Approved Methods* whereby our daily model predictions are combined with the monitoring data for that matching day or hour in order to determine the cumulative impact.
Criteria pollutant	Air pollutants that have been regulated and are used as indicators of air quality.
DEC	NSW Department of Environment and Conservation (now Office of Environment and Heritage)
DECCW	NSW Department of the Environment Climate Change and Water (now Office of Environment and Heritage)
Deposited dust	Any particulate matter that falls out from suspension in the atmosphere. This measurement is expressed in units of mass per area per unit time (e.g. g/m^2/month).
DoEE	Australian Government Department of the Environment (now Department of the Environment and Energy)
EDMS	Emissions and Dispersion Modelling System
EIS	Environmental Impact Statement
EP&A Act	*NSW Environmental Planning and Assessment Act 1979* (NSW)
EPA	(NSW) Environment Protection Agency
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Fugitive emissions	Dust derived from a mixture of sources (non-point source) or not easily defined sources. Examples of fugitive dust include dust from vehicular traffic on unpaved roads, materials transport and handling, and un-vegetated soils and surfaces.
GMR	(Sydney) Greater Metropolitan Region
GSE	Ground support equipment
ha	Hectare
ICAO	International Civil Aviation Organisation – A specialised agency of the United Nations which codifies the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.
JUHI	Joint User Hydrant Installation
Km/h	Kilometres per hour
KSA	Kingsford Smith Airport

Term	Description
m	Metre
m^2	Square metres
mg/m^3	Milligrams per cubic metre
NEPC	National Environment Protection Council
NEPM	Broad framework-setting statutory instruments which outline agreed national objectives for protecting or managing particular aspects of the environment. NEPMs are similar to environmental protection policies and may consist of any combination of goals, standards, protocols, and guidelines.
NEPM-AAQ	National Environmental Protection (Ambient Air Quality) Measure
NHMRC	National Health and Medical Research Council
NMHC	Non-methane hydrocarbons
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NSW	New South Wales
Nuisance dust	Dust which reduces environmental amenity without necessarily resulting in material harm. Nuisance dust comprises particles with diameters nominally from about one millimetre to 50 micrometres (microns).
O_3	Ozone
$OU.m^3/s$	Odour unit - cubic metres (odour unit volumes) per second
OEH	Office of Environment and Heritage
OLM	Ozone Limiting Method
PAHs	Polycyclic aromatic hydrocarbons
Particulate	A complex mixture of extremely small particles and liquid droplets.
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.
POEO Act	*Protection of the Environment and Operations Act (1997)* (NSW)
POEO Regulations	*Protection of the Environment and Operations Regulations (2010)* (NSW)
ppm	Parts per million
Proposed airport	The proposed Western Sydney Airport which is subject to assessment.
SACL	Sydney Airport Corporation Limited
SO_2	Sulfur dioxide
SO_X	Oxides of sulfur
STP	Sewerage Treatment Plant
THC	Total hydrocarbons
TSP	Total suspended particulate
VOCs	Volatile organic compounds

Appendix B CRITERIA AIR POLLUTANTS: HEALTH EFFECTS AND SOURCES

B.1 CARBON MONOXIDE

B.1.1 Health effects

Carbon monoxide (CO) is a colourless, odourless gas. It can be harmful to humans because, when inhaled, it is taken up by haemoglobin in the blood (forming carboxyhaemoglobin) in preference to oxygen, thus reducing the capacity of the blood to transport oxygen. The affinity of CO for haemoglobin is more than 200 times greater than that of oxygen.

At low concentrations the symptoms of CO intoxication include lethargy in healthy adults, and chest pain in people with heart disease. At higher concentrations CO leads to impaired vision and coordination, headaches, dizziness, confusion and nausea. CO is fatal at very high concentrations[a].

Symptoms are not generally reported until the carboxyhaemoglobin level in the blood exceeds 10%. This is approximately the equilibrium value achieved with an ambient concentration of 70 mg/m^3 for a person engaged in light activity. There is evidence that there is a risk for individuals with cardiovascular disease at lower carboxyhaemoglobin levels. A carboxyhaemoglobin level in the blood of 40-50% usually leads to death. However, in most Australian towns and cities the levels of CO in ambient air are well below those that are hazardous to human health. Only in larger cities do CO levels have the potential to have harmful effects[b].

B.1.2 Other effects

CO plays a role in the formation of ground-level ozone through a series of reactions with the following net chemistry:

$$\mathbf{CO + 2O_2 + hv \rightarrow CO_2 + O_3}$$

where **hv** refers to a photon of light

CO also has an indirect radiative forcing effect by elevating concentrations of methane and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g. the hydroxyl radical, OH) that would otherwise destroy them.

B.2 NITROGEN DIOXIDE

B.2.1 Health effects

NO_2 is one of the most important aircraft pollutants. It is an irritant and oxidant which has been linked to a range of adverse health effects, including deterioration in lung function, respiratory symptoms, asthma prevalence and incidence, cancer incidence, and birth outcomes (*e.g.* birth weight). The most consistent associations, however, have been found with respiratory outcomes **(COMEAP, 2009)**. The evidence relating to the health effects of ambient NO_2 concentrations has strengthened in recent years, and some of the main findings are summarised below.

B.2.1.1 Short-term exposure to NO_2

In an extensive review of the health evidence, the **WHO Regional Office for Europe (2013)** noted that many studies have documented associations between day-to-day variations in NO_2 concentration and variations in respiratory symptoms, hospital admissions and mortality.

[a] http://www.epa.gov/iaq/co.html#Health_Effects
[b] http://www.environment.gov.au/protection/publications/factsheet-carbon-monoxide-co

- Short-term exposure to NO_2 has some direct effects on respiratory morbidity, even after adjustment for particles and other pollutants

- There are positive associations between short-term exposure to NO_2 and hospital admissions/visits for cardiovascular and/or cardiac diagnoses, although these outcomes are mixed after adjustment for co-pollutants.

- Significant associations between short-term ambient concentrations of NO_2 and mortality have been reported. In some studies the associations have remained significant after adjustment for $PM_{2.5}$ and black smoke. NO_2 could also act as a marker for other traffic pollutants such as volatile organic compounds, aldehydes and organic compounds bound to primary particles. To summarise, the evidence is suggestive but not sufficient to infer a causal relationship between short-term exposure to NO_2 and all-cause mortality **(USEPA, 2015)**.

B.2.1.2 Long-term exposures to NO_2

Although it is possible that NO_2 acts as a marker for other traffic pollutants, there is likely to be a causal relationship for long-term exposure to NO_2 and respiratory effects. The evidence for cardiovascular effects and total mortality is suggestive, but not sufficient to infer a causal relationship (**WHO Regional Office for Europe, 2013; USEPA, 2015**). There are associations between long-term exposure to NO_2 and morbidity and mortality at concentrations that are at or below the current EU annual mean limit value (40 µg/m^3).

B.3 PARTICULATE MATTER

B.3.1 Health effects

B.3.1.1 Background

The pollutant generally accepted as having the greatest public health impact is particulate matter **(Harrison, 2010)**. The biological effects of inhaled particles are determined by their physical and chemical properties, by their sites of deposition, and by their mechanisms of action. The extent to which particles can penetrate the respiratory tract, and their potential for causing health effects, is directly related to their size (**Harrison *et al.*, 2010**). With normal nasal breathing, larger particles (those greater than 10 µm) are generally deposited in the extrathoracic part (nose, mouth and throat) of the respiratory tract. They adhere to the mucus in the nose, mouth, pharynx and larger bronchi, and from there are removed by either swallowing or expectorating. Particles between 10 and 2.5 µm can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing which increases during exercise. However, particles with a diameter of less than 2.5 µm can penetrate deep into the human respiratory system. Fine particles can be deposited in the pulmonary region, and it is these which are of particular concern.

In recent years epidemiological evidence has accumulated indicating that airborne particles have a range of adverse effects on health. These effects – which are diverse in scope, severity and duration - include the following:

- Premature mortality.

- Aggravation of cardiovascular disease such as atherosclerosis.

- Aggravation of respiratory disease such as asthma.

- Changes to lung tissue, structure and function.

- Cancer[c].
- Reproductive and developmental effects.
- Changes in the function of the nervous system.

Importantly, the International Agency for Research on Cancer has recently classified outdoor air pollution as carcinogenic to humans, with a specific emphasis on PM and diesel engine exhaust **(IARC, 2012, 2013)**.

Research shows that particle pollution can exacerbate existing respiratory symptoms, and at high concentrations cause respiratory symptoms. Particles can also adversely impact cardiovascular health. No safe threshold has been identified for the human health effects of particles **(NSW DECCW, 2010)**. The health effects of PM are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulfur dioxide. Airborne particles also reduce visual amenity and visibility **(NSW DECCW, 2010)**.

B.3.1.2 PM_{10} and $PM_{2.5}$

Ambient concentrations of PM are most commonly defined in terms of two metrics: PM_{10} and $PM_{2.5}$, the mass concentrations of particles with an aerodynamic diameter of less than 10 µm and 2.5 µm respectively. There are many natural and anthropogenic sources of airborne particles, and as a consequence particulate matter displays a wide range of physical and chemical characteristics. When discussing PM sources and composition it is essential to distinguish between 'primary' and 'secondary' particles. Primary particles are emitted directly into the atmosphere as a result of natural processes (e.g. wind erosion, marine aerosols) and anthropogenic processes involving either combustion (e.g. industrial activity, domestic wood heaters, vehicle exhaust) or abrasion (e.g. tyre wear). Secondary particles are not emitted directly, but are formed by reactions involving gas-phase components of the atmosphere. Various studies have shown that secondary particles contribute significantly to PM concentrations, especially $PM_{2.5}$ at background sites, although their characteristics vary significantly with both location and time.

There is sufficient evidence to conclude that short-term and long-term exposure to $PM_{2.5}$ causes illness and death from cardiovascular conditions, and is likely to cause respiratory conditions (**USEPA 2009; WHO Regional Office for Europe, 2013**). The effects observed in relation to $PM_{2.5}$ from a large study conducted in Australia and New Zealand (**EPHC, 2010**) are consistent with the effects reported in the international literature. Associations have also been observed between exposure to $PM_{2.5}$, reproductive and developmental effects, and cancer. In 2009, the USEPA concluded the evidence was suggestive of a causal relationship (**USEPA, 2009**).

There is extensive evidence that short-term exposure to PM_{10} is associated with health effects, and that these effects are independent of the effects of $PM_{2.5}$. In 2009 the USEPA concluded that there was suggestive evidence of a causal relationship between short-term exposure to coarse particles ($PM_{2.5-10}$) and cardiovascular and respiratory effects and mortality (**USEPA, 2009**). Since that time, evidence of these short-term effects has increased significantly, and the WHO has stated that "sufficient evidence exists for proposing a short-term standard for PM_{10}, to protect against the short-term health effects of coarse particles, in addition to fine particles" (**WHO Regional Office for Europe, 2013**). There is substantially less evidence that long-term exposure to PM_{10} has health effects that are independent of those caused by long-term exposure to $PM_{2.5}$. However, in regard to management of long-term exposure, the WHO has stated that "a limit to protect against long-term exposure should be maintained as new evidence is published on health effects of long-term exposure to PM_{10} from Europe, and as long

[c] Particles may contain carcinogenic substances such as polycyclic aromatic hydrocarbons (PAHs) or heavy metals.

as there remains uncertainty about if these health effects would be eliminated by reduction of long-term exposure to $PM_{2.5}$ alone" (**WHO Regional Office for Europe, 2013**). As with $PM_{2.5}$, the effects observed in the Australian and New Zealand NEPC multi-city study (**EPHC, 2010**) in relation to PM_{10} exposure are consistent with those observed internationally.

There is increasing, but as yet limited, epidemiological evidence on the association between short-term exposure to ultrafine particles and cardiovascular and respiratory health (**WHO Regional Office for Europe, 2013**). This is an area of ongoing research.

Studies have also investigated the relationship between specific PM components (for example, black carbon, secondary organic aerosol (SOA) and secondary inorganic aerosol (SIA)) and health effects (**WHO Regional Office for Europe, 2013**). In the future, the use of these metrics may provide a better indication of exposure to PM from particular sources, such as vehicle exhaust, and may improve the understanding of the associated health risks. While there is some evidence that the relationship between particles and their health effects depends on their chemical composition, the evidence is insufficient to conclude this relationship is causal **(Bell, 2012)**.

The linearity of the relationship between exposure to $PM_{2.5}$ and health response - and correspondingly the existence or otherwise of a threshold for health effects - has been the subject of several studies since the WHO 2005 air quality guidelines global update. For studies of short-term exposure to $PM_{2.5}$ there is substantial evidence of associations down to very low levels. Studies of long-term exposure face greater methodological challenges to fully assess thresholds and linearity, and fewer long-term studies have examined the shape of the concentration–response functions. WHO Regional Office for Europe (2013) commented that long-term studies have not detected significant deviations from linearity (*i.e.* no evidence of a threshold for effects) for the ambient levels of $PM_{2.5}$ observed in Europe. Similarly, researchers in the United States have consistently found no evidence of a threshold concentration below which adverse health effects are not observed (**Pope and Dockery, 2006; Brook *et al*., 2010; USEPA, 2009**). In Canada, **Crouse *et al.* (2012)** investigated the long-term exposure to ambient $PM_{2.5}$ in non-immigrant adults, and observed associations with cardiovascular mortality at concentrations as low as only a few micrograms per cubic meter. This last study is particularly relevant, because it investigated the effects of $PM_{2.5}$ at levels commonly experienced in Australia.

B.3.1.3 Ultrafine particles

A considerable amount of attention in recent years has focussed on 'ultrafine particles' (UFPs). These are particles with a diameter of less than 0.1 µm. Whilst there is some evidence particles in this size range are associated with adverse health effects, it is not currently practical to incorporate them into an environmental impact assessment. There are several reasons for this, including the rapid transformation of such particles in the atmosphere, the need to treat UFPs in terms of number rather than mass, the lack of robust emission factors, the lack of robust concentration-response functions, the lack of ambient background measurements, and the absence of air quality standards.

In relation to concentration-response functions, the **WHO Regional Office for Europe (2013)** has stated the following:

'… the richest set of studies provides quantitative information for PM2.5. For ultrafine particle numbers, no general risk functions have been published yet, and there are far fewer studies available. Therefore, at this time, a health impact assessment for ultrafine particles is not recommended.'

For the purpose of this assessment it is therefore assumed that the effects of UFPs on health are adequately represented by $PM_{2.5}$.

B.3.2 Other effects

Particulate matter is one of the pollutants that have the capacity to influence climate locally, regionally, and globally; for example, black carbon from combustion sources has much the same effect as a greenhouse gas, although the precise mechanisms are different. Airborne particles also affect radiative transfer in the atmosphere and provide one of the largest uncertainties in estimating the anthropogenic influences upon climate change. White particles such as ammonium sulfate are reflective and have a net cooling effect by reflecting incoming solar radiation back to space. Water-soluble particles can act as cloud condensation nuclei affecting the albedo (reflectivity) of clouds leading to a reduction in land surface warming (**Harrison, 2010**).

Particulate matter can clog the stomatal openings of plants and interfere with photosynthesis functions. When PM concentrations in the atmosphere are well in excess of health criteria, this can therefore lead to stunted growth or mortality in some plant species.

B.4 LEAD

Lead is a highly toxic metal that can be absorbed in the human body through both ingestion and inhalation. It accumulates in the body, and the toxic effects are numerous and severe. The main concern is the potential to impair the intellectual development in children, but lead is also associated with effects on the circulatory system, the central nervous system, and the gastrointestinal system (**NSW DECCW, 2010**).

Under the National Fuel Quality Standards Act 2000, the Australian Government announced a phase-out of leaded petrol in Australia. On 1 January 2002, that phase-out was completed. The sale of leaded petrol in Australia is now prohibited, except in cases specifically authorised by the Minister.

One exception to this relevant to airport operations is the allowance for lead within Aviation Gasoline, or Avgas. Avgas is used in small piston engine powered aircraft within the General Aviation community. Predominately activities such as private pilots, flight training, flying clubs and crop spraying. Piston engines operate using the same basic principles as spark ignition engines of cars, but they have a much higher performance requirement.

There are two main Avgas grades available in Australia - 100 and 100LL low lead. The former is permitted to contain lead up to 1.12 g/litre of fuel and the latter 0.56 g/litre. This is compared with 0.005 g/litre for all conventional grades of petrol.

Notwithstanding the above, the proportion of small piston aircraft servicing the WSA is anticipated to be low (less than 5% of all aircraft). The resultant lead emission inventory associated with Avgas use at the airport is not considered significant and this air quality metric has not been considered further within the assessment.

B.5 OZONE

Ozone is a colourless, strongly oxidising gas that is an important component of summer-time smog in the troposphere. Ground-level ozone is not produced directly from emission sources but is created by complex photochemical reactions involving NO_X and VOCs in the atmosphere. Ozone can be transported over long distances, and in contrast to other pollutants the concentrations are generally highest at rural locations downwind of large cities. Ozone is therefore regarded as a regional air pollution problem. In urban areas ozone is depleted through the titration reaction with NO.

Elevated concentrations of ozone occur in Sydney in the warmer months under suitable weather conditions including sufficient sunlight, high temperatures, and favourable wind conditions (**NSW DECCW, 2010).**

B.5.1 Health effects

As ozone is a powerful oxidant it can react with a wide range of cellular components and biological materials. Even relatively low levels of ozone can cause health effects. In particular, exposure to ozone damages lung tissue and reduces lung function. High concentrations therefore lead to increases in the frequency of respiratory symptoms and in deaths. Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue. High concentrations of ozone affect not only people with respiratory problems such as asthma, but also healthy adults and children **(NSW DECCW, 2010**).

Evidence from observational studies strongly indicates that higher daily ozone concentrations are associated with increased asthma attacks, increased hospital admissions, increased daily mortality, and other markers of morbidity. The consistency and coherence of the evidence for effects upon asthmatics suggests that ozone can make asthma symptoms worse and can increase sensitivity to asthma triggers[d]. According to **WHO Regional Office for Europe (2013)**, recent epidemiological studies have indicated potentially larger mortality effects than previously thought. This is because new evidence has emerged detailing the negative effects of long-term exposure to ozone on mortality as well as adverse effects such as asthma incidence, asthma severity, hospital care for asthma and lung function growth.

B.5.2 Other effects

Exposure to ozone can reduce the overall productivity of plants by damaging cells and causing the destruction of leaf tissue. Plants become more susceptible to disease, pests, cold and drought, causing economic losses. Ozone may also result in sensitive species dying out, with additional effects on wildlife **(CARB, 2008)**.

Ozone can also cause substantial damage to materials such as rubber, plastics, fabrics, paint and metals. Exposure to ozone progressively damages both functional and aesthetic qualities, and shortens the life spans of materials. Damage from ozone exposure can result in significant economic loss as a result of the increased need for maintenance, upkeep and replacement **(CARB, 2008)**.

B.6 SULFUR DIOXIDE

Sulfur dioxide (SO_2) is an acidic gas which is colourless and has an unpleasant odour. It reacts readily with other substances to form harmful compounds, including sulfate particles. SO_2 can have harmful effects on health, vegetation and materials. The major health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease. SO_2 reacts with water vapour to form sulfuric acid (acid rain) that can damage vegetation, alter the mineral content in soils, and corrode materials.

B.7 AIR TOXICS

People exposed to toxic air pollutants at high concentrations may have an increased chance of getting cancer or experiencing other serious health effects. These health effects can include damage to the immune system, as well as neurological, reproductive (e.g. reduced fertility), developmental, respiratory and other health problems. In addition to exposure from breathing air toxics, some toxic air pollutants can deposit onto soils or surface waters, where they are taken up by plants and ingested by animals and are eventually magnified up through the food chain[e].

It is uncommon for air quality assessments to address a large number of organic pollutants. It is more usual for a small number of the most important components to be assessed, with inferences being

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[d] http://www.epa.gov/groundlevelozone/health.html
[e] http://www.epa.gov/oar/toxicair/newtoxics.html#effects

made in relation to others. The compounds that have been considered here are those included in the Air Toxics NEPM:

- Benzene
- Toluene
- Xylenes (the total of ortho, meta and para isomers)
- Benzo(a)pyrene, as a marker for polycyclic aromatic hydrocarbons (PAHs)
- Formaldehyde

These pollutants are generally less of a concern that in the past. Improvements in fuel quality in recent years have reduced their significance.

B.7.1 Benzene

Benzene is a constituent of road transport fuel, but since 2006 the benzene content of petrol in Australia has been limited to 1% by volume (compared with 5% previously). This reduction has had an immediate and sustained impact on ambient benzene levels.

Short-term inhalation exposure to benzene can cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Long-term inhalation exposure has caused blood disorders including reduced numbers of red blood cells and anaemia. Reproductive effects have been reported for women. Increased incidence of leukaemia has been observed in humans occupationally exposed to benzene. The USEPA has classified benzene as known human carcinogen[f].

B.7.2 Toluene

Toluene is added to gasoline to improve octane ratings, and motor vehicle emissions are the principal source of it in ambient air. The symptoms of exposure to elevated levels of toluene include fatigue, headaches, nausea, irritation of the upper respiratory tract and eyes, and a sore throat. The USEPA has concluded that that there is inadequate information to assess the carcinogenic potential of toluene[g].

B.7.3 Xylenes

Xylenes are released into the atmosphere as fugitive emissions from industrial sources, from auto exhaust, and through volatilization from their use as solvents. Short-term exposure to xylenes results in irritation of the eyes, nose, and throat, gastrointestinal effects, eye irritation, and neurological effects. Long-term exposure results primarily in central nervous system effects, such as headache, dizziness, fatigue, tremors, and incoordination; respiratory, cardiovascular, and kidney effects have also been reported. USEPA has classified mixed xylenes as a Group D, not classifiable as to human carcinogenicity[h].

B.7.4 Polycyclic aromatic hydrocarbons (PAHs)

The term PAH covers a large group of organic compounds with two or more fused aromatic rings. About 500 PAHs and related compounds have been detected in the air (**WHO Regional Office for Europe, 2000**). PAHs are formed by incomplete combustion of fuels, including transport fuels, and can

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[f] http://www.epa.gov/ttn/atw/hlthef/benzene.html
[g] http://www.epa.gov/ttn/atw/hlthef/toluene.html
[h] http://www.epa.gov/ttnatw01/hlthef/xylenes.html

be present in both gas and (more commonly) particle phases. The USEPA has designated 32 PAH compounds as priority pollutants. A short list of compounds is often targeted for measurement in environmental samples. Of these, the most measurements have been made for benzo(a)pyrene, and this compound is used as a marker for PAHs in the Air Toxics NEPM.

PAHs are a concern because they are persistent in the environment for long periods of time. There is little information available on the health effects of exposure to individual PAHs at specific concentrations. Short-term exposure to mixtures of PAHs is known to cause skin irritation and inflammation. Anthracene, benzo(a)pyrene and naphthalene are direct skin irritants, while anthracene and benzo(a)pyrene are reported to cause an allergic skin response. The health effects of long-term exposure to PAHs may include cataracts, kidney and liver damage and jaundice. Naphthalene, a specific PAH, can cause the breakdown of red blood cells if inhaled or ingested in large amounts. Long-term studies of workers exposed to mixtures of PAHs and other workplace chemicals have shown an increased risk of skin, lung, bladder and gastrointestinal cancers (**USEPA, 2008; SA Health, 2009**).

B.7.5 Formaldehyde

Formaldehyde is a colourless gas with a pungent odour. Major sources include power plants, manufacturing facilities, incinerators, and automobile exhaust. Short-term and long-term inhalation of formaldehyde can result in respiratory symptoms, and eye, nose, and throat irritation. Limited human studies have reported an association between formaldehyde exposure and lung and nasopharyngeal cancer. USEPA considers formaldehyde a probable human carcinogen[i].

[i] http://www.epa.gov/ttn/atw/hlthef/formalde.html

Appendix C CHARACTERISATION OF EMISSION SOURCES

C.1 OPERATIONS

The following sections provide the detailed information that was used for input to EMDS for modelling operations.

C.2 EDMS SOURCE CONFIGURATION

Figure C-1 and **Figure C-2** show how the airport was configured in EDMS for the proposed Stage 1 and longer term development scenarios. The key shows the different source categories that were modelled, as well as receptor locations and buildings.

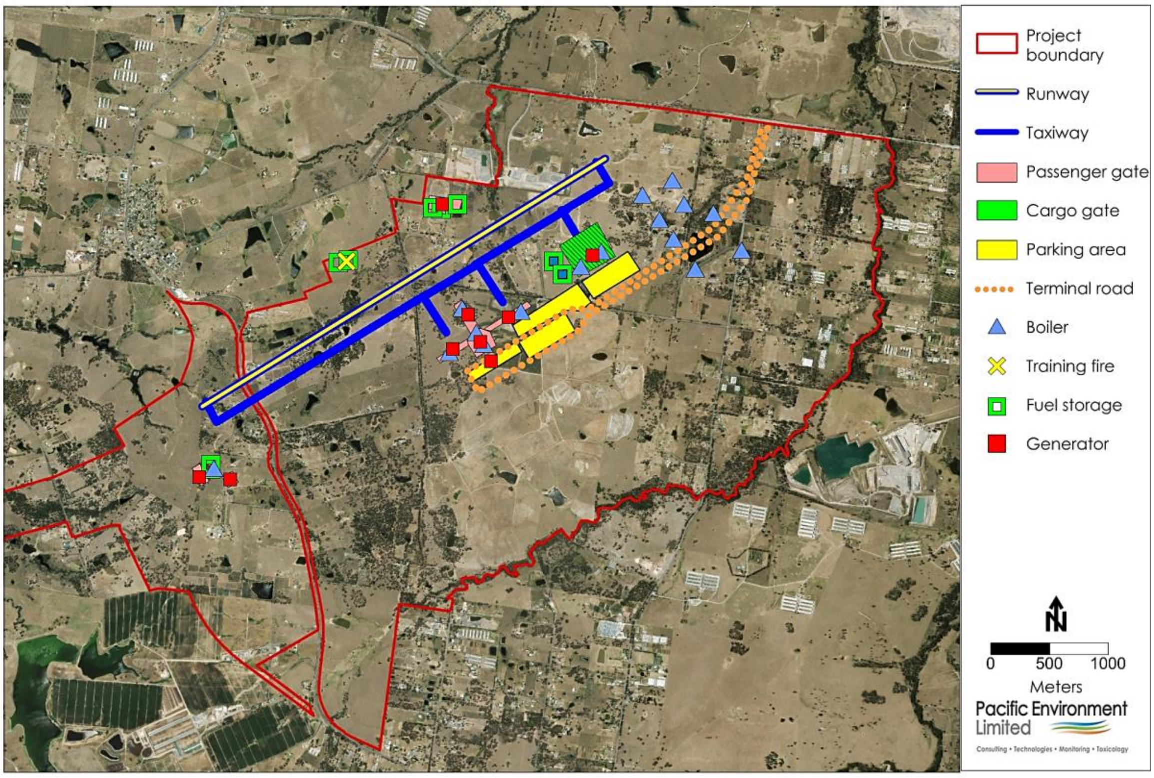

Figure C-1: EDMS source configuration for Stage 1 development

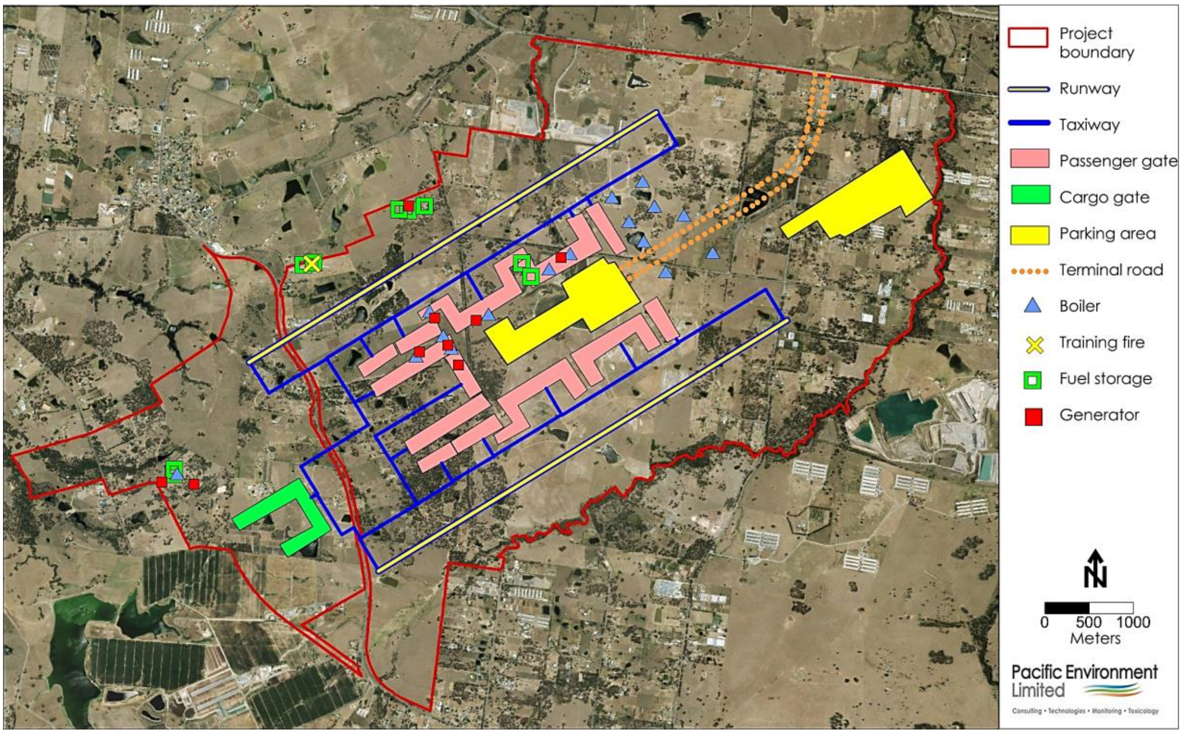

Figure C-2: EDMS source configuration for longer term development

C.3 AIRCRAFT MAIN ENGINES AND APUS

C.3.1 Description

The operation of aircraft is one of the most important sources of air pollution at airports. Aircraft are equipped with main engines for propulsion and on-board APUs that provide electrical power when the aircraft is taxiing or parked at a gate. These sources are described in more detail below.

C.3.1.1 Main engines

Aircraft main engines are generally classified as either gas turbine turbofans/turbojets, turboprops, or internal combustion piston engines. Turbofans/turbojets and turboprops are fuelled with aviation kerosene (jet fuel). Piston engines are fuelled with aviation gasoline (AVGAS).

Emissions from main engines vary according to the operational mode. The landing/take-off (LTO) cycle represents a useful way of incorporating all normal flight and ground operation activities, including descent/approach from a reference height above ground, touchdown, landing run, taxi in, idle and shut-down, start-up and idle, checkout, taxi out, take-off and climb-out to the reference height **(DEWHA, 2008)**. All flight and ground operations in the LTO cycle are grouped into four standard modes for which emission rate data are readily available. These modes are:

- The *approach* mode, for which emissions are estimated from a height of 1,000 m to ground level.
- The *taxi/idle* mode, which applies to both incoming and outgoing aircraft during taxiing and idling operations.
- The *take-off* mode, which is defined as the period between commencement of acceleration on the runway and the aircraft reaching a height of 200 m, during which time the engine is operated at full throttle and fuel usage is at a maximum for any given engine.
- The *climb-out* mode, for which emissions are calculated for the period between 200 and 1,000 m above ground level.

In each of the modes the main engines operate at different power settings. The power settings determine the rate at which fuel is burned which, in turn, determines the quantity and nature of emissions released into the atmosphere.

ICAO publishes emission factors for the operational modes listed above, expressed in grams of pollutant per kilogram of fuel used during the time-in-mode. For estimating emissions over the complete LTO cycle the amount of time each aircraft spends in each operational mode is therefore required. Emission factors are also expressed in grams of pollutant for the entire LTO cycle. Engine manufacturers calculate this value, based on default LTO times-in-mode, as part of the engine certification process.

C.3.1.2 Auxiliary power units (APUs)

An APU is a small turbine engine coupled to an electrical generator that generates electricity and compressed air to operate the aircraft's instruments, lights, ventilation and other equipment while the main aircraft engines are shut down. It is also used to provide power for starting the main aircraft engines. APUs are usually mounted in the tail cone of the aircraft and run on aviation kerosene (jet fuel) fed from the main fuel tanks. Although the use of APUs on jet aircraft is almost universal, some turboprops and business jets do not have APUs **(DEWHA, 2008)**.

DEWHA (2008) note that emissions from APUs are also usually expressed in terms of specific modes of operation, such as: 'idle', '400 Hz' (provides electricity when an aircraft is on the ground and in operation), 'PCA' (provides pre-conditioned air during pre- or post-flight activities), and 'bleed air' (bleed air for main engine start).

It is worth noting that APUs may also occasionally be used to provide power and preconditioned air during maintenance.

C.3.2 Approach in EDMS

C.3.2.1 Main engines

In EDMS the emissions from aircraft main engines are computed based on the engine specifications, taking into account aircraft performance characteristics and weather. Once emissions are calculated for one of the engines, EDMS multiplies the single engine results with the number of engines of the aircraft to compute the emissions of the aircraft.

EDMS utilises the latest aircraft engine emission factors from the ICAO Engine Exhaust Emissions Data Bank. It is worth noting that EDMS actually uses six operational modes, due a formal separation of 'taxi in' and 'taxi out', and the inclusion of a 'start-up' mode at the gate (only for aircraft with ICAO certified engines). In the absence of specific information on time in mode for the airport, the ICAO default values in EDMS were used in this study.

Each aircraft activity is expressed as an arrival or a departure, with each type consisting of different modes of operation. An arrival consists of the approach and taxi-in modes. A departure consists of the start-up, taxi-out, take-off and climb-out modes. An LTO cycle consists of an arrival and a departure, and therefore consists of one of each of the six modes of operation.

EDMS calculates the amount of emissions (up to a height of 915 m) released in the airborne segments and approach ground roll using the aircraft performance module, which dynamically models the flight of the aircraft, based a flight profile. Operational information for aircraft can be entered by specifying a *schedule of operations.* This provides a precise and accurate modelling of aircraft performance by taking into account the aircraft type, engine, weight, approach angle to be flown (for arrivals), elevation and weather. Using hourly meteorological weather data, variations in the thrust used (and emissions released) for the same aircraft can be observed at different times of the day and at different airports due to the changing weather conditions. For the EDMS Taxi In and Taxi Out modes of operation, the taxi times are generated by the sequencing model. For the majority of aircraft the duration of Taxi out was 19 minutes and Taxi In was 7 minutes. The default approach and climb out times in mode of both system aircraft using ICAO times in mode and user-created aircraft are based on a mixing height of 3,000 feet but are adjusted to reflect the user-specified local mixing height. As noted earlier, for aircraft sequencing there is a need to define the airport gates, the taxiways, the runways and the taxipaths (how the taxiways and runways are used).

C.3.2.2 APUs

Emissions are generated by an APU while an aircraft is parked at a gate. The emission calculations for APUs are similar to those for an aircraft main engine operating at one power setting. The methodology for calculating emissions from APUs is adapted from the USEPA *Procedures for Emission Inventory Preparation*, *Volume IV*[i]. APU emissions generated per LTO cycle are the product of the emission factor and operating time, multiplied by the number of applicable aircraft LTO cycles. APU emissions for arrivals and departures are computed in the same way. For the purpose of emissions calculations, APUs are assigned to the same category as GSE. External APUs used by an aircraft fall into the category of ground support equipment. In the absence of an APU or applicable GSE, a combination of 400 Hz electric power and preconditioned air (PCA) can be supplied to the aircraft using a fixed system at each gate to allow for normal operation. Fixed systems usually generate little or no emissions at the airport and are not included in EDMS.

C.3.3 Definition of input data for the airport

C.3.3.1 Main engines

The parameters required to be input to aircraft schedule were:

- date and time of movement (1-minute);
- type of flight (passenger or freight);
- type of operation (arrival or departure);
- aircraft type;
- engine type;
- gate number (to simplify the calculation the gates were grouped); and
- runway allocation.

Aircraft schedules

The projected annual ATMs of 63,302 during the Stage 1 development and 369,952during the longer term development were used as the basis for the development of the aircraft schedule for these two investigation scenarios.

A ‘worst case’ daily synthetic schedule was supplied by L.E.K. Consulting. These data included information on aircraft use (passenger or freight), aircraft family, operation type and operation time (to the nearest15 minutes) In accordance with the feasibility design report **(DIRD, 2015)**, this worst case day was chosen to represent October 17 2013, KSA’s busiest day for 2013. The projected ATMs were combined with the monthly, daily and hourly weighting factors presented in **DIRD (2005)** to develop an annual schedule of aircraft movements to be used as the basis for the calculation of aircraft emissions.

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[i] www.epa.gov/otaq/invntory.htm.

The annual profile of the daily ATMs for Stage 1 and the longer term development are shown in **Figure C-3**.

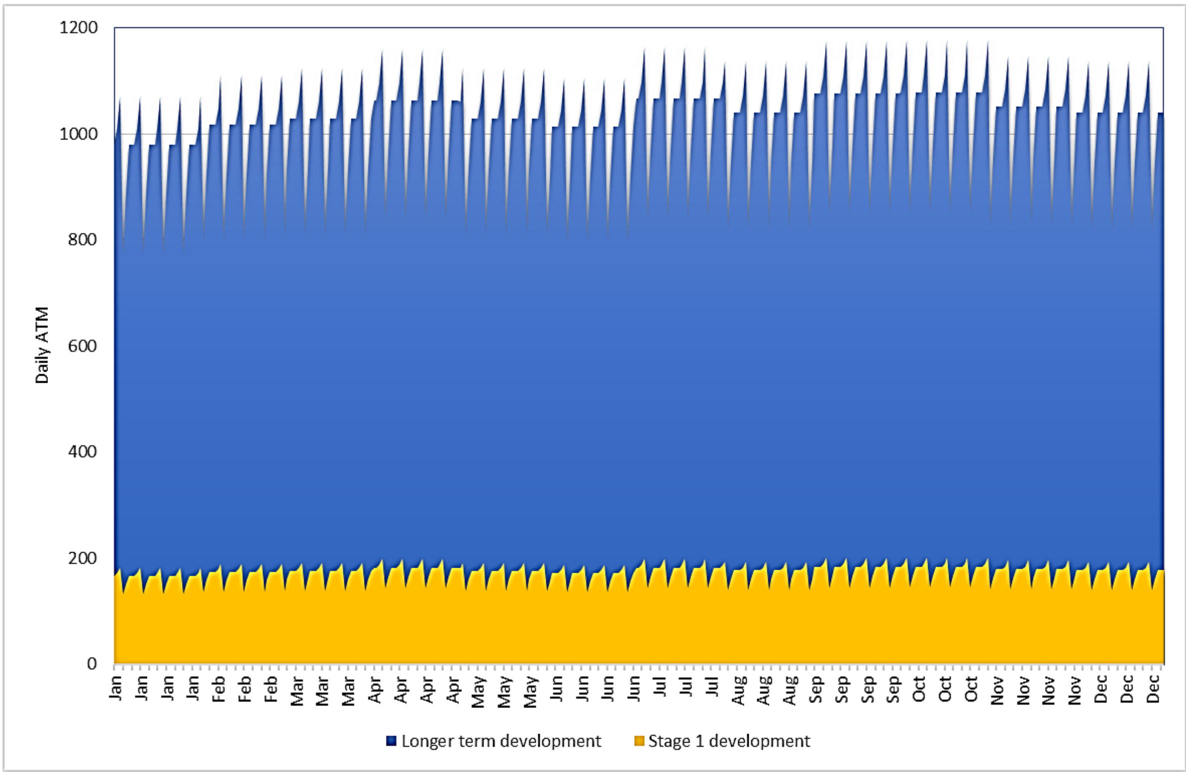


Figure C-3: Annual profile of daily ATM for Stage 1 and longer term development

As only aircraft family was provided as part of the synthetic schedule the default range of aircraft and engine combinations in EDMS were adopted. The projected ATMs by aircraft family and adopted engine type are provided in **Table C-1**.

Table C-1: Annual movements by aircraft type for Stage 1 and Ultimate scenarios

Row Labels	Aircraft name	Engine Type	2030	2063
A320-2	Airbus A320-200 Series	CFM56-5A3	33,357	128,386
A330-2	Airbus A330-200 Series	CF6-80E1A4 (STD) CF6-80E1A3 PW4168A TRENT-772 CF6-80C2B5F	689	n/a [a]
A330-2F	Airbus A330-200 Series Freighter	PW4164 (Floatwall) PW4168 (Floatwall) TRENT-772 PW4168A (Floatwall)	632	583

Row Labels	Aircraft name	Engine Type	2030	2063
A330-3	Airbus A330-300 Series	CF6-80E1A4 Low Emis TRENT-772 CF6-80E1A3 PW4168A CF6-80E1A2 old comb TRENT-768 old comb CF6-80E1A4 (STD)	2,598	48,309
A350-8	Airbus A350-800 Series	TRENT-772	1,300	26,809
A350-9	Airbus A350-900 series	TRENT-772	1,357	26,711
A380-8	Airbus A380-800 Series	GP7270 TRENT 970-84	n/a [(a)]	2,682
B737-3F	Boeing 737-300 Series Freighter	CFM56-3-B1 CFM56-3B-2	518	6,194
B737-7	Boeing 737-700 Series	CFM56-7B27 CFM56-7B22 CFM56-7B20 CFM56-7B24	2,949	n/a [(a)]
B737-8	Boeing 737-800 Series	CFM56-3C-1 CFM56-7B24	2,954	n/a [(a)]
B737-8-BBJ2	Boeing Business Jet II	CFM56-7B27	1,446	n/a [(a)]
B737-9	Boeing 737-900 Series	CFM56-7B26	1,923	66,397
B747-3F	Boeing 747-300 Series Freighter	CF6-50E2	502	2,192
B747-4F	Boeing 747-400 Freighter	RB211-524H-T CF6-80C2B1F revised PW4X56 Phase 3 CF6-80C2B5F	1,575	8,678
B747-8I	Boeing 747-8	GENEX-1B GENEX-2B	n/a [(a)]	670
B767-2F	Boeing 767-200 Series Freighter	JT9D-7R4D1 CF6-80A (A1)	665	1,868
B767-3F	Boeing 767-300 ER Freighter	CF6-80C2B7F	352	992
B777-2	Boeing 777-200 Series	PW4074D GE90-110B1 TRENT-772	234	n/a [(a)]
B777-2ER	Boeing 777-200-ER	TRENT 895 GE90-90B (DAC II) Trent 892 GE90-77B TRENT-884 PW4074D	425	n/a [(a)]
B777-2LR	Boeing 777-200-LR	GE90-115B GE90-110B1	150	n/a [(a)]

Row Labels	Aircraft name	Engine Type	2030	2063
B777-3	Boeing 777-300 Series	Trent 892	64	n/a [a]
B777-3ER	Boeing 777-300 ER	GE90-115B	206	27,603
B787-8	Boeing 787-8 Dreamliner	CF6-80C2B6F	203	5,867
BAE146-200	BAE 146-200	ALF502R-5	1,303	4,581
BAE146-300	BAE 146-300	ALF502R-5	1,275	4,708
DHC8Q-3	Bombardier de Havilland Dash 8 Q300	PW123E	2,068	1,674
DHC8Q-4	Bombardier de Havilland Dash 8 Q400	PW123	665	1,627
SAAB340-A	Saab 340-A	CT7-5	3,892	3,421
Total			**63,302**	**369,952**

Notes: (a) Not included in model scenario

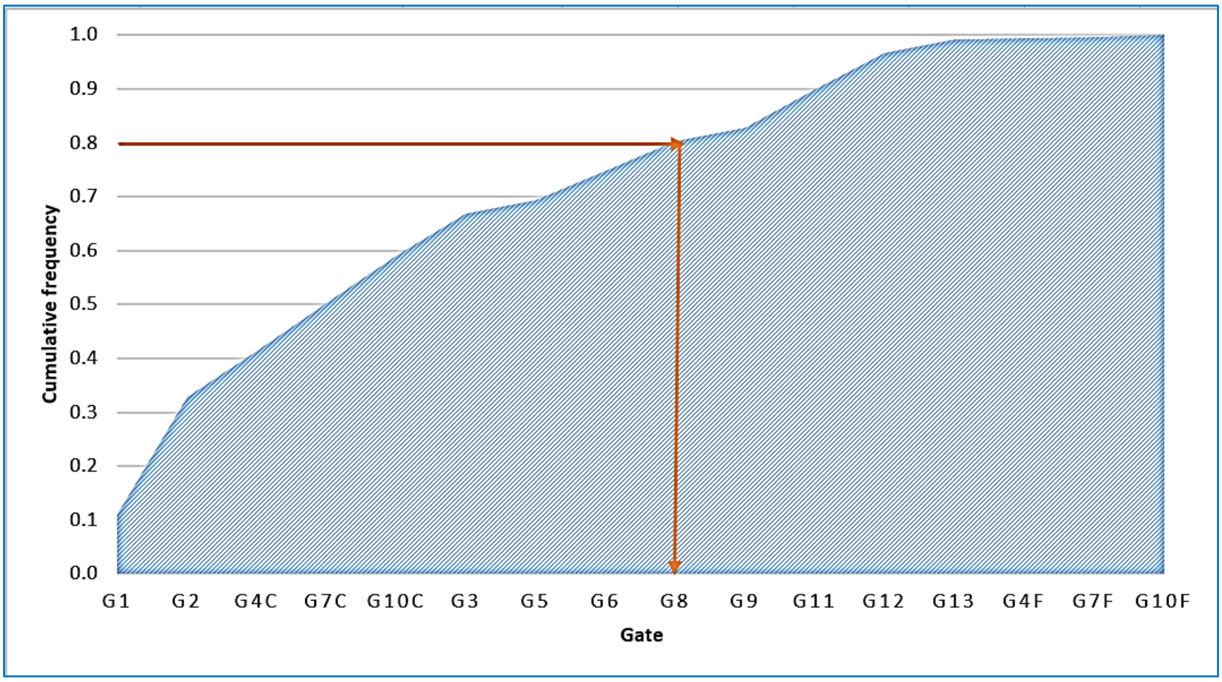
Gate allocation

The gate allocation was not available and therefore was based on the aircraft code (size of the aircraft) and capacity of each gate to accommodate that particular aircraft. This was relatively straightforward for the Stage 1 development given the grouping of available gates by aircraft code (i.e. Gate group 1 for 'C code' or smaller, 'E Code' for larger aircraft and 'Cargo').

The gate allocations are shown in **Figure C-1** and **Figure C-2** for the Stage 1 development and longer term development scenarios, respectively.

However, for the longer term development the gate arrangement is more complex. A probabilistic approach was used to determine the gate and subsequent taxipath based on aircraft code. For each aircraft movement a random number (between 0 and 1) was generated, and the value of the random number was used to identify the gate using the cumulative frequency. This approach is explained graphically in **Figure C-4**.

Figure C-4: Identification of gate based on probability



Runway allocation

During the Stage 1 development operation there is a single runway comprising two runway combinations '5L' and '23R'. For the longer term development this increases to four, with the addition of the southern runway and now includes '5R' and '23L'. The location of the runways can be seen in the site layout shown in **Figure C-1** and **Figure C-2** for each of the respective scenarios.

The runway allocation was not contained in the information provided by LEK Consulting. Therefore the following assumptions were made:

- Stage 1 development: 50 per cent of ATMs were allocated to each runway combination; and
- Longer term development: 50 per cent of ATMs were allocated to each runway. This was then further split to assume 50 per cent of ATMs on each runway will use each runway combination.

It is acknowledged that in reality the runway combinations are a function of the prevailing weather conditions and gate availability. Given the uncertainty in predicting future events, the approach adopted is considered a reasonable approach and has been adopted for similar airports, such as in the local air quality modelling for KSA **(Pacific Environment, 2014)**.

Flight profiles and time in mode

Flight profiles based on the performance of aircraft-engine combinations were used to determine times in mode within EDMS. Take-off, climb-out, approach, and landing roll times were calculated by the EDMS performance module using aircraft weight (EDMS default values), the approach angle and the mixing height.

Dispersion parameters

As per the EDMS model recommendations aircraft taxiing, aircraft queuing, aircraft accelerating on the runway, and on-road vehicle operations were considered to be a series of area sources, since their movement along a path approximates a line of continuous emissions. Similarly, aircraft after take-off and during the landing approach were also represented as a series of area sources. The area source was selected, as opposed to using a series of volume sources based on recommendations from the American Meteorological Society/EPA Regulatory Model Improvement Committee (AERMIC) **(CSSI, 2013)**.APUs

The EDMS defaults were used for both allocating APUs to aircraft and for the operational time for APUs during arrivals and departures. For the user-defined aircraft, the default APUs for the representative aircraft types mentioned above were used.

The default value for operational time was 13 minutes (for both arrivals and departures).

Dispersion parameters

An area source was selected as the most appropriate source type to represent the multiple sources of emissions that would be released from within each allocated 'gate' (see **Figure C-1** and **Figure C-2**).Ground support equipment

C.3.4 Description

Upon arrival at a gate, aircraft are serviced by various airside vehicles and mobile plant, collectively known as ground support equipment (GSE). GSE are necessary to handle the aircraft during the turnaround at the stand. Examples of GSE include:

- Aircraft push-back tugs
- Mobile generators to provide electricity
- Air conditioning units
- Conveyer belts for loading and unloading baggage
- Baggage tugs
- Powered passenger stairs
- Fork lifts
- Tractors
- Cargo tractors and loaders
- Hydrant trucks for refuelling
- Catering trucks
- Lavatory trucks

The extent of GSE activity is generally dependent on the size and usage of the aircraft, ranging from a wide range of equipment in service for extended periods for large passenger aircraft embarking on international flights to limited GSE activity for small aircraft used for local business flights **(DEWHA, 2008)**.

Emissions from GSE are dependent on fuel type, engine size, load factor, technology, age (or deterioration factor) and emission reduction devices in place. GSE are generally powered by internal combustion engines of various kinds, although other technologies are sometimes used. Several of the GSE are non-road vehicles that are specifically designed to provide the services required for aircraft (*e.g*. cargo loaders, baggage belts, aircraft tugs). GSE are generally designed for low-speed, high-torque functions, and are built to be easily manoeuvrable within the confined environments surrounding aircraft **(DEWHA, 2008)**.

C.3.5 Approach in EDMS

GSE can be modelled in EDMS both by assignment to an aircraft and by population. GSE that are assigned to an aircraft will have their operations depend on the activity of that aircraft. GSE that are modelled as a population operate independently from aircraft activity. The GSE emission factors used by EDMS are derived from the USEPA's NONROAD2005 model and are based on the following variables: fuel, brake horsepower and load factor. In addition, a deterioration factor is applied based on the age of the engine. GSE emission factors are given in grams per horsepower-hour. EDMS allows users to select the EPA-derived national fleet average age for a particular vehicle type, or to specify the exact age of an individual piece of equipment.

GSE that are assigned to an aircraft are given times (minutes per arrival, minutes per departure) based upon the type of service. For example, a fuel truck servicing a large commercial aircraft will have a different operating time than the same fuel truck servicing a commuter aircraft. Tugs are generally used to move commercial aircraft away from the gates, but are typically not used by general aviation (GA) aircraft.

As system aircraft are added to the study, default GSE assignments are made for each newly added aircraft. Default assumptions are used in EDMS, but the user also has the flexibility to add and remove GSE to and from aircraft and modify the operating times as well as other parameters for assigned GSE. These default assignments are based upon several categories of aircraft types (e.g., wide body jets, cargo planes, commuter aircraft, general aviation, military jets, military transports, business jets, etc.).

No data on the proposed GSE for the airport were available for the air quality assessment. Consequently the default approach in EDMS was used, whereby EDMS associated default GSE to each aircraft LTO and calculates emissions accordingly. The default values included operational time, power and load factor.

The default allocation of GSE in EDMS was used for the Stage 1 development and the longer term development. The unit emission factors for GSE are linked to the study year, and take into account future improvements in technology.

Dispersion parameters

An area source was selected as the most appropriate source type to represent the multiple sources of emissions that would be released from within each allocated 'gate' (see **Figure C-1** and **Figure C-2**).

C.4 PARKING FACILITIES

C.4.1 Description

In EDMS it is assumed that airport parking facilities generate emissions due to on-road vehicles operations and vehicle idling. The location of the carpark facilities is shown in **Figure C-1** and **Figure C-2** for each scenario.

Several airport parking facilities were included in the study:

- Stage 1 development (up to 12,500 spaces):
- A multi-level carpark comprising 4 storeys
- 3 surface carparks
- Longer term development (up to 70,000 spaces):
- A multi-level carpark comprising 4 storeys
- One surface carpark

C.4.2 Approach in EDMS

Exhaust emissions from landside road traffic in parking facilities are accounted for in EDMS through the use of the distance travelled in the facility, the speed and the idle time. Specific vehicle categories and emission factors can be defined. EDMS does not take into account so-called 'cold-start'[k] exhaust emissions.

C.4.2.1 Emissions inputs

Emissions from a given car park were calculated in EDMS for vehicles moving and idling, and were defined in terms of the following:

- The number of vehicle movements.
- The vehicle speed.
- The distance travelled (the average distance a vehicle travels between entry and exit).
- The idle duration (the time with the engine at idle between entry and exit).

The data used for each of these parameters are summarised for each car park in **Table C-2**. The projected vehicle number to use the parking facilities were calculated as art of the *Traffic Assessment*

[k] Cold-start emissions occur during the period following an engine start. Emissions are elevated during this period as the engine and exhaust-after-treatment system are not at their full operational temperatures.

(GHD, 2015). The distribution of the total vehicle number across the four carparks was based on the area of the car park as provided in the *Airport Plan* **(DIRD, 2015)**.

The speed and distance were used to determine the moving emission factors. The moving emissions and idle emissions were then combined. The emission factors were generated within EDMS using the USEPA's MOBILE 6.2 model[l].

Table C-2: Input data for parking facilities (Stage 1 development)

Parameter	Stage 1 development				Longer term development	
	Car park 1	Car park 2	Car park 3	Car park 4	Car park 1	Car park 2
Number of vehicle movements per year[(a)]	6,544,625	2,825,795	3,472,676	3,038,402	45,381,153	11,208,885
Average speed of vehicles in parking facility (km/h)	16	16	16	16	16	16
Average distance travelled in car park (m)	250[(a)]	250[(a)]	250[(a)]	250[(a)]	250[(a)]	250[(a)]
Average vehicle idle time (minutes)	1.5[(a)]	1.5[(a)]	1.5[(a)]	1.5[(a)]	1.5[(a)]	1.5[(a)]

(a) EDMS default.

Emissions are also a function of vehicle type, fuel type and year of manufacture. However, the use of a custom vehicle fleet in EDMS requires a significant amount of input data, as each vehicle type and model year must be defined separately (each as a separate parking facility). Moreover, emission factors for specific vehicle categories are not available in EDMS for years beyond 2011. Therefore, whilst it could have been assumed that most vehicles in the airport car parks would have been cars and light commercial vehicles, this assumption would have complicated the modelling disproportionately. The default vehicle mix in EDMS was therefore used for simplicity. This had the additional advantage of automatically adjusting the fleet emissions for the modelled year. The default traffic mix was the US national average fleet of vehicles for the year being modelled, and changed automatically with the study year. The default traffic mix would have included both heavy-duty and light-duty vehicles, and would therefore not have been fully representative of the vehicles using the car parks at the airport. However, the impacts of this assumption in relation to overall emissions from the airport would have been negligible.

C.4.2.2 Dispersion parameters

The parking facility height is specified in EDMS to represent the height at which emissions are released. Facilities with multiple parking levels are modelled using stacked area sources. The dispersion parameters for the parking facilities at the airport are given in **Table C-3**.

[l] MOBILE 6 is a USPEA model for estimating emissions from road vehicles. It is worth noting that t has now been replaced by MOVES as USEPA's official model for estimating emissions.

Table C-3: Dispersion parameters for parking facilities

Parking facility	Number of levels	Release height (m)
Stage 1 development		
Car park 1	4	10.5
Car park 2	1	1.5
Car park 3	1	1.5
Car park 4	1	1.5
Longer term development		
Car park 1	4	10.5
Car park 2	1	1.5

C.5 ROAD TRAFFIC

C.5.1 Description

In EDMS it is assumed that roadways generate emissions due to on-road vehicles operations and vehicle idling travelling within and outside of the project boundary.

In total, 573 roadway links were included in the study:

- The airport terminal roadways; and
- Roadways outside of the airport study boundary, extending as far north as the M4 and as far east as the M7. Future emissions from the proposed M12 roadways were also included.

C.5.2 Approach in EDMS

Exhaust emissions from landside road traffic are calculated in EDMS based on the roadway length, the volume of the traffic, the traffic mix, and the average speed. Either default or user-defined emission factors can be used. The default emission factors are calculated using the MOBILE 6.2 algorithms in conjunction with a default traffic mix (the US national average fleet) and a user-defined speed.

C.5.3 Definition of input data

C.5.3.1 Overview

EDMS requires the total annual traffic volume on each road link. The model then breaks this annual value down to determine the traffic volume in each hour of the year based on operational profiles for (i) hour of the day, (ii) day of the week and (iii) month of the year. The values in the operational profiles are all normalised to the highest value (taken to be 1).

EDMS also requires an emission factor (g/vkm) for each pollutant. For road traffic we used NSW-specific emission factors and a local traffic mix, rather than the default US values.

The derivation of total annual traffic, volume, the operational profiles, and the emission factors is described below.

C.5.3.2 Annual traffic volume

Traffic data were provided to Pacific Environment for the following conditions:

- Stage 1 development;
- Longer term development (with rail network); and
- Longer term development (without rail network).

As it is not possible for the longer term development to achieve the projected passenger numbers without the rail network the traffic scenario that does not include the rail network was disregarded.

The traffic model output included the following information:

- Total traffic volume for the following periods of an average weekday:
- AM peak (7:00 am to 9:00 am);
- In between peaks (9:00 am to 3:00 pm);
- PM peak (3:00 pm to 6:00 pm);
- Evening (6:00 pm to 7:00 am);
- Traffic speed for the above periods; and
- Numbers of cars, light duty vehicles, rigid vehicles and articulated trucks for the above periods.

C.5.3.3 Operational profiles – hour of day

Hourly traffic volumes for each road link and each hour of the day were derived as noted above. For each road link the hourly profiles were normalised to the highest value (the format required by EDMS). However, this resulted in many different profiles (573 links and 2 scenarios). This was too much information to enter into EDMS and representative profiles were identified based on the hourly traffic data provided. Seven traffic profiles were developed for Stage 1 development and five for the longer term development. As more detailed information was available for the airport terminal traffic an additional profile for each scenario was developed. The hourly profiles for the terminal traffic are shown in **Figure C-6**. In EDMS one of the three profile types was allocated to each road link.

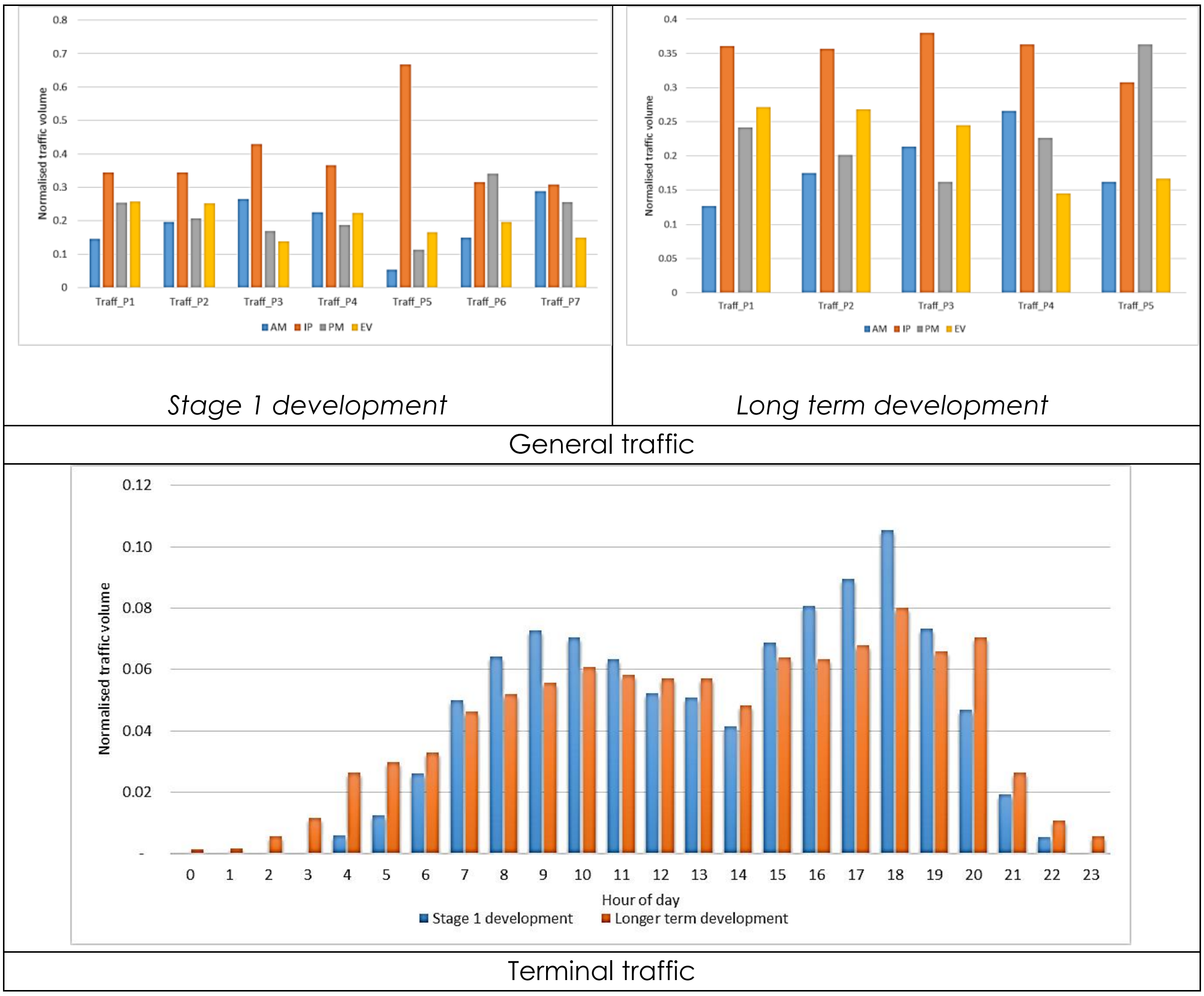


Figure C-6: Operational profile for roads – hour of day

C.5.3.4 Speed

Average hourly traffic speeds during the AM and PM peak periods were provided by the traffic model. For the terminal traffic it was assume that vehicles would travel at 20 km/hr.

C.5.3.5 Emission factors

'Hot running'[m] emissions from the road traffic were calculated using the emission factors developed by NSW Environment Protection Authority (EPA) for the latest emissions inventory for the Greater Metropolitan Region (GMR) **(NSW EPA, 2012)**. The calculation involved the use of base 'composite' emission factors for various vehicle types (CP, CD, LDCP, LDCD, HDCP, RT, AT, BusD and MC)[n], with the emission factor for each vehicle type taking into account vehicle-km travelled (VKT) by age and the associated emission factors by sub-type (such as emission standard). Five road types (residential, arterial, commercial arterial, commercial highway, highway/freeway) are specified in the emissions inventory. In the development of the emission factors, EPA has taken various real-world effects into consideration, including the deterioration in emissions performance with mileage, the effects of

[m] Hot running emissions are those that are produced once a vehicle's engine and exhaust emission-control system have reached their full operational temperatures.

[n] CP = petrol passenger vehicles; CD = diesel passenger vehicles; LDCP = light-duty commercial petrol vehicles (<=3500 kg); LDCD = light-duty commercial diesel vehicles (<=3500 kg); HDCP = heavy-duty commercial petrol vehicles (>3500kg); RT = rigid trucks (3.5-25 tonnes, diesel only); AT = articulated trucks (> 25 tonnes, diesel only); BusD = heavy public transport buses (diesel only); MC = motorcycles.

tampering or failures in emission-control systems, and the use of ethanol in petrol. For each case, the base emission factor is defined for a VKT-weighted average speed (the base speed) associated with the corresponding road type. Correction factors – in the form of 6th-order polynomial functions - are then applied to the base emission factors taking into account the actual speed on a road. It was assumed that all roads in the study were in the 'arterial'[o] category.

The emission factors from the NSW GMR inventory were only available for specific years (2008, 2011, 2016, 2021, etc.). An interpolation routine was therefore developed to determine emission factors for the nominal scenario years 2030 (Stage 1 development) and 2060 (longer term development).

Hot running emissions were calculated for CO, NO_X, PM_{10}, $PM_{2.5}$, hydrocarbons (HC)[p] and SO_2. Emissions of CO_2 were also calculated, but these were only used to estimate fuel consumption which was used, in turn to estimate SO_2 emissions based on fuel sulphur content (taken to be 10 ppm). Neither cold-start emissions nor evaporative emissions were estimated as part of the assessment. The inclusion of these would have complicated the assessment considerably, and would not have had a large impact on the results.

For each road link and pollutant the emissions were calculated for each hour of the typical weekday 24-hour period, and then an average fleet-weighted emission factor (converted to grams per vehicle-mile for input into EDMS) was determined.

C.5.3.6 Dispersion parameters

All roadways (external and terminal) were modelled as a series of area sources. It was assumed that the width of each road was 20m.

C.6 STATIONARY SOURCES – AIRCRAFT ENGINE TESTS

C.6.1 Description

All aircraft returning to service after maintenance must undergo an engine test. Engine testing may involve the operation of engines without their removal from the aircraft (known as 'ground runs') or the use of dedicated test cells.

When testing a jet engine in a test cell, the engine is removed from the aircraft and placed in a stand. Emissions from the engine are typically directed through a stack. Test cells are typically used when a jet engine is down for overhaul or major maintenance.

Engine ground running involves the running of aircraft engines while they are attached to the aircraft. An engine run may also be carried out if an engine has been in storage for a long period to ensure engine deterioration has not occurred. The testing of engines without their removal from the aircraft may involve the entire aircraft being placed into a building that serves as the test cell. Ground runs are usually conducted at idle thrust, with some excursions to medium or high power (take off) thrust should testing require it. Testing at medium and high power can generally only be sustained for a few minutes without causing potential damage or failure of the engine **(Holmes, air Sciences, 2008)**.

[o] Roads that distribute traffic within residential, commercial and industrial areas. Speed limit 50-70 km/h, 1-2 lanes. Regular intersections, mostly uncontrolled. Lower intersection delays than residential roads, but significant congestion impact at high volume:capacity ratios.
[p] Assumed to be equivalent to volatile organic compounds (VOCs).

C.6.2 Approach in EDMS

EDMS calculates emissions for engine tests based on the engine model and the time spent at 7 per cent, 30 per cent, 85 per cent and 100 per cent of the rated power.

C.6.3 Definition of input data

No information on engine testing was available for this study. Therefore engine testing was pro-rated based on the calculated emissions information published in the *Sydney Airport Master Plan* **(SACL, 2014**). The total number of aircraft tests was approximated to be 817 during Stage 1 operations and 4,796 during longer term operations.

It was assumed that all aircraft testing was undertaken within the immediate vicinity of the aircraft maintenance building.

C.7 STATIONARY SOURCES - BOILER/SPACE HEATERS

C.7.1 Description

Facilities that produce energy for airport infrastructure - such as boiler houses and heating/cooling plants - are a source of emissions through fuel combustion.

C.7.2 Approach in EDMS

EDMS calculates emissions for stationary sources from an internal database for boilers/space heaters.

C.7.3 Definition of input data

No information on boiler usage was available. It was assumed that all boilers at the airport will use natural gas. The annual consumption of natural gas by the airport is 57,000 Gj during the proposed Stage 1 and 449,000 Gj during the longer term operations. It was assumed that each building would include at least one boiler. It was assumed that there would be 16 boilers during Stage 1 and 19 during the longer term development. Emissions from the total gas consumption were evenly split across assumed number of boilers.

Table C-4 shows the dispersion parameters used for boilers (treated as point sources).

Table C-4: Dispersion parameters for boilers

Source	Source type	Relative height (m)	Diameter (m)	Gas velocity (m/s)	Temperature
Boilers	Point	20	0.1	15	400 F

C.8 STATIONARY SOURCES - EMERGENCY GENERATORS

C.8.1 Description

Generators are used for emergency power generation for buildings or runway lights during power outages.

C.8.2 Approach in EDMS

EDMS calculates emissions for stationary sources from an internal database for emergency generators.

C.8.3 Definition of input data

No information on the use of generators at the airport was available for this study. Therefore it was assumed that each building would include an emergency generator and would operate for 1 hour per month as part of routine maintenance. Each emergency generator was assumed to use 233L per hour of diesel fuel.

An emergency generator was located at each building. **Table C-5** shows the dispersion parameters used for generators.

Table C-5: Dispersion parameters for generators

Source	Source type	Relative height (m)	Diameter (m)	Gas velocity (m/s)	Temperature
Generators	Point	5	0.1	15	400 F

C.9 STATIONARY SOURCES - FUEL TANKS

C.9.1 Description

Evaporation from fuel storage tanks, trucks and pipelines at airports is a source of VOCs, including specific air toxics such as benzene, toluene and xylenes. Emissions occur as a result of tank standing losses and working losses. Standing loss is the expulsion of vapour from a tank through vapour expansion and contraction resulting from changes in temperature and barometric pressure. This loss occurs without any liquid level change in the tank. The combined loss from filling and emptying is called working loss. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space **(USEPA, 1995)**.

At major airports, fuel companies typically operate systems that involve the reticulation of aviation fuel[q] via underground pipelines from a so-called 'Joint User Hydrant Installation' (JUHI). Aviation fuel is distributed from the JUHI storage facility to apron hydrant outlets located adjacent to aircraft gates. Into-plane dispensing is undertaken directly by the fuel companies. Specialist hydrant refuelling vehicles are used for this task. Bulk tanker vehicles are used for the fuelling of regional, general aviation (GA) aircraft and helicopters where hydrant access is not available **(SACL, 2009)**.

The primary storage of jet fuel will be at the fuel farm located to the north of the site boundary (see **Figure C-1**). Fuel will be distributed via a purpose built underground pipeline grid served from the on-site fuel farm. There will also be a number of diesel and petroleum fuel storage tanks located across the airport, such as at the ARFFs and airport maintenance areas.

[q] Commonly known as AVTUR, Aviation Jet Fuel A-1, or Aviation kerosene.

C.9.2 Approach in EDMS

EDMS calculates emissions for stationary sources from an internal database for fuel tanks.

C.9.3 Definition of input data

EDMS uses a simplified version of the USEPA TANKS software to calculate VOC emissions from fuel tanks. Information on fuel throughput was only available for Jet-A1. The diesel and petroleum fuel throughputs were based on the fuel consumptions rates of the on-site GSE for each investigation scenario. Details of the airport fuel tanks are presented in **Table C-6**.

Table C-6: Fuel tanks

Fuel tank	Tank type	Stage 1 fuel throughput (KL)	Longer term throughput (KL)
Jet fuel			
Fuel farm	Horizontal fixed roof	985,500	8,030,000
ARFF1	Horizontal fixed roof	5,682	16,687
ARFF2	Horizontal fixed roof	n/a	16,687
Diesel			
Fuel farm	Horizontal fixed roof	3,872	7,570
Refueler stand and GSE storage	Horizontal fixed roof	726	1,419
Aircraft maintenance	Horizontal fixed roof	121	237
ARFF	Horizontal fixed roof	121	237
Petroleum			
Fuel farm	Horizontal fixed roof	0	10,327
Refueler stand and GSE storage	Horizontal fixed roof	0	2,259
Aircraft maintenance	Horizontal fixed roof	0	323

The locations of each fuel tank is shown in **Figure C-1** and **C2**. The JUHI storage facility is located at the northern end of the airport. **Table C-7** shows the dispersion parameters used for fuel tanks.

Table C-7: Dispersion parameters for fuel tanks

Source	Source type	Relative height (m)	Diameter (m)	Gas velocity (m/s)	Temperature
Fuel tanks	Volume	20	1	15	Ambient

C.10 STATIONARY SOURCES - SURFACE COATING/PAINTING

C.10.1 Description

Airport maintenance facilities at most large airports are typically operated by commercial airlines or other services that perform scheduled aircraft inspections and repairs on the aircraft fuselage, engines and other apparatus. A variety of surface treatment, coating and painting operations may also occur.

Volatile organic compounds (VOCs) are emitted to the atmosphere during surface treating, coating and painting operations mainly as a result of evaporation and/or over-spray of the materials used **(DEWHA, 2008)**.

C.10.2 Approach in EDMS

EDMS calculates emissions for stationary sources from an internal database for surface coating/painting.

C.10.3 Definition of input data

Information on paints and solvents at the airport were not available for this study. Therefore paint and solvent usage was pro-rated based on the calculated emissions information published in the Sydney Airport Master Plan **(SACL, 2014)**. The total volume of paints and solvents was approximated to be 16.1 kl during Stage 1 operations and 94.3 kl during longer term operations.

Table C-8 shows the dispersion parameters used for stationary sources (all sources were treated as point sources).

Table C-8: Dispersion parameters for surface coating/painting

Source	Source type	Relative height (m)	Diameter (m)	Gas velocity (m/s)	Temperature
Surface coating/painting	Volume	20	1	15	Ambient

C.11 TRAINING FIRES

C.11.1 Description

Airservices Australia is responsible for the provision of safe and environmentally sound air traffic management and related services to aircraft operators in Australia under the *Air Services Act 1995*. This responsibility includes the provision of Aviation Rescue and Fire Fighting (ARFF) services at major airports. Regular training activities for fire rescue are undertaken to ensure firefighting crews are fully prepared. Fire training facilities are distinguished by the type of fuel burned in the simulations. Internationally, the most commonly used fuels are propane, AVTUR (kerosene), diesel and petrol. Airservices Australia currently primarily uses AVTUR for aircraft fire simulations, and burn times are generally limited to less than three minutes. The air pollutants generated from the burning training fires include PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO and VOCs. Pollution-control systems are generally in place to separate effluent residue from the firefighting activity from the unburned fuel which is captured and reused **(DEWHA, 2008)**.

C.11.2 Approach in EDMS

EDMS calculates emissions from training fires based on an internal database. Input information includes the fuel type and annual number of training fires completed annually.

EDMS does not contain emission factors for Jet A-1 fuel. However, it does contain emission factors for JP-8, which is the military equivalent of Jet A-1[r]. It was therefore assumed that the JP-8 emission factors would be representative of Jet A-1. There are also no emission factors in EDMS for the open burning of

[r] http://www.csgnetwork.com/jetfuel.html

petrol. In this case the EDMS emission factors for JP-4 fuel were used (JP-4 is a 50-50 kerosene-petrol blend).

C.11.3 Definition of input data

Information on training fires at the airport were not available for this study. Therefore the volume of fuel consumed by the airport was pro-rated based on the calculated emissions information published in the *Sydney Airport Master Plan* **(SACL, 2014)**. The total volume of fuel consumed during training fires was calculated to be 5,682 L during Stage 1 operations and 33,373 L during the longer term operations.

There is one allocated training fire area located at ARFF1 (northern end of airport site). For air pollutant dispersion, training fires were treated a point sources and the default parameters in EDMS for were used. The dispersion parameters for training fires are shown in **Table C-9**.

Table C-9: Dispersion parameters for training fires

Source	Source type	Relative height (m)	Diameter (m)	Gas velocity (m/s)	Temperature
Training fires	Point	4	5	10	204°C

C.12 WASTE WATER TREATMENT PLANT

C.12.1 Definition of input data

It was assumed the waste water treatment plant was an 'extended aeration plant'. Data was drawn from Haas & Lant (2009) in order to find an approximate GHG emission. This treatment plant was assumed to have 100% throughput of potable water (3.5ML/day) and recycled water (1.8ML/day) for 2030.

C.13 CONSTRUCTION

The following sections provide the detailed information that was used for input to AERMOD for modelling construction.

C.13.1 Source parameters

Dust generating activities during construction were represented by a series of volume sources situated according to the location of activities. The vertical height was set to 2m with a horizontal spread of 10m.

C.13.2 Bulk earthworks

C.13.2.1 Assumptions

The following assumptions were adopted in the inventory:

- Haul roads to lengths to be estimated from maps
- Assumed soil will be artificially moist through use of water cart
- Wind Erosion (East) - Assumed that 40% of the area would be exposed at any one time. Assumed 50% control through regular watering
- Wind Erosion (North) - Assumed that 50% of the area would be exposed at any one time. Assumed 50% control through regular watering
- Wind Erosion (Northwest) - Assumed that 50% of the area would be exposed at any one time. Assumed 50% control through regular watering
- Wind Erosion (southwest) - Assumed that 50% of the area would be exposed at any one time. Assumed 50% control through regular watering
- 1 grader operating 70% of operating hours at 8 km/hr. Grader speed has been assumed.

C.13.2.2 Inventory

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Emission Factor Source
Dozer (7 load and haul groups)	54126	26208	h/y	2.07	kg/hr	10	Silt content	10	moisture content							0	% control	AP 42 11.9 Table 11.9-2
Loading East (cut)	913	16,848,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading East (fill)	913	16,848,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading North (cut)	104	1,920,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading North (fill)	104	1,920,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Northwest (cut)	130	2,400,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Northwest (fill)	221	4,080,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Southwest (cut)	115	2,112,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading South (fill)	109	2,016,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in	10	moisture content in %							0	% control	Ap 42 13.2.4
Hauling unpaved East	177,340	16,848,000	t/y	0.04210	kg/t	50	t/load	60	Vehicle gross mass (t	1	km/return tri	2.1052	kg/VKT	3	% silt conter	75	% control	AP 42 13.2.2
Hauling unpaved North	10,105	1,920,000	t/y	0.02105	kg/t	50	t/load	60	Vehicle gross mass (t	0.5	km/return tri	2.1052	kg/VKT	3	% silt conter	75	% control	AP 42 13.2.2
Hauling unpaved Northwest	21,473	4,080,000	t/y	0.02105	kg/t	50	t/load	60	Vehicle gross mass (t	0.5	km/return tri	2.1052	kg/VKT	3	% silt conter	75	% control	AP 42 13.2.2
Hauling unpaved Northwest	11,115	2,112,000	t/y	0.02105	kg/t	50	t/load	60	Vehicle gross mass (t	0.5	km/return tri	2.1052	kg/VKT	3	% silt conter	75	% control	AP 42 13.2.2
Scraper loading topsoil for rehabilitation	60,448	4,168,800	t/yr	0.029	kg/t											50	% control	NPI EET for Mining S1.1.5
Scraper transporting topsoil for rehabilitation	31157	4,168,800	t/y	0.02990	kg/t	47	t/load	115	Vehicle gross mass (t	0.5	km/return tri	2.8206	kg/VKT	3	% silt conter	75	% control	AP 42 13.2.2
Wind Erosion (East)	124849	306	ha	0.10	kg/ha/h	8160	h/y									50	% control	AP 42 13.2.5
Wind Erosion (North)	846	28.2	ha	0.10	kg/ha/h	600	h/y									50	% control	AP 42 13.2.5
Wind Erosion (Northwest)	1383	46.1	ha	0.10	kg/ha/h	600	h/y									50	% control	AP 42 13.2.5
Wind Erosion (southwest)	4036	56.1	ha	0.10	kg/ha/h	1440	h/y									50	% control	AP 42 13.2.5
Grading roads	45623	209,664	km	0.2	kg/VKT	8	speed of graders in km/h	26208	Hours per year									AP 42 11.9 Table 11.9-2
Total (kg/y)	**545,111**																	

ACTIVITY	PM10 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Emission Factor Source
Dozer (7 load and haul groups)	17648	26208	h/y	0.67	kg/hr	10	Silt content	10	moisture content							0	% control	AP 42 11.9 Table 11.9-2
Loading East (cut)	432	16,848,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading East (fill)	432	16,848,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading North (cut)	49	1,920,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading North (fill)	49	1,920,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Northwest (cut)	62	2,400,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Northwest (fill)	105	4,080,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading Southwest (cut)	54	2,112,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Loading South (fill)	52	2,016,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in r	10	moisture content in %							0	% control	Ap 42 13.2.4
Hauling unpaved East	54,288	16,848,000	t/y	0.01289	kg/t	50	t/load	60	Vehicle gross mass (t)	1	km/return	0.644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Hauling unpaved North	3,093	1,920,000	t/y	0.00644	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Hauling unpaved Northwest	6,573	4,080,000	t/y	0.00644	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Hauling unpaved Northwest	3,403	2,112,000	t/y	0.00644	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Scraper loading topsoil for rehabilitation	31,433	4,168,800	t/yr	0.015	kg/t											50	% control	NPI EET for Mining S1.1.5
Scraper transporting topsoil for rehabilita	9538	4,168,800	t/y	0.009152	kg/t	47	t/load	115	Vehicle gross mass (t)	0.5	km/return	0.863462	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Wind Erosion (East)	62425	306	ha	0.05	kg/ha/h	8160	h/y									50	% control	AP 42 13.2.5
Wind Erosion (North)	423	28.2	ha	0.05	kg/ha/h	600	h/y									50	% control	AP 42 13.2.5
Wind Erosion (Northwest)	691	46.1	ha	0.05	kg/ha/h	600	h/y									50	% control	AP 42 13.2.5
Wind Erosion (southwest)	2018	56.1	ha	0.05	kg/ha/h	1440	h/y									50	% control	AP 42 13.2.5
Grading roads	45086	209,664	km	0.2	kg/VKT	8	speed of graders in km/h	26208	Hours per year									AP 42 11.9 Table 11.9-2
Total (kg/y)	**237,854**																	

ACTIVITY	PM2.5 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Source type	Emission Factor Source
Dozers	5683	26208	h/y	0.22	kg/hr	10	Silt content	10	moisture content							0	% control	1	AP 42 11.9 Table 11.9-2
Loading East (cut)	65	16,848,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading East (fill)	65	16,848,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading North (cut)	7	1,920,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading North (fill)	7	1,920,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading Northwest (cut)	9	2,400,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading Northwest (fill)	16	4,080,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading Southwest (cut)	8	2,112,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Loading South (fill)	8	2,016,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Hauling unpaved East	5,429	16,848,000	t/y	0.00129	kg/t	50	t/load	60	Vehicle gross mass (t)	1	km/return	0.064444	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Hauling unpaved North	309	1,920,000	t/y	0.00064	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.064444	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Hauling unpaved Northwest	657	4,080,000	t/y	0.00064	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.064444	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Hauling unpaved Northwest	340	2,112,000	t/y	0.00064	kg/t	50	t/load	60	Vehicle gross mass (t)	0.5	km/return	0.064444	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Scraper loading topsoil for rehabilitation	1,813	4,168,800	t/yr	0.001	kg/t											50	% control	1	NPI EET for Mining S1.1.5
Scraper transporting topsoil for rehabilitation	954	4,168,800	t/y	0.000915	kg/t	47	t/load	115	Vehicle gross mass (t)	0.5	km/return	0.086346	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Wind Erosion (East)	9364	306	ha	0.01	kg/ha/h	8160	h/y									50	% control	3	AP 42 13.2.5
Wind Erosion (North)	63	28.2	ha	0.01	kg/ha/h	600	h/y									50	% control	3	AP 42 13.2.5
Wind Erosion (Northwest)	104	46.1	ha	0.01	kg/ha/h	600	h/y									50	% control	3	AP 42 13.2.5
Wind Erosion (southwest)	303	56.1	ha	0.01	kg/ha/h	1440	h/y									50	% control	3	AP 42 13.2.5
Grading roads	4000	209,664	km	0.02	kg/VKT	8	speed of graders in km/h	26208	Hours per year									1	AP 42 11.9 Table 11.9-2
Total (kg/y)	**29,207**																		

C.13.3 Aviation infrastructure

C.13.3.1 Assumptions

The following assumptions were adopted in the inventory:

- Haul roads to lengths to be estimated from maps
- Assumed that 40% of the area would be exposed at any one time. Assumed 50% control through regular watering
- 1 grader operating 70% of operating hours at 8 km/hr. Grader speed has been assumed.

C.13.3.2 Inventory

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Source type	Emission Factor Source
Dozer (7 load and haul groups)	23197	11232	h/y	2.07	kg/hr	10	Silt content	10	moisture content							0	% control	1	AP 42 11.9 Table 11.9-2
Loading subgrade	96	1,768,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Unloading subgrade	96	1,768,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Unloading unbound gravel	163	3,000,000	t/y	0.00005	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	2	Ap 42 13.2.4
Hauling subgrade	37,220	1,768,000	t/y	0.08421	kg/t	50	t/load	60	Vehicle gross mass (t)	2	km/return trip	2.1051766	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Hauling gravel	150,370	3,000,000	t/y	0.20049	kg/t	42	t/load	60	Vehicle gross mass (t)	4	km/return trip	2.1051766	kg/VKT	3	% silt content	75	% control	1	AP 42 13.2.2
Wind Erosion of subgrade area	28854	71	ha	0.10	kg/ha/h	8160	h/y									50	% control	3	AP 42 13.2.5
Grading roads	13035	59,904	km	0.2	kg/VKT	8	speed of graders in km/h	7488	Hours per year									1	AP 42 11.9 Table 11.9-2
Total (kg/y)	**253,029**																		

ACTIVITY	PM 10emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Emission Factor Source
Dozer (7 load and haul groups)	7564	11232	h/y	0.67	kg/hr	10	Silt content	10	moisture content							0	% control	AP 42 11.9 Table 11.9-2
Loading subgrade	45	1,768,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Unloading subgrade	45	1,768,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Unloading unbound gravel	77	3,000,000	t/y	0.00003	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Hauling subgrade	11,394	1,768,000	t/y	0.02578	kg/t	50	t/load	60	Vehicle gross mass (t)	2	km/return trip	0.6444418	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Hauling gravel	46,032	3,000,000	t/y	0.06138	kg/t	42	t/load	60	Vehicle gross mass (t)	4	km/return trip	0.6444418	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Wind Erosion of subgrade area	14427	71	ha	0.05	kg/ha/h	8160	h/y									50	% control	AP 42 13.2.5
Grading roads	12882	59,904	km	0.2	kg/VKT	8	speed of graders in km/h	7488	Hours per year									AP 42 11.9 Table 11.9-2
Total (kg/y)	**92,465**																	

ACTIVITY	PM2.5 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Emission Factor Source
Dozers	2436	11232	h/y	0.22	kg/hr	10	Silt content	10	moisture content							0	% control	AP 42 11.9 Table 11.9-2
Loading subgrade	7	1,768,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Unloading subgrade	7	1,768,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Unloading unbound gravel	12	3,000,000	t/y	0.00000	kg/t	1.15	average of (wind speed/2.2)^1.3 in m/s	10	moisture content in %							0	% control	Ap 42 13.2.4
Hauling subgrade	1,139	1,768,000	t/y	0.00258	kg/t	50	t/load	60	Vehicle gross mass (t)	2	km/return trip	0.0644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Hauling gravel	4,603	3,000,000	t/y	0.00614	kg/t	42	t/load	60	Vehicle gross mass (t)	4	km/return trip	0.0644442	kg/VKT	3	% silt content	75	% control	AP 42 13.2.2
Wind Erosion of subgrade area	2164	71	ha	0.01	kg/ha/h	8160	h/y									50	% control	AP 42 13.2.5
Grading roads	1143	59,904	km	0.02	kg/VKT	8	speed of graders in km/h	7488	Hours per year									AP 42 11.9 Table 11.9-2
Total (kg/y)	**11,511**																	

C.13.4 Concrete batching

C.13.4.1 Assumptions

The following assumptions were adopted in the inventory:

- Heavy duty vehicles travel at 10 km/hr

C.13.4.2 Inventory

Activity - Annual Average	TSP Emission (k	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units			Source
Movement of delivery trucks onsite	6641	7488	trucks/year	0.887	kg/VKT	39.086957	payload (tonnes)	53.1	Gross vehicle mass (tonnes)	1	km/ return trip	0.887	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.2
Movement cement trucks onsite	53294	11339	trucks/year	0.783	kg/VKT	28	payload (tonnes)	47	Gross vehicle mass (tonnes)	6	km/ return trip	0.783	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.2
Vehicle exhaust	0	18827	trucks/year	0.000	g/vehle/km	2	Average trip distance (km)											PIARC (2012)
Unloading to aggregate storage bins	399	292683	t/y	0.001	kg/t	1.1501816	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									Ap 42 13.2.4
Residual from de-dusted air loading cement and fly-ash	0	317491	t/y	0.050	g/Nm3	34	Nm3/minute	1	minutes/tonne	28	t/truck	11339	truck/y					Ap 42 11.12
Wind erosion	88	0.1	ha	0.100	kg/ha/h	8760	h/y											AP 42 13.2.5
Total	60421																	

Activity - Annual Average	PM10 Emission (	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units			Source
Movement of delivery trucks onsite	1275	7488	trucks/year	0.170	kg/VKT	39.086957	payload (tonnes)	53.1	Gross vehicle mass (tonnes)	1	km/ return trip	0.170	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.
Movement cement trucks onsite	10230	11339	trucks/year	0.150	kg/VKT	28	payload (tonnes)	47	Gross vehicle mass (tonnes)	6	km/ return trip	0.150	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.
Vehicle exhaust	156	18827	trucks/year	0.004	g/vehle/km	2	Average trip distance (km)											PIARC (201
Unloading to aggregate storage bins	203	292683	t/y	0.001	kg/t	1.1501816	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									Ap 42 13.2
Residual from de-dusted air loading cement and fly-ash	540	317491	t/y	0.050	g/Nm3	34	Nm3/minute	1	minutes/tonne	28	t/truck	11339	truck/y					Ap 42 11.1
Wind erosion	45	0.1	ha	0.100	kg/ha/h	8760	h/y											AP 42 13.2.
Total	12448																	

Activity - Annual Average	PM2.5 Emission	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units			Source
Movement of delivery trucks onsite	308	7488	trucks/year	0.041	kg/VKT	39.086957	payload (tonnes)	53.1	Gross vehicle mass (tonnes)	1	km/ return trip	0.041	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.
Movement cement trucks onsite	2475	11339	trucks/year	0.036	kg/VKT	28	payload (tonnes)	47	Gross vehicle mass (tonnes)	6	km/ return trip	0.036	kg/VKT	5	g/m2 silt loading	50	%control	AP 42 13.2.
Vehicle exhaust	131	18827	trucks/year	0.003	g/vehle/km	2	Average trip distance (km)											PIARC (201
Unloading to aggregate storage bins	52	292683	t/y	0.001	kg/t	1.1501816	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									Ap 42 13.2
Residual from de-dusted air loading cement and fly-ash	30	317491	t/y	0.050	g/Nm3	34	Nm3/minute	1	minutes/tonne	28	t/truck	11339	truck/y					Ap 42 11.1
Wind erosion	11	0.1	ha	0.100	kg/ha/h	8760	h/y											AP 42 13.2.
Total	3007																	

C.13.5 Asphalt plant

C.13.5.1 Assumptions

Reference: Project description						
Site Size	40000	m2				
Total throughput	356000	tonnes over 48 months	1300	Tonnes/day	130	6am - 6pm Mo
Typical hours	6am - 6pm Monda	550 days in total				
Truck movements					delivery truck capacity	
Aggregate trucks	6240	trips/year	20	trips/day	42	
Sand trucks	624	trips/year	2	trips/day	42	
Crusher dust trucks	2184	trips/year	7	trips/day	42	
Lime filter trucks	312	trips/year	1	trips/day	32	
Bitumen	624	trips/year	2	trips/day	32	
Asphalt	14486	trips/year	46	trips/day	28	
Equivalent trucks for diesel modelling	2039		7	trucks per day		
Truck Weights						
Delivery trucks	41	average tonnes				
Asphalt trucks	28	average tonnes				
Site data, Reference: Assumptions						
Average wind speed - Badgerys Creek 2014	2.45	m2	1.15018162	average of (wind speed/2.2)^1.3 in m/s		
Percentage ws greater than 5.4 m/s	6.48	% time ws>5.4 m/s				
Area of raw aggregate	100	m2	0.01	Ha	Assumed	
Area of raw sand	100	m2	0.01	Ha	Assumed	
Area of raw crusher dust	100	m2	0.01	Ha	Assumed	
Area of lime filler	100	m2	0.01	Ha	Assumed	
Area of bitumen	100	m2	0.01	Ha	Assumed	
Area of raw aggregate material stockpile TOTAL	500	m2	0.05	Ha	Assumed	

C.13.5.2 Inventory

PM10	Activity		Emissions (kg/year)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	src type	Emission Factor Source		
	Wind erosion from raw material stockpiles	WE1/WE2	87.60	0.05	ha	0.200000	kg/ha/year	8760	h/y					0	% control	3	SPCC, 1983		
	Loading aggregate to material stockpiles	ID3	129.98	356,000	t/y	0.000365	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Loading aggregate to conveyors using FEL	ID4	129.98	356,000	t/y	0.000365	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Conveying / aggregate transfer	ID5	129.98	356,000	t/y	0.000365	kg/t	1.15	average c	3.00	moisture content in %			0	% control	3	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Oil-fired dryer	STCK1	4094.00	356,000	t/y	0.011500	kg/t							0	% control	1	AP-42 11.1-1 Hot Mix Asphalt Plants		
	Mixer and sorting in Mixer	ID7	4806.00	356,000	t/y	0.013500	kg/t							0	% control	1	AP 42 11.1-1 Hot Mix Asphalt Plants		
	Product Load Out	ID9	129.98	356,000	t/y	0.000365	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Delivery trucks		799.51	9,984	VKT	0.160158	kg/VKT	41	payload (	50.00	Gross vehicle mass (tor	1.00	km/trip	0	kg/VKT	5	g/m2 silt loading	50	% control
	Asphalt trucks		5119.50	14,486	VKT	0.117806	kg/VKT	28	payload (	37.00	Gross vehicle mass (tor	6.00	km/trip	0	kg/VKT	5	g/m2 silt loading	50	% control
	TOTAL		15426.53																

TSP	Activity		Emissions (kg/year)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	src type	Emission Factor Source		
	WE - Raw material stockpiles	WE1/WE2	175.20	0.05	ha	0.400000	kg/ha/year	8760	h/y					0	% control	3	SPCC, 1983		
	Loading Aggregate to material stockpiles	ID3	274.81	356,000	t/y	0.000772	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Loading aggregate to conveyors using FEL	ID4	274.81	356,000	t/y	0.000772	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Conveying / aggregate transfer	ID5	274.81	356,000	t/y	0.000772	kg/t	1.15	average c	3.00	moisture content in %			0	% control	3	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Oil-fired dryer	STCK1	5874.00	356,000	t/y	0.016500	kg/t							0	% control	1	AP-42 11.1-1 Hot Mix Asphalt Plants		
	Mixer and sorting in Mixer	ID7	7476.00	356,000	t/y	0.021000	kg/t							0	% control	1	AP 42 11.1-1 Hot Mix Asphalt Plants		
	Product Load Out	ID9	274.81	356,000	t/y	0.000772	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Truck movement on paved roads - entry		4165.19	9,984	VKT	0.834373	kg/VKT	41	payload (	50.00	Gross vehicle mass (tor	1.00	km/trip	1	kg/VKT	5	g/m2 silt loading	50	% control
	Truck movement on paved roads - exit (tarped)		26670.92	14,486	VKT	0.613729	kg/VKT	28	payload (	37.00	Gross vehicle mass (tor	6.00	km/trip	1	kg/VKT	5	g/m2 silt loading	50	% control
	TOTAL		45460.57																

PM2.5	Activity		Emissions (kg/year)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	src type	Emission Factor Source		
	WE - Raw material stockpiles	WE1/WE2	13.14	0.05	ha	0.030000	kg/ha/year	8760	h/y					0	% control	3	SPCC, 1983		
	Loading Aggregate to material stockpiles	ID3	19.68	356,000	t/y	0.000055	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Loading aggregate to conveyors using FEL	ID4	19.68	356,000	t/y	0.000055	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Conveying / aggregate transfer	ID5	19.68	356,000	t/y	0.000055	kg/t	1.15	average c	3.00	moisture content in %			0	% control	3	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Oil-fired dryer	STCK1	176.22	356,000	t/y	0.000495	kg/t							0	% control	1	AP-42 11.1-1 Hot Mix Asphalt Plants		
	Mixer and sorting in Mixer	ID7	224.28	356,000	t/y	0.000630	kg/t							0	% control	1	AP 42 11.1-1 Hot Mix Asphalt Plants		
	Product Load Out	ID9	19.68	356,000	t/y	0.000055	kg/t	1.15	average c	3.00	moisture content in %			0	% control	2	AP-42 13.2.4 Aggregate handling and Storage Piles		
	Truck movement on paved roads - entry		193.43	9,984	VKT	0.038748	kg/VKT	41	payload (	50.00	Gross vehicle mass (tor	1.00	km/trip	0	kg/VKT	5	g/m2 silt loading	50	% control
	Truck movement on paved roads - exit (tarped)		1238.59	14,486	VKT	0.028501	kg/VKT	28	payload (	37.00	Gross vehicle mass (tor	6.00	km/trip	0	kg/VKT	5	g/m2 silt loading	50	% control
	TOTAL		1924.39																

Appendix D DISPERSION MODEL INPUTS

D.1 DISPERSION MODEL

D.1.1 AERMOD technical overview

AERMOD is a steady-state plume model that assumes a Gaussian concentration distribution in both the horizontal and vertical directions in the stable boundary layer. In the convective boundary layer, dispersion is Gaussian in the horizontal direction, with the vertical direction being modelled by a bi-Gaussian probability density function **(CSSI, 2013)**. Whilst all mathematical models of airborne pollutant dispersion are simplifications of reality, for most practical purposes steady-state models such as AERMOD provide useful and adequate indications of ground level concentrations.

AERMOD is capable of simulating the effects of multiple sources. For dispersion modelling purposes each source is assigned one of three categories.

- Point sources, which cover stationary sources such as power plant and training fires. Point source emission rates are generally given in grams per second (g/s).
- Area sources, which are defined as an area with a uniform rate of emission. Aircraft movements and on-road vehicle operations are considered to be a series of area sources, since their movement along a path approximates a line of continuous emissions. Parking facilities are also categorised as area sources. In the case of a multi-level parking facility, area sources are stacked at a defined increment to characterise the structure. Area source emission rates are generally given in grams per second per square metre ($g/s/m^2$).
- Volume sources. The activity at gates are considered to be volume sources when the emissions from start-up, GSE and APUs are estimated to originate from a single point of discharge, and area sources when multiple points are used to model the gate. The latter case is typically used when a terminal or part of a terminal is represented as an EDMS gate.

The effects of these different sources can be integrated in AERMOD over a long time period or evaluated for short-term maximum impacts (as short as one hour[s]). Calculations are performed at receptor points, which may number from one up to many hundreds, depending on requirements and program limitations.

D.1.2 Meteorological data and land use

The Bureau of Meteorology's (BoM) operates an Automatic Weather Station (AWS) at Badgerys Creek. The Badgerys Creek AWS collects hourly readings of wind speed, wind direction, temperature, relative humidity, precipitation and sea level pressure. Cloud amount and ceiling height is not recorded at Badgerys Creek and therefore the readings from the next closest station that measures cloud data at Camden Airport were used for this assessment.

Data were obtained from the Badgerys Creek AWS for the years between 2010 and 2014. The data were used both to illustrate the meteorological conditions at the site, and to determine an appropriate meteorological year for dispersion modelling.

A review of the local meteorology between 2010 and 2014 is provided in **Section 4**.

When choosing a representative meteorological year for dispersion modelling, all six full years (2010 to 2014) were analysed. All years are similar in pattern, percentage of calms and average wind speed. The use of the most recently available full year of data in 2014 was therefore considered to be suitable for the dispersion modelling.

[s] Whilst AERMOD operates on a one-hour time base, for calculating emissions EDMS uses 15-minute intervals to provide a better representation of aircraft movements.

D.1.2.1 Data processing

The basic meteorological parameters required for input to AERMOD are:

- Air temperature;
- Wind speed;
- Wind direction;
- Surface characteristics (i.e. roughness);
- Stability characteristics (i.e. Monin-Obukhov Length); and
- Mixing height.

Air temperature is important in determining the buoyancy of (heated) plumes emitted into the atmosphere. Buoyancy affects the extent of plume rise, with more buoyant plumes tending to rise higher above the ground, thus reducing the ground level impact. Wind speed has two main effects on plume dispersion. Firstly, it influences the initial dilution of the plume as it leaves the source. Greater wind speeds result in greater plume dilution - plume concentration is inversely proportional to the wind speed. Secondly, wind speed affects plume rise, with higher wind speeds reducing its extent. Wind direction affects the direction in which the plume travels. Only points downwind and within the lateral bounds of the plume are affected at any given time. The atmospheric stability is related to the degree of turbulence or mixing in the region of the atmosphere relevant to plume dispersion. The degree of mixing affects the rate of plume dilution by determining the rate of lateral and vertical spread of the plume. Traditionally, stability class has been defined under the Pasquill-Gifford scheme through designation of a letter from A to F, ranging from highly unstable to strongly stable. Unstable conditions are associated with strong turbulence and mixing, and are most strongly developed on sunny days with light winds. Strongly stable conditions are associated with very limited plume mixing and are most developed on calm clear nights and into the early hours after sunrise. Such conditions are common during winter. Neutral stability conditions, between stable and unstable and designated class D, occur most often during windy and/or cloudy weather. AERMOD uses a continuous representation of stability through the Monin-Obukhov length.

However, the above meteorological data requirements cannot be directly met through the observations. The data were therefore run through a pre-processor to ensure that they were in the correct format for use in AERMOD. The meteorological parameters used in the dispersion analysis were generated using AERMET, a USEPA-approved meteorological processor **(USEPA, 2004b).**

In applying the AERMET meteorological processor to prepare the meteorological data for the AERMOD model appropriate values for three surface characteristics needed to be determined:

- Surface roughness length;
- Albedo; and
- Bowen ratio.

The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer.

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

Aerial photographs were used to inform the designation of land use and associated effective surface roughness on a sector-by-sector basis around the airport site. Values of Bowen ratio and albedo were determined using land use type over a greater domain again centred over the Badgerys Creek AWS as recommended **(USEPA, 2004b).** Reference was made to the AERMET user's guide **(USEPA, 2004b)** in assigning surface roughness, Bowen ratio and albedo values to designated land cover categories. The designated land use types are shown in **Figure D-3**.

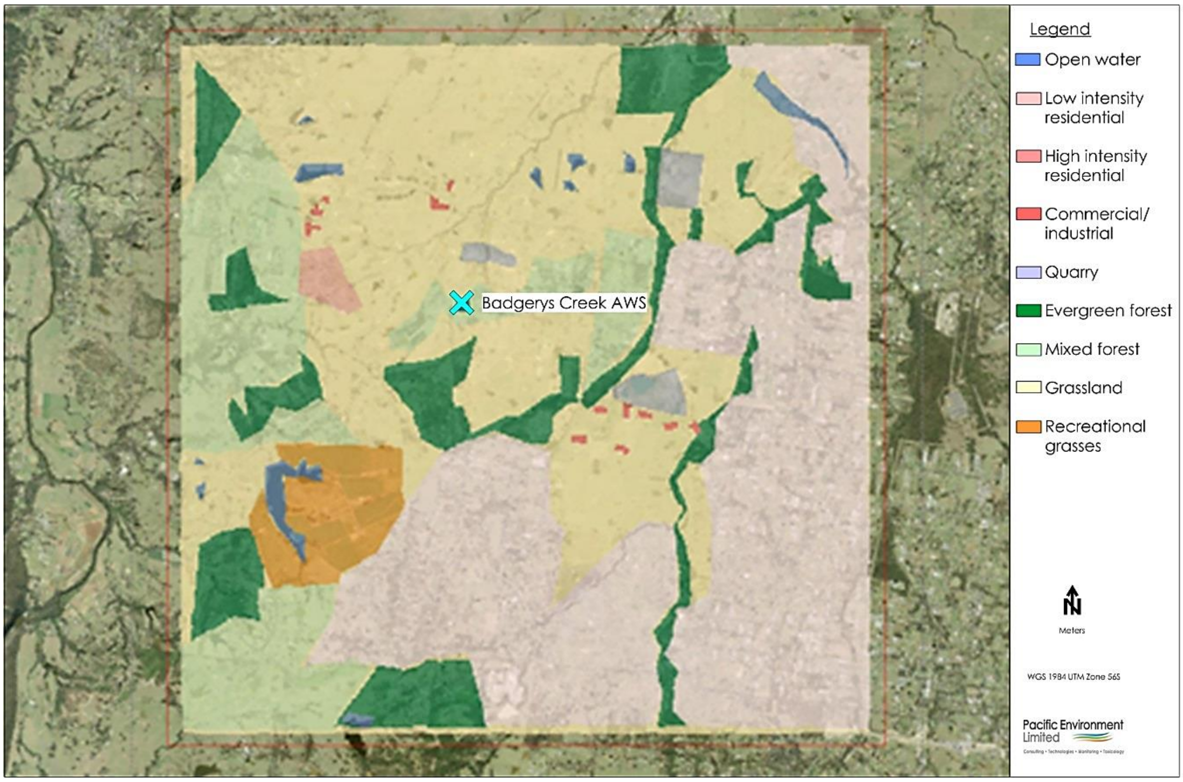


Figure D-3: Summary of land-use characteristics adopted within AERMET

AERMET calculates planetary boundary layer parameters, including: friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height and surface heat flux. These parameters are used, in conjunction with measurements, to calculate vertical profiles of wind speed, lateral and vertical turbulent fluctuations, potential temperature gradient and potential temperature.

The surface data and profile files from AERMET was used for input into AERMOD **(USEPA, 2004b)**. The profile file was generated using the upper air estimator tool as no hourly observational upper air data were available for the site.

D.1.3 Atmospheric stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). The EDMS default value of 3,000 feet was used in this study. Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface, and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (**Seinfeld and Pandis 2006**). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

Figure D-2 shows the hourly averaged 1/L for the Project site computed from all data in the AERMET surface file. Based on **Table D-1** this plot indicates that the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

Table D-1: Inverse of the Monin-Obukhov length L with respect to Atmospheric stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

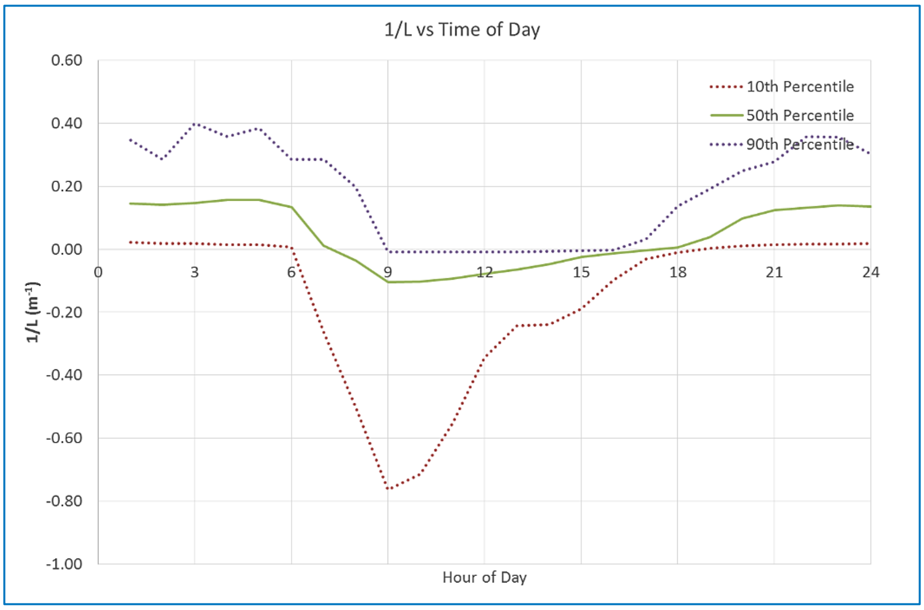


Figure D-2: Annual statistics of 1/L by hour of the day

Figure D-3 shows the variations in stability over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by **Golder (1972)** set out in **NSW DEC (2005).** Note that the reference to stability categories here is only for convenience in describing stability. The model uses calculated values of L across a continuum. **Figure D-3** shows that stable and very stable conditions occur for about 50 per cent of the time, which is typical for inland locations that regularly experience temperature inversions at night. Atmospheric instability increases during the day and reaches a peak around noon as solar-driven convective energy peaks. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

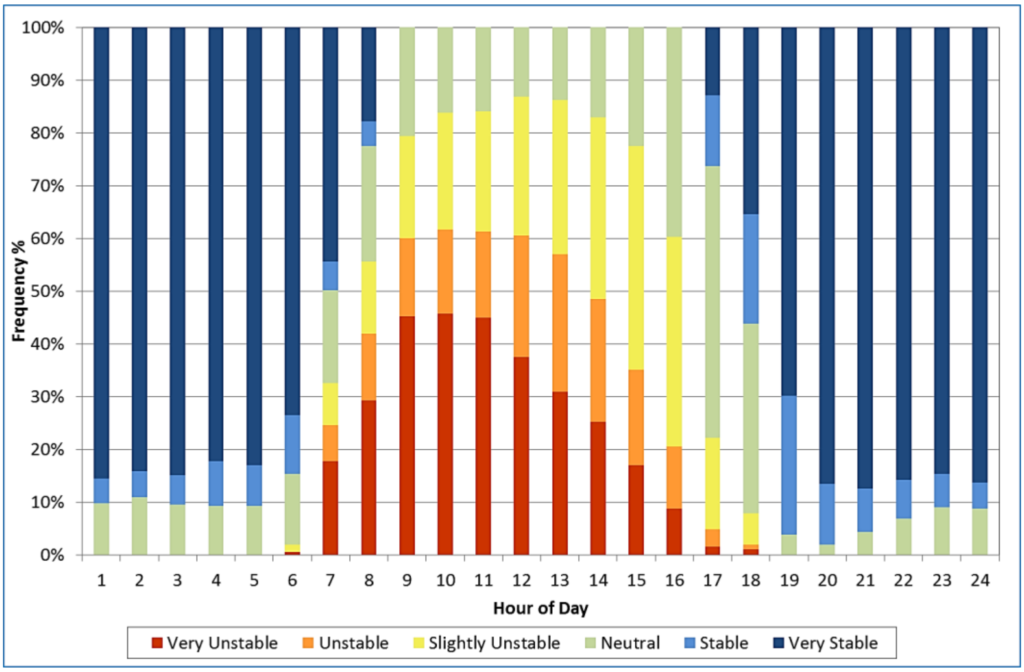


Figure D-3: Annual distribution of stability type by hour of the day

D.1.4 Meteorological data input for EDMS

EMDS requires that the same year of meteorological data is used as the year of emissions being modelled. For this reason the AERMET compiled for 2014 was modified to reflect the years 2030 and 2063.

D.1.5 Terrain

Terrain for this the model domain was derived from 90m DEM data sourced from the NASA Shuttle Radar Topography Mission (SRTM) data set.

D.1.6 Buildings

In AERMOD buildings affect plumes from point source by acting as obstacles, and can therefore have a significant impact on concentrations resulting from stationary source emissions. Buildings have no effect on the concentrations estimated from volume and area sources such as aircraft, APU, GSE, roadways, and parking facilities. The buildings included in EDMS are shown in **Figure C-1** and **Figure C-2** for the Stage 1 and longer term development, respectively. The height of the each building is provided in **Table D-2**

Table D-2: Building height data for airport

No.	Building Facility	Height Above Ground (m)
1	Terminal Headhouse	25
2	Terminal Concourse	15
3	Air Traffic Control Tower	120
4	Multi-story Car Park (4-levels)	15
5	Freighter	20
6	Aircraft Maintenance Hangar (Code F)	35
7	Aircraft Engine Run-up (Code F)	35
8	Corporate Aviation Hangars	20
9	ARFFS Station (north)	5
10	ARFFS Station (south)	5
11	Fuel Farm Tanks	20
12	Catering	15
13	Waste water treatment plant	10
14	Rental Car	5
15	Airport Maintenance (north)	10
16	Airport Maintenance (south)	10
17	Train Station (elevated)	10
18	Commercial Development Area	Various
19	Taxi/Bus Staging	5

Appendix E SENSITIVE RECEPTORS

Table E-1: Sensitive receptor information

ID	Receptor location	Type	ID	Receptor location	Type
R1	Bringelly	Residential	R75	Trinity Catholic Primary School	Community
R2	Luddenham	Residential	R76	Bringelly Public School	Community
R3	Greendale, Greendale Road	Residential	R78	Mulgoa Public School	Community
R4	Kemps Creek	Residential	R79	Rossmore Public School	Community
R6	Mulgoa	Residential	R80	Wallacia Public School	Community
R7	Wallacia	Residential	R82	Bellfield College - Junior Campus	Community
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	Residential	R84	Bringelly Park	Community
R14	Lawson Road, Badgerys Creek	Residential	R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	Community
R15	Mersey Rd, Greendale	Residential	R86	Blaxland Crossing Reserve	Community
R17	Luddenham Road	Residential	R87	Bill Anderson Reserve	Community
R18	Cnr Adams & Elizabeth Drive	Residential	R88	Kemps Creek Nature Reserve	Community
R19	Cnr Adams & Anton Road	Residential	R91	Western Sydney Parklands	Community
R21	Cnr Willowdene Ave and Vicar Park Lane	Residential	R93	Rossmore Grange	Community
R22	Rossmore, Victor Ave	Residential	R94	Freeburn Park	Community
R23	Wallacia, Greendale Rd	Residential	R95	Overett Reserve	Community
R24	Badgerys Creek 1 NE	On-site	R97	Mulgoa Park	Community
R25	Badgerys Creek 2 SW	On-site	R98	Wallacia Bowling and Recreation Club	Community
R27	Greendale, Dwyer Rd	Residential	R99	Hubertus Country Club	Community
R30	Rossmore residential	Residential	R100	Sugarloaf Cobbitty Equestrian Club	Community
R31	Mt Vernon residential	Residential	R102	Panthers Wallacia	Community
R34	Emmaus Residential Aged Care	Community	R103	Twin Creeks Golf and Country Club	Community
R35	Mamre After School and Vacation Care	Community	R104	Sydney International Shooting Centre	Community
R36	Head Start After School Care	Community	R108	Luddenham Showground	Community
R37	Schoolies at Mulgoa	Community	R109	Kemps Creek Sporting and Bowling Club	Community
R38	Do-re-mi Day Care Centre	Community	R110	St James Luddenham	Community
R39	Little Amigos Austral Early Learning Centre	Community	R111	Lin Ying temple	Community
R40	Little Smarties Childcare Centre	Community	R112	Vat Ketanak Khmer Kampuchea Krom	Community
R41	The Grove Academy	Community	R114	Anglican Church Sydney Diocese	Community
R42	Horsley Kids	Community	R115	Anglican Parish of Mulgoa	Community
R44	Bringelly Child Care Centre	Community	R117	Bringelly Vineyard Church	Community
R46	Clementson Drive Early Educational Centre	Community	R118	Free Church of Tonga	Community
R48	Kids Korner West Hoxton Early Learning Centre	Community	R120	Our Lady Queen of Peace	Community
R49	Luddenham Child Care Centre	Community	R122	St Anthony	Community
R52	The Frogs Lodge	Community	R123	St Marys Church	Community
R53	Rossmore Community Preschool	Community	R124	Wallacia Christian Church	Community
R54	Mulgoa Preschool	Community	R126	St Francis Xavier Church	Community

ID	Receptor location	Type	ID	Receptor location	Type
R55	Jillys Educational Childcare Centre	Community	R127	Luddenham Uniting Church	Community
R57	Wallacia Progress Hall	Community	R130	Hopewood Health Retreat	Community
R59	Bringelly Community Centre	Community	R131	Science of the Soul Study Centre	Community
R63	Luddenham Progress Hall	Community	R132	Bringelly shops	Community
R64	Mulgoa Hall	Community	R134	Kemps Creek shops	Community
R65	Emmaus Catholic College	Community	R135	Luddenham shops	Community
R66	University of Sydney Farms	Community	R136	Mulgoa shops	Community
R68	Christadelphian Heritage College Sydney	Community	R137	Rossmore shops	Community
R69	Mamre Anglican School	Community	R138	Wallacia Shops	Community
R72	Irfan College	Community	R140	Holy Family Catholic Primary and Church	Community
R73	Luddenham Public School	Community	R141	Edmund Rice Retreat and Conference Centre	Community
R74	Kemps Creek Public School	Community			

Appendix F CONTOUR PLOTS DURING OPERATIONS

F.1 STAGE 1 DEVELOPMENT

F.1.1 Nitrogen dioxide

Table F1: Predicted NO_2 concentrations during Stage 1 development

Receptor	Receptor location	Airport increment (µg/m³)		Cumulative - airport + external roads + existing background (µg/m³)	
		1-hour	Annual	1-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*320*	*62*
R1	Bringelly	84	11	145	19
R2	Luddenham	91	13	92	15
R3	Greendale, Greendale Road	194	12	213	13
R4	Kemps Creek	76	11	109	17
R6	Mulgoa	84	12	85	13
R7	Wallacia	90	11	92	13
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	86	13	91	17
R14	Lawson Road, Badgerys Creek	147	13	153	18
R15	Mersey Rd, Greendale	130	13	135	16
R17	Luddenham Road	96	13	103	17
R18	Cnr Adams & Elizabeth Drive	107	17	108	21
R19	Cnr Adams & Anton Road	111	19	112	23
R21	Cnr Willowdene Ave and Vicar Park Lane	171	13	177	15
R22	Rossmore, Victor Ave	68	11	104	15
R23	Wallacia, Greendale Rd	87	11	101	12
R24	Badgerys Creek 1 NE	166	18	169	26
R25	Badgerys Creek 2 SW	104	12	215	26
R27	Greendale, Dwyer Rd	80	11	108	12
R30	Rossmore residential	66	11	126	18
R31	Mt Vernon residential	142	12	142	16
R34	Emmaus Residential Aged Care	85	12	101	18
R35	Mamre After School and Vacation Care	97	12	121	21
R36	Head Start After School Care	75	11	98	16
R37	Schoolies at Mulgoa	95	13	97	15
R38	Do-re-mi Day Care Centre	108	11	120	18
R39	Little Amigos Austral Early Learning Centre	82	11	97	15
R40	Little Smarties Childcare Centre	93	12	96	20
R41	The Grove Academy	72	11	127	17
R42	Horsley Kids	67	11	84	15
R44	Bringelly Child Care Centre	97	11	111	14
R46	Clementson Drive Early Educational Centre	77	11	99	15
R48	Kids Korner West Hoxton Early Learning Centre	69	11	91	14
R49	Luddenham Child Care Centre	89	12	188	18
R52	The Frogs Lodge	70	11	126	18

Receptor	Receptor location	Airport increment (µg/m³)		Cumulative - airport + external roads + existing background (µg/m³)	
		1-hour	Annual	1-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*320*	*62*
R53	Rossmore Community Preschool	65	11	99	14
R54	Mulgoa Preschool	84	11	122	16
R55	Jillys Educational Childcare Centre	80	11	86	14
R57	Wallacia Progress Hall	77	11	84	13
R59	Bringelly Community Centre	93	11	88	13
R63	Luddenham Progress Hall	83	12	86	14
R64	Mulgoa Hall	86	12	86	13
R65	Emmaus Catholic College	87	12	90	19
R66	University of Sydney Farms	114	11	158	19
R68	Christadelphian Heritage College Sydney	104	11	113	16
R69	Mamre Anglican School	96	12	99	22
R72	Irfan College	67	10	124	25
R73	Luddenham Public School	90	13	92	15
R74	Kemps Creek Public School	111	11	119	15
R75	Trinity Catholic Primary School	96	12	151	21
R76	Bringelly Public School	85	11	145	22
R78	Mulgoa Public School	85	11	101	21
R79	Rossmore Public School	68	11	92	13
R80	Wallacia Public School	90	11	92	13
R82	Bellfield College - Junior Campus	69	11	87	16
R84	Bringelly Park	96	11	153	12
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	121	11	91	13
R86	Blaxland Crossing Reserve	89	11	92	12
R87	Bill Anderson Reserve	75	11	107	17
R88	Kemps Creek Nature Reserve	68	11	80	12
R91	Western Sydney Parklands	93	11	99	16
R93	Rossmore Grange	71	11	95	14
R94	Freeburn Park	91	13	93	15
R95	Overett Reserve	83	12	108	17
R97	Mulgoa Park	86	12	86	13
R98	Wallacia Bowling and Recreation Club	77	11	87	13
R99	Hubertus Country Club	113	19	103	13
R100	Sugarloaf Cobbitty Equestrian Club	95	11	100	12
R102	Panthers Wallacia	87	12	119	18
R103	Twin Creeks Golf and Country Club	80	12	89	16
R104	Sydney International Shooting Centre	110	11	305	34
R108	Luddenham Showground	83	12	87	14
R109	Kemps Creek Sporting and Bowling Club	80	11	115	18

Receptor	Receptor location	Airport increment (µg/m³)		Cumulative - airport + external roads + existing background (µg/m³)	
		1-hour	Annual	1-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*320*	*62*
R110	St James Luddenham	104	13	143	19
R111	Lin Ying temple	88	11	125	16
R112	Vat Ketanak Khmer Kampuchea Krom	68	11	86	15
R114	Anglican Church Sydney Diocese	68	11	87	16
R115	Anglican Parish of Mulgoa	86	11	89	13
R117	Bringelly Vineyard Church	89	11	94	16
R118	Free Church of Tonga	105	12	241	35
R120	Our Lady Queen of Peace	71	11	117	16
R122	St Anthony	78	11	91	13
R123	St Marys Church	85	12	89	13
R124	Wallacia Christian Church	89	11	60	10
R126	St Francis Xavier Church	103	11	88	13
R127	Luddenham Uniting Church	83	11	54	10
R130	Hopewood Health Retreat	78	11	86	12
R131	Science of the Soul Study Centre	79	11	104	17
R132	Bringelly shops	83	11	103	18
R134	Kemps Creek shops	72	11	107	17
R135	Luddenham shops	111	14	89	14
R136	Mulgoa shops	83	12	84	13
R137	Rossmore shops	67	11	91	21
R138	Wallacia Shops	88	11	64	10
R140	Holy Family Catholic Primary and Church	108	14	117	13
R141	Edmund Rice Retreat and Conference Centre	114	11	116	13

Figure F1: NO_2 1-hour Contour Plot during Stage 1 development -Cumulative

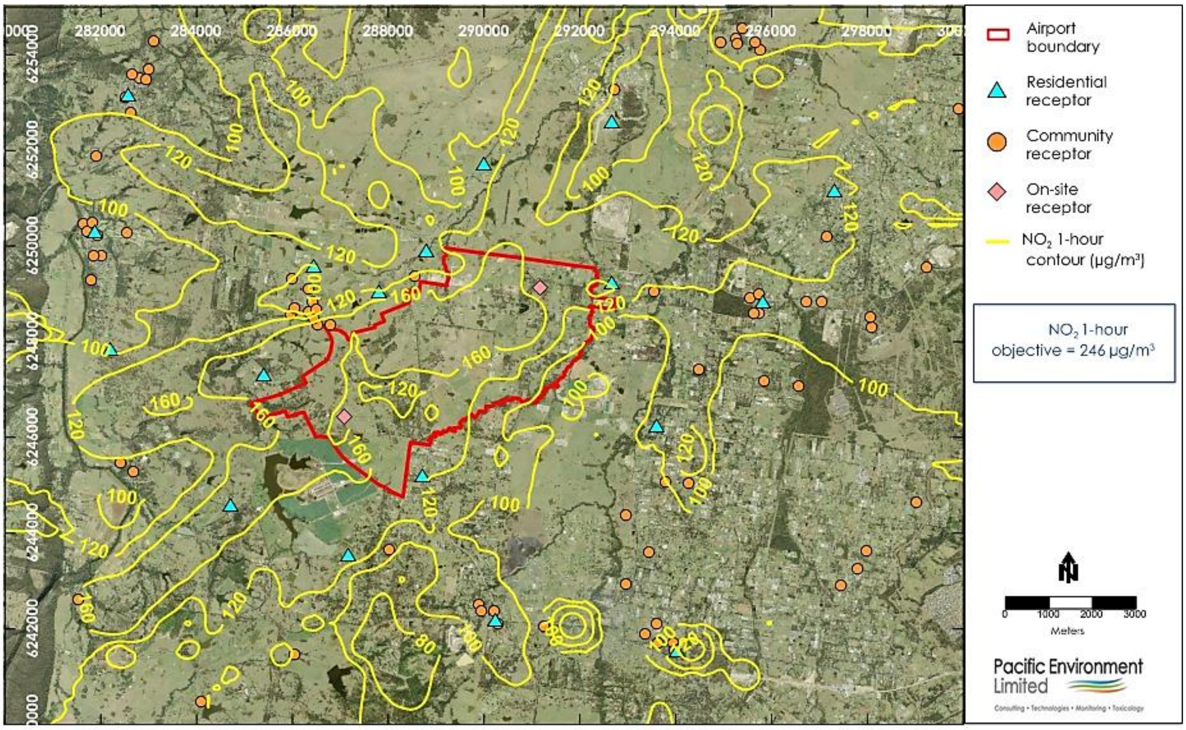
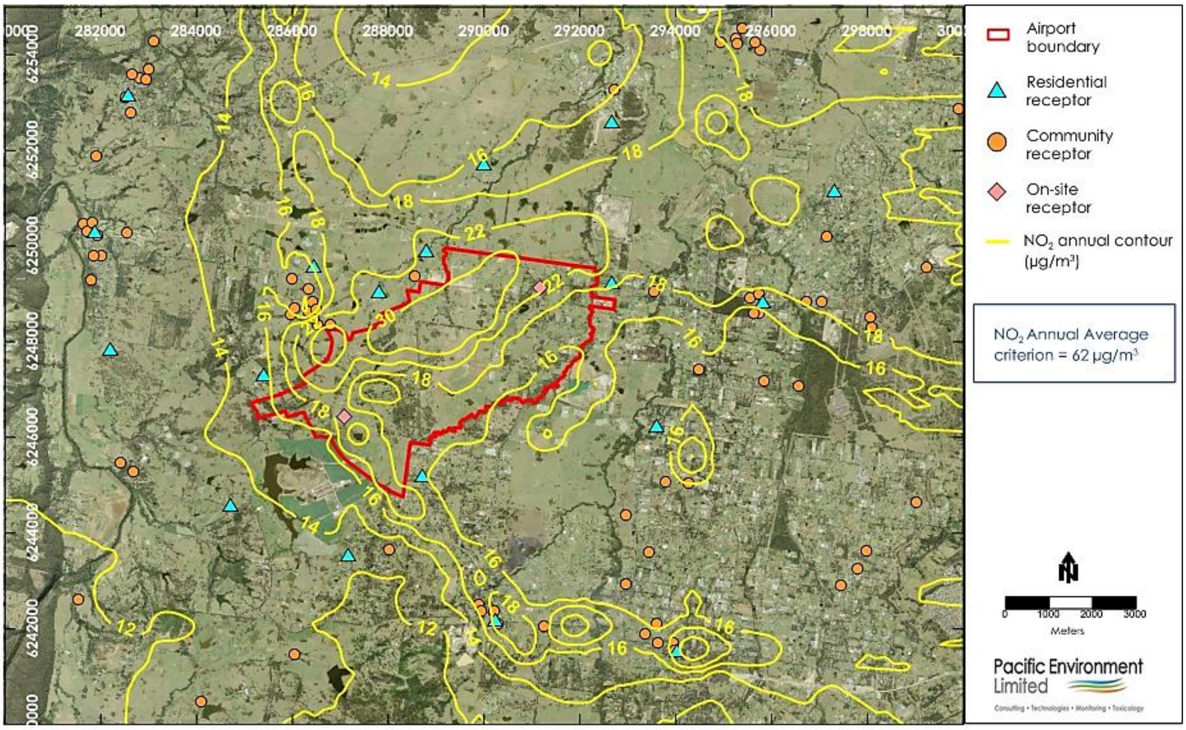


Figure F2: NO_2 Annual Average Contour Plot during Stage 1 development -Cumulative



F.1.2 Particulate matter PM10

Table F2: Predicted incremental and cumulative PM10 concentrations during Stage 1 development.

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R1	Bringelly	0.5	<0.1	7.3	1.0	44	18
R2	Luddenham	0.5	<0.1	1.7	0.3	43	17
R3	Greendale, Greendale Road	1.0	<0.1	2.5	0.2	43	17
R4	Kemps Creek	0.6	<0.1	4.4	0.8	44	18
R6	Mulgoa	0.5	<0.1	1.5	0.2	43	17
R7	Wallacia	0.4	<0.1	1.4	0.2	43	17
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.6	<0.1	2.6	0.5	44	18
R14	Lawson Road, Badgerys Creek	1.5	0.1	6.0	0.8	44	18
R15	Mersey Rd, Greendale	1.1	0.1	2.1	0.5	44	17
R17	Luddenham Road	0.7	<0.1	2.9	0.5	43	18
R18	Cnr Adams & Elizabeth Drive	0.7	0.1	3.2	0.7	44	18
R19	Cnr Adams & Anton Road	2.0	0.2	3.1	0.7	44	18
R21	Cnr Willowdene Ave and Vicar Park Lane	0.9	<0.1	3.4	0.4	43	17
R22	Rossmore, Victor Ave	0.9	<0.1	3.4	0.5	44	18
R23	Wallacia, Greendale Rd	0.6	<0.1	2.0	0.2	43	17
R24	Badgerys Creek 1 NE	4.1	0.4	5.9	1.5	44	18
R25	Badgerys Creek 2 SW	0.6	<0.1	18.6	1.9	47	19
R27	Greendale, Dwyer Rd	0.1	<0.1	1.7	0.2	43	17
R30	Rossmore residential	0.3	<0.1	6.0	1.1	44	18
R31	Mt Vernon residential	0.9	<0.1	4.0	0.5	43	18
R34	Emmaus Residential Aged Care	0.4	<0.1	3.3	0.8	44	18
R35	Mamre After School and Vacation Care	0.3	<0.1	3.8	0.9	44	18
R36	Head Start After School Care	0.3	<0.1	7.7	1.2	47	18
R37	Schoolies at Mulgoa	0.8	<0.1	1.8	0.4	43	17
R38	Do-re-mi Day Care Centre	0.8	<0.1	3.8	0.8	44	18
R39	Little Amigos Austral Early Learning Centre	1.2	<0.1	3.9	0.6	43	18
R40	Little Smarties Childcare Centre	0.4	<0.1	4.2	1.0	44	18
R41	The Grove Academy	0.4	<0.1	3.3	0.5	43	18
R42	Horsley Kids	0.3	<0.1	2.7	0.5	43	17
R44	Bringelly Child Care Centre	0.6	<0.1	2.2	0.3	43	17
R46	Clementson Drive Early Educational Centre	1.4	<0.1	4.2	0.5	44	18
R48	Kids Korner West Hoxton Early Learning Centre	0.2	<0.1	6.0	1.2	44	18
R49	Luddenham Child Care Centre	0.5	<0.1	1.7	0.3	43	17
R52	The Frogs Lodge	0.6	<0.1	3.5	0.8	45	18

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R53	Rossmore Community Preschool	0.3	<0.1	5.0	0.9	44	18
R54	Mulgoa Preschool	0.3	<0.1	1.3	0.2	43	17
R55	Jillys Educational Childcare Centre	0.6	<0.1	3.1	0.5	44	17
R57	Wallacia Progress Hall	0.4	<0.1	1.5	0.2	43	17
R59	Bringelly Community Centre	0.7	<0.1	4.7	0.7	44	18
R63	Luddenham Progress Hall	0.4	<0.1	1.2	0.3	43	17
R64	Mulgoa Hall	0.4	<0.1	1.3	0.2	43	17
R65	Emmaus Catholic College	0.3	<0.1	3.6	0.9	44	18
R66	University of Sydney Farms	0.3	<0.1	1.7	0.2	43	17
R68	Christadelphian Heritage College Sydney	0.9	<0.1	3.8	0.6	44	18
R69	Mamre Anglican School	0.3	<0.1	4.6	1.3	44	18
R72	Irfan College	0.3	<0.1	7.0	1.8	45	19
R73	Luddenham Public School	0.6	<0.1	1.7	0.4	43	17
R74	Kemps Creek Public School	1.0	<0.1	3.5	0.5	43	18
R75	Trinity Catholic Primary School	0.3	<0.1	2.9	0.8	44	18
R76	Bringelly Public School	0.6	<0.1	11.7	1.5	46	19
R78	Mulgoa Public School	0.4	<0.1	1.3	0.2	43	17
R79	Rossmore Public School	0.3	<0.1	5.7	1.8	44	19
R80	Wallacia Public School	0.3	<0.1	1.4	0.2	43	17
R82	Bellfield College - Junior Campus	0.4	<0.1	2.9	0.7	43	18
R84	Bringelly Park	0.7	<0.1	4.2	0.7	44	18
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.4	<0.1	1.7	0.1	43	17
R86	Blaxland Crossing Reserve	0.3	<0.1	1.4	0.2	43	17
R87	Bill Anderson Reserve	0.7	<0.1	3.7	0.8	44	18
R88	Kemps Creek Nature Reserve	0.3	<0.1	3.2	0.6	44	18
R91	Western Sydney Parklands	0.5	<0.1	3.7	0.7	44	18
R93	Rossmore Grange	0.6	<0.1	3.2	0.4	44	17
R94	Freeburn Park	0.7	<0.1	2.0	0.3	43	17
R95	Overett Reserve	0.9	<0.1	4.4	0.8	44	18
R97	Mulgoa Park	0.4	<0.1	1.3	0.2	43	17
R98	Wallacia Bowling and Recreation Club	0.4	<0.1	1.5	0.2	43	17
R99	Hubertus Country Club	1.8	0.2	2.9	0.6	44	18
R100	Sugarloaf Cobbitty Equestrian Club	0.4	<0.1	1.8	0.2	43	17
R102	Panthers Wallacia	0.3	<0.1	1.9	0.2	43	17
R103	Twin Creeks Golf and Country Club	0.3	<0.1	2.7	0.5	44	18

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
AEPR ambient objective / NSW EPA Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R104	Sydney International Shooting Centre	0.7	<0.1	5.3	0.7	44	18
R108	Luddenham Showground	0.4	<0.1	1.5	0.3	43	17
R109	Kemps Creek Sporting and Bowling Club	0.4	<0.1	4.8	0.9	45	18
R110	St James Luddenham	0.6	<0.1	2.2	0.6	44	18
R111	Lin Ying temple	1.6	<0.1	3.9	0.6	45	18
R112	Vat Ketanak Khmer Kampuchea Krom	0.4	<0.1	3.2	0.5	43	18
R114	Anglican Church Sydney Diocese	0.3	<0.1	3.2	0.7	43	18
R115	Anglican Parish of Mulgoa	0.2	<0.1	1.4	0.2	43	17
R117	Bringelly Vineyard Church	0.7	<0.1	4.5	0.7	44	18
R118	Free Church of Tonga	0.7	<0.1	2.8	0.2	43	17
R120	Our Lady Queen of Peace	0.4	<0.1	4.9	0.8	44	18
R122	St Anthony	0.8	<0.1	5.5	1.3	48	18
R123	St Marys Church	0.5	<0.1	1.9	0.2	43	17
R124	Wallacia Christian Church	0.4	<0.1	1.4	0.2	43	17
R126	St Francis Xavier Church	0.7	<0.1	3.0	0.2	43	17
R127	Luddenham Uniting Church	0.3	<0.1	1.1	0.3	43	17
R130	Hopewood Health Retreat	0.4	<0.1	1.7	0.2	43	17
R131	Science of the Soul Study Centre	0.4	<0.1	4.8	0.9	45	18
R132	Bringelly shops	0.5	<0.1	5.5	1.0	44	18
R134	Kemps Creek shops	0.7	<0.1	4.1	0.8	44	18
R135	Luddenham shops	0.7	<0.1	2.2	0.7	44	18
R136	Mulgoa shops	0.5	<0.1	1.7	0.2	43	17
R137	Rossmore shops	0.3	<0.1	5.5	1.5	44	18
R138	Wallacia Shops	0.4	<0.1	1.4	0.2	43	17
R140	Holy Family Catholic Primary and Church	0.7	<0.1	2.6	0.4	43	17
R141	Edmund Rice Retreat and Conference Centre	0.3	<0.1	1.3	0.2	43	17

Figure F3: PM_{10} 24-hour maximum Contour Plot during Stage 1 development - Airport

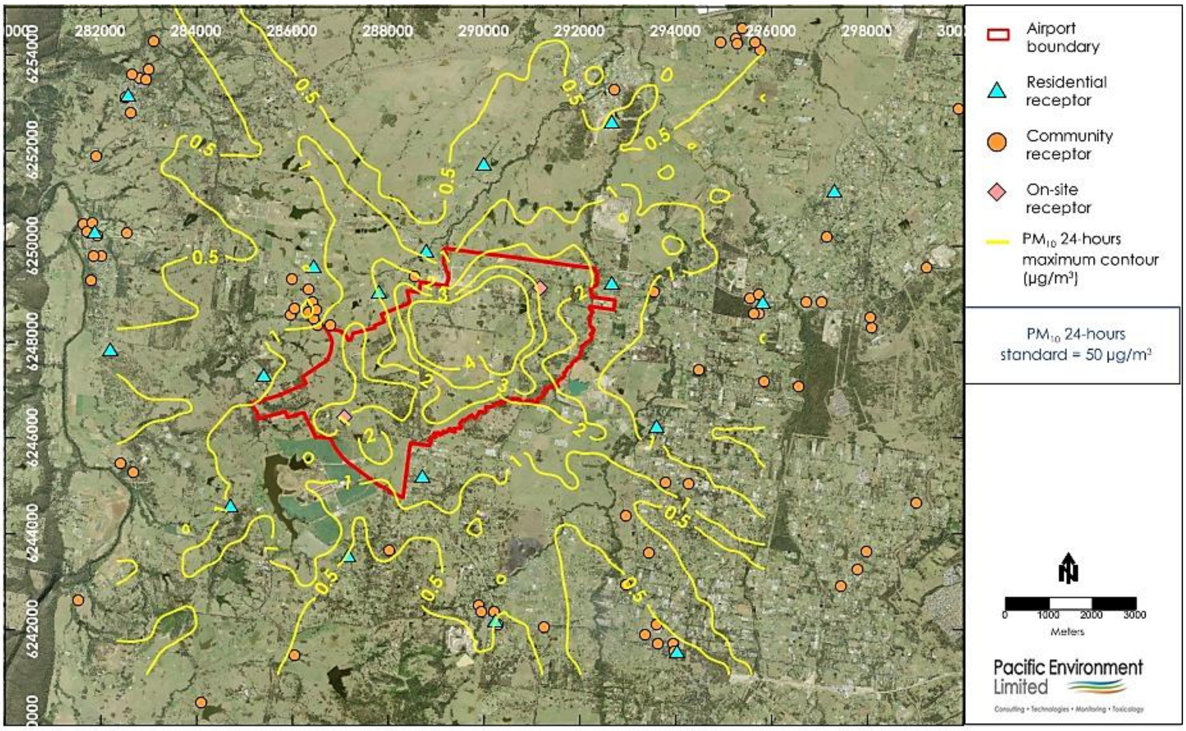


Figure F4: PM_{10} Annual Average Contour Plot during Stage 1 development - Airport

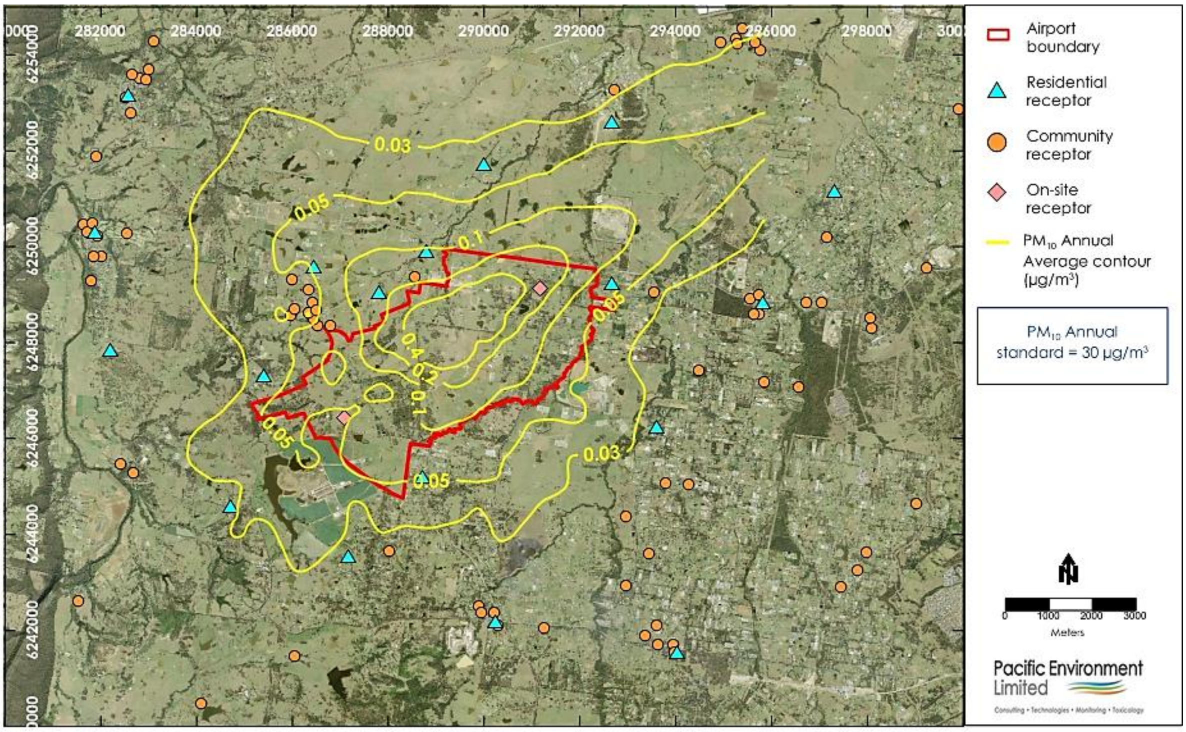


Figure F5: PM$_{10}$ 24-hour maximum Contour Plot during Stage 1 development - Airport + external roadways

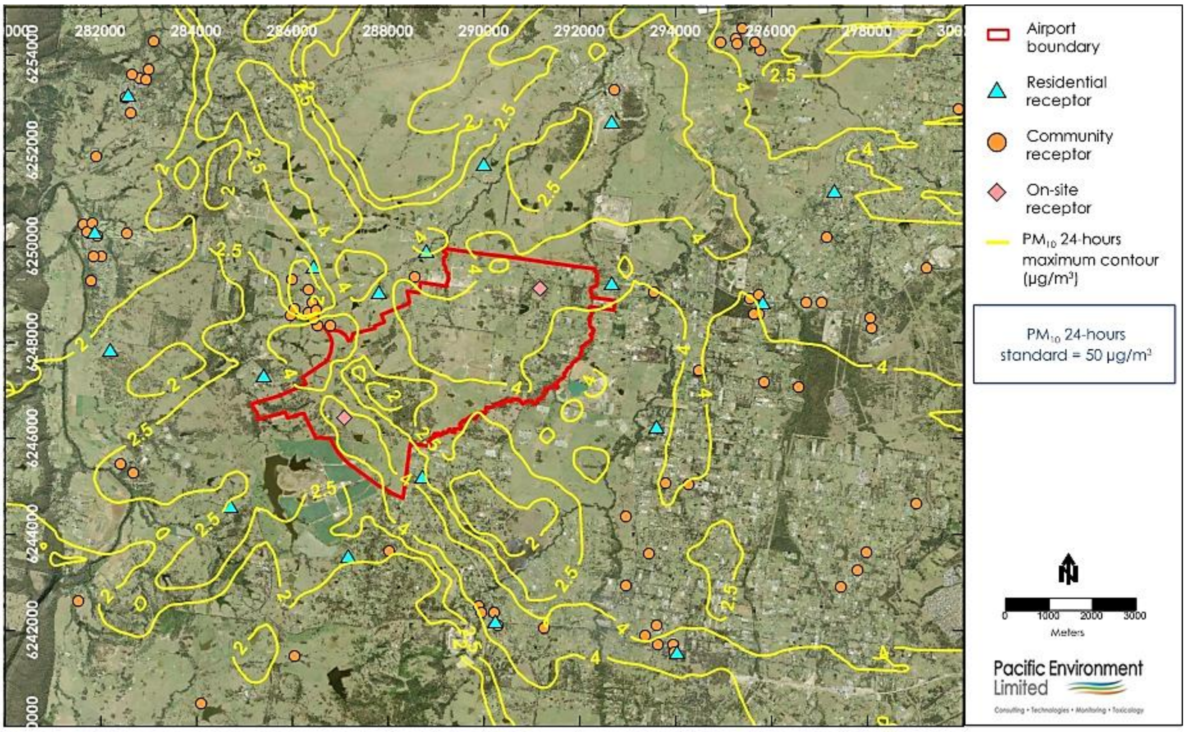


Figure F6: PM$_{10}$ Annual Average Contour Plot during Stage 1 development - Airport + external

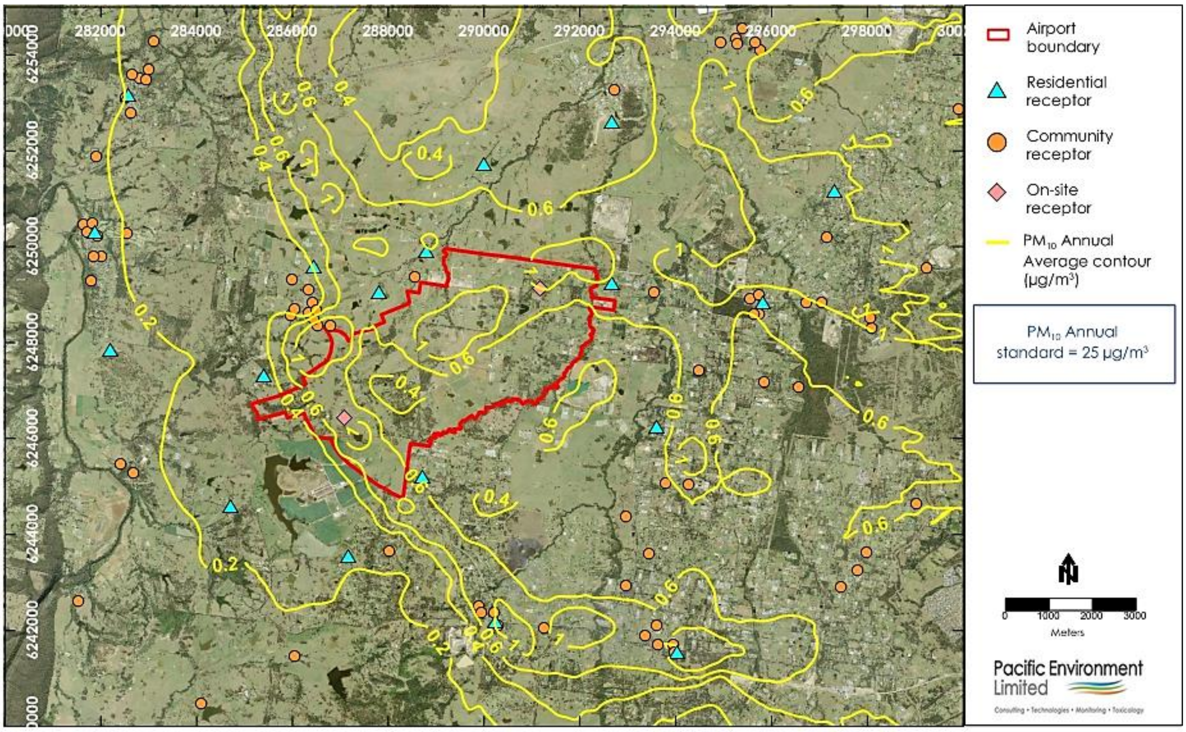


Figure F7: PM10 24-hour maximum Contour Plot during Stage 1 development – Cumulative

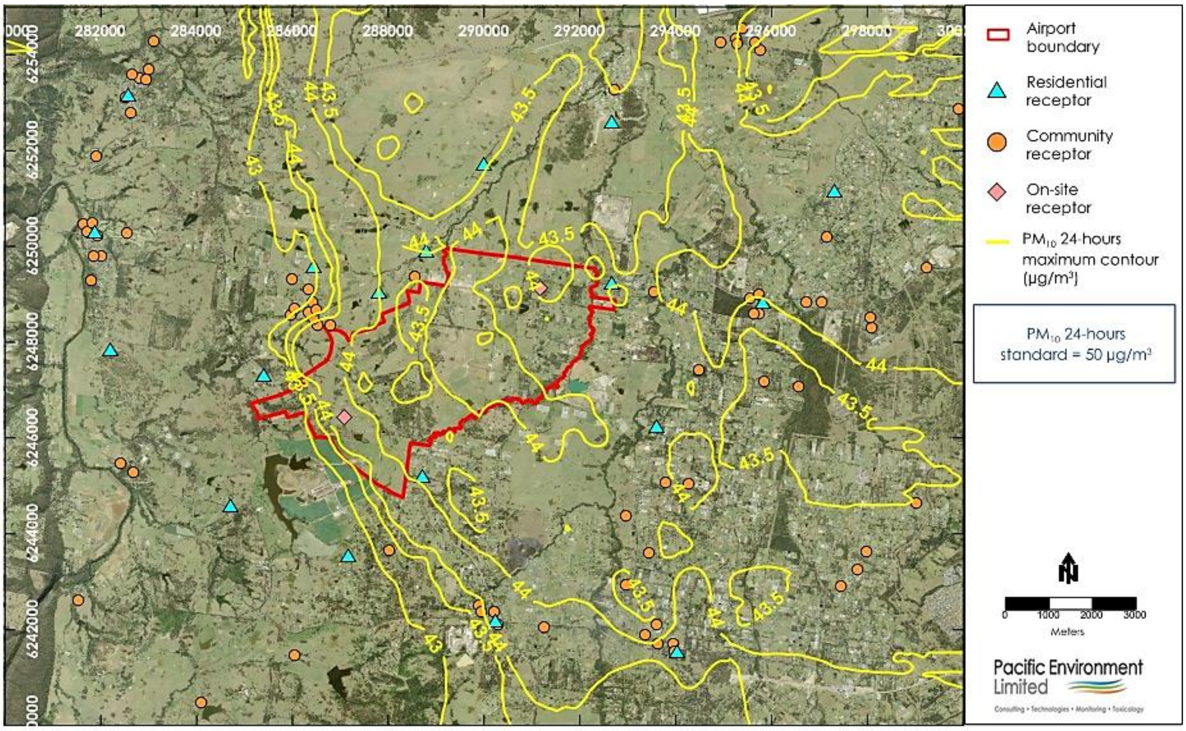
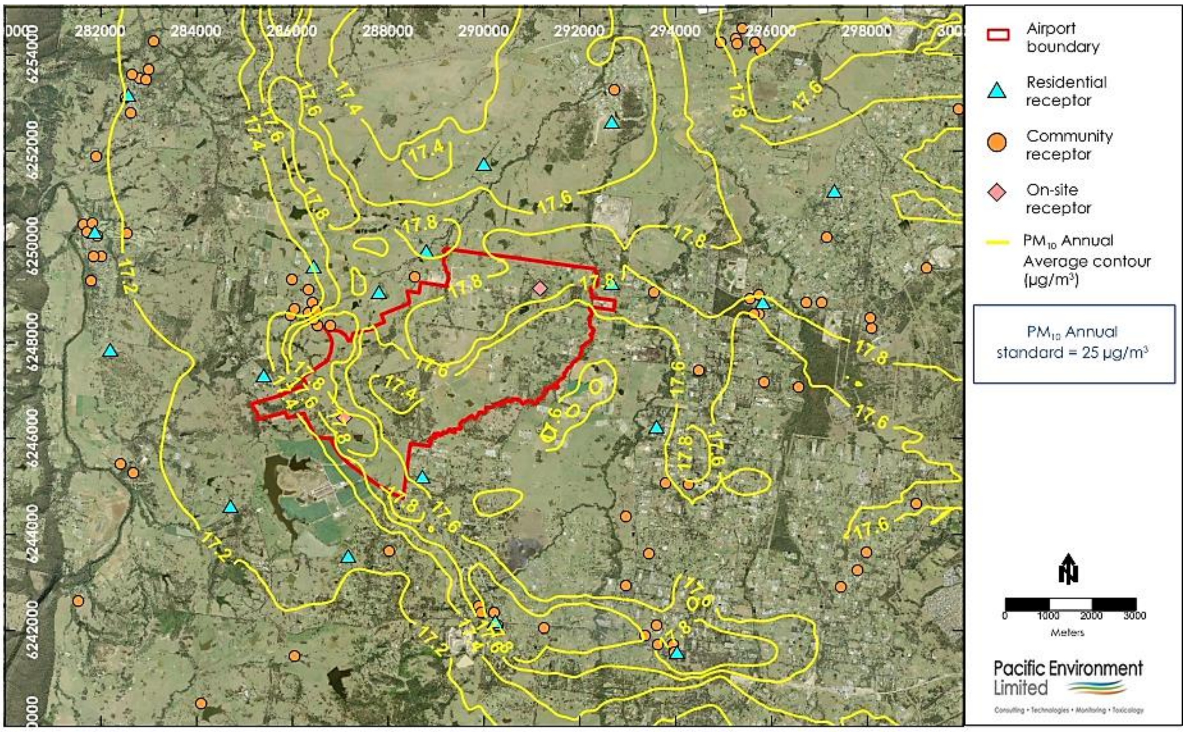


Figure F8: PM10 Annual Average Contour Plot during Stage 1 development -Cumulative



F.1.3 Particulate matter $PM_{2.5}$

Table F3: Predicted incremental and cumulative $PM_{2.5}$ concentrations during Stage 1 development

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R1	Bringelly	0.5	<0.1	4.3	0.6	14	8
R2	Luddenham	0.5	<0.1	1.1	0.2	14	7
R3	Greendale, Greendale Road	1.0	<0.1	1.9	0.1	13	7
R4	Kemps Creek	0.6	<0.1	2.6	0.5	14	7
R6	Mulgoa	0.5	<0.1	1.0	0.1	13	7
R7	Wallacia	0.4	<0.1	0.9	0.1	13	7
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.6	<0.1	1.5	0.3	14	7
R14	Lawson Road, Badgerys Creek	1.4	0.1	4.1	0.5	14	7
R15	Mersey Rd, Greendale	1.0	0.1	1.5	0.3	14	7
R17	Luddenham Road	0.7	<0.1	1.7	0.3	14	7
R18	Cnr Adams & Elizabeth Drive	0.7	0.1	2.0	0.4	14	7
R19	Cnr Adams & Anton Road	1.9	0.2	2.5	0.5	14	7
R21	Cnr Willowdene Ave and Vicar Park Lane	0.8	<0.1	2.1	0.2	14	7
R22	Rossmore, Victor Ave	0.9	<0.1	2.0	0.3	14	7
R23	Wallacia, Greendale Rd	0.6	<0.1	1.2	0.1	13	7
R24	Badgerys Creek 1 NE	3.9	0.3	4.3	0.9	14	8
R25	Badgerys Creek 2 SW	0.6	<0.1	11.1	1.1	18	8
R27	Greendale, Dwyer Rd	0.1	<0.1	1.0	0.1	13	7
R30	Rossmore residential	0.3	<0.1	3.5	0.6	14	8
R31	Mt Vernon residential	0.9	<0.1	2.4	0.3	14	7
R34	Emmaus Residential Aged Care	0.4	<0.1	2.0	0.5	14	7
R35	Mamre After School and Vacation Care	0.3	<0.1	2.4	0.5	14	8
R36	Head Start After School Care	0.3	<0.1	4.6	0.7	16	8
R37	Schoolies at Mulgoa	0.7	<0.1	1.3	0.2	13	7
R38	Do-re-mi Day Care Centre	0.8	<0.1	2.3	0.5	14	7
R39	Little Amigos Austral Early Learning Centre	1.1	<0.1	2.3	0.4	14	7
R40	Little Smarties Childcare Centre	0.3	<0.1	2.6	0.6	14	8
R41	The Grove Academy	0.4	<0.1	2.0	0.3	14	7
R42	Horsley Kids	0.2	<0.1	1.6	0.3	13	7
R44	Bringelly Child Care Centre	0.6	<0.1	1.4	0.2	14	7
R46	Clementson Drive Early Educational Centre	1.3	<0.1	2.5	0.3	14	7
R48	Kids Korner West Hoxton Early Learning Centre	0.2	<0.1	3.6	0.7	14	8
R49	Luddenham Child Care Centre	0.5	<0.1	1.2	0.2	14	7
R52	The Frogs Lodge	0.6	<0.1	2.1	0.5	15	7

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R53	Rossmore Community Preschool	0.3	<0.1	2.9	0.5	14	8
R54	Mulgoa Preschool	0.3	<0.1	0.8	0.1	13	7
R55	Jillys Educational Childcare Centre	0.6	<0.1	1.9	0.3	14	7
R57	Wallacia Progress Hall	0.4	<0.1	1.0	0.1	13	7
R59	Bringelly Community Centre	0.6	<0.1	3.0	0.4	14	7
R63	Luddenham Progress Hall	0.4	<0.1	0.8	0.2	14	7
R64	Mulgoa Hall	0.4	<0.1	0.8	0.1	13	7
R65	Emmaus Catholic College	0.3	<0.1	2.2	0.5	14	8
R66	University of Sydney Farms	0.3	<0.1	1.1	0.1	13	7
R68	Christadelphian Heritage College Sydney	0.8	<0.1	2.5	0.4	14	7
R69	Mamre Anglican School	0.3	<0.1	2.8	0.8	14	8
R72	Irfan College	0.3	<0.1	4.2	1.1	15	8
R73	Luddenham Public School	0.6	<0.1	1.2	0.2	14	7
R74	Kemps Creek Public School	0.9	<0.1	2.4	0.3	14	7
R75	Trinity Catholic Primary School	0.3	<0.1	1.8	0.5	14	7
R76	Bringelly Public School	0.5	<0.1	6.9	0.9	15	8
R78	Mulgoa Public School	0.3	<0.1	0.8	0.1	13	7
R79	Rossmore Public School	0.3	<0.1	3.4	1.0	14	8
R80	Wallacia Public School	0.3	<0.1	0.8	0.1	13	7
R82	Bellfield College - Junior Campus	0.4	<0.1	1.7	0.4	14	7
R84	Bringelly Park	0.7	<0.1	2.7	0.4	14	7
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.4	<0.1	1.1	0.1	13	7
R86	Blaxland Crossing Reserve	0.3	<0.1	0.8	0.1	13	7
R87	Bill Anderson Reserve	0.7	<0.1	2.2	0.5	14	7
R88	Kemps Creek Nature Reserve	0.3	<0.1	1.9	0.3	14	7
R91	Western Sydney Parklands	0.5	<0.1	2.4	0.4	14	7
R93	Rossmore Grange	0.6	<0.1	1.9	0.3	14	7
R94	Freeburn Park	0.7	<0.1	1.5	0.2	14	7
R95	Overett Reserve	0.8	<0.1	2.9	0.5	14	7
R97	Mulgoa Park	0.4	<0.1	0.8	0.1	13	7
R98	Wallacia Bowling and Recreation Club	0.4	<0.1	1.0	0.1	13	7
R99	Hubertus Country Club	1.7	0.2	2.4	0.4	14	7
R100	Sugarloaf Cobbitty Equestrian Club	0.4	<0.1	1.2	0.1	13	7
R102	Panthers Wallacia	0.3	<0.1	1.1	0.1	13	7
R103	Twin Creeks Golf and Country Club	0.3	<0.1	1.6	0.3	14	7

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R104	Sydney International Shooting Centre	0.7	<0.1	3.5	0.4	14	7
R108	Luddenham Showground	0.4	<0.1	1.0	0.2	13	7
R109	Kemps Creek Sporting and Bowling Club	0.4	<0.1	2.9	0.5	15	8
R110	St James Luddenham	0.5	<0.1	1.4	0.4	14	7
R111	Lin Ying temple	1.6	<0.1	2.3	0.4	15	7
R112	Vat Ketanak Khmer Kampuchea Krom	0.4	<0.1	1.9	0.3	14	7
R114	Anglican Church Sydney Diocese	0.3	<0.1	2.0	0.4	14	7
R115	Anglican Parish of Mulgoa	0.2	<0.1	0.9	0.1	13	7
R117	Bringelly Vineyard Church	0.6	<0.1	2.7	0.4	14	7
R118	Free Church of Tonga	0.7	<0.1	1.8	0.1	13	7
R120	Our Lady Queen of Peace	0.4	<0.1	2.9	0.5	14	7
R122	St Anthony	0.7	<0.1	3.1	0.7	16	8
R123	St Marys Church	0.4	<0.1	1.2	0.1	13	7
R124	Wallacia Christian Church	0.4	<0.1	0.9	0.1	13	7
R126	St Francis Xavier Church	0.6	<0.1	2.0	0.1	13	7
R127	Luddenham Uniting Church	0.3	<0.1	0.7	0.2	14	7
R130	Hopewood Health Retreat	0.4	<0.1	1.1	0.1	13	7
R131	Science of the Soul Study Centre	0.4	<0.1	2.9	0.5	15	8
R132	Bringelly shops	0.5	<0.1	3.2	0.6	14	8
R134	Kemps Creek shops	0.6	<0.1	2.5	0.5	14	8
R135	Luddenham shops	0.6	<0.1	1.5	0.4	14	7
R136	Mulgoa shops	0.5	<0.1	1.1	0.1	13	7
R137	Rossmore shops	0.3	<0.1	3.3	0.9	14	8
R138	Wallacia Shops	0.4	<0.1	0.8	0.1	13	7
R140	Holy Family Catholic Primary and Church	0.7	<0.1	1.6	0.3	14	7
R141	Edmund Rice Retreat and Conference Centre	0.3	<0.1	0.8	0.1	13	7

Figure F9: PM2.5 24-hour maximum Contour Plot during Stage 1 development - Airport

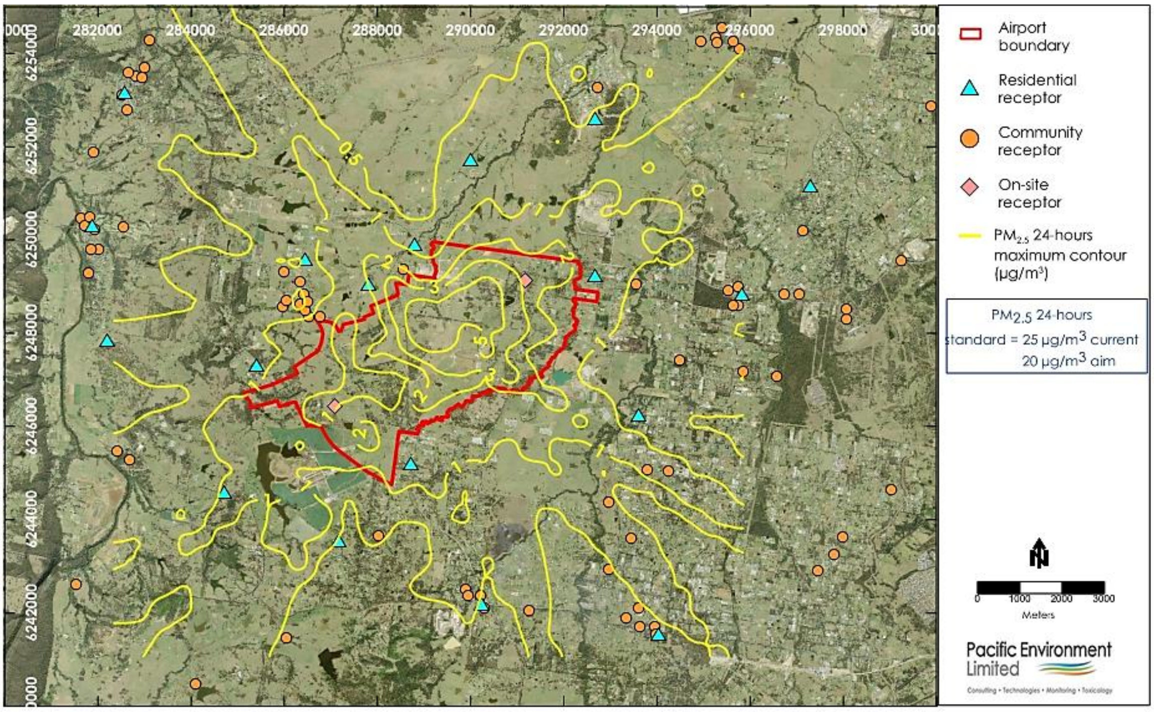


Figure F10: PM2.5 Annual Average Contour Plot during Stage 1 development - Airport

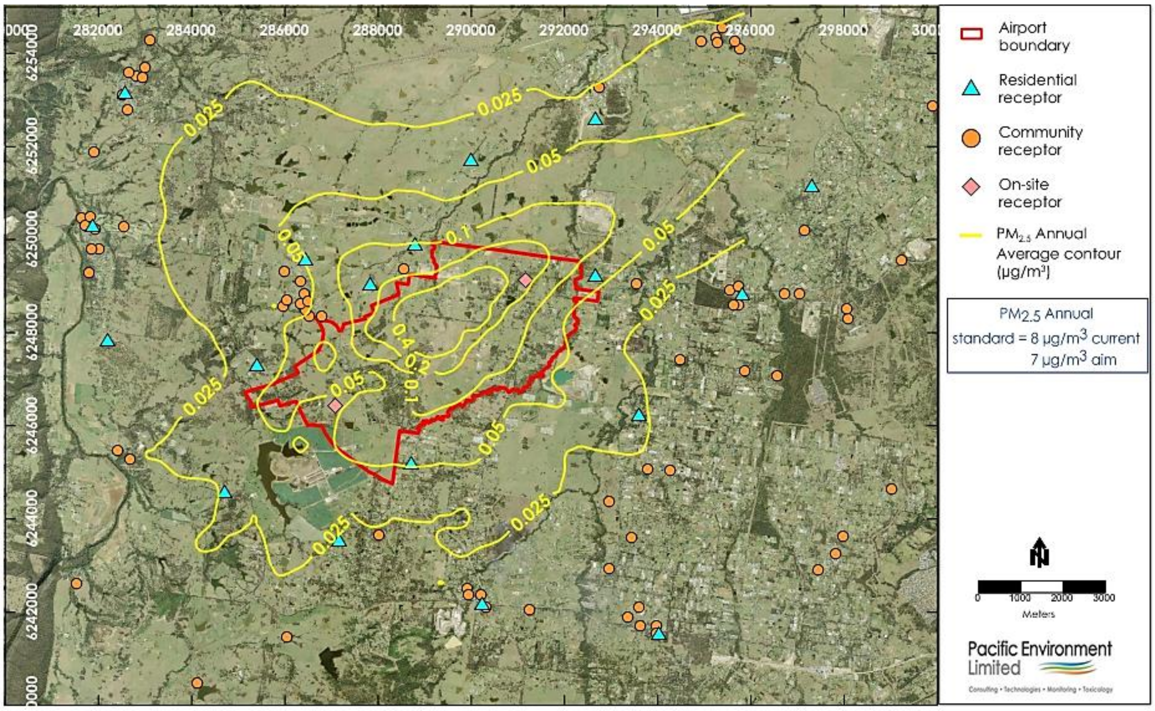


Figure F11: PM2.5 24-hour maximum Contour Plot during Stage 1 development - Airport + External Roadways

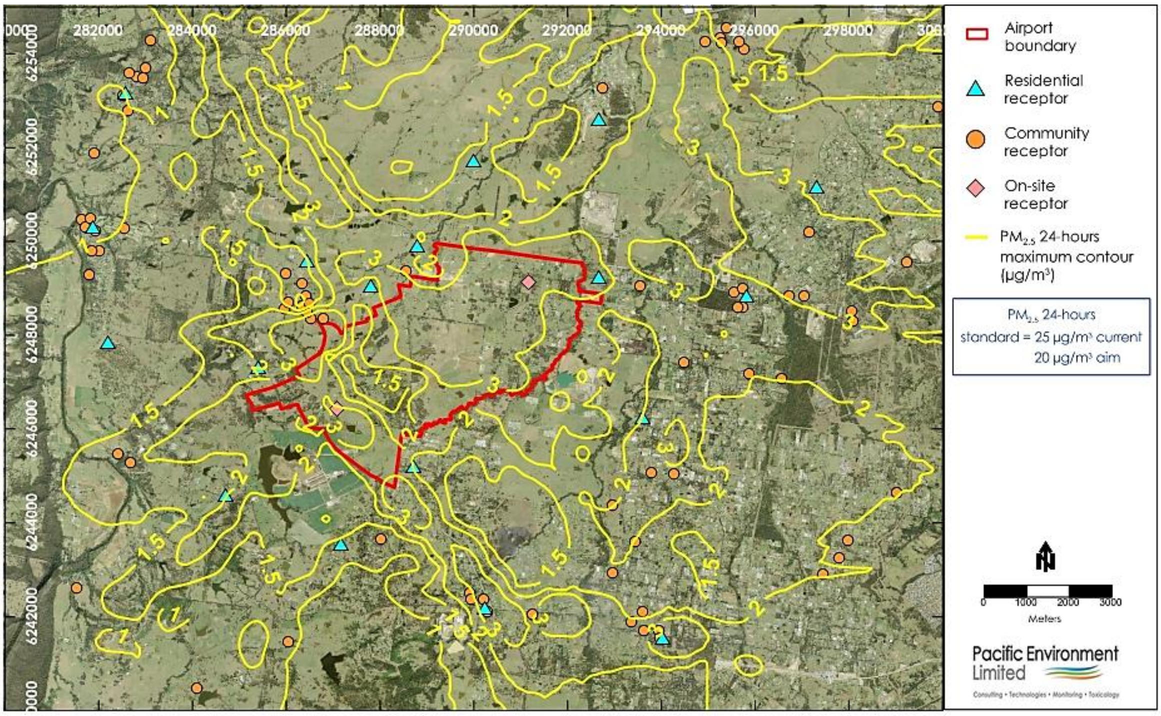


Figure F12: PM2.5 Annual Contour Plot during Stage 1 development - Airport + External Roadways

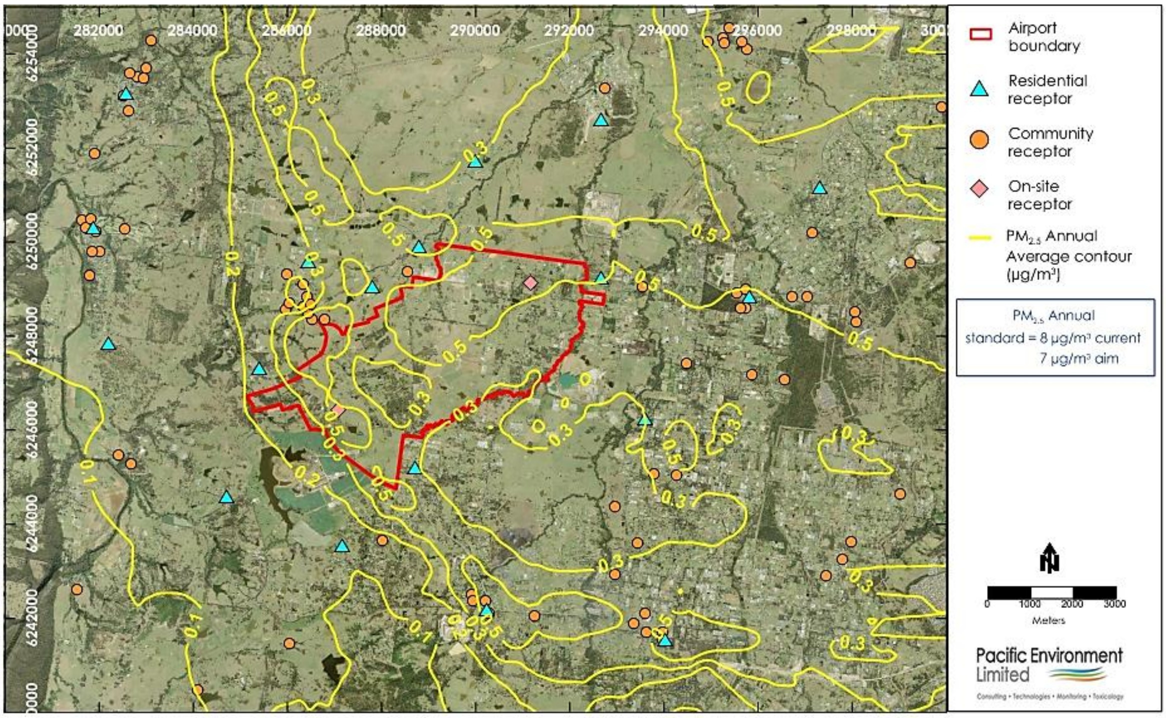


Figure F13: PM2.5 24-hour maximum Contour Plot during Stage 1 development – Cumulative

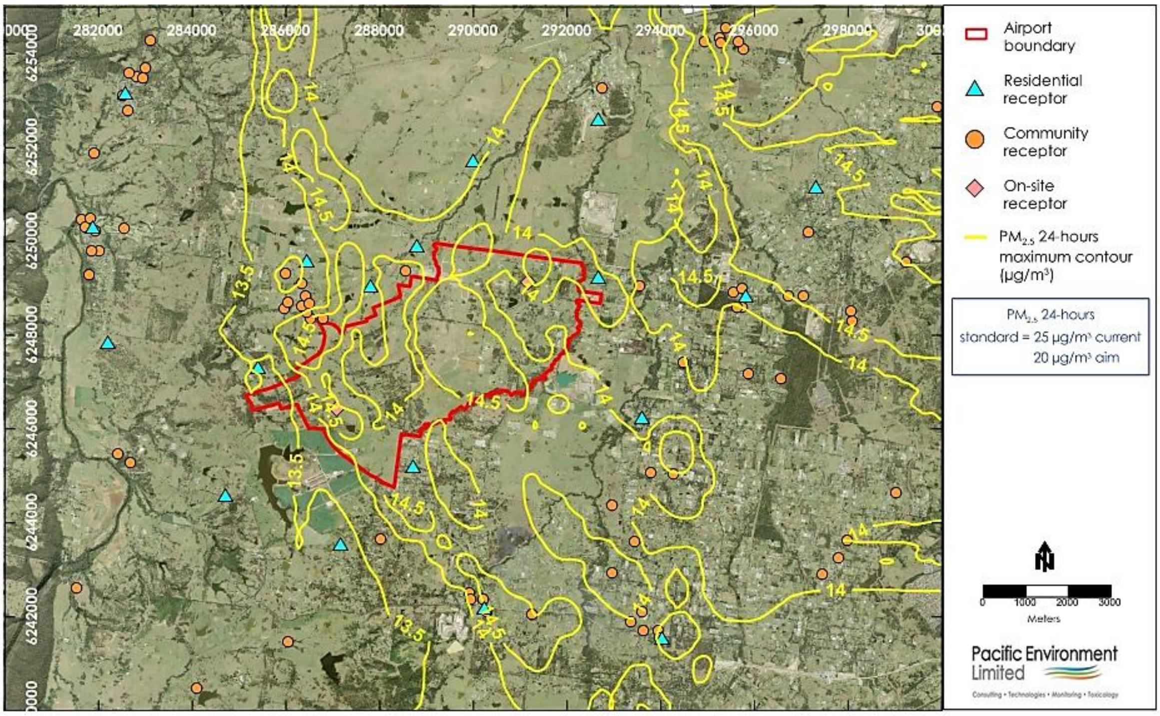
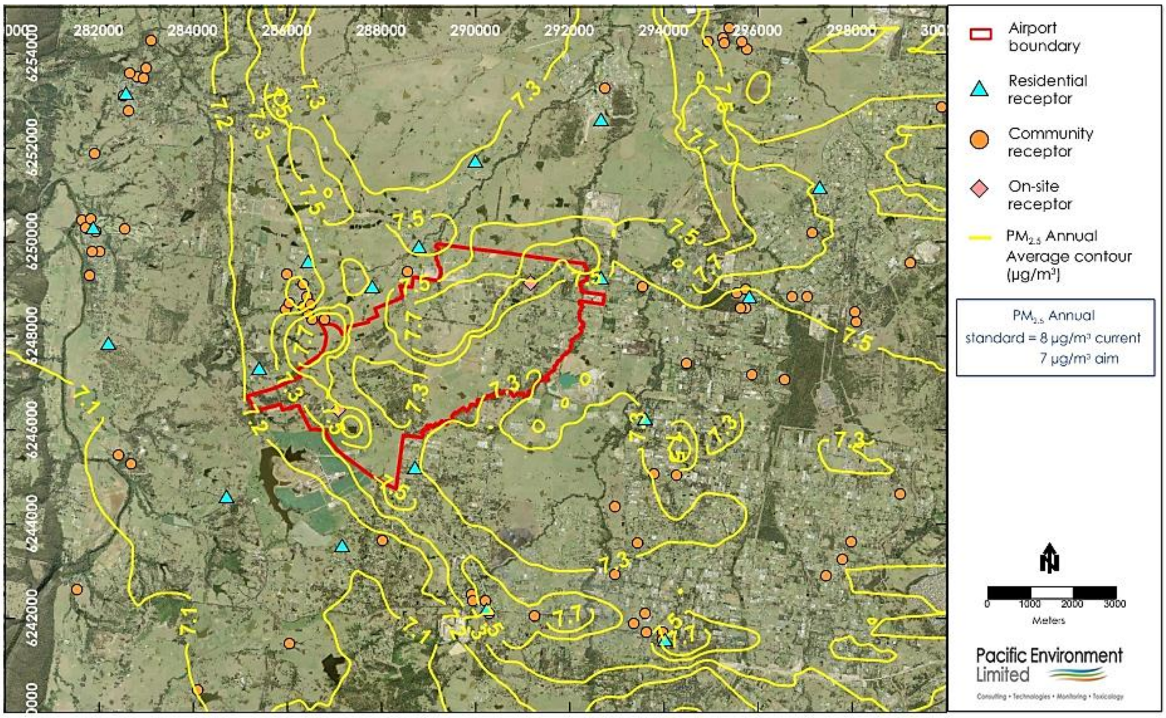


Figure F14: PM2.5 Annual Average Contour Plot during Stage 1 development - Cumulative



F.1.4 Carbon monoxide

Table F4: Predicted incremental and cumulative CO concentrations during Stage 1 development.

Receptor	Receptor location	Airport (mg/m³)			Airport + external roadways (mg/m³)			Cumulative (mg/m³)		
		15-minute	1-hour	8-hour	15-minute	1-hour	8-hour	15-minute	1-hour	8-hour
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*100*	*30*	*10*
R1	Bringelly	0.6	0.4	0.1	3.8	2.9	0.4	5.9	4.4	1.6
R2	Luddenham	0.5	0.4	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R3	Greendale, Greendale Road	0.9	0.7	0.1	1.4	1.0	0.2	3.5	2.5	1.4
R4	Kemps Creek	0.7	0.5	0.1	1.9	1.5	0.3	4.0	3.0	1.5
R6	Mulgoa	0.7	0.5	0.1	0.9	0.6	0.1	3.0	2.1	1.3
R7	Wallacia	0.3	0.2	<0.1	0.9	0.7	0.1	3.0	2.2	1.3
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.9	0.7	0.1	1.2	0.9	0.1	3.3	2.4	1.3
R14	Lawson Road, Badgerys Creek	1.8	1.4	0.2	2.2	1.7	0.3	4.3	3.2	1.5
R15	Mersey Rd, Greendale	1.1	0.8	0.2	1.3	1.0	0.2	3.4	2.5	1.4
R17	Luddenham Road	0.5	0.4	0.1	1.0	0.7	0.1	3.1	2.2	1.3
R18	Cnr Adams & Elizabeth Drive	0.7	0.5	0.1	1.6	1.2	0.3	3.7	2.7	1.5
R19	Cnr Adams & Anton Road	2.3	1.7	0.3	2.4	1.8	0.3	4.5	3.3	1.5
R21	Cnr Willowdene Ave and Vicar Park Lane	1.1	0.8	0.2	1.7	1.3	0.2	3.8	2.8	1.4
R22	Rossmore, Victor Ave	1.0	0.8	0.1	1.1	0.8	0.2	3.2	2.3	1.4
R23	Wallacia, Greendale Rd	0.4	0.3	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R24	Badgerys Creek 1 NE	3.1	2.3	0.5	4.6	3.4	0.6	6.7	4.9	1.8
R25	Badgerys Creek 2 SW	0.5	0.4	0.1	4.8	3.6	0.9	6.9	5.1	2.1
R27	Greendale, Dwyer Rd	0.2	0.1	<0.1	0.8	0.6	0.1	2.9	2.1	1.3
R30	Rossmore residential	0.4	0.3	0.1	3.1	2.3	0.3	5.2	3.8	1.5
R31	Mt Vernon residential	0.8	0.6	0.1	0.8	0.6	0.2	2.9	2.1	1.4
R34	Emmaus Residential Aged Care	0.5	0.4	0.1	1.1	0.9	0.2	3.2	2.4	1.4
R35	Mamre After School and Vacation Care	0.4	0.3	0.1	0.9	0.7	0.2	3.0	2.2	1.4
R36	Head Start After School Care	0.7	0.5	0.1	2.3	1.7	0.3	4.4	3.2	1.5
R37	Schoolies at Mulgoa	0.4	0.3	0.1	0.8	0.6	0.1	2.9	2.1	1.3
R38	Do-re-mi Day Care Centre	1.2	0.9	0.1	1.7	1.2	0.2	3.8	2.7	1.4
R39	Little Amigos Austral Early Learning Centre	0.7	0.5	0.2	0.8	0.6	0.2	2.9	2.1	1.4
R40	Little Smarties Childcare Centre	0.5	0.4	0.1	1.4	1.0	0.2	3.5	2.5	1.4
R41	The Grove Academy	0.5	0.3	0.1	0.8	0.6	0.1	2.9	2.1	1.3
R42	Horsley Kids	0.4	0.3	<0.1	0.5	0.3	0.1	2.6	1.8	1.3
R44	Bringelly Child Care Centre	0.6	0.4	0.1	0.9	0.7	0.2	3.0	2.2	1.4
R46	Clementson Drive Early Educational Centre	0.6	0.5	0.2	1.0	0.8	0.3	3.1	2.3	1.5

Receptor	Receptor location	Airport (mg/m³)			Airport + external roadways (mg/m³)			Cumulative (mg/m³)		
		15-minute	1-hour	8-hour	15-minute	1-hour	8-hour	15-minute	1-hour	8-hour
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*100*	*30*	*10*
R48	Kids Korner West Hoxton Early Learning Centre	0.3	0.2	<0.1	1.4	1.0	0.2	3.5	2.5	1.4
R49	Luddenham Child Care Centre	0.3	0.3	<0.1	0.4	0.3	0.1	2.5	1.8	1.3
R52	The Frogs Lodge	0.5	0.4	0.1	0.9	0.7	0.2	3.0	2.2	1.4
R53	Rossmore Community Preschool	0.4	0.3	0.1	2.6	1.9	0.3	4.7	3.4	1.5
R54	Mulgoa Preschool	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R55	Jillys Educational Childcare Centre	0.6	0.5	0.1	1.0	0.7	0.2	3.1	2.2	1.4
R57	Wallacia Progress Hall	0.3	0.2	0.1	0.4	0.3	0.1	2.5	1.8	1.3
R59	Bringelly Community Centre	0.5	0.4	0.1	1.1	0.8	0.3	3.2	2.3	1.5
R63	Luddenham Progress Hall	0.3	0.2	0.1	0.5	0.3	0.1	2.6	1.8	1.3
R64	Mulgoa Hall	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R65	Emmaus Catholic College	0.5	0.3	0.1	1.0	0.7	0.1	3.1	2.2	1.3
R66	University of Sydney Farms	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R68	Christadelphian Heritage College Sydney	1.4	1.0	0.1	1.6	1.2	0.2	3.7	2.7	1.4
R69	Mamre Anglican School	0.4	0.3	0.1	1.6	1.2	0.3	3.7	2.7	1.5
R72	Irfan College	0.4	0.3	<0.1	3.1	2.4	0.5	5.2	3.9	1.7
R73	Luddenham Public School	0.3	0.3	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R74	Kemps Creek Public School	1.5	1.1	0.2	1.7	1.3	0.2	3.8	2.8	1.4
R75	Trinity Catholic Primary School	0.4	0.3	0.1	0.8	0.6	0.2	2.9	2.1	1.4
R76	Bringelly Public School	0.6	0.4	0.1	2.5	1.8	0.5	4.6	3.3	1.7
R78	Mulgoa Public School	0.4	0.3	0.1	0.6	0.4	0.1	2.7	1.9	1.3
R79	Rossmore Public School	0.4	0.3	0.1	1.4	1.1	0.3	3.5	2.6	1.5
R80	Wallacia Public School	0.3	0.3	<0.1	1.1	0.8	0.1	3.2	2.3	1.3
R82	Bellfield College - Junior Campus	0.4	0.3	0.1	0.7	0.5	0.1	2.8	2.0	1.3
R84	Bringelly Park	0.5	0.4	0.1	1.1	0.8	0.3	3.2	2.3	1.5
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.3	0.2	0.1	0.8	0.6	0.1	2.9	2.1	1.3
R86	Blaxland Crossing Reserve	0.3	0.2	<0.1	1.0	0.7	0.1	3.1	2.2	1.3
R87	Bill Anderson Reserve	0.6	0.4	0.1	1.8	1.3	0.3	3.9	2.8	1.5
R88	Kemps Creek Nature Reserve	0.4	0.3	<0.1	0.9	0.6	0.1	3.0	2.1	1.3
R91	Western Sydney Parklands	0.9	0.6	0.1	1.2	0.9	0.2	3.3	2.4	1.4
R93	Rossmore Grange	0.6	0.5	0.1	0.8	0.6	0.1	2.9	2.1	1.3
R94	Freeburn Park	0.5	0.4	0.1	0.6	0.4	0.1	2.7	1.9	1.3

Receptor	Receptor location	Airport (mg/m³)			Airport + external roadways (mg/m³)			Cumulative (mg/m³)		
		15-minute	1-hour	8-hour	15-minute	1-hour	8-hour	15-minute	1-hour	8-hour
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*100*	*30*	*10*
R95	Overett Reserve	0.8	0.6	0.1	1.5	1.1	0.3	3.6	2.6	1.5
R97	Mulgoa Park	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R98	Wallacia Bowling and Recreation Club	0.3	0.2	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R99	Hubertus Country Club	1.7	1.3	0.2	1.8	1.3	0.2	3.9	2.8	1.4
R100	Sugarloaf Cobbitty Equestrian Club	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R102	Panthers Wallacia	0.3	0.3	<0.1	1.0	0.7	0.1	3.1	2.2	1.3
R103	Twin Creeks Golf and Country Club	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R104	Sydney International Shooting Centre	1.2	0.9	0.1	1.8	1.3	0.2	3.9	2.8	1.4
R108	Luddenham Showground	0.3	0.2	0.1	0.5	0.4	0.1	2.6	1.9	1.3
R109	Kemps Creek Sporting and Bowling Club	0.8	0.6	0.1	1.9	1.4	0.3	4.0	2.9	1.5
R110	St James Luddenham	0.4	0.3	0.1	0.7	0.5	0.1	2.8	2.0	1.3
R111	Lin Ying temple	0.9	0.7	0.3	1.0	0.8	0.3	3.1	2.3	1.5
R112	Vat Ketanak Khmer Kampuchea Krom	0.4	0.3	0.1	0.9	0.6	0.1	3.0	2.1	1.3
R114	Anglican Church Sydney Diocese	0.3	0.3	<0.1	0.7	0.5	0.1	2.8	2.0	1.3
R115	Anglican Parish of Mulgoa	0.4	0.3	0.1	0.6	0.5	0.1	2.7	2.0	1.3
R117	Bringelly Vineyard Church	1.0	0.7	0.1	2.4	1.8	0.4	4.5	3.3	1.6
R118	Free Church of Tonga	0.8	0.6	0.1	0.9	0.7	0.2	3.0	2.2	1.4
R120	Our Lady Queen of Peace	0.5	0.3	0.1	1.5	1.1	0.2	3.6	2.6	1.4
R122	St Anthony	0.6	0.5	0.2	1.2	0.9	0.3	3.3	2.4	1.5
R123	St Marys Church	0.7	0.5	0.1	0.9	0.7	0.1	3.0	2.2	1.3
R124	Wallacia Christian Church	0.3	0.2	<0.1	0.8	0.6	0.1	2.9	2.1	1.3
R126	St Francis Xavier Church	0.8	0.6	0.1	0.9	0.7	0.2	3.0	2.2	1.4
R127	Luddenham Uniting Church	0.2	0.2	<0.1	0.4	0.3	0.1	2.5	1.8	1.3
R130	Hopewood Health Retreat	0.4	0.3	0.1	0.6	0.4	0.2	2.7	1.9	1.4
R131	Science of the Soul Study Centre	0.8	0.6	0.1	1.6	1.2	0.3	3.7	2.7	1.5
R132	Bringelly shops	0.5	0.4	0.1	1.4	1.1	0.3	3.5	2.6	1.5
R134	Kemps Creek shops	0.6	0.4	0.1	1.3	1.0	0.2	3.4	2.5	1.4
R135	Luddenham shops	0.4	0.3	0.1	0.6	0.4	0.1	2.7	1.9	1.3
R136	Mulgoa shops	0.7	0.5	0.1	0.9	0.7	0.1	3.0	2.2	1.3
R137	Rossmore shops	0.4	0.3	0.1	1.6	1.2	0.2	3.7	2.7	1.4
R138	Wallacia Shops	0.3	0.2	<0.1	0.9	0.6	0.1	3.0	2.1	1.3
R140	Holy Family Catholic Primary and Church	0.5	0.4	0.1	0.8	0.6	0.2	2.9	2.1	1.4
R141	Edmund Rice Retreat and Conference Centre	0.5	0.3	0.1	0.6	0.4	0.1	2.7	1.9	1.3

F.1.5 Sulphur dioxide

Table F5-a: Predicted incremental SO_2 concentrations during Stage 1 development

Receptor	Receptor location	Airport (µg/m³)				Airport + external roadways (µg/m³)			
		10-minute	1-hour	24-hour	Annual	10-minute	1-hour	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
R1	Bringelly	28	19	1.8	0.1	29	19	2.0	0.1
R2	Luddenham	18	12	1.4	0.2	25	16	1.4	0.2
R3	Greendale, Greendale Road	63	42	4.6	0.2	83	55	4.6	0.2
R4	Kemps Creek	24	16	2.2	0.1	54	36	2.3	0.1
R6	Mulgoa	122	81	2.4	0.1	52	34	2.4	0.1
R7	Wallacia	66	44	1.5	0.1	32	21	1.5	0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	64	42	2.2	0.2	64	43	2.2	0.2
R14	Lawson Road, Badgerys Creek	85	56	4.6	0.3	122	81	4.8	0.3
R15	Mersey Rd, Greendale	49	32	3.9	0.3	66	44	3.9	0.3
R17	Luddenham Road	133	88	2.7	0.2	54	35	2.8	0.2
R18	Cnr Adams & Elizabeth Drive	39	26	2.5	0.6	36	24	2.5	0.6
R19	Cnr Adams & Anton Road	102	67	4.4	0.8	102	68	4.4	0.8
R21	Cnr Willowdene Ave and Vicar Park Lane	51	34	3.8	0.2	86	57	3.8	0.2
R22	Rossmore, Victor Ave	25	16	2.4	0.1	49	32	2.5	0.1
R23	Wallacia, Greendale Rd	83	55	2.8	0.1	43	29	2.9	0.1
R24	Badgerys Creek 1 NE	87	57	7.4	0.7	133	88	7.4	0.7
R25	Badgerys Creek 2 SW	84	56	2.2	0.1	40	27	2.3	0.2
R27	Greendale, Dwyer Rd	16	11	0.6	0.1	16	11	0.7	0.1
R30	Rossmore residential	24	16	1.7	0.1	29	19	1.9	0.1
R31	Mt Vernon residential	90	59	4.2	0.1	90	59	4.3	0.2
R34	Emmaus Residential Aged Care	42	28	2.1	0.2	42	28	2.1	0.2
R35	Mamre After School and Vacation Care	47	31	2.1	0.2	47	31	2.1	0.2
R36	Head Start After School Care	28	19	1.6	<0.1	55	36	1.8	0.1
R37	Schoolies at Mulgoa	45	30	2.3	0.2	24	16	2.3	0.3
R38	Do-re-mi Day Care Centre	65	43	3.2	0.1	88	58	3.3	0.1
R39	Little Amigos Austral Early Learning Centre	61	40	4.1	0.1	42	28	4.2	0.1
R40	Little Smarties Childcare Centre	42	28	1.8	0.2	42	28	1.9	0.2
R41	The Grove Academy	30	20	1.2	0.1	25	16	1.2	0.1
R42	Horsley Kids	28	19	1.5	0.1	28	19	1.6	0.1
R44	Bringelly Child Care Centre	23	16	2.3	0.1	36	24	2.3	0.1
R46	Clementson Drive Early Educational Centre	37	24	4.1	0.1	37	25	4.2	0.1
R48	Kids Korner West Hoxton Early Learning Centre	51	34	1.2	0.1	36	24	1.2	0.1

Receptor	Receptor location	Airport (µg/m³)				Airport + external roadways (µg/m³)			
		10-minute	1-hour	24-hour	Annual	10-minute	1-hour	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
R49	Luddenham Child Care Centre	56	37	1.7	0.2	19	13	1.7	0.2
R52	The Frogs Lodge	34	22	2.9	0.1	34	22	3.0	0.1
R53	Rossmore Community Preschool	28	18	1.6	0.1	27	18	1.8	0.1
R54	Mulgoa Preschool	27	18	1.8	0.1	28	18	1.8	0.1
R55	Jillys Educational Childcare Centre	32	21	2.1	0.1	36	24	2.2	0.1
R57	Wallacia Progress Hall	28	19	1.6	0.1	29	19	1.6	0.1
R59	Bringelly Community Centre	33	22	1.9	0.1	33	22	2.0	0.1
R63	Luddenham Progress Hall	60	40	1.2	0.1	22	15	1.2	0.1
R64	Mulgoa Hall	37	25	2.2	0.1	38	25	2.2	0.1
R65	Emmaus Catholic College	45	30	2.2	0.2	44	29	2.2	0.2
R66	University of Sydney Farms	41	27	1.4	0.1	29	19	1.4	0.1
R68	Christadelphian Heritage College Sydney	32	21	2.7	0.1	85	56	2.8	0.1
R69	Mamre Anglican School	48	32	2.2	0.2	48	32	2.2	0.2
R72	Irfan College	10	7	1.3	<0.1	30	20	1.3	0.1
R73	Luddenham Public School	38	25	1.7	0.2	24	16	1.7	0.2
R74	Kemps Creek Public School	52	34	2.9	0.1	91	60	3.0	0.1
R75	Trinity Catholic Primary School	45	30	2.0	0.2	45	30	2.0	0.2
R76	Bringelly Public School	45	30	1.8	0.1	30	20	2.0	0.2
R78	Mulgoa Public School	36	24	1.9	0.1	35	23	2.0	0.1
R79	Rossmore Public School	22	14	1.7	0.1	23	15	1.8	0.1
R80	Wallacia Public School	29	19	1.3	0.1	33	22	1.3	0.1
R82	Bellfield College - Junior Campus	33	22	1.8	0.1	29	19	1.9	0.1
R84	Bringelly Park	32	21	1.9	0.1	32	21	2.0	0.1
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	27	18	1.9	0.1	33	22	2.0	0.1
R86	Blaxland Crossing Reserve	36	24	1.3	0.1	32	21	1.3	0.1
R87	Bill Anderson Reserve	22	14	2.4	0.1	46	30	2.5	0.1
R88	Kemps Creek Nature Reserve	29	19	1.0	0.1	21	14	1.0	0.1
R91	Western Sydney Parklands	59	39	2.2	0.1	70	46	2.3	0.1
R93	Rossmore Grange	56	37	1.9	0.1	30	20	1.9	0.1
R94	Freeburn Park	54	36	2.0	0.2	25	16	2.0	0.2
R95	Overett Reserve	49	33	2.4	0.1	62	41	2.6	0.2
R97	Mulgoa Park	38	25	2.2	0.1	39	26	2.2	0.1
R98	Wallacia Bowling and Recreation Club	28	19	1.5	0.1	28	19	1.6	0.1

Receptor	Receptor location	Airport (µg/m³)				Airport + external roadways (µg/m³)			
		10-minute	1-hour	24-hour	Annual	10-minute	1-hour	24-hour	Annual
Ambient objective / Assessment criterion		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
R99	Hubertus Country Club	73	48	4.3	0.8	73	48	4.3	0.8
R100	Sugarloaf Cobbitty Equestrian Club	84	56	2.3	0.1	33	22	2.3	0.1
R102	Panthers Wallacia	49	32	1.5	0.1	32	21	1.5	0.1
R103	Twin Creeks Golf and Country Club	56	37	1.6	0.2	33	22	1.6	0.2
R104	Sydney International Shooting Centre	36	24	2.6	0.1	86	57	2.8	0.1
R108	Luddenham Showground	33	22	1.6	0.2	16	11	1.6	0.2
R109	Kemps Creek Sporting and Bowling Club	29	19	1.9	0.1	61	41	2.0	0.1
R110	St James Luddenham	33	22	1.9	0.3	30	20	1.9	0.3
R111	Lin Ying temple	49	32	4.6	0.1	49	32	4.6	0.1
R112	Vat Ketanak Khmer Kampuchea Krom	24	16	1.8	0.1	29	19	1.9	0.1
R114	Anglican Church Sydney Diocese	19	13	1.7	0.1	24	16	1.8	0.1
R115	Anglican Parish of Mulgoa	29	19	1.6	0.1	29	19	1.7	0.1
R117	Bringelly Vineyard Church	161	106	2.0	0.1	52	34	2.1	0.1
R118	Free Church of Tonga	61	41	3.5	0.1	62	41	3.6	0.1
R120	Our Lady Queen of Peace	32	21	1.4	0.1	24	16	1.5	0.1
R122	St Anthony	40	26	3.9	0.1	40	27	4.1	0.1
R123	St Marys Church	52	35	2.3	0.1	53	35	2.3	0.1
R124	Wallacia Christian Church	30	20	1.5	0.1	32	21	1.6	0.1
R126	St Francis Xavier Church	70	46	4.3	0.1	57	37	4.4	0.1
R127	Luddenham Uniting Church	41	27	1.0	0.1	19	13	1.0	0.1
R130	Hopewood Health Retreat	25	16	1.7	0.1	36	24	1.8	0.1
R131	Science of the Soul Study Centre	25	16	1.9	0.1	61	40	2.0	0.1
R132	Bringelly shops	62	41	1.9	0.1	27	18	2.0	0.1
R134	Kemps Creek shops	31	20	2.3	0.1	42	28	2.3	0.1
R135	Luddenham shops	31	20	2.0	0.3	31	20	2.1	0.3
R136	Mulgoa shops	59	39	2.5	0.1	54	36	2.5	0.1
R137	Rossmore shops	22	15	1.8	0.1	31	21	1.9	0.1
R138	Wallacia Shops	32	21	1.5	0.1	31	21	1.5	0.1
R140	Holy Family Catholic Primary and Church	32	21	2.4	0.3	39	26	2.4	0.3
R141	Edmund Rice Retreat and Conference Centre	44	29	1.8	0.1	44	29	1.8	0.1

Table F5-b: Predicted cumulative SO_2 concentrations during Stage 1 development.

Receptor	Receptor location	Cumulative (µg/m³)			
		10-minute	1-hour	24-hour	Annual
	Ambient objective / Assessment criterion	*712*	*570*	*228*	*60*
R1	Bringelly	109	53	11.9	1.3
R2	Luddenham	105	50	11.3	1.4
R3	Greendale, Greendale Road	163	89	14.5	1.4
R4	Kemps Creek	134	70	12.2	1.3
R6	Mulgoa	132	68	12.3	1.3
R7	Wallacia	112	55	11.4	1.3
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	144	77	12.1	1.4
R14	Lawson Road, Badgerys Creek	202	115	14.7	1.5
R15	Mersey Rd, Greendale	146	78	13.8	1.5
R17	Luddenham Road	134	69	12.7	1.4
R18	Cnr Adams & Elizabeth Drive	116	58	12.4	1.8
R19	Cnr Adams & Anton Road	182	102	14.3	2.0
R21	Cnr Willowdene Ave and Vicar Park Lane	166	91	13.7	1.4
R22	Rossmore, Victor Ave	129	66	12.4	1.3
R23	Wallacia, Greendale Rd	123	63	12.8	1.3
R24	Badgerys Creek 1 NE	213	122	17.3	1.9
R25	Badgerys Creek 2 SW	120	61	12.2	1.4
R27	Greendale, Dwyer Rd	96	45	10.6	1.3
R30	Rossmore residential	109	53	11.8	1.3
R31	Mt Vernon residential	170	93	14.2	1.4
R34	Emmaus Residential Aged Care	122	62	12.0	1.4
R35	Mamre After School and Vacation Care	127	65	12.0	1.4
R36	Head Start After School Care	135	70	11.7	1.3
R37	Schoolies at Mulgoa	104	50	12.2	1.5
R38	Do-re-mi Day Care Centre	168	92	13.2	1.3
R39	Little Amigos Austral Early Learning Centre	122	62	14.1	1.3
R40	Little Smarties Childcare Centre	122	62	11.8	1.4
R41	The Grove Academy	105	50	11.1	1.3
R42	Horsley Kids	108	53	11.5	1.3
R44	Bringelly Child Care Centre	116	58	12.2	1.3
R46	Clementson Drive Early Educational Centre	117	59	14.1	1.3
R48	Kids Korner West Hoxton Early Learning Centre	116	58	11.1	1.3
R49	Luddenham Child Care Centre	99	47	11.6	1.4
R52	The Frogs Lodge	114	56	12.9	1.3
R53	Rossmore Community Preschool	107	52	11.7	1.3
R54	Mulgoa Preschool	108	52	11.7	1.3
R55	Jillys Educational Childcare Centre	116	58	12.1	1.3
R57	Wallacia Progress Hall	109	53	11.5	1.3
R59	Bringelly Community Centre	113	56	11.9	1.3
R63	Luddenham Progress Hall	102	49	11.1	1.3
R64	Mulgoa Hall	118	59	12.1	1.3

Receptor	Receptor location	Cumulative (µg/m³)			
		10-minute	1-hour	24-hour	Annual
Ambient objective / Assessment criterion		*712*	*570*	*228*	*60*
R65	Emmaus Catholic College	124	63	12.1	1.4
R66	University of Sydney Farms	109	53	11.3	1.3
R68	Christadelphian Heritage College Sydney	165	90	12.7	1.3
R69	Mamre Anglican School	128	66	12.1	1.4
R72	Irfan College	110	54	11.2	1.3
R73	Luddenham Public School	104	50	11.6	1.4
R74	Kemps Creek Public School	171	94	12.9	1.3
R75	Trinity Catholic Primary School	125	64	11.9	1.4
R76	Bringelly Public School	110	54	11.9	1.4
R78	Mulgoa Public School	115	57	11.9	1.3
R79	Rossmore Public School	103	49	11.7	1.3
R80	Wallacia Public School	113	56	11.2	1.3
R82	Bellfield College - Junior Campus	109	53	11.8	1.3
R84	Bringelly Park	112	55	11.9	1.3
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	113	56	11.9	1.3
R86	Blaxland Crossing Reserve	112	55	11.2	1.3
R87	Bill Anderson Reserve	126	64	12.4	1.3
R88	Kemps Creek Nature Reserve	101	48	10.9	1.3
R91	Western Sydney Parklands	150	80	12.2	1.3
R93	Rossmore Grange	110	54	11.8	1.3
R94	Freeburn Park	105	50	11.9	1.4
R95	Overett Reserve	142	75	12.5	1.4
R97	Mulgoa Park	119	60	12.1	1.3
R98	Wallacia Bowling and Recreation Club	108	53	11.5	1.3
R99	Hubertus Country Club	153	82	14.2	2.0
R100	Sugarloaf Cobbitty Equestrian Club	113	56	12.2	1.3
R102	Panthers Wallacia	112	55	11.4	1.3
R103	Twin Creeks Golf and Country Club	113	56	11.5	1.4
R104	Sydney International Shooting Centre	166	91	12.7	1.3
R108	Luddenham Showground	96	45	11.5	1.4
R109	Kemps Creek Sporting and Bowling Club	141	75	11.9	1.3
R110	St James Luddenham	110	54	11.8	1.5
R111	Lin Ying temple	129	66	14.5	1.3
R112	Vat Ketanak Khmer Kampuchea Krom	109	53	11.8	1.3
R114	Anglican Church Sydney Diocese	104	50	11.7	1.3
R115	Anglican Parish of Mulgoa	109	53	11.6	1.3
R117	Bringelly Vineyard Church	132	68	12.0	1.3
R118	Free Church of Tonga	142	75	13.5	1.3
R120	Our Lady Queen of Peace	104	50	11.4	1.3
R122	St Anthony	120	61	14.0	1.3
R123	St Marys Church	133	69	12.2	1.3
R124	Wallacia Christian Church	112	55	11.5	1.3

Receptor	Receptor location	Cumulative (µg/m³)			
		10-minute	1-hour	24-hour	Annual
Ambient objective / Assessment criterion		*712*	*570*	*228*	*60*
R126	St Francis Xavier Church	137	71	14.3	1.3
R127	Luddenham Uniting Church	99	47	10.9	1.3
R130	Hopewood Health Retreat	116	58	11.7	1.3
R131	Science of the Soul Study Centre	141	74	11.9	1.3
R132	Bringelly shops	107	52	11.9	1.3
R134	Kemps Creek shops	122	62	12.2	1.3
R135	Luddenham shops	111	54	12.0	1.5
R136	Mulgoa shops	134	70	12.4	1.3
R137	Rossmore shops	111	55	11.8	1.3
R138	Wallacia Shops	111	55	11.4	1.3
R140	Holy Family Catholic Primary and Church	119	60	12.3	1.5
R141	Edmund Rice Retreat and Conference Centre	124	63	11.7	1.3

F.1.6 Air toxics

Table F6-a: Predicted incremental 99.9th percentile 1-hour average air toxic concentrations during Stage 1 development

Receptor ID	Receptor description	Airport (µg/m³)				Airport + external roadways (µg/m³)			
		Benzene	Toluene	Xylene	Formaldehyde	Benzene	Toluene	Xylene	Formaldehyde
NSW EPA criterion		*29*	*360*	*180*	*20*	*29*	*360*	*180*	*20*
R1	Bringelly	0.1	<0.1	<0.1	0.7	1.5	0.6	0.4	11.1
R2	Luddenham	0.2	0.1	0.1	1.5	1.3	0.5	0.3	9.2
R3	Greendale, Greendale Road	0.2	0.1	<0.1	1.2	1.0	0.4	0.3	7.4
R4	Kemps Creek	0.1	<0.1	<0.1	0.9	1.3	0.5	0.4	9.8
R6	Mulgoa	0.1	<0.1	<0.1	0.7	0.7	0.3	0.2	5.3
R7	Wallacia	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.2
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.1	<0.1	<0.1	0.8	0.9	0.3	0.2	6.3
R14	Lawson Road, Badgerys Creek	0.3	0.1	0.1	2.2	1.5	0.6	0.4	10.7
R15	Mersey Rd, Greendale	0.3	0.1	0.1	1.8	1.4	0.5	0.4	10.5
R17	Luddenham Road	0.1	0.1	<0.1	1.0	0.9	0.3	0.2	6.6
R18	Cnr Adams & Elizabeth Drive	0.2	0.1	<0.1	1.4	1.4	0.5	0.4	1<0.1
R19	Cnr Adams & Anton Road	0.4	0.1	0.1	2.6	2.1	0.8	0.6	15.6
R21	Cnr Willowdene Ave and Vicar Park Lane	0.2	0.1	0.1	1.5	1.3	0.5	0.4	9.7
R22	Rossmore, Victor Ave	0.2	0.1	<0.1	1.1	0.9	0.4	0.2	6.8
R23	Wallacia, Greendale Rd	0.1	<0.1	<0.1	0.9	0.6	0.2	0.2	4.3
R24	Badgerys Creek 1 NE	0.6	0.2	0.2	4.2	3.2	1.2	0.8	23.2
R25	Badgerys Creek 2 SW	0.3	0.1	0.1	2.0	2.6	1.0	0.7	18.8

Receptor ID	Receptor description	Airport (µg/m³) Benzene	Toluene	Xylene	Formaldehyde	Airport + external roadways (µg/m³) Benzene	Toluene	Xylene	Formaldehyde
NSW EPA criterion		*29*	*360*	*180*	*20*	*29*	*360*	*180*	*20*
R27	Greendale, Dwyer Rd	0.1	0.1	<0.1	1.0	1.1	0.4	0.3	7.9
R30	Rossmore residential	0.1	<0.1	<0.1	0.5	1.5	0.6	0.4	11.1
R31	Mt Vernon residential	0.2	0.1	0.1	1.4	1.1	0.4	0.3	8.3
R34	Emmaus Residential Aged Care	0.1	<0.1	<0.1	0.9	0.9	0.4	0.2	6.8
R35	Mamre After School and Vacation Care	0.1	<0.1	<0.1	0.7	0.9	0.4	0.2	6.8
R36	Head Start After School Care	0.1	<0.1	<0.1	0.6	1.3	0.5	0.4	9.8
R37	Schoolies at Mulgoa	0.3	0.1	0.1	2.0	1.1	0.4	0.3	8.3
R38	Do-re-mi Day Care Centre	0.1	<0.1	<0.1	0.9	0.9	0.3	0.2	6.6
R39	Little Amigos Austral Early Learning Centre	0.2	0.1	<0.1	1.3	0.9	0.3	0.2	6.3
R40	Little Smarties Childcare Centre	0.1	<0.1	<0.1	0.7	0.9	0.4	0.2	6.8
R41	The Grove Academy	0.1	<0.1	<0.1	0.4	0.7	0.3	0.2	5.4
R42	Horsley Kids	0.1	<0.1	<0.1	0.8	0.8	0.3	0.2	5.5
R44	Bringelly Child Care Centre	0.2	0.1	0.1	1.7	1.2	0.5	0.3	9.0
R46	Clementson Drive Early Educational Centre	0.2	0.1	0.1	1.5	1.1	0.4	0.3	7.9
R48	Kids Korner West Hoxton Early Learning Centre	<0.1	<0.1	<0.1	0.4	1.1	0.4	0.3	8.4
R49	Luddenham Child Care Centre	0.2	0.1	0.1	1.7	1.2	0.5	0.3	8.6
R52	The Frogs Lodge	0.1	<0.1	<0.1	0.9	1.0	0.4	0.3	7.4
R53	Rossmore Community Preschool	0.1	<0.1	<0.1	0.5	1.1	0.4	0.3	8.1
R54	Mulgoa Preschool	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	4.8
R55	Jillys Educational Childcare Centre	0.1	<0.1	<0.1	0.8	0.7	0.3	0.2	4.9
R57	Wallacia Progress Hall	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.2
R59	Bringelly Community Centre	0.1	<0.1	<0.1	0.8	1.2	0.5	0.3	9.0
R63	Luddenham Progress Hall	0.3	0.1	0.1	2.3	1.1	0.4	0.3	7.8
R64	Mulgoa Hall	0.1	<0.1	<0.1	0.6	0.8	0.3	0.2	5.7
R65	Emmaus Catholic College	0.1	<0.1	<0.1	0.7	0.9	0.3	0.2	6.2
R66	University of Sydney Farms	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	5.4
R68	Christadelphian Heritage College Sydney	0.1	0.1	<0.1	1.1	1.0	0.4	0.3	7.4
R69	Mamre Anglican School	0.1	<0.1	<0.1	0.7	1.2	0.4	0.3	8.5
R72	Irfan College	0.1	<0.1	<0.1	0.7	1.4	0.5	0.4	10.3
R73	Luddenham Public School	0.3	0.1	0.1	2.5	1.4	0.5	0.4	9.9
R74	Kemps Creek Public School	0.2	0.1	<0.1	1.2	1.0	0.4	0.3	7.6

Receptor ID	Receptor description	Airport (µg/m³)				Airport + external roadways (µg/m³)			
		Benzene	Toluene	Xylene	Formaldehyde	Benzene	Toluene	Xylene	Formaldehyde
NSW EPA criterion		*29*	*360*	*180*	*20*	*29*	*360*	*180*	*20*
R75	Trinity Catholic Primary School	0.1	<0.1	<0.1	0.7	0.8	0.3	0.2	5.9
R76	Bringelly Public School	0.1	<0.1	<0.1	0.8	2.4	0.9	0.6	17.7
R78	Mulgoa Public School	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	5.5
R79	Rossmore Public School	0.1	<0.1	<0.1	0.5	1.5	0.6	0.4	11.0
R80	Wallacia Public School	0.1	<0.1	<0.1	0.6	0.6	0.2	0.2	4.3
R82	Bellfield College - Junior Campus	0.1	<0.1	<0.1	0.5	0.8	0.3	0.2	6.1
R84	Bringelly Park	0.1	<0.1	<0.1	0.8	1.2	0.5	0.3	9.1
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.3
R86	Blaxland Crossing Reserve	0.1	<0.1	<0.1	0.6	0.6	0.2	0.1	4.1
R87	Bill Anderson Reserve	0.1	0.1	<0.1	1.0	1.2	0.5	0.3	9.0
R88	Kemps Creek Nature Reserve	<0.1	<0.1	<0.1	0.3	0.8	0.3	0.2	5.7
R91	Western Sydney Parklands	0.1	<0.1	<0.1	0.8	1.0	0.4	0.3	7.4
R93	Rossmore Grange	0.1	<0.1	<0.1	0.7	0.8	0.3	0.2	5.6
R94	Freeburn Park	0.4	0.1	0.1	2.6	1.4	0.5	0.4	1<0.1
R95	Overett Reserve	0.1	<0.1	<0.1	0.9	1.4	0.6	0.4	10.6
R97	Mulgoa Park	0.1	<0.1	<0.1	0.6	0.8	0.3	0.2	5.8
R98	Wallacia Bowling and Recreation Club	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.3
R99	Hubertus Country Club	0.3	0.1	0.1	2.0	1.6	0.6	0.4	12.0
R100	Sugarloaf Cobbitty Equestrian Club	0.1	<0.1	<0.1	0.7	0.9	0.3	0.2	6.3
R102	Panthers Wallacia	0.1	<0.1	<0.1	0.7	0.7	0.2	0.2	4.8
R103	Twin Creeks Golf and Country Club	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	5.2
R104	Sydney International Shooting Centre	0.1	0.1	<0.1	1.0	1.0	0.4	0.3	7.1
R108	Luddenham Showground	0.1	<0.1	<0.1	0.9	1.1	0.4	0.3	7.7
R109	Kemps Creek Sporting and Bowling Club	0.1	<0.1	<0.1	0.7	1.3	0.5	0.3	9.6
R110	St James Luddenham	0.3	0.1	0.1	1.8	1.3	0.5	0.3	9.5
R111	Lin Ying temple	0.2	0.1	0.1	1.8	1.1	0.4	0.3	8.0
R112	Vat Ketanak Khmer Kampuchea Krom	0.1	<0.1	<0.1	0.5	0.8	0.3	0.2	5.5
R114	Anglican Church Sydney Diocese	0.1	<0.1	<0.1	0.5	0.9	0.3	0.2	6.4
R115	Anglican Parish of Mulgoa	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	4.9
R117	Bringelly Vineyard Church	0.1	<0.1	<0.1	0.9	1.0	0.4	0.3	7.5
R118	Free Church of Tonga	0.1	0.1	<0.1	1.0	1.0	0.4	0.3	7.2

Receptor ID	Receptor description	Airport (µg/m³) Benzene	Toluene	Xylene	Formaldehyde	Airport + external roadways (µg/m³) Benzene	Toluene	Xylene	Formaldehyde
NSW EPA criterion		*29*	*360*	*180*	*20*	*29*	*360*	*180*	*20*
R120	Our Lady Queen of Peace	0.1	<0.1	<0.1	0.5	1.0	0.4	0.3	7.3
R122	St Anthony	0.1	0.1	<0.1	1.1	1.2	0.4	0.3	8.5
R123	St Marys Church	0.1	<0.1	<0.1	0.7	0.7	0.3	0.2	4.9
R124	Wallacia Christian Church	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.4
R126	St Francis Xavier Church	0.2	0.1	<0.1	1.2	1.0	0.4	0.3	7.2
R127	Luddenham Uniting Church	0.2	0.1	0.1	1.8	0.9	0.3	0.2	6.6
R130	Hopewood Health Retreat	0.1	<0.1	<0.1	0.6	0.6	0.2	0.2	4.7
R131	Science of the Soul Study Centre	0.1	<0.1	<0.1	0.7	1.3	0.5	0.3	9.6
R132	Bringelly shops	0.1	<0.1	<0.1	0.8	1.4	0.5	0.4	10.5
R134	Kemps Creek shops	0.1	<0.1	<0.1	1.0	1.1	0.4	0.3	8.2
R135	Luddenham shops	0.3	0.1	0.1	2.0	1.4	0.5	0.4	9.9
R136	Mulgoa shops	0.1	<0.1	<0.1	0.7	0.7	0.3	0.2	5.3
R137	Rossmore shops	0.1	<0.1	<0.1	0.5	1.4	0.5	0.4	10.5
R138	Wallacia Shops	0.1	<0.1	<0.1	0.7	0.6	0.2	0.2	4.1
R140	Holy Family Catholic Primary and Church	0.2	0.1	0.1	1.4	1.1	0.4	0.3	8.1
R141	Edmund Rice Retreat and Conference Centre	0.1	<0.1	<0.1	0.6	0.7	0.3	0.2	4.9

Table F6-a: Predicted incremental 24-hour average air toxic concentrations during Stage 1 development

Receptor	Receptor location	Airport (µg/m³) Toluene	Xylene	Formaldehyde	Airport + external roadways (µg/m³) Toluene	Xylene	Formaldehyde
NEPM-AAQ investigation level		*4,160*	*1,170*	*853*	*4,160*	*1,170*	*853*
R1	Bringelly	<0.1	<0.1	0.9	0.1	0.1	2.2
R2	Luddenham	0.1	0.1	1.6	0.1	0.1	1.5
R3	Greendale, Greendale Road	0.1	0.1	1.5	0.1	0.1	1.5
R4	Kemps Creek	0.1	<0.1	1.1	0.1	0.1	1.7
R6	Mulgoa	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R7	Wallacia	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<0.1	<0.1	0.8	0.1	<0.1	1.1
R14	Lawson Road, Badgerys Creek	0.1	0.1	2.4	0.1	0.1	2.6
R15	Mersey Rd, Greendale	0.1	0.1	2.0	0.1	0.1	1.7
R17	Luddenham Road	0.1	<0.1	1.1	0.1	<0.1	1.1
R18	Cnr Adams & Elizabeth Drive	0.1	0.1	1.5	0.1	<0.1	1.3
R19	Cnr Adams & Anton Road	0.1	0.1	2.7	0.2	0.1	3.0

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Toluene	Xylene	Formaldehyde	Toluene	Xylene	Formaldehyde
NEPM-AAQ investigation level		*4,160*	*1,170*	*853*	*4,160*	*1,170*	*853*
R21	Cnr Willowdene Ave and Vicar Park Lane	0.1	0.1	1.7	0.1	0.1	1.4
R22	Rossmore, Victor Ave	0.1	<0.1	1.2	0.1	<0.1	1.3
R23	Wallacia, Greendale Rd	0.1	<0.1	1.1	0.1	<0.1	1.1
R24	Badgerys Creek 1 NE	0.2	0.2	4.6	0.3	0.2	4.9
R25	Badgerys Creek 2 SW	0.1	0.1	2.1	0.3	0.2	5.0
R27	Greendale, Dwyer Rd	0.1	<0.1	1.0	0.1	<0.1	1.3
R30	Rossmore residential	<0.1	<0.1	0.5	0.1	0.1	1.9
R31	Mt Vernon residential	0.1	0.1	1.4	0.1	0.1	1.5
R34	Emmaus Residential Aged Care	0.1	<0.1	1.1	0.1	<0.1	1.1
R35	Mamre After School and Vacation Care	<0.1	<0.1	0.7	0.1	<0.1	1.1
R36	Head Start After School Care	<0.1	<0.1	0.6	0.1	0.1	1.9
R37	Schoolies at Mulgoa	0.1	0.1	2.5	0.1	0.1	2.2
R38	Do-re-mi Day Care Centre	0.1	<0.1	1.0	0.1	<0.1	1.3
R39	Little Amigos Austral Early Learning Centre	0.1	0.1	1.6	0.1	0.1	1.5
R40	Little Smarties Childcare Centre	<0.1	<0.1	0.8	0.1	<0.1	1.3
R41	The Grove Academy	<0.1	<0.1	0.5	0.1	<0.1	1.0
R42	Horsley Kids	<0.1	<0.1	0.8	<0.1	<0.1	0.7
R44	Bringelly Child Care Centre	0.1	0.1	1.9	0.1	0.1	1.7
R46	Clementson Drive Early Educational Centre	0.1	0.1	1.7	0.1	0.1	1.5
R48	Kids Korner West Hoxton Early Learning Centre	<0.1	<0.1	0.4	0.1	0.1	1.7
R49	Luddenham Child Care Centre	0.1	0.1	2.1	0.1	0.1	1.9
R52	The Frogs Lodge	0.1	<0.1	1.0	0.1	<0.1	1.1
R53	Rossmore Community Preschool	<0.1	<0.1	0.5	0.1	0.1	1.5
R54	Mulgoa Preschool	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R55	Jillys Educational Childcare Centre	<0.1	<0.1	0.9	0.1	0.1	1.4
R57	Wallacia Progress Hall	<0.1	<0.1	0.7	<0.1	<0.1	0.8
R59	Bringelly Community Centre	<0.1	<0.1	0.9	0.1	0.1	1.9
R63	Luddenham Progress Hall	0.1	0.1	2.5	0.1	0.1	2.0
R64	Mulgoa Hall	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R65	Emmaus Catholic College	<0.1	<0.1	0.8	0.1	<0.1	1.3
R66	University of Sydney Farms	<0.1	<0.1	0.7	<0.1	<0.1	0.9
R68	Christadelphian Heritage College Sydney	0.1	<0.1	1.2	0.1	0.1	2.1
R69	Mamre Anglican School	<0.1	<0.1	0.7	0.1	0.1	1.6
R72	Irfan College	<0.1	<0.1	0.8	0.1	0.1	2.7
R73	Luddenham Public School	0.1	0.1	2.8	0.1	0.1	2.3

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Toluene	Xylene	Formaldehyde	Toluene	Xylene	Formaldehyde
NEPM-AAQ investigation level		*4,160*	*1,170*	*853*	*4,160*	*1,170*	*853*
R74	Kemps Creek Public School	0.1	<0.1	1.3	0.1	0.1	2.1
R75	Trinity Catholic Primary School	<0.1	<0.1	0.7	<0.1	<0.1	0.9
R76	Bringelly Public School	<0.1	<0.1	0.9	0.2	0.1	3.0
R78	Mulgoa Public School	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R79	Rossmore Public School	<0.1	<0.1	0.5	0.1	0.1	2.0
R80	Wallacia Public School	<0.1	<0.1	0.7	<0.1	<0.1	0.8
R82	Bellfield College - Junior Campus	<0.1	<0.1	0.5	<0.1	<0.1	1.0
R84	Bringelly Park	<0.1	<0.1	0.9	0.1	0.1	1.7
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.1	<0.1	1.0	<0.1	<0.1	0.9
R86	Blaxland Crossing Reserve	<0.1	<0.1	0.7	<0.1	<0.1	0.8
R87	Bill Anderson Reserve	0.1	<0.1	1.3	0.1	0.1	1.5
R88	Kemps Creek Nature Reserve	<0.1	<0.1	0.3	0.1	<0.1	1.0
R91	Western Sydney Parklands	<0.1	<0.1	0.8	0.1	0.1	1.8
R93	Rossmore Grange	<0.1	<0.1	0.8	0.1	<0.1	1.3
R94	Freeburn Park	0.2	0.1	3.4	0.1	0.1	2.8
R95	Overett Reserve	0.1	<0.1	1.0	0.1	0.1	1.6
R97	Mulgoa Park	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R98	Wallacia Bowling and Recreation Club	<0.1	<0.1	0.7	<0.1	<0.1	0.8
R99	Hubertus Country Club	0.1	0.1	2.0	0.1	0.1	1.9
R100	Sugarloaf Cobbitty Equestrian Club	<0.1	<0.1	0.7	0.1	<0.1	1.1
R102	Panthers Wallacia	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R103	Twin Creeks Golf and Country Club	<0.1	<0.1	0.6	<0.1	<0.1	0.7
R104	Sydney International Shooting Centre	0.1	<0.1	1.1	0.1	0.1	2.6
R108	Luddenham Showground	0.1	<0.1	1.0	0.1	<0.1	1.2
R109	Kemps Creek Sporting and Bowling Club	<0.1	<0.1	0.8	0.1	0.1	1.9
R110	St James Luddenham	0.1	0.1	2.2	0.1	0.1	1.9
R111	Lin Ying temple	0.1	0.1	2.2	0.1	0.1	1.8
R112	Vat Ketanak Khmer Kampuchea Krom	<0.1	<0.1	0.5	0.1	<0.1	1.0
R114	Anglican Church Sydney Diocese	<0.1	<0.1	0.5	0.1	<0.1	1.0
R115	Anglican Parish of Mulgoa	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R117	Bringelly Vineyard Church	<0.1	<0.1	0.9	0.1	0.1	1.6
R118	Free Church of Tonga	0.1	<0.1	1.2	0.1	<0.1	1.2
R120	Our Lady Queen of Peace	<0.1	<0.1	0.6	0.1	0.1	1.4
R122	St Anthony	0.1	<0.1	1.1	0.1	0.1	1.6
R123	St Marys Church	<0.1	<0.1	0.7	<0.1	<0.1	0.9

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Toluene	Xylene	Formaldehyde	Toluene	Xylene	Formaldehyde
NEPM-AAQ investigation level		*4,160*	*1,170*	*853*	*4,160*	*1,170*	*853*
R124	Wallacia Christian Church	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R126	St Francis Xavier Church	0.1	<0.1	1.2	0.1	0.1	1.5
R127	Luddenham Uniting Church	0.1	0.1	2.3	0.1	0.1	1.9
R130	Hopewood Health Retreat	<0.1	<0.1	0.6	<0.1	<0.1	0.8
R131	Science of the Soul Study Centre	<0.1	<0.1	0.8	0.1	0.1	1.9
R132	Bringelly shops	<0.1	<0.1	0.9	0.1	0.1	1.8
R134	Kemps Creek shops	0.1	<0.1	1.2	0.1	0.1	1.6
R135	Luddenham shops	0.1	0.1	2.2	0.1	0.1	1.9
R136	Mulgoa shops	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R137	Rossmore shops	<0.1	<0.1	0.5	0.1	0.1	1.7
R138	Wallacia Shops	<0.1	<0.1	0.8	<0.1	<0.1	0.9
R140	Holy Family Catholic Primary and Church	0.1	0.1	1.7	0.1	0.1	1.5
R141	Edmund Rice Retreat and Conference Centre	<0.1	<0.1	0.7	<0.1	<0.1	0.7

Table F6-b: Predicted cumulative 24-hour average air toxic concentrations during Stage 1 development.

Receptor	Receptor location	Cumulative (µg/m³)		
		Toluene	Xylene	Formaldehyde
	NEPM-AAQ investigation level	*4,160*	*1,170*	*53*
R1	Bringelly	15.4	16.7	6.5
R2	Luddenham	15.4	16.7	5.8
R3	Greendale, Greendale Road	15.4	16.7	5.8
R4	Kemps Creek	15.4	16.7	6.0
R6	Mulgoa	15.3	16.6	5.2
R7	Wallacia	15.3	16.6	5.2
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	15.4	16.6	5.4
R14	Lawson Road, Badgerys Creek	15.4	16.7	6.9
R15	Mersey Rd, Greendale	15.4	16.7	6.0
R17	Luddenham Road	15.4	16.6	5.4
R18	Cnr Adams & Elizabeth Drive	15.4	16.6	5.6
R19	Cnr Adams & Anton Road	15.5	16.7	7.3
R21	Cnr Willowdene Ave and Vicar Park Lane	15.4	16.7	5.7
R22	Rossmore, Victor Ave	15.4	16.6	5.6
R23	Wallacia, Greendale Rd	15.4	16.6	5.4
R24	Badgerys Creek 1 NE	15.6	16.8	9.2
R25	Badgerys Creek 2 SW	15.6	16.8	9.3
R27	Greendale, Dwyer Rd	15.4	16.6	5.6
R30	Rossmore residential	15.4	16.7	6.2

Receptor	Receptor location	Cumulative (µg/m³)		
		Toluene	Xylene	Formaldehyde
	NEPM-AAQ investigation level	*4,160*	*1,170*	*53*
R31	Mt Vernon residential	15.4	16.7	5.8
R34	Emmaus Residential Aged Care	15.4	16.6	5.4
R35	Mamre After School and Vacation Care	15.4	16.6	5.4
R36	Head Start After School Care	15.4	16.7	6.2
R37	Schoolies at Mulgoa	15.4	16.7	6.5
R38	Do-re-mi Day Care Centre	15.4	16.6	5.6
R39	Little Amigos Austral Early Learning Centre	15.4	16.7	5.8
R40	Little Smarties Childcare Centre	15.4	16.6	5.6
R41	The Grove Academy	15.4	16.6	5.3
R42	Horsley Kids	15.3	16.6	5.0
R44	Bringelly Child Care Centre	15.4	16.7	6.0
R46	Clementson Drive Early Educational Centre	15.4	16.7	5.8
R48	Kids Korner West Hoxton Early Learning Centre	15.4	16.7	6.0
R49	Luddenham Child Care Centre	15.4	16.7	6.2
R52	The Frogs Lodge	15.4	16.6	5.4
R53	Rossmore Community Preschool	15.4	16.7	5.8
R54	Mulgoa Preschool	15.3	16.6	5.1
R55	Jillys Educational Childcare Centre	15.4	16.7	5.7
R57	Wallacia Progress Hall	15.3	16.6	5.1
R59	Bringelly Community Centre	15.4	16.7	6.2
R63	Luddenham Progress Hall	15.4	16.7	6.3
R64	Mulgoa Hall	15.3	16.6	5.1
R65	Emmaus Catholic College	15.4	16.6	5.6
R66	University of Sydney Farms	15.3	16.6	5.2
R68	Christadelphian Heritage College Sydney	15.4	16.7	6.4
R69	Mamre Anglican School	15.4	16.7	5.9
R72	Irfan College	15.4	16.7	7.0
R73	Luddenham Public School	15.4	16.7	6.6
R74	Kemps Creek Public School	15.4	16.7	6.4
R75	Trinity Catholic Primary School	15.3	16.6	5.2
R76	Bringelly Public School	15.5	16.7	7.3
R78	Mulgoa Public School	15.3	16.6	5.1
R79	Rossmore Public School	15.4	16.7	6.3
R80	Wallacia Public School	15.3	16.6	5.1
R82	Bellfield College - Junior Campus	15.3	16.6	5.3
R84	Bringelly Park	15.4	16.7	6.0
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	15.3	16.6	5.2
R86	Blaxland Crossing Reserve	15.3	16.6	5.1
R87	Bill Anderson Reserve	15.4	16.7	5.8

Receptor	Receptor location	Cumulative (µg/m³)		
		Toluene	Xylene	Formaldehyde
	NEPM-AAQ investigation level	*4,160*	*1,170*	*53*
R88	Kemps Creek Nature Reserve	15.4	16.6	5.3
R91	Western Sydney Parklands	15.4	16.7	6.1
R93	Rossmore Grange	15.4	16.6	5.6
R94	Freeburn Park	15.4	16.7	7.1
R95	Overett Reserve	15.4	16.7	5.9
R97	Mulgoa Park	15.3	16.6	5.1
R98	Wallacia Bowling and Recreation Club	15.3	16.6	5.1
R99	Hubertus Country Club	15.4	16.7	6.2
R100	Sugarloaf Cobbitty Equestrian Club	15.4	16.6	5.4
R102	Panthers Wallacia	15.3	16.6	5.2
R103	Twin Creeks Golf and Country Club	15.3	16.6	5.0
R104	Sydney International Shooting Centre	15.4	16.7	6.9
R108	Luddenham Showground	15.4	16.6	5.5
R109	Kemps Creek Sporting and Bowling Club	15.4	16.7	6.2
R110	St James Luddenham	15.4	16.7	6.2
R111	Lin Ying temple	15.4	16.7	6.1
R112	Vat Ketanak Khmer Kampuchea Krom	15.4	16.6	5.3
R114	Anglican Church Sydney Diocese	15.4	16.6	5.3
R115	Anglican Parish of Mulgoa	15.3	16.6	5.1
R117	Bringelly Vineyard Church	15.4	16.7	5.9
R118	Free Church of Tonga	15.4	16.6	5.5
R120	Our Lady Queen of Peace	15.4	16.7	5.7
R122	St Anthony	15.4	16.7	5.9
R123	St Marys Church	15.3	16.6	5.2
R124	Wallacia Christian Church	15.3	16.6	5.2
R126	St Francis Xavier Church	15.4	16.7	5.8
R127	Luddenham Uniting Church	15.4	16.7	6.2
R130	Hopewood Health Retreat	15.3	16.6	5.1
R131	Science of the Soul Study Centre	15.4	16.7	6.2
R132	Bringelly shops	15.4	16.7	6.1
R134	Kemps Creek shops	15.4	16.7	5.9
R135	Luddenham shops	15.4	16.7	6.2
R136	Mulgoa shops	15.3	16.6	5.2
R137	Rossmore shops	15.4	16.7	6.0
R138	Wallacia Shops	15.3	16.6	5.2
R140	Holy Family Catholic Primary and Church	15.4	16.7	5.8
R141	Edmund Rice Retreat and Conference Centre	15.3	16.6	5.0

Table F7-a: Predicted incremental annual average air toxic concentrations during Stage 1 development.

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Benzene	Toluene	Xylene	Benzene	Toluene	Xylene
	NEPM-AAQ investigation level	*10*	*406*	*935*	*935*	*10*	*406*
R1	Bringelly	0.01	<0.01	<0.01	0.05	0.02	0.01
R2	Luddenham	0.02	0.01	0.01	0.03	0.01	0.01
R3	Greendale, Greendale Road	0.01	<0.01	<0.01	0.02	0.01	<0.01
R4	Kemps Creek	0.01	<0.01	<0.01	0.07	0.03	0.02
R6	Mulgoa	0.01	<0.01	<0.01	0.02	0.01	<0.01
R7	Wallacia	0.01	<0.01	<0.01	0.01	0.01	<0.01
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.01	0.01	<0.01	0.04	0.01	0.01
R14	Lawson Road, Badgerys Creek	0.02	0.01	<0.01	0.06	0.02	0.02
R15	Mersey Rd, Greendale	0.01	0.01	<0.01	0.04	0.01	0.01
R17	Luddenham Road	0.01	0.01	<0.01	0.04	0.01	0.01
R18	Cnr Adams & Elizabeth Drive	0.03	0.01	0.01	0.05	0.02	0.01
R19	Cnr Adams & Anton Road	0.04	0.02	0.01	0.06	0.02	0.02
R21	Cnr Willowdene Ave and Vicar Park Lane	0.01	<0.01	<0.01	0.02	0.01	0.01
R22	Rossmore, Victor Ave	0.01	<0.01	<0.01	0.03	0.01	0.01
R23	Wallacia, Greendale Rd	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
R24	Badgerys Creek 1 NE	0.06	0.02	0.02	0.10	0.04	0.03
R25	Badgerys Creek 2 SW	0.02	0.01	<0.01	0.04	0.02	0.01
R27	Greendale, Dwyer Rd	0.01	<0.01	<0.01	0.01	0.01	<0.01
R30	Rossmore residential	<0.01	<0.01	<0.01	0.06	0.02	0.02
R31	Mt Vernon residential	0.01	<0.01	<0.01	0.03	0.01	0.01
R34	Emmaus Residential Aged Care	0.01	0.01	<0.01	0.05	0.02	0.01
R35	Mamre After School and Vacation Care	0.01	<0.01	<0.01	0.04	0.02	0.01
R36	Head Start After School Care	<0.01	<0.01	<0.01	0.05	0.02	0.01
R37	Schoolies at Mulgoa	0.02	0.01	<0.01	0.03	0.01	0.01
R38	Do-re-mi Day Care Centre	0.01	<0.01	<0.01	0.02	0.01	<0.00
R39	Little Amigos Austral Early Learning Centre	<0.01	<0.01	<0.01	0.04	0.02	0.01
R40	Little Smarties Childcare Centre	0.01	<0.01	<0.01	0.02	0.01	<0.00
R41	The Grove Academy	<0.01	<0.01	<0.01	0.01	0.01	<0.00
R42	Horsley Kids	0.01	<0.01	<0.01	0.04	0.01	0.01
R44	Bringelly Child Care Centre	0.01	<0.01	<0.01	0.05	0.02	0.01
R46	Clementson Drive Early Educational Centre	0.01	<0.01	<0.01	0.03	0.01	0.01
R48	Kids Korner West Hoxton Early Learning Centre	<0.01	<0.01	<0.01	0.04	0.01	0.01
R49	Luddenham Child Care Centre	0.02	0.01	<0.01	0.06	0.02	0.01
R52	The Frogs Lodge	<0.01	<0.01	<0.01	0.07	0.02	0.02
R53	Rossmore Community Preschool	<0.01	<0.01	<0.01	0.03	0.01	0.01
R54	Mulgoa Preschool	0.01	<0.01	<0.01	0.03	0.01	0.01
R55	Jillys Educational Childcare Centre	<0.01	<0.01	<0.01	0.01	<0.00	<0.00
R57	Wallacia Progress Hall	0.01	<0.01	<0.01	0.12	0.05	0.03
R59	Bringelly Community Centre	0.01	<0.01	<0.01	0.11	0.04	0.03
R63	Luddenham Progress Hall	0.01	0.01	<0.01	0.02	0.01	<0.00
R64	Mulgoa Hall	0.01	<0.01	<0.01	0.06	0.02	0.01
R65	Emmaus Catholic College	0.01	0.01	<0.01	0.03	0.01	0.01
R66	University of Sydney Farms	0.01	<0.01	<0.01	0.05	0.02	0.01
R68	Christadelphian Heritage College Sydney	0.01	<0.01	<0.01	0.05	0.02	0.01
R69	Mamre Anglican School	0.01	<0.01	<0.01	0.05	0.02	0.01

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Benzene	Toluene	Xylene	Benzene	Toluene	Xylene
NEPM-AAQ investigation level		*10*	*406*	*935*	*935*	*10*	*406*
R72	Irfan College	<0.01	<0.01	<0.01	0.03	0.01	0.01
R73	Luddenham Public School	0.02	0.01	<0.01	0.04	0.02	0.01
R74	Kemps Creek Public School	0.01	<0.01	<0.01	0.03	0.01	0.01
R75	Trinity Catholic Primary School	0.01	<0.01	<0.01	0.06	0.02	0.01
R76	Bringelly Public School	0.01	<0.01	<0.01	0.03	0.01	0.01
R78	Mulgoa Public School	0.01	<0.01	<0.01	0.03	0.01	0.01
R79	Rossmore Public School	<0.01	<0.01	<0.01	0.02	0.01	0.01
R80	Wallacia Public School	0.01	<0.01	<0.01	0.03	0.01	0.01
R82	Bellfield College - Junior Campus	<0.01	<0.01	<0.01	0.06	0.02	0.01
R84	Bringelly Park	0.01	<0.01	<0.01	0.03	0.01	0.01
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	<0.01	<0.01	<0.01	0.04	0.01	0.01
R86	Blaxland Crossing Reserve	0.01	<0.01	<0.01	0.05	0.02	0.01
R87	Bill Anderson Reserve	0.01	<0.01	<0.01	0.02	0.01	<0.00
R88	Kemps Creek Nature Reserve	<0.01	<0.01	<0.01	0.03	0.01	0.01
R91	Western Sydney Parklands	<0.01	<0.01	<0.01	0.01	0.01	<0.00
R93	Rossmore Grange	<0.01	<0.01	<0.01	0.04	0.01	0.01
R94	Freeburn Park	0.02	0.01	<0.01	0.03	0.01	0.01
R95	Overett Reserve	0.01	<0.01	<0.01	0.02	0.01	<0.00
R97	Mulgoa Park	0.01	<0.01	<0.01	0.05	0.02	0.01
R98	Wallacia Bowling and Recreation Club	0.01	<0.01	<0.01	0.01	<0.00	<0.00
R99	Hubertus Country Club	0.04	0.01	0.01	0.03	0.01	0.01
R100	Sugarloaf Cobbitty Equestrian Club	0.01	<0.01	<0.01	0.07	0.03	0.02
R102	Panthers Wallacia	0.01	<0.01	<0.01	0.09	0.03	0.02
R103	Twin Creeks Golf and Country Club	0.01	<0.01	<0.01	0.03	0.01	0.01
R104	Sydney International Shooting Centre	<0.01	<0.01	<0.01	0.03	0.01	0.01
R108	Luddenham Showground	0.02	0.01	<0.01	0.04	0.02	0.01
R109	Kemps Creek Sporting and Bowling Club	<0.01	<0.01	<0.01	0.08	0.03	0.02
R110	St James Luddenham	0.02	0.01	<0.01	0.02	0.01	<0.00
R111	Lin Ying temple	0.01	<0.01	<0.01	0.09	0.03	0.02
R112	Vat Ketanak Khmer Kampuchea Krom	<0.01	<0.01	<0.01	0.01	0.01	<0.00
R114	Anglican Church Sydney Diocese	<0.01	<0.01	<0.01	0.04	0.01	0.01
R115	Anglican Parish of Mulgoa	0.01	<0.01	<0.01	0.04	0.01	0.01
R117	Bringelly Vineyard Church	0.01	<0.01	<0.01	0.01	<0.00	<0.00
R118	Free Church of Tonga	0.01	<0.01	<0.01	0.01	<0.00	<0.00
R120	Our Lady Queen of Peace	0.01	<0.01	<0.01	0.04	0.02	0.01
R122	St Anthony	<0.01	<0.01	<0.01	0.03	0.01	0.01
R123	St Marys Church	0.01	<0.01	<0.01	0.03	0.01	0.01
R124	Wallacia Christian Church	0.01	<0.01	<0.01	0.02	0.01	0.01
R126	St Francis Xavier Church	0.01	<0.01	<0.01	0.03	0.01	0.01
R127	Luddenham Uniting Church	0.01	<0.01	<0.01	0.04	0.02	0.01
R130	Hopewood Health Retreat	0.01	<0.01	<0.01	0.02	0.01	<0.00
R131	Science of the Soul Study Centre	<0.01	<0.01	<0.01	0.01	0.01	<0.00
R132	Bringelly shops	0.01	<0.01	<0.01	0.06	0.02	0.02
R134	Kemps Creek shops	0.01	<0.01	<0.01	0.01	<0.00	<0.00
R135	Luddenham shops	0.02	0.01	0.01	0.02	0.01	<0.00
R136	Mulgoa shops	0.01	<0.01	<0.01	0.03	0.01	0.01

Receptor	Receptor location	Airport (µg/m³)			Airport + external roadways (µg/m³)		
		Benzene	Toluene	Xylene	Benzene	Toluene	Xylene
NEPM-AAQ investigation level		*10*	*406*	*935*	*935*	*10*	*406*
R137	Rossmore shops	<0.01	<0.01	<0.01	0.04	0.01	0.01
R138	Wallacia Shops	0.01	<0.01	<0.01	0.03	0.01	0.01
R140	Holy Family Catholic Primary and Church	0.02	0.01	<0.01	0.04	0.02	0.01
R141	Edmund Rice Retreat and Conference Centre	0.01	<0.01	<0.01	0.05	0.02	0.01

Table F7-b: Predicted cumulative annual average air toxic concentrations during Stage 1 development.

Receptor	Receptor location	Cumulative (µg/m³)		
		Benzene	Toluene	Xylene
NEPM-AAQ investigation level		*10*	*406*	*935*
R1	Bringelly	1.1	3.7	2.4
R2	Luddenham	1.0	3.7	2.4
R3	Greendale, Greendale Road	1.0	3.7	2.4
R4	Kemps Creek	1.0	3.7	2.4
R6	Mulgoa	1.0	3.7	2.4
R7	Wallacia	1.0	3.7	2.4
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	1.0	3.7	2.4
R14	Lawson Road, Badgerys Creek	1.1	3.7	2.4
R15	Mersey Rd, Greendale	1.0	3.7	2.4
R17	Luddenham Road	1.0	3.7	2.4
R18	Cnr Adams & Elizabeth Drive	1.1	3.7	2.4
R19	Cnr Adams & Anton Road	1.1	3.7	2.4
R21	Cnr Willowdene Ave and Vicar Park Lane	1.0	3.7	2.4
R22	Rossmore, Victor Ave	1.0	3.7	2.4
R23	Wallacia, Greendale Rd	1.0	3.7	2.4
R24	Badgerys Creek 1 NE	1.1	3.7	2.4
R25	Badgerys Creek 2 SW	1.1	3.7	2.4
R27	Greendale, Dwyer Rd	1.0	3.7	2.4
R30	Rossmore residential	1.1	3.7	2.4
R31	Mt Vernon residential	1.0	3.7	2.4
R34	Emmaus Residential Aged Care	1.0	3.7	2.4
R35	Mamre After School and Vacation Care	1.0	3.7	2.4
R36	Head Start After School Care	1.0	3.7	2.4
R37	Schoolies at Mulgoa	1.0	3.7	2.4
R38	Do-re-mi Day Care Centre	1.0	3.7	2.4
R39	Little Amigos Austral Early Learning Centre	1.0	3.7	2.4
R40	Little Smarties Childcare Centre	1.1	3.7	2.4
R41	The Grove Academy	1.0	3.7	2.4
R42	Horsley Kids	1.0	3.7	2.4
R44	Bringelly Child Care Centre	1.0	3.7	2.4
R46	Clementson Drive Early Educational Centre	1.0	3.7	2.4
R48	Kids Korner West Hoxton Early Learning Centre	1.1	3.7	2.4

Receptor	Receptor location	Cumulative (µg/m³)		
		Benzene	Toluene	Xylene
NEPM-AAQ investigation level		*10*	*406*	*935*
R49	Luddenham Child Care Centre	1.0	3.7	2.4
R52	The Frogs Lodge	1.0	3.7	2.4
R53	Rossmore Community Preschool	1.0	3.7	2.4
R54	Mulgoa Preschool	1.0	3.7	2.4
R55	Jillys Educational Childcare Centre	1.0	3.7	2.4
R57	Wallacia Progress Hall	1.0	3.7	2.4
R59	Bringelly Community Centre	1.0	3.7	2.4
R63	Luddenham Progress Hall	1.0	3.7	2.4
R64	Mulgoa Hall	1.0	3.7	2.4
R65	Emmaus Catholic College	1.1	3.7	2.4
R66	University of Sydney Farms	1.0	3.7	2.4
R68	Christadelphian Heritage College Sydney	1.0	3.7	2.4
R69	Mamre Anglican School	1.1	3.7	2.4
R72	Irfan College	1.1	3.7	2.4
R73	Luddenham Public School	1.0	3.7	2.4
R74	Kemps Creek Public School	1.0	3.7	2.4
R75	Trinity Catholic Primary School	1.0	3.7	2.4
R76	Bringelly Public School	1.1	3.7	2.4
R78	Mulgoa Public School	1.0	3.7	2.4
R79	Rossmore Public School	1.1	3.7	2.4
R80	Wallacia Public School	1.0	3.7	2.4
R82	Bellfield College - Junior Campus	1.0	3.7	2.4
R84	Bringelly Park	1.0	3.7	2.4
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	1.0	3.7	2.4
R86	Blaxland Crossing Reserve	1.0	3.7	2.4
R87	Bill Anderson Reserve	1.0	3.7	2.4
R88	Kemps Creek Nature Reserve	1.0	3.7	2.4
R91	Western Sydney Parklands	1.0	3.7	2.4
R93	Rossmore Grange	1.0	3.7	2.4
R94	Freeburn Park	1.0	3.7	2.4
R95	Overett Reserve	1.0	3.7	2.4
R97	Mulgoa Park	1.0	3.7	2.4
R98	Wallacia Bowling and Recreation Club	1.0	3.7	2.4
R99	Hubertus Country Club	1.1	3.7	2.4
R100	Sugarloaf Cobbitty Equestrian Club	1.0	3.7	2.4
R102	Panthers Wallacia	1.0	3.7	2.4
R103	Twin Creeks Golf and Country Club	1.0	3.7	2.4
R104	Sydney International Shooting Centre	1.0	3.7	2.4
R108	Luddenham Showground	1.0	3.7	2.4
R109	Kemps Creek Sporting and Bowling Club	1.0	3.7	2.4
R110	St James Luddenham	1.0	3.7	2.4
R111	Lin Ying temple	1.0	3.7	2.4

Receptor	Receptor location	Cumulative (µg/m³)		
		Benzene	Toluene	Xylene
NEPM-AAQ investigation level		*10*	*406*	*935*
R112	Vat Ketanak Khmer Kampuchea Krom	1.0	3.7	2.4
R114	Anglican Church Sydney Diocese	1.0	3.7	2.4
R115	Anglican Parish of Mulgoa	1.0	3.7	2.4
R117	Bringelly Vineyard Church	1.0	3.7	2.4
R118	Free Church of Tonga	1.0	3.7	2.4
R120	Our Lady Queen of Peace	1.0	3.7	2.4
R122	St Anthony	1.1	3.7	2.4
R123	St Marys Church	1.0	3.7	2.4
R124	Wallacia Christian Church	1.0	3.7	2.4
R126	St Francis Xavier Church	1.0	3.7	2.4
R127	Luddenham Uniting Church	1.0	3.7	2.4
R130	Hopewood Health Retreat	1.0	3.7	2.4
R131	Science of the Soul Study Centre	1.0	3.7	2.4
R132	Bringelly shops	1.1	3.7	2.4
R134	Kemps Creek shops	1.0	3.7	2.4
R135	Luddenham shops	1.0	3.7	2.4
R136	Mulgoa shops	1.0	3.7	2.4
R137	Rossmore shops	1.1	3.7	2.4
R138	Wallacia Shops	1.0	3.7	2.4
R140	Holy Family Catholic Primary and Church	1.0	3.7	2.4
R141	Edmund Rice Retreat and Conference Centre	1.0	3.7	2.4

F.1.7 Odour

Table F8: Predicted 99th percentile odour concentrations from aircraft exhaust

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
Criterion		2
R1	Bringelly	<1
R2	Luddenham	<1
R3	Greendale, Greendale Road	<1
R4	Kemps Creek	<1
R6	Mulgoa	<1
R7	Wallacia	<1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<1
R14	Lawson Road, Badgerys Creek	<1
R15	Mersey Rd, Greendale	<1
R17	Luddenham Road	<1
R18	Cnr Adams & Elizabeth Drive	1
R19	Cnr Adams & Anton Road	1
R21	Cnr Willowdene Ave and Vicar Park Lane	<1
R22	Rossmore, Victor Ave	<1
R23	Wallacia, Greendale Rd	<1
R24	Badgerys Creek 1 NE	1
R25	Badgerys Creek 2 SW	<1
R27	Greendale, Dwyer Rd	<1

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
Criterion		*2*
R30	Rossmore residential	<1
R31	Mt Vernon residential	<1
R34	Emmaus Residential Aged Care	<1
R35	Mamre After School and Vacation Care	<1
R36	Head Start After School Care	<1
R37	Schoolies at Mulgoa	<1
R38	Do-re-mi Day Care Centre	<1
R39	Little Amigos Austral Early Learning Centre	<1
R40	Little Smarties Childcare Centre	<1
R41	The Grove Academy	<1
R42	Horsley Kids	<1
R44	Bringelly Child Care Centre	<1
R46	Clementson Drive Early Educational Centre	<1
R48	Kids Korner West Hoxton Early Learning Centre	<1
R49	Luddenham Child Care Centre	<1
R52	The Frogs Lodge	<1
R53	Rossmore Community Preschool	<1
R54	Mulgoa Preschool	<1
R55	Jillys Educational Childcare Centre	<1
R57	Wallacia Progress Hall	<1
R59	Bringelly Community Centre	<1
R63	Luddenham Progress Hall	<1
R64	Mulgoa Hall	<1
R65	Emmaus Catholic College	<1
R66	University of Sydney Farms	<1
R68	Christadelphian Heritage College Sydney	<1
R69	Mamre Anglican School	<1
R72	Irfan College	<1
R73	Luddenham Public School	<1
R74	Kemps Creek Public School	<1
R75	Trinity Catholic Primary School	<1
R76	Bringelly Public School	<1
R78	Mulgoa Public School	<1
R79	Rossmore Public School	<1
R80	Wallacia Public School	<1
R82	Bellfield College - Junior Campus	<1
R84	Bringelly Park	<1
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	<1
R86	Blaxland Crossing Reserve	<1
R87	Bill Anderson Reserve	<1
R88	Kemps Creek Nature Reserve	<1
R91	Western Sydney Parklands	<1
R93	Rossmore Grange	<1
R94	Freeburn Park	<1
R95	Overett Reserve	<1
R97	Mulgoa Park	<1
R98	Wallacia Bowling and Recreation Club	<1
R99	Hubertus Country Club	1
R100	Sugarloaf Cobbitty Equestrian Club	<1
R102	Panthers Wallacia	<1
R103	Twin Creeks Golf and Country Club	<1
R104	Sydney International Shooting Centre	<1

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
Criterion		2
R108	Luddenham Showground	<1
R109	Kemps Creek Sporting and Bowling Club	<1
R110	St James Luddenham	<1
R111	Lin Ying temple	<1
R112	Vat Ketanak Khmer Kampuchea Krom	<1
R114	Anglican Church Sydney Diocese	<1
R115	Anglican Parish of Mulgoa	<1
R117	Bringelly Vineyard Church	<1
R118	Free Church of Tonga	<1
R120	Our Lady Queen of Peace	<1
R122	St Anthony	<1
R123	St Marys Church	<1
R124	Wallacia Christian Church	<1
R126	St Francis Xavier Church	<1
R127	Luddenham Uniting Church	<1
R130	Hopewood Health Retreat	<1
R131	Science of the Soul Study Centre	<1
R132	Bringelly shops	<1
R134	Kemps Creek shops	<1
R135	Luddenham shops	<1
R136	Mulgoa shops	<1
R137	Rossmore shops	<1
R138	Wallacia Shops	<1
R140	Holy Family Catholic Primary and Church	<1
R141	Edmund Rice Retreat and Conference Centre	<1

Table F8: Predicted 99th percentile odour concentrations from STP

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
Criterion		2
R1	Bringelly	<0.1
R2	Luddenham	<0.1
R3	Greendale, Greendale Road	<0.1
R4	Kemps Creek	<0.1
R6	Mulgoa	<0.1
R7	Wallacia	<0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<0.1
R14	Lawson Road, Badgerys Creek	<0.1
R15	Mersey Rd, Greendale	<0.1
R17	Luddenham Road	<0.1
R18	Cnr Adams & Elizabeth Drive	<0.1
R19	Cnr Adams & Anton Road	<0.1
R21	Cnr Willowdene Ave and Vicar Park Lane	<0.1
R22	Rossmore, Victor Ave	<0.1
R23	Wallacia, Greendale Rd	<0.1
R24	Badgerys Creek 1 NE	0.1
R25	Badgerys Creek 2 SW	<0.1
R27	Greendale, Dwyer Rd	<0.1
R30	Rossmore residential	<0.1
R31	Mt Vernon residential	<0.1
R34	Emmaus Residential Aged Care	<0.1

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
Criterion		2
R35	Mamre After School and Vacation Care	<0.1
R36	Head Start After School Care	<0.1
R37	Schoolies at Mulgoa	<0.1
R38	Do-re-mi Day Care Centre	<0.1
R39	Little Amigos Austral Early Learning Centre	<0.1
R40	Little Smarties Childcare Centre	<0.1
R41	The Grove Academy	<0.1
R42	Horsley Kids	<0.1
R44	Bringelly Child Care Centre	<0.1
R46	Clementson Drive Early Educational Centre	<0.1
R48	Kids Korner West Hoxton Early Learning Centre	<0.1
R49	Luddenham Child Care Centre	<0.1
R52	The Frogs Lodge	<0.1
R53	Rossmore Community Preschool	<0.1
R54	Mulgoa Preschool	<0.1
R55	Jillys Educational Childcare Centre	<0.1
R57	Wallacia Progress Hall	<0.1
R59	Bringelly Community Centre	<0.1
R63	Luddenham Progress Hall	<0.1
R64	Mulgoa Hall	<0.1
R65	Emmaus Catholic College	<0.1
R66	University of Sydney Farms	<0.1
R68	Christadelphian Heritage College Sydney	<0.1
R69	Mamre Anglican School	<0.1
R72	Irfan College	<0.1
R73	Luddenham Public School	<0.1
R74	Kemps Creek Public School	<0.1
R75	Trinity Catholic Primary School	<0.1
R76	Bringelly Public School	<0.1
R78	Mulgoa Public School	<0.1
R79	Rossmore Public School	<0.1
R80	Wallacia Public School	<0.1
R82	Bellfield College - Junior Campus	<0.1
R84	Bringelly Park	<0.1
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	<0.1
R86	Blaxland Crossing Reserve	<0.1
R87	Bill Anderson Reserve	<0.1
R88	Kemps Creek Nature Reserve	<0.1
R91	Western Sydney Parklands	<0.1
R93	Rossmore Grange	<0.1
R94	Freeburn Park	<0.1
R95	Overett Reserve	<0.1
R97	Mulgoa Park	<0.1
R98	Wallacia Bowling and Recreation Club	<0.1
R99	Hubertus Country Club	<0.1
R100	Sugarloaf Cobbitty Equestrian Club	<0.1
R102	Panthers Wallacia	<0.1
R103	Twin Creeks Golf and Country Club	<0.1
R104	Sydney International Shooting Centre	<0.1
R108	Luddenham Showground	<0.1
R109	Kemps Creek Sporting and Bowling Club	<0.1
R110	St James Luddenham	<0.1
R111	Lin Ying temple	<0.1

Receptor	Receptor location	OU, 1-second nose-response, 99th percentile (OU)
	Criterion	2
R112	Vat Ketanak Khmer Kampuchea Krom	<0.1
R114	Anglican Church Sydney Diocese	<0.1
R115	Anglican Parish of Mulgoa	<0.1
R117	Bringelly Vineyard Church	<0.1
R118	Free Church of Tonga	<0.1
R120	Our Lady Queen of Peace	<0.1
R122	St Anthony	<0.1
R123	St Marys Church	<0.1
R124	Wallacia Christian Church	<0.1
R126	St Francis Xavier Church	<0.1
R127	Luddenham Uniting Church	<0.1
R130	Hopewood Health Retreat	<0.1
R131	Science of the Soul Study Centre	<0.1
R132	Bringelly shops	<0.1
R134	Kemps Creek shops	<0.1
R135	Luddenham shops	<0.1
R136	Mulgoa shops	<0.1
R137	Rossmore shops	<0.1
R138	Wallacia Shops	<0.1
R140	Holy Family Catholic Primary and Church	<0.1
R141	Edmund Rice Retreat and Conference Centre	<0.1

F.2 LONG TERM DEVELOPMENT

F.2.1 Nitrogen dioxide

Table F9: Predicted cumulative NO_2 concentrations during longer term development

Receptor	Receptor location	Airport (µg/m³)			Cumulative (µg/m³)		
		1-hour	Number of hours > 320	Annual	1-hour	Number of hours > 320	Annual
Ambient objective / Assessment criterion		*320*	*n/a*	*62*	*320*	*n/a*	*62*
R1	Bringelly	237	0	17	243	0	23
R2	Luddenham	111	0	22	119	0	28
R3	Greendale, Greendale Road	**347**	2	22	**367**	1	24
R4	Kemps Creek	223	0	17	234	0	26
R6	Mulgoa	188	0	18	205	0	19
R7	Wallacia	241	0	17	247	0	18
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	155	0	21	178	0	27
R14	Lawson Road, Badgerys Creek	**517**	1	34	**538**	1	43
R15	Mersey Rd, Greendale	**343**	3	31	**350**	2	34
R17	Luddenham Road	310	4	22	312	0	27
R18	Cnr Adams & Elizabeth Drive	229	0	38	231	0	49
R19	Cnr Adams & Anton Road	211	0	47	212	0	51

Receptor	Receptor location	Airport (µg/m³) 1-hour	Airport (µg/m³) Number of hours > 320	Airport (µg/m³) Annual	Cumulative (µg/m³) 1-hour	Cumulative (µg/m³) Number of hours > 320	Cumulative (µg/m³) Annual
Ambient objective / Assessment criterion		*320*	*n/a*	*62*	*320*	*n/a*	*62*
R21	Cnr Willowdene Ave and Vicar Park Lane	**408**	1	24	**440**	1	30
R22	Rossmore, Victor Ave	242	1	18	253	0	23
R23	Wallacia, Greendale Rd	**342**	2	15	**347**	1	17
R24	Badgerys Creek 1 NE	**335**	4	55	**365**	2	52
R25	Badgerys Creek 2 SW	281	2	23	284	0	26
R27	Greendale, Dwyer Rd	116	0	14	118	0	16
R30	Rossmore residential	312	1	14	**326**	1	20
R31	Mt Vernon residential	**345**	1	22	**349**	1	27
R34	Emmaus Residential Aged Care	**337**	1	#N/A	**353**	1	28
R35	Mamre After School and Vacation Care	119	0	19	126	0	27
R36	Head Start After School Care	236	0	13	291	0	22
R37	Schoolies at Mulgoa	150	0	24	157	0	27
R38	Do-re-mi Day Care Centre	**398**	1	19	**417**	1	26
R39	Little Amigos Austral Early Learning Centre	260	1	14	270	0	20
R40	Little Smarties Childcare Centre	152	0	19	152	0	26
R41	The Grove Academy	203	0	15	205	0	20
R42	Horsley Kids	166	0	16	173	0	21
R44	Bringelly Child Care Centre	192	0	19	203	0	22
R46	Clementson Drive Early Educational Centre	239	1	16	252	0	24
R48	Kids Korner West Hoxton Early Learning Centre	302	2	14	311	0	19
R49	Luddenham Child Care Centre	163	0	21	164	0	23
R52	The Frogs Lodge	231	0	14	235	0	20
R53	Rossmore Community Preschool	265	1	14	267	0	19
R54	Mulgoa Preschool	271	1	17	280	0	19
R55	Jillys Educational Childcare Centre	173	0	16	176	0	21
R57	Wallacia Progress Hall	153	0	17	156	0	18
R59	Bringelly Community Centre	244	0	18	250	0	24
R63	Luddenham Progress Hall	122	0	18	132	0	20
R64	Mulgoa Hall	221	0	18	224	0	20
R65	Emmaus Catholic College	184	0	20	213	0	28
R66	University of Sydney Farms	257	1	17	265	0	18
R68	Christadelphian Heritage College Sydney	195	0	17	212	0	24

Receptor	Receptor location	Airport (µg/m³)			Cumulative (µg/m³)		
		1-hour	Number of hours > 320	Annual	1-hour	Number of hours > 320	Annual
Ambient objective / Assessment criterion		*320*	*n/a*	*62*	*320*	*n/a*	*62*
R69	Mamre Anglican School	314	1	19	**327**	1	28
R72	Irfan College	158	0	13	175	0	27
R73	Luddenham Public School	171	0	22	182	0	29
R74	Kemps Creek Public School	206	0	18	217	0	24
R75	Trinity Catholic Primary School	230	0	18	239	0	27
R76	Bringelly Public School	216	0	17	223	0	22
R78	Mulgoa Public School	183	0	17	191	0	19
R79	Rossmore Public School	149	0	14	157	0	22
R80	Wallacia Public School	207	0	16	209	0	18
R82	Bellfield College - Junior Campus	217	0	15	222	0	21
R84	Bringelly Park	248	1	18	255	0	24
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	278	1	15	298	0	16
R86	Blaxland Crossing Reserve	196	0	16	199	0	18
R87	Bill Anderson Reserve	231	0	18	243	0	26
R88	Kemps Creek Nature Reserve	174	0	14	177	0	20
R91	Western Sydney Parklands	307	2	15	313	0	23
R93	Rossmore Grange	211	0	17	215	0	21
R94	Freeburn Park	129	0	23	150	0	27
R95	Overett Reserve	**330**	1	28	**373**	1	40
R97	Mulgoa Park	246	1	18	265	0	20
R98	Wallacia Bowling and Recreation Club	163	0	16	166	0	18
R99	Hubertus Country Club	258	1	45	259	0	51
R100	Sugarloaf Cobbitty Equestrian Club	164	0	16	179	0	17
R102	Panthers Wallacia	254	1	18	**326**	1	19
R103	Twin Creeks Golf and Country Club	257	2	19	**335**	1	24
R104	Sydney International Shooting Centre	252	1	15	263	0	25
R108	Luddenham Showground	161	0	21	166	0	23
R109	Kemps Creek Sporting and Bowling Club	247	1	15	253	0	26
R110	St James Luddenham	186	0	25	195	0	30
R111	Lin Ying temple	296	1	16	314	0	22
R112	Vat Ketanak Khmer Kampuchea Krom	158	0	15	163	0	20
R114	Anglican Church Sydney Diocese	139	0	14	154	0	20
R115	Anglican Parish of Mulgoa	168	0	16	173	0	18

Receptor	Receptor location	Airport (µg/m³)			Cumulative (µg/m³)		
		1-hour	Number of hours > 320	Annual	1-hour	Number of hours > 320	Annual
Ambient objective / Assessment criterion		*320*	*n/a*	*62*	*320*	*n/a*	*62*
R117	Bringelly Vineyard Church	240	0	16	241	0	21
R118	Free Church of Tonga	257	1	16	261	0	18
R120	Our Lady Queen of Peace	172	0	17	176	0	23
R122	St Anthony	225	0	14	233	0	19
R123	St Marys Church	221	0	18	225	0	19
R124	Wallacia Christian Church	193	0	17	195	0	18
R126	St Francis Xavier Church	260	1	16	265	0	18
R127	Luddenham Uniting Church	168	0	17	172	0	20
R130	Hopewood Health Retreat	152	0	16	153	0	17
R131	Science of the Soul Study Centre	188	0	16	206	0	27
R132	Bringelly shops	**340**	1	17	**362**	1	22
R134	Kemps Creek shops	**334**	1	18	**353**	1	27
R135	Luddenham shops	205	0	26	213	0	30
R136	Mulgoa shops	251	1	18	261	0	19
R137	Rossmore shops	200	0	14	203	0	20
R138	Wallacia Shops	190	0	16	202	0	18
R140	Holy Family Catholic Primary and Church	175	0	27	183	0	30
R141	Edmund Rice Retreat and Conference Centre	189	0	17	192	0	18

Figure F55: NO_2 1-hour maximum Contour Plot during long term development – Cumulative

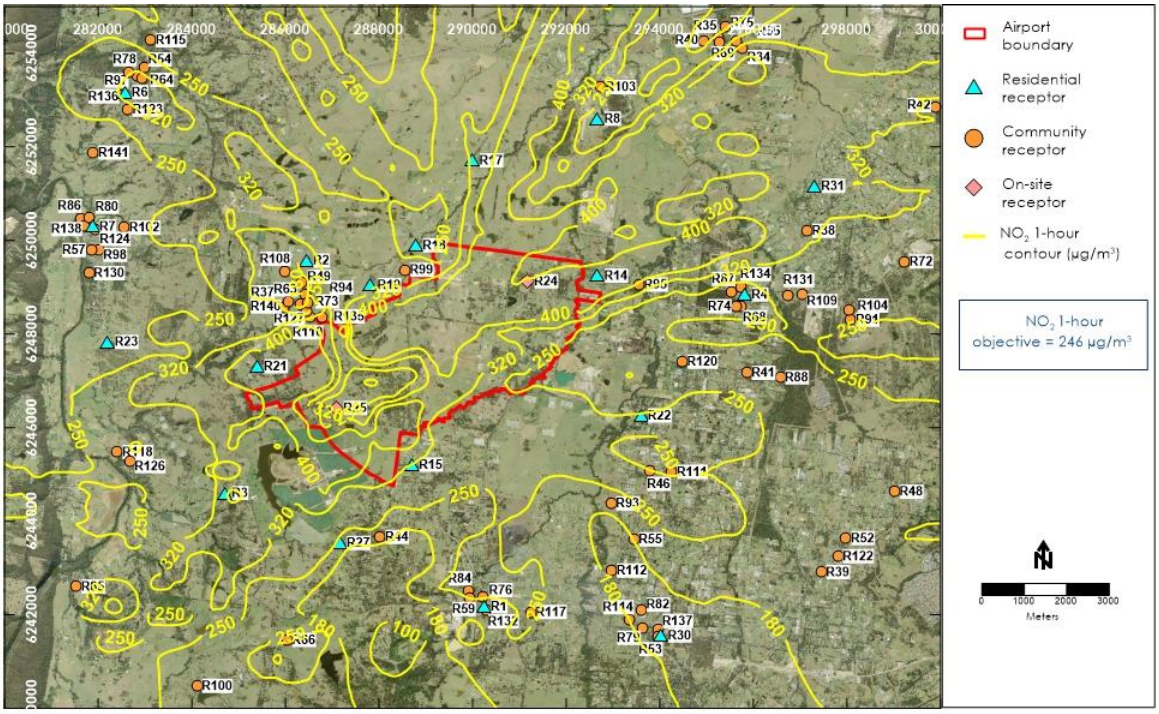
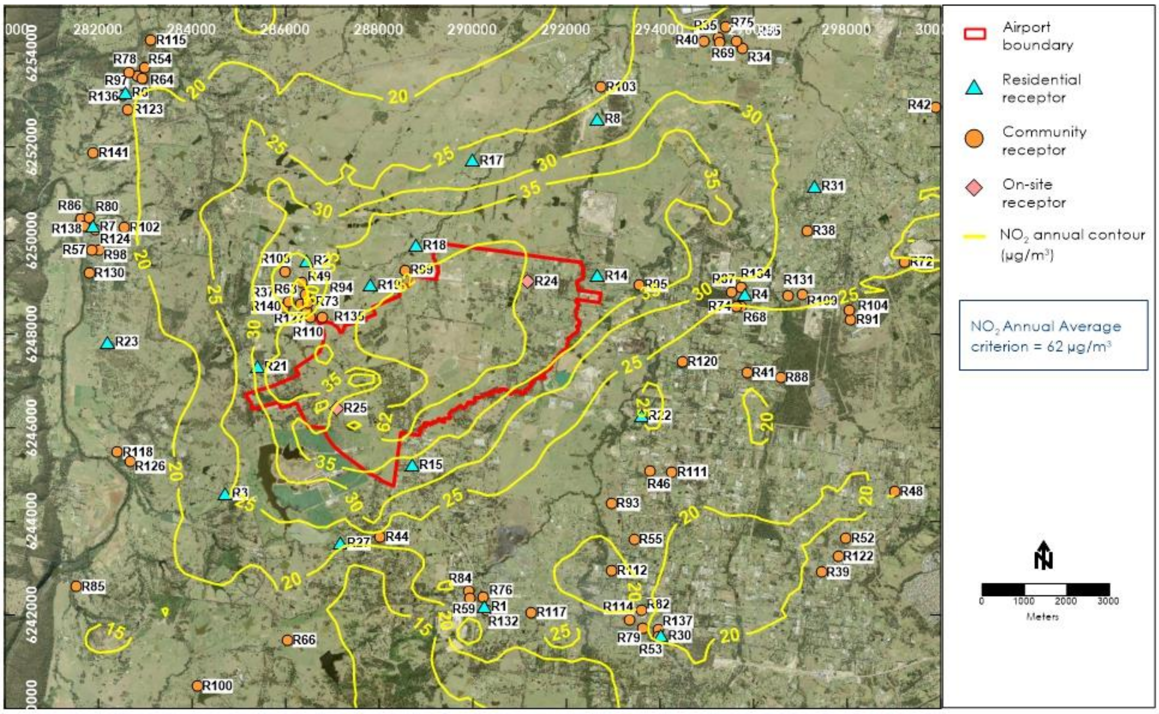


Figure F56: NO_2 Annual Average Contour Plot during long term development – Cumulative



F.2.2 Particulate matter PM_{10}

Table F10: Predicted incremental and cumulative PM_{10} concentrations during longer term development

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R1	Bringelly	3.7	0.1	5.6	1.3	46	18
R2	Luddenham	1.7	0.3	6.0	1.4	45	18
R3	Greendale, Greendale Road	5.7	0.3	7.4	0.6	43	18
R4	Kemps Creek	2.6	0.2	8.8	1.6	46	19
R6	Mulgoa	1.8	0.1	3.5	0.4	43	17
R7	Wallacia	1.3	0.1	3.1	0.4	43	17
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	2.2	0.2	4.4	1.1	44	18
R14	Lawson Road, Badgerys Creek	9.6	0.7	13.6	2.4	46	19
R15	Mersey Rd, Greendale	6.1	0.5	11.7	1.3	46	18
R17	Luddenham Road	3.4	0.2	5.5	1.3	45	18
R18	Cnr Adams & Elizabeth Drive	5.3	0.6	11.2	2.8	46	20
R19	Cnr Adams & Anton Road	5.3	0.8	9.0	1.6	45	19
R21	Cnr Willowdene Ave and Vicar Park Lane	5.9	0.3	7.6	1.4	44	18
R22	Rossmore, Victor Ave	4.1	0.2	8.0	1.2	45	18
R23	Wallacia, Greendale Rd	2.3	0.1	3.8	0.4	43	17
R24	Badgerys Creek 1 NE	31.6	8.9	18.2	3.8	46	21
R25	Badgerys Creek 2 SW	3.6	0.5	4.9	1.1	44	18
R27	Greendale, Dwyer Rd	1.4	0.1	3.0	0.5	43	17
R30	Rossmore residential	1.7	0.1	4.8	1.3	45	18
R31	Mt Vernon residential	4.2	0.2	6.4	1.0	44	18
R34	Emmaus Residential Aged Care	2.3	0.2	5.1	1.5	45	19
R35	Mamre After School and Vacation Care	2.1	0.2	4.8	1.5	44	19
R36	Head Start After School Care	1.7	0.1	11.5	1.5	46	19
R37	Schoolies at Mulgoa	1.9	0.3	3.9	0.8	44	18
R38	Do-re-mi Day Care Centre	3.5	0.2	9.0	1.5	44	18
R39	Little Amigos Austral Early Learning Centre	3.9	0.1	7.6	1.1	46	18
R40	Little Smarties Childcare Centre	2.8	0.2	4.6	1.3	44	18
R41	The Grove Academy	2.9	0.1	5.6	1.0	44	18
R42	Horsley Kids	2.0	0.1	3.9	0.8	43	18
R44	Bringelly Child Care Centre	2.6	0.2	5.0	0.9	45	18
R46	Clementson Drive Early Educational Centre	4.1	0.1	8.4	1.8	48	19
R48	Kids Korner West Hoxton Early Learning Centre	1.8	0.1	7.5	1.1	46	18

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R49	Luddenham Child Care Centre	1.5	0.2	3.9	0.8	44	18
R52	The Frogs Lodge	3.3	0.1	7.7	1.1	45	18
R53	Rossmore Community Preschool	1.6	0.1	4.6	1.3	45	18
R54	Mulgoa Preschool	2.2	0.1	4.3	0.5	43	17
R55	Jillys Educational Childcare Centre	3.2	0.1	6.1	1.0	46	18
R57	Wallacia Progress Hall	1.5	0.1	2.6	0.4	43	17
R59	Bringelly Community Centre	4.8	0.2	7.5	1.4	46	18
R63	Luddenham Progress Hall	1.2	0.2	2.8	0.7	44	18
R64	Mulgoa Hall	2.2	0.1	4.2	0.5	43	17
R65	Emmaus Catholic College	2.1	0.2	4.9	1.5	45	18
R66	University of Sydney Farms	3.8	0.1	6.1	0.5	43	17
R68	Christadelphian Heritage College Sydney	3.4	0.2	9.1	1.4	45	18
R69	Mamre Anglican School	2.1	0.2	4.8	1.5	44	18
R72	Irfan College	1.6	0.1	9.7	2.6	44	20
R73	Luddenham Public School	1.6	0.3	5.4	1.6	44	19
R74	Kemps Creek Public School	3.8	0.2	8.7	1.2	44	18
R75	Trinity Catholic Primary School	2.0	0.2	4.9	1.6	45	19
R76	Bringelly Public School	3.9	0.2	6.0	1.2	46	18
R78	Mulgoa Public School	1.9	0.1	3.8	0.4	43	17
R79	Rossmore Public School	1.7	0.1	6.4	1.8	48	19
R80	Wallacia Public School	1.4	0.1	2.9	0.4	43	17
R82	Bellfield College - Junior Campus	2.4	0.1	6.1	1.4	45	18
R84	Bringelly Park	5.0	0.2	7.5	1.4	46	18
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	3.6	0.1	5.2	0.3	43	17
R86	Blaxland Crossing Reserve	1.2	0.1	2.7	0.4	43	17
R87	Bill Anderson Reserve	2.6	0.2	8.7	1.6	46	19
R88	Kemps Creek Nature Reserve	2.2	0.1	5.5	1.1	45	18
R91	Western Sydney Parklands	2.7	0.1	8.5	1.5	45	18
R93	Rossmore Grange	3.2	0.2	6.6	0.9	46	18
R94	Freeburn Park	1.8	0.3	4.4	1.0	44	18
R95	Overett Reserve	5.7	0.4	14.3	2.8	47	20
R97	Mulgoa Park	2.1	0.1	4.1	0.4	43	17
R98	Wallacia Bowling and Recreation Club	1.5	0.1	2.6	0.4	43	17
R99	Hubertus Country Club	7.2	0.8	9.6	1.9	46	19
R100	Sugarloaf Cobbitty Equestrian Club	4.0	0.1	5.4	0.4	43	17
R102	Panthers Wallacia	1.7	0.1	3.3	0.5	43	17

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*50*	*25*
R103	Twin Creeks Golf and Country Club	2.1	0.2	3.9	1.1	44	18
R104	Sydney International Shooting Centre	2.8	0.1	10.4	1.7	46	19
R108	Luddenham Showground	1.6	0.2	3.7	0.7	43	18
R109	Kemps Creek Sporting and Bowling Club	2.2	0.1	9.1	2.0	46	19
R110	St James Luddenham	2.0	0.3	4.1	1.5	45	18
R111	Lin Ying temple	5.2	0.2	8.3	1.2	46	18
R112	Vat Ketanak Khmer Kampuchea Krom	2.7	0.1	5.2	1.0	45	18
R114	Anglican Church Sydney Diocese	2.0	0.1	5.0	1.2	45	18
R115	Anglican Parish of Mulgoa	2.4	0.1	5.1	0.5	43	17
R117	Bringelly Vineyard Church	2.2	0.1	5.1	1.2	47	18
R118	Free Church of Tonga	3.7	0.1	5.0	0.4	43	17
R120	Our Lady Queen of Peace	3.4	0.2	7.2	1.3	46	18
R122	St Anthony	4.2	0.1	7.0	0.9	45	18
R123	St Marys Church	1.6	0.1	3.4	0.4	43	17
R124	Wallacia Christian Church	1.3	0.1	3.1	0.4	43	17
R126	St Francis Xavier Church	3.3	0.1	5.8	0.4	43	17
R127	Luddenham Uniting Church	1.0	0.2	2.5	0.7	44	18
R130	Hopewood Health Retreat	1.5	0.1	2.8	0.4	43	17
R131	Science of the Soul Study Centre	2.3	0.1	9.2	2.0	46	19
R132	Bringelly shops	3.3	0.1	4.8	1.2	46	18
R134	Kemps Creek shops	2.4	0.2	9.3	1.9	47	19
R135	Luddenham shops	2.0	0.3	4.9	1.1	45	18
R136	Mulgoa shops	1.8	0.1	3.4	0.4	43	17
R137	Rossmore shops	1.9	0.1	5.3	1.2	45	18
R138	Wallacia Shops	1.3	0.1	3.0	0.4	43	17
R140	Holy Family Catholic Primary and Church	2.1	0.3	4.3	0.9	44	18
R141	Edmund Rice Retreat and Conference Centre	1.2	0.1	2.9	0.4	43	17

Figure F57: PM10 24-hours Contour Plot during long term development – Airport

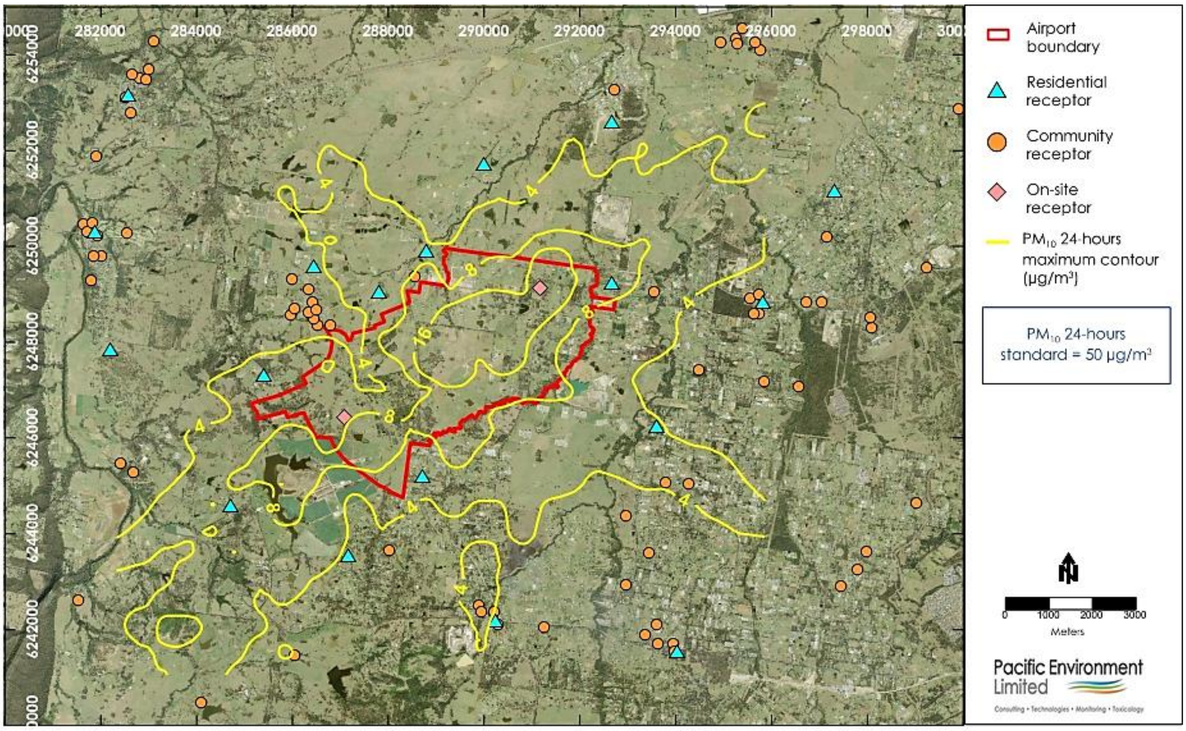


Figure F58: PM10 Annual Average Contour Plot during long term development – Airport

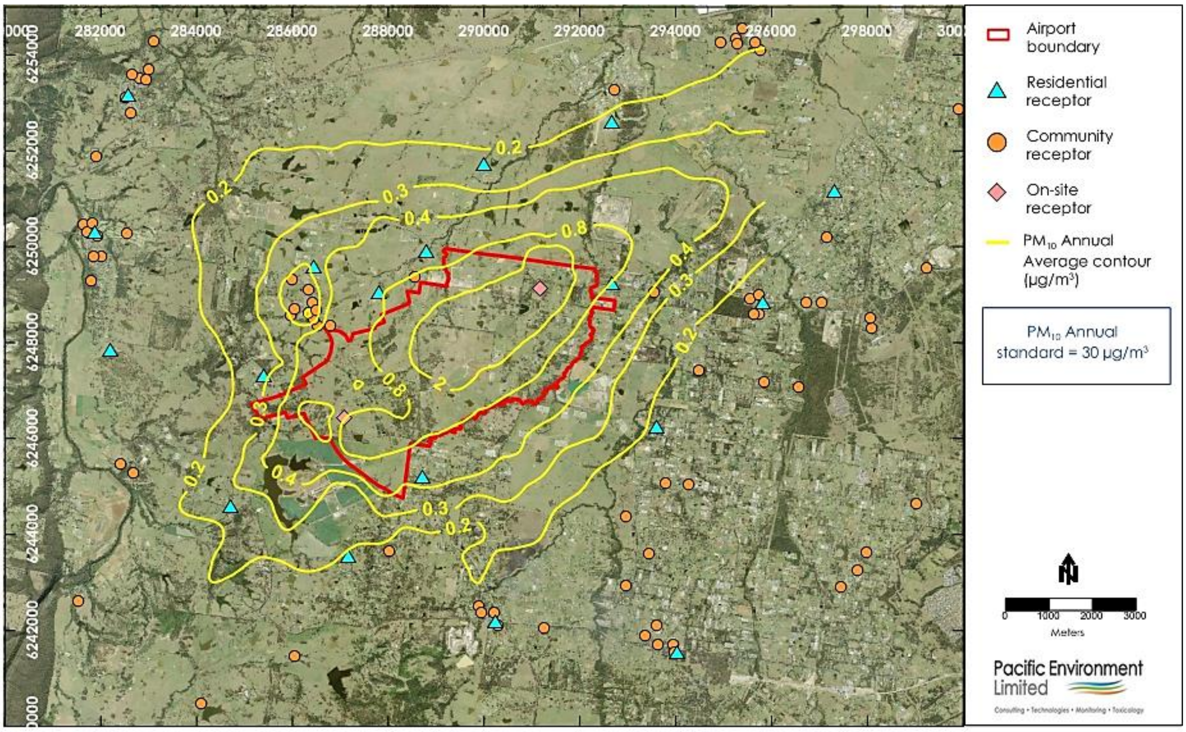


Figure F59: PM10 24-hours Contour Plot during long term development – Airport + External Roadways

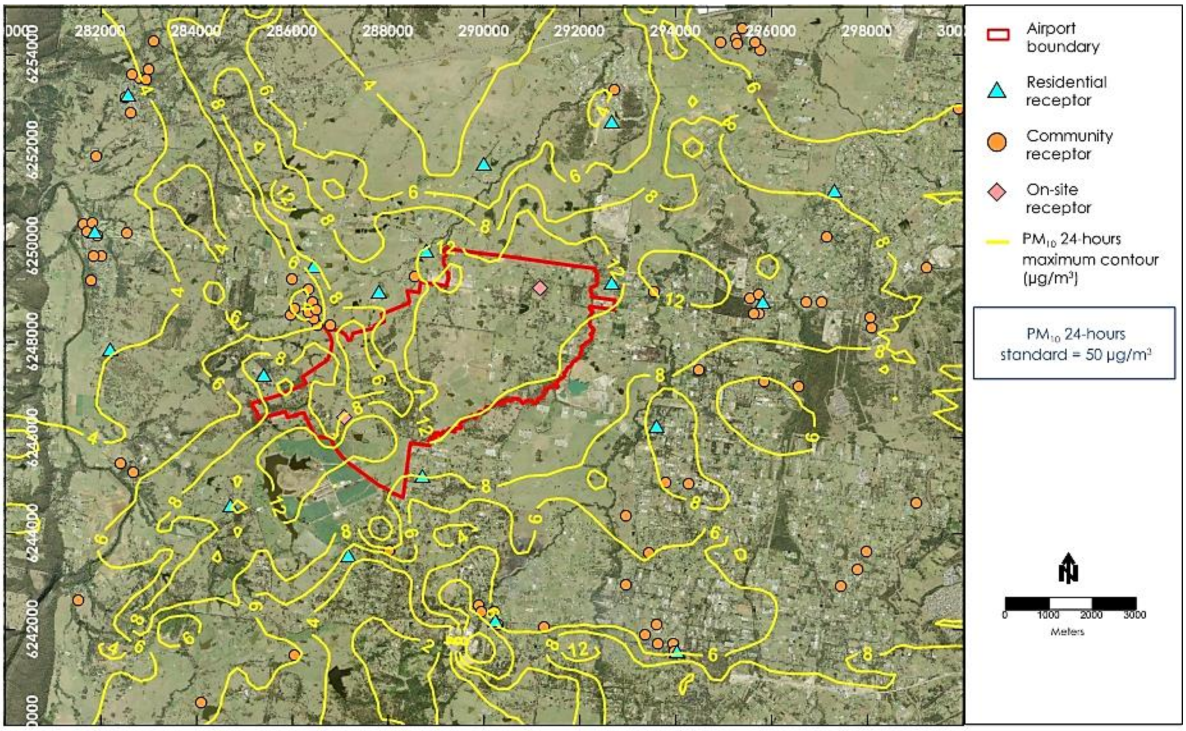


Figure F60: PM10 Annual Average Contour Plot during long term development – Airport + External Roadways

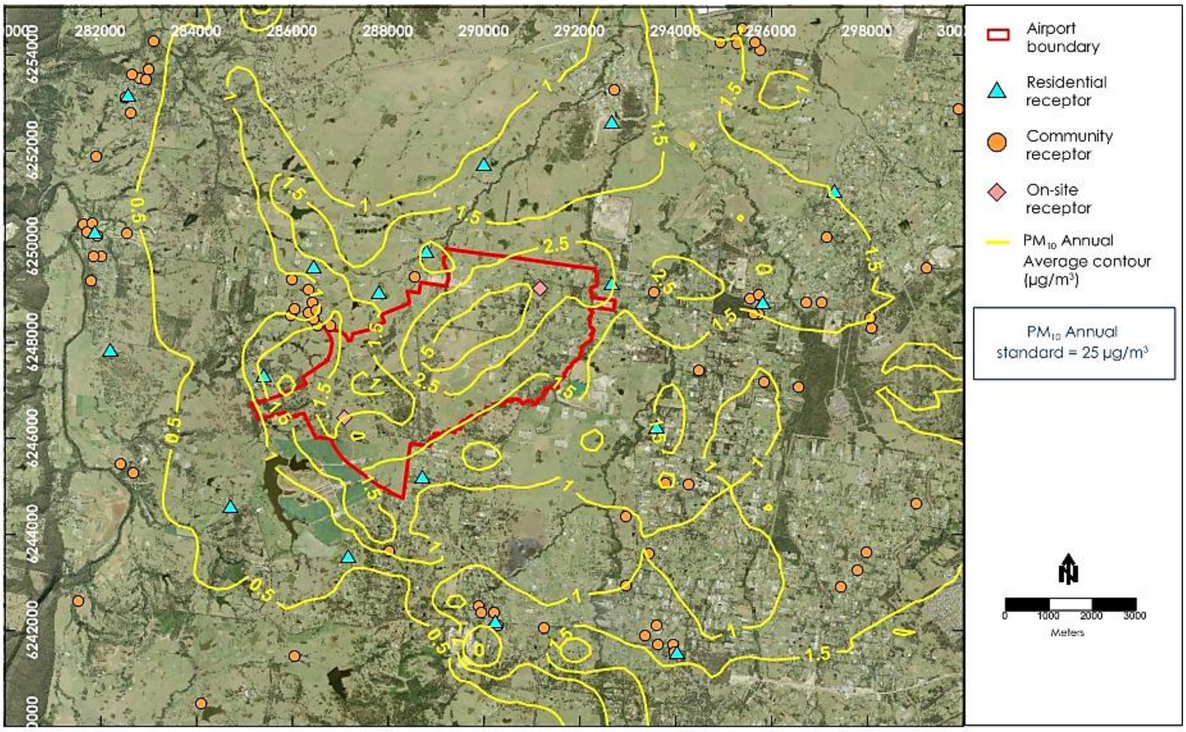


Figure F61: PM10 24-hours Contour Plot during long term development – Cumulative

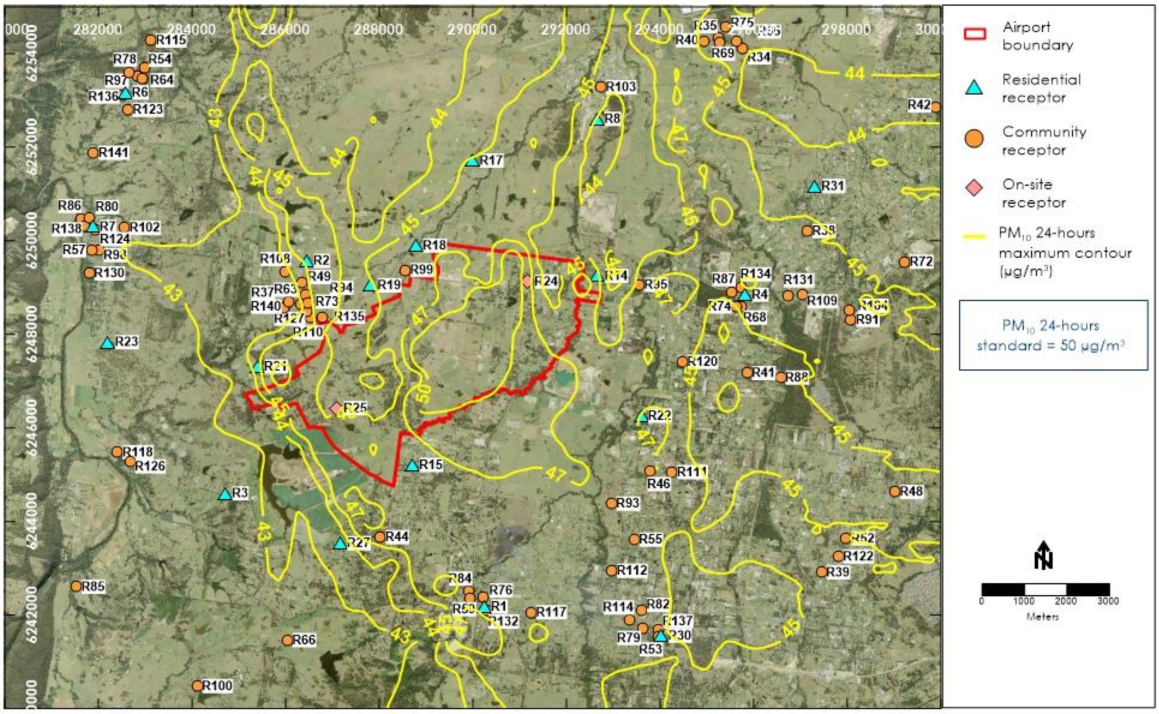
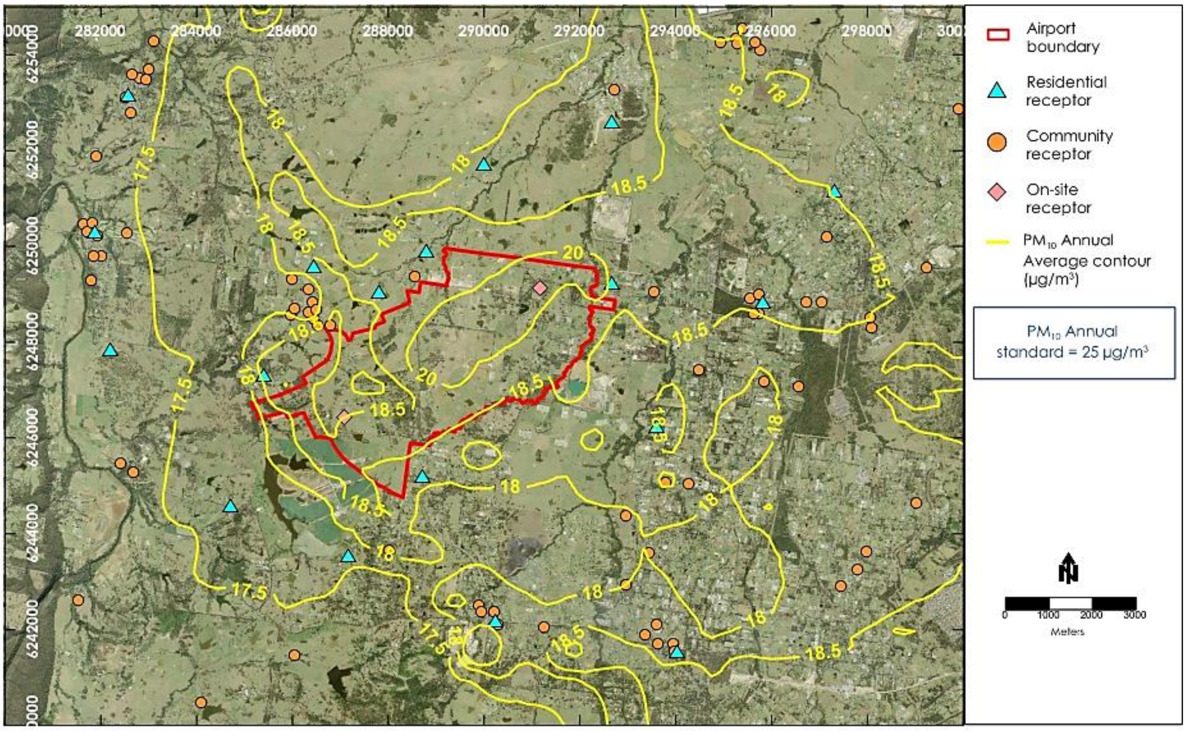


Figure F62: PM10 Annual Average Contour Plot during long term development - Cumulative



F.2.3 Particulate matter $PM_{2.5}$

Table F11: Predicted incremental and cumulative $PM_{2.5}$ concentrations during longer term development

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R1	Bringelly	2.4	0.1	3.5	0.8	16	8
R2	Luddenham	1.5	0.2	3.5	0.9	15	8
R3	Greendale, Greendale Road	4.3	0.2	5.4	0.4	14	7
R4	Kemps Creek	2.0	0.1	5.6	1.0	16	8
R6	Mulgoa	1.6	0.1	2.5	0.3	14	7
R7	Wallacia	1.1	0.1	1.8	0.3	14	7
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	1.6	0.2	2.9	0.7	14	8
R14	Lawson Road, Badgerys Creek	6.8	0.6	9.0	1.5	18	**9**
R15	Mersey Rd, Greendale	4.6	0.5	8.1	0.9	16	8
R17	Luddenham Road	2.8	0.2	4.0	0.8	15	8
R18	Cnr Adams & Elizabeth Drive	3.8	0.5	7.2	1.7	16	**9**
R19	Cnr Adams & Anton Road	4.0	0.6	6.1	1.1	15	8
R21	Cnr Willowdene Ave and Vicar Park Lane	4.0	0.2	5.2	0.9	15	8
R22	Rossmore, Victor Ave	2.9	0.2	5.1	0.8	15	8
R23	Wallacia, Greendale Rd	1.7	0.1	2.6	0.3	14	7
R24	Badgerys Creek 1 NE	18.6	5.3	11.8	2.4	19	**9**
R25	Badgerys Creek 2 SW	2.3	0.4	3.2	0.8	14	8
R27	Greendale, Dwyer Rd	1.1	0.1	1.8	0.3	14	7
R30	Rossmore residential	1.2	0.1	3.2	0.7	15	8
R31	Mt Vernon residential	2.9	0.2	4.6	0.6	14	8
R34	Emmaus Residential Aged Care	1.5	0.2	3.3	0.9	15	8
R35	Mamre After School and Vacation Care	1.3	0.1	3.0	0.9	14	8
R36	Head Start After School Care	1.4	0.0	6.7	0.9	16	8
R37	Schoolies at Mulgoa	1.4	0.2	2.6	0.6	14	8
R38	Do-re-mi Day Care Centre	2.9	0.1	5.3	0.9	14	8
R39	Little Amigos Austral Early Learning Centre	2.9	0.1	5.1	0.7	15	8
R40	Little Smarties Childcare Centre	1.7	0.2	3.0	0.8	14	8
R41	The Grove Academy	2.2	0.1	3.8	0.6	14	8
R42	Horsley Kids	1.6	0.1	2.3	0.5	14	8
R44	Bringelly Child Care Centre	1.9	0.1	3.5	0.6	15	8
R46	Clementson Drive Early Educational Centre	3.0	0.1	5.5	1.0	17	8
R48	Kids Korner West Hoxton Early Learning Centre	1.4	0.1	4.4	0.7	15	8
R49	Luddenham Child Care Centre	1.3	0.2	2.6	0.5	14	8
R52	The Frogs Lodge	2.4	0.1	4.9	0.6	15	8

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R53	Rossmore Community Preschool	1.1	0.1	3.0	0.7	15	8
R54	Mulgoa Preschool	1.9	0.1	3.1	0.3	14	7
R55	Jillys Educational Childcare Centre	2.5	0.1	4.1	0.6	16	8
R57	Wallacia Progress Hall	1.2	0.1	1.8	0.3	14	7
R59	Bringelly Community Centre	3.4	0.1	4.9	0.8	16	8
R63	Luddenham Progress Hall	1.0	0.2	1.9	0.4	14	7
R64	Mulgoa Hall	1.9	0.1	3.1	0.3	14	7
R65	Emmaus Catholic College	1.4	0.1	3.1	0.9	15	8
R66	University of Sydney Farms	2.8	0.1	4.1	0.3	14	7
R68	Christadelphian Heritage College Sydney	2.7	0.1	5.9	0.8	16	8
R69	Mamre Anglican School	1.5	0.2	2.9	0.9	14	8
R72	Irfan College	1.2	0.1	5.6	1.5	15	**8**
R73	Luddenham Public School	1.2	0.2	3.4	1.0	14	8
R74	Kemps Creek Public School	2.9	0.1	5.7	0.8	16	8
R75	Trinity Catholic Primary School	1.2	0.1	3.0	1.0	14	8
R76	Bringelly Public School	2.5	0.1	3.7	0.7	16	8
R78	Mulgoa Public School	1.6	0.1	2.7	0.3	14	7
R79	Rossmore Public School	1.3	0.1	4.1	1.1	17	8
R80	Wallacia Public School	1.2	0.1	1.8	0.3	14	7
R82	Bellfield College - Junior Campus	1.9	0.1	4.1	0.8	15	8
R84	Bringelly Park	3.6	0.1	5.0	0.8	16	8
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	2.6	0.1	3.5	0.2	13	7
R86	Blaxland Crossing Reserve	0.9	0.1	1.7	0.2	14	7
R87	Bill Anderson Reserve	1.9	0.1	5.4	1.0	16	8
R88	Kemps Creek Nature Reserve	1.7	0.1	3.6	0.6	15	8
R91	Western Sydney Parklands	2.2	0.1	5.5	0.9	16	8
R93	Rossmore Grange	2.6	0.1	4.4	0.6	16	8
R94	Freeburn Park	1.5	0.2	3.0	0.7	14	8
R95	Overett Reserve	4.1	0.3	9.0	1.7	18	**9**
R97	Mulgoa Park	1.8	0.1	2.9	0.3	14	7
R98	Wallacia Bowling and Recreation Club	1.1	0.1	1.7	0.3	14	7
R99	Hubertus Country Club	5.4	0.6	6.7	1.3	16	8
R100	Sugarloaf Cobbitty Equestrian Club	2.9	0.1	3.7	0.2	14	7
R102	Panthers Wallacia	1.4	0.1	2.0	0.3	14	7
R103	Twin Creeks Golf and Country Club	1.4	0.1	2.4	0.7	14	8

Receptor	Receptor location	Airport (µg/m³)		Airport + external roadways (µg/m³)		Cumulative (µg/m³)	
		24-hour	Annual	24-hour	Annual	24-hour	Annual
	NEPM-AAQ goal	*n/a*	*n/a*	*n/a*	*n/a*	*25*	*8*
R104	Sydney International Shooting Centre	2.2	0.1	6.2	1.0	16	8
R108	Luddenham Showground	1.3	0.2	2.5	0.5	14	7
R109	Kemps Creek Sporting and Bowling Club	1.7	0.1	5.7	1.2	16	8
R110	St James Luddenham	1.6	0.2	2.6	0.9	15	8
R111	Lin Ying temple	4.0	0.1	5.8	0.7	15	8
R112	Vat Ketanak Khmer Kampuchea Krom	2.1	0.1	3.3	0.6	15	8
R114	Anglican Church Sydney Diocese	1.5	0.1	3.4	0.7	15	8
R115	Anglican Parish of Mulgoa	2.0	0.1	3.6	0.3	13	7
R117	Bringelly Vineyard Church	1.7	0.1	3.3	0.7	16	8
R118	Free Church of Tonga	2.6	0.1	3.3	0.3	13	7
R120	Our Lady Queen of Peace	2.4	0.1	4.9	0.8	15	8
R122	St Anthony	3.3	0.1	4.9	0.6	15	8
R123	St Marys Church	1.4	0.1	2.4	0.3	13	7
R124	Wallacia Christian Church	1.1	0.1	1.8	0.3	14	7
R126	St Francis Xavier Church	2.4	0.1	4.0	0.3	13	7
R127	Luddenham Uniting Church	0.8	0.1	1.6	0.5	14	7
R130	Hopewood Health Retreat	1.2	0.1	1.9	0.3	14	7
R131	Science of the Soul Study Centre	1.8	0.1	5.8	1.2	16	8
R132	Bringelly shops	2.1	0.1	3.2	0.7	16	8
R134	Kemps Creek shops	1.8	0.1	5.7	1.1	16	8
R135	Luddenham shops	1.6	0.3	2.9	0.7	15	8
R136	Mulgoa shops	1.5	0.1	2.5	0.3	14	7
R137	Rossmore shops	1.5	0.1	3.6	0.7	15	8
R138	Wallacia Shops	1.0	0.1	1.7	0.3	14	7
R140	Holy Family Catholic Primary and Church	1.6	0.2	2.9	0.6	14	8
R141	Edmund Rice Retreat and Conference Centre	1.0	0.1	1.9	0.3	13	7

Figure F63: PM2.5 24-hours Contour Plot during long term development – Airport

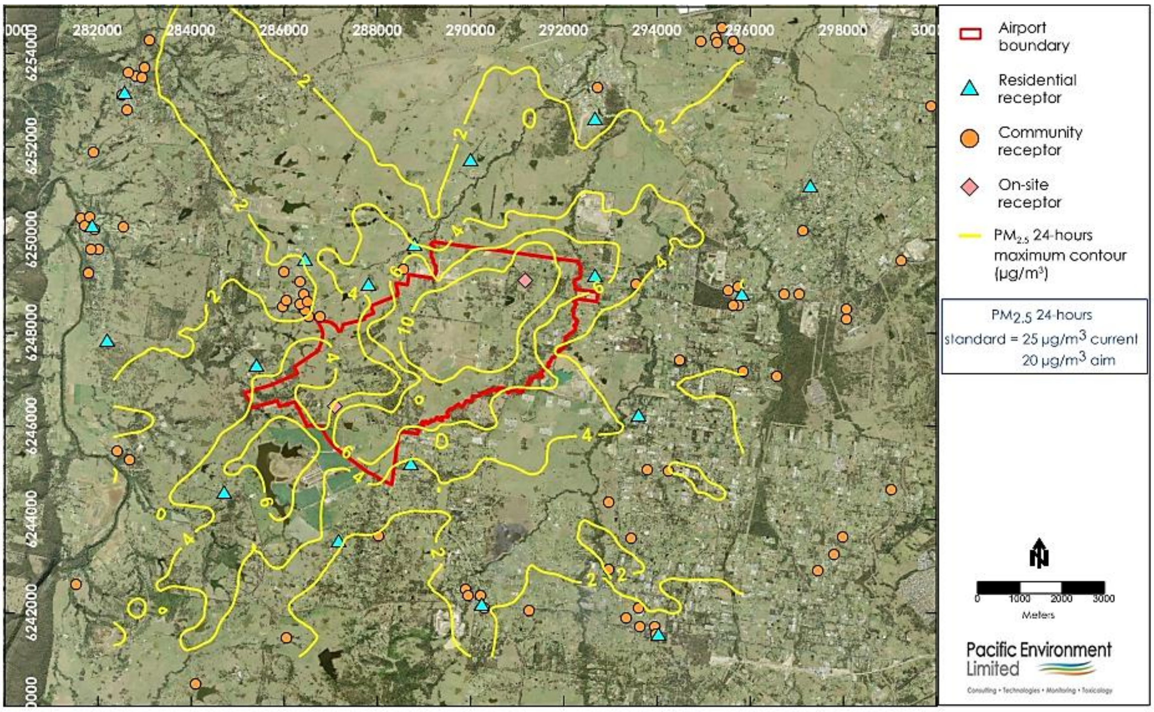


Figure F64: PM2.5 Annual Average Contour Plot during long term development – Airport

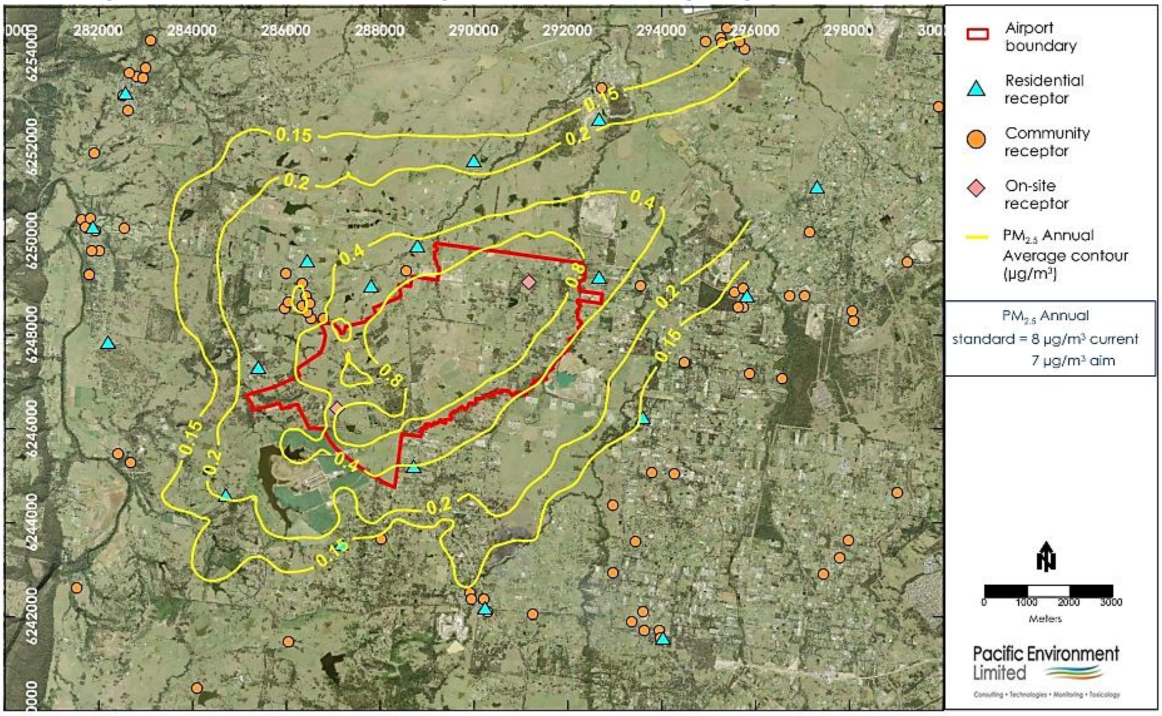


Figure F65: PM2.5 24-hours Contour Plot during long term development – Airport + External Roadways

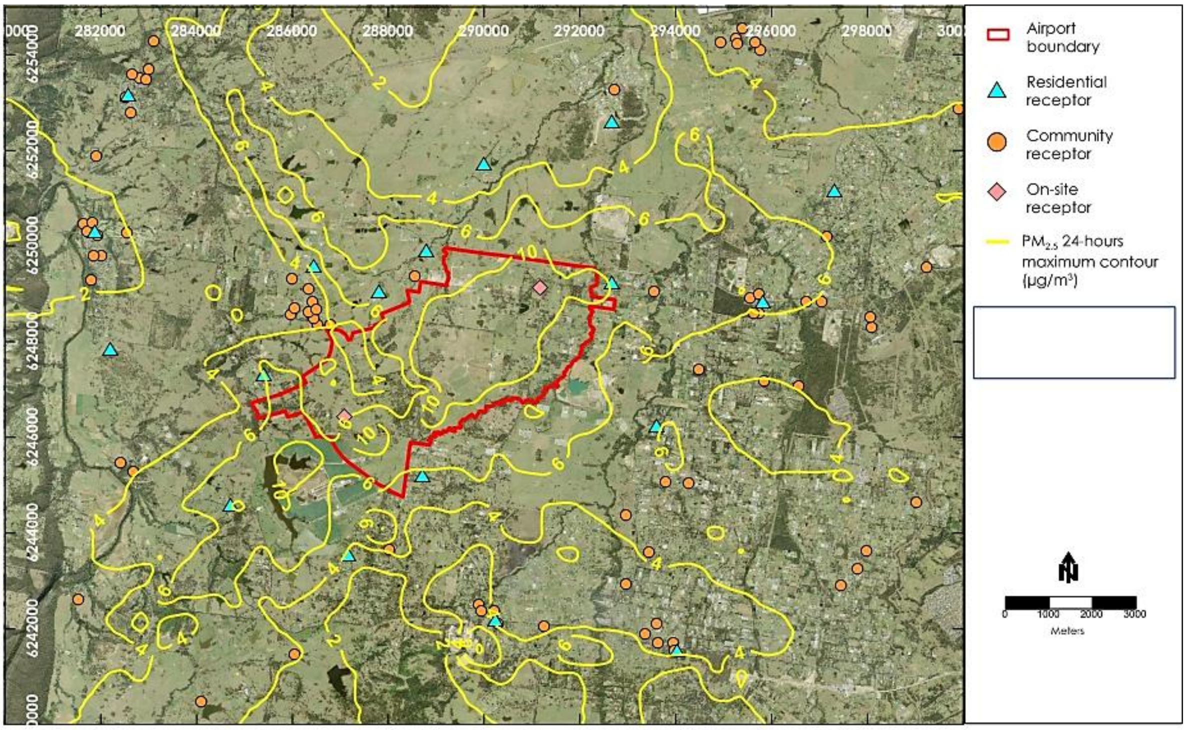


Figure F66: PM2.5 Annual Average Contour Plot during long term development – Airport + External Roadways

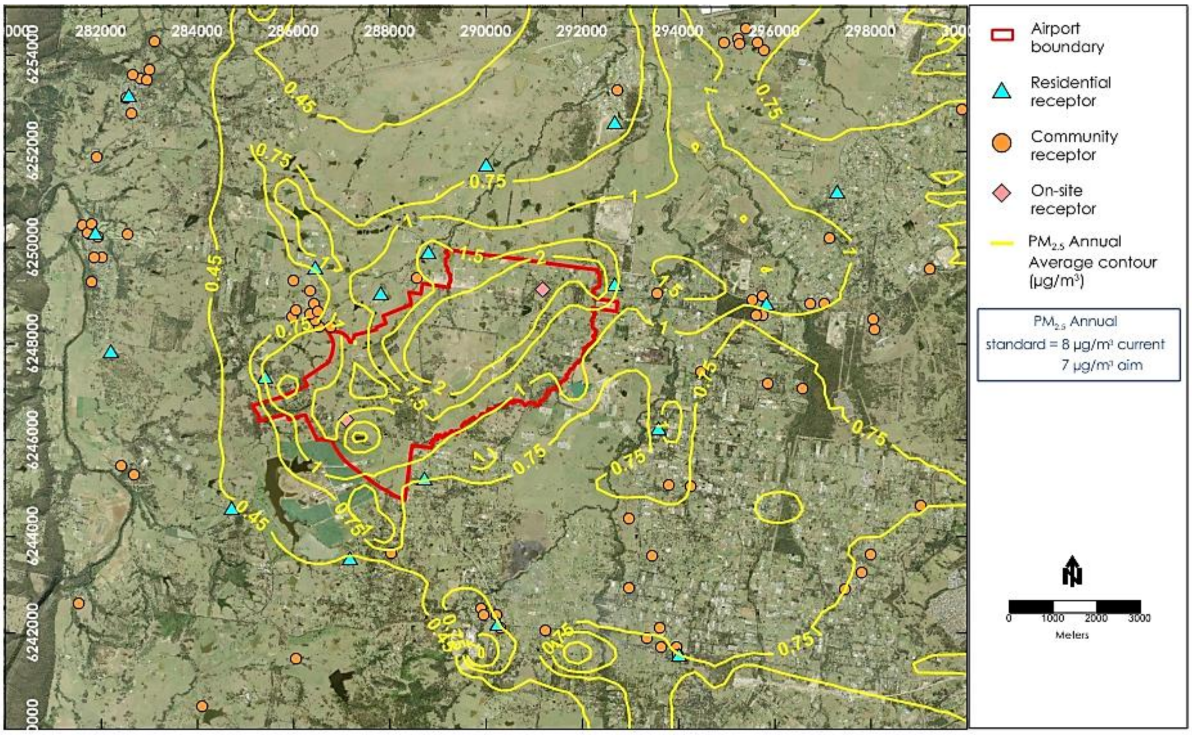


Figure F67: $PM_{2.5}$ 24-hours Contour Plot during long term development – Cumulative

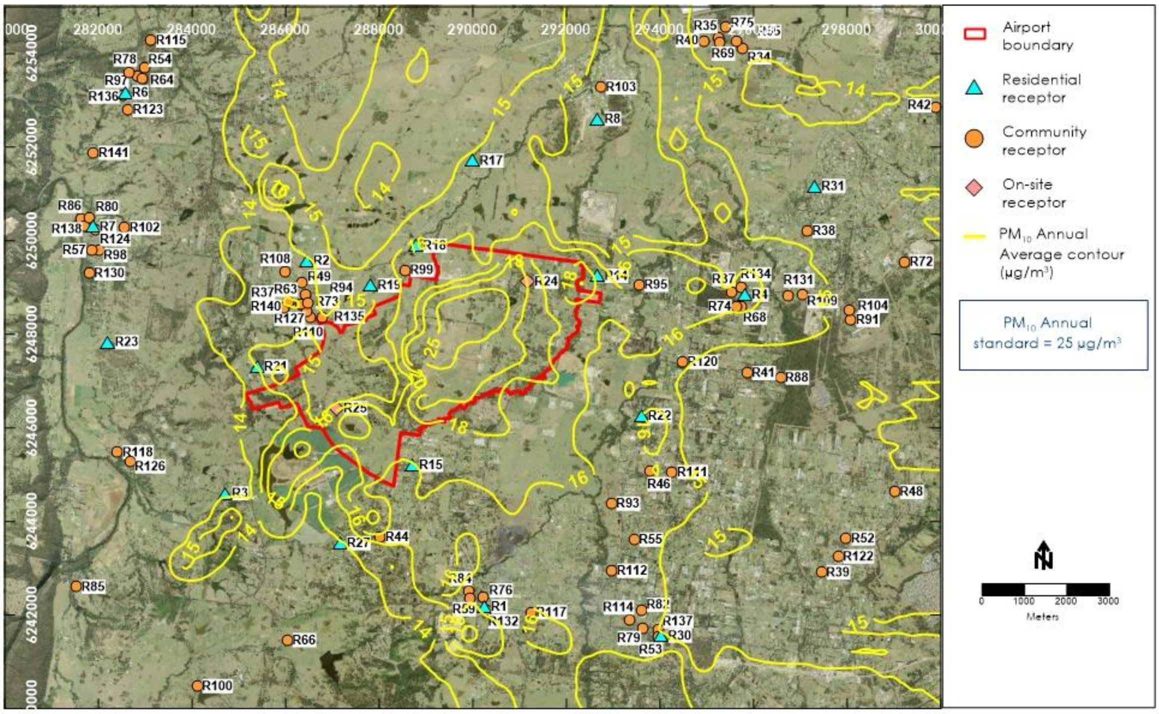
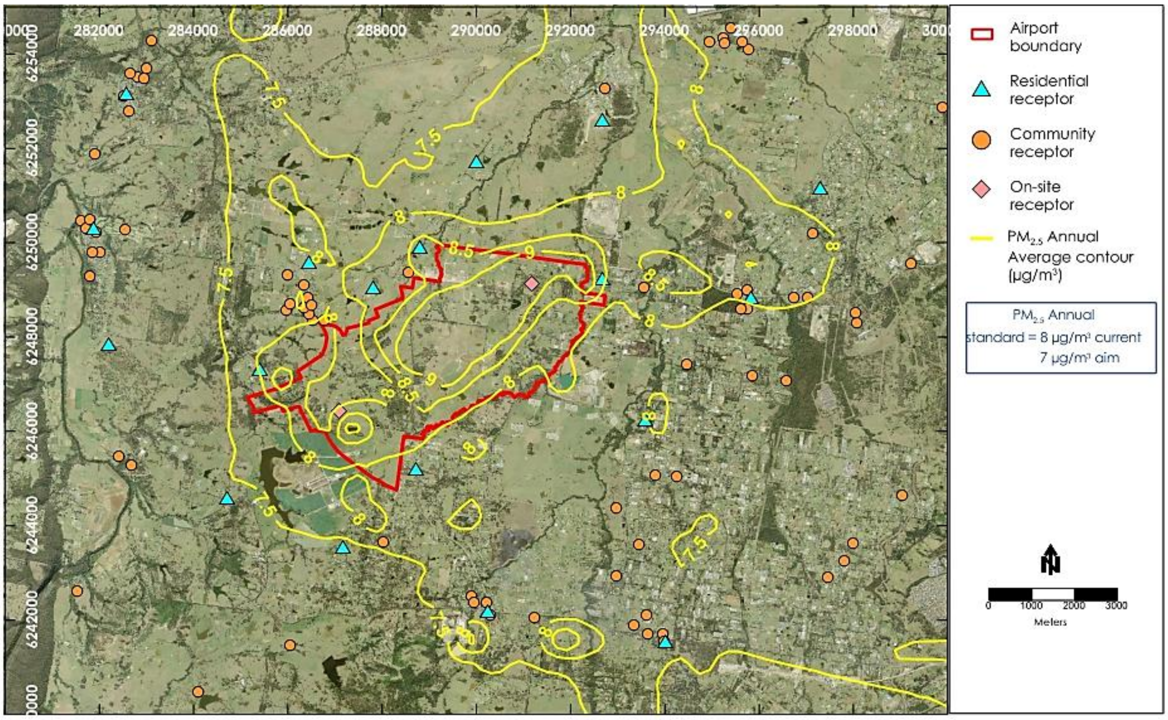


Figure F68: PM 2.5 Annual Average Contour Plot during long term development - Cumulative



Appendix G TABULATED RESULTS AND CONTOUR PLOTS DURING CONSTRUCTION

G.1.1 Bulk earthworks

Table G-1: Predicted incremental results during bulk earthworks

Receptor ID	Receptor location	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	2
R1	Bringelly	1.0	0.1	0.4	<0.0	<0.0
R2	Luddenham	2.1	0.3	0.5	0.1	0.1
R3	Greendale, Greendale Road	2.7	0.1	1.4	0.1	<0.0
R4	Kemps Creek	1.3	0.1	0.8	<0.0	<0.0
R6	Mulgoa	0.4	0.1	0.2	<0.0	<0.0
R7	Wallacia	0.6	0.1	0.3	<0.0	<0.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	2.0	0.3	0.7	0.1	<0.0
R14	Lawson Road, Badgerys Creek	4.8	0.6	2.0	0.2	0.1
R15	Mersey Rd, Greendale	3.3	0.4	1.2	0.1	0.1
R17	Luddenham Road	2.2	0.3	0.6	0.1	0.1
R18	Cnr Adams & Elizabeth Drive	6.5	1.0	1.8	0.2	0.2
R19	Cnr Adams & Anton Road	7.2	0.9	2.1	0.2	0.2
R21	Cnr Willowdene Ave and Vicar Park Lane	2.9	0.5	0.7	0.1	0.1
R22	Rossmore, Victor Ave	1.4	0.1	0.7	<0.0	<0.0
R23	Wallacia, Greendale Rd	0.8	0.1	0.3	<0.0	<0.0
R24	Badgerys Creek 1 NE	68.4	6.3	15.6	1.3	1.1
R25	Badgerys Creek 2 SW	39.4	3.8	5.0	0.6	0.8
R27	Greendale, Dwyer Rd	1.2	0.2	0.4	<0.0	<0.0
R30	Rossmore residential	0.7	0.1	0.3	<0.0	<0.0
R31	Mt Vernon residential	1.8	0.1	1.0	<0.0	<0.0
R34	Emmaus Residential Aged Care	1.3	0.2	0.6	0.1	<0.0
R35	Mamre After School and Vacation Care	1.4	0.2	0.4	0.1	<0.0
R36	Head Start After School Care	0.5	<0.0	0.3	<0.0	<0.0
R37	Schoolies at Mulgoa	2.6	0.4	0.6	0.1	0.1
R38	Do-re-mi Day Care Centre	1.1	0.1	0.6	<0.0	<0.0
R39	Little Amigos Austral Early Learning Centre	0.4	<0.0	0.3	<0.0	<0.0
R40	Little Smarties Childcare Centre	1.4	0.2	0.4	0.1	<0.0
R41	The Grove Academy	1.0	0.1	0.4	<0.0	<0.0
R42	Horsley Kids	0.6	0.1	0.5	<0.0	<0.0
R44	Bringelly Child Care Centre	2.0	0.2	0.6	0.1	<0.0
R46	Clementson Drive Early Educational Centre	1.0	0.1	0.5	<0.0	<0.0
R48	Kids Korner West Hoxton Early Learning Centre	0.4	<0.0	0.3	<0.0	<0.0
R49	Luddenham Child Care Centre	2.8	0.4	0.7	0.1	0.1
R52	The Frogs Lodge	0.5	<0.0	0.5	<0.0	<0.0
R53	Rossmore Community Preschool	0.7	0.1	0.3	<0.0	<0.0
R54	Mulgoa Preschool	0.4	0.1	0.2	<0.0	<0.0
R55	Jillys Educational Childcare Centre	0.9	0.1	0.5	<0.0	<0.0
R57	Wallacia Progress Hall	0.6	0.1	0.3	<0.0	<0.0
R59	Bringelly Community Centre	1.0	0.1	0.4	<0.0	<0.0
R63	Luddenham Progress Hall	3.6	0.5	1.0	0.1	0.1
R64	Mulgoa Hall	0.4	0.1	0.3	<0.0	<0.0

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*2*
R65	Emmaus Catholic College	1.3	0.2	0.4	0.1	<0.0
R66	University of Sydney Farms	0.8	0.1	0.4	<0.0	<0.0
R68	Christadelphian Heritage College Sydney	1.9	0.1	0.7	<0.0	<0.0
R69	Mamre Anglican School	1.4	0.2	0.5	0.1	<0.0
R72	Irfan College	1.1	0.1	0.4	<0.0	<0.0
R73	Luddenham Public School	4.6	0.5	1.0	0.1	0.1
R74	Kemps Creek Public School	2.2	0.1	0.6	<0.0	<0.0
R75	Trinity Catholic Primary School	1.4	0.2	0.4	0.1	<0.0
R76	Bringelly Public School	1.0	0.1	0.4	<0.0	<0.0
R78	Mulgoa Public School	0.3	0.1	0.2	<0.0	<0.0
R79	Rossmore Public School	0.6	0.1	0.3	<0.0	<0.0
R80	Wallacia Public School	0.5	0.1	0.3	<0.0	<0.0
R82	Bellfield College - Junior Campus	0.7	0.1	0.3	<0.0	<0.0
R84	Bringelly Park	1.0	0.1	0.4	<0.0	<0.0
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.8	<0.0	0.5	<0.0	<0.0
R86	Blaxland Crossing Reserve	0.5	0.1	0.3	<0.0	<0.0
R87	Bill Anderson Reserve	1.4	0.1	0.9	<0.0	<0.0
R88	Kemps Creek Nature Reserve	0.9	0.1	0.3	<0.0	<0.0
R91	Western Sydney Parklands	1.0	0.1	0.6	<0.0	<0.0
R93	Rossmore Grange	1.0	0.1	0.6	<0.0	<0.0
R94	Freeburn Park	2.4	0.4	0.7	0.1	0.1
R95	Overett Reserve	2.9	0.3	1.4	0.1	<0.0
R97	Mulgoa Park	0.4	0.1	0.3	<0.0	<0.0
R98	Wallacia Bowling and Recreation Club	0.6	0.1	0.3	<0.0	<0.0
R99	Hubertus Country Club	6.9	1.4	2.0	0.3	0.3
R100	Sugarloaf Cobbitty Equestrian Club	0.6	0.1	0.3	<0.0	<0.0
R102	Panthers Wallacia	0.7	0.1	0.3	<0.0	<0.0
R103	Twin Creeks Golf and Country Club	1.4	0.2	0.5	0.1	<0.0
R104	Sydney International Shooting Centre	0.8	0.1	0.5	<0.0	<0.0
R108	Luddenham Showground	2.5	0.3	0.6	0.1	0.1
R109	Kemps Creek Sporting and Bowling Club	1.0	0.1	0.5	<0.0	<0.0
R110	St James Luddenham	6.0	0.7	1.1	0.1	0.1
R111	Lin Ying temple	1.3	0.1	0.5	<0.0	<0.0
R112	Vat Ketanak Khmer Kampuchea Krom	0.8	0.1	0.5	<0.0	<0.0
R114	Anglican Church Sydney Diocese	0.9	0.1	0.4	<0.0	<0.0
R115	Anglican Parish of Mulgoa	0.4	0.1	0.2	<0.0	<0.0
R117	Bringelly Vineyard Church	0.9	0.1	0.4	<0.0	<0.0
R118	Free Church of Tonga	1.5	0.1	0.6	<0.0	<0.0
R120	Our Lady Queen of Peace	1.4	0.2	0.5	0.1	<0.0
R122	St Anthony	0.5	<0.0	0.4	<0.0	<0.0
R123	St Marys Church	0.5	0.1	0.3	<0.0	<0.0
R124	Wallacia Christian Church	0.6	0.1	0.3	<0.0	<0.0
R126	St Francis Xavier Church	1.8	0.1	0.8	<0.0	<0.0

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	2
R127	Luddenham Uniting Church	3.7	0.5	0.9	0.1	0.1
R130	Hopewood Health Retreat	0.6	0.1	0.3	<0.0	<0.0
R131	Science of the Soul Study Centre	1.1	0.1	0.5	<0.0	<0.0
R132	Bringelly shops	1.0	0.1	0.4	<0.0	<0.0
R134	Kemps Creek shops	1.4	0.1	0.7	<0.0	<0.0
R135	Luddenham shops	5.1	0.8	1.0	0.2	0.2
R136	Mulgoa shops	0.4	0.1	0.2	<0.0	<0.0
R137	Rossmore shops	0.7	0.1	0.3	<0.0	<0.0
R138	Wallacia Shops	0.6	0.1	0.3	<0.0	<0.0
R140	Holy Family Catholic Primary and Church	2.9	0.4	0.8	0.1	0.1
R141	Edmund Rice Retreat and Conference Centre	0.3	0.1	0.2	<0.0	<0.0

Figure G-1: Incremental PM_{10} 24-hours Contour Plot during bulk earthworks

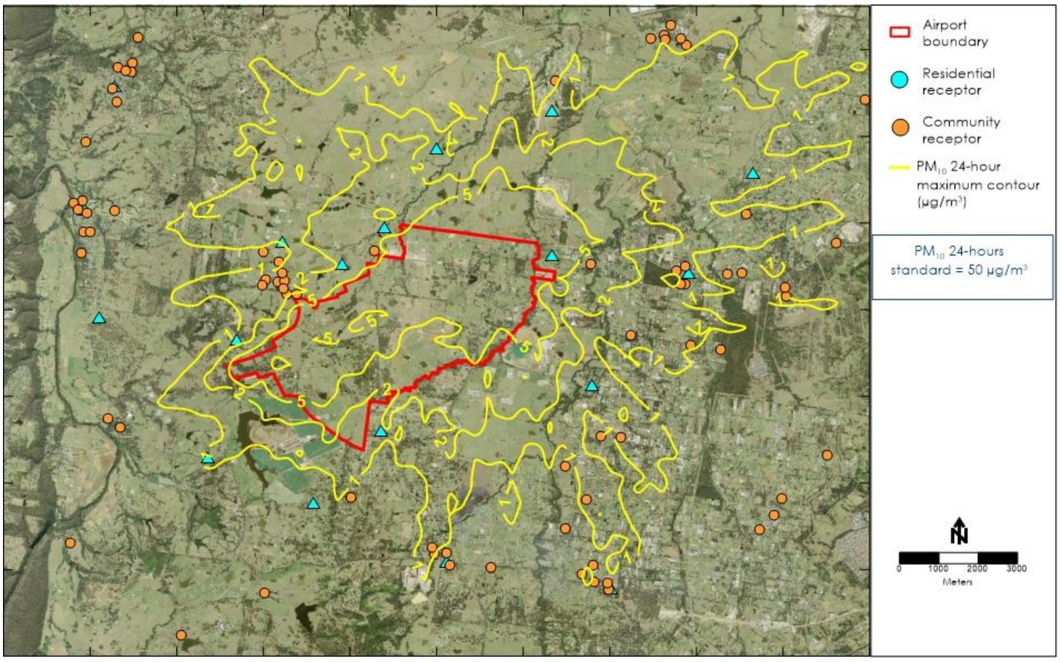


Figure G-2: Incremental PM10 Annual Average Contour Plot during bulk earthworks

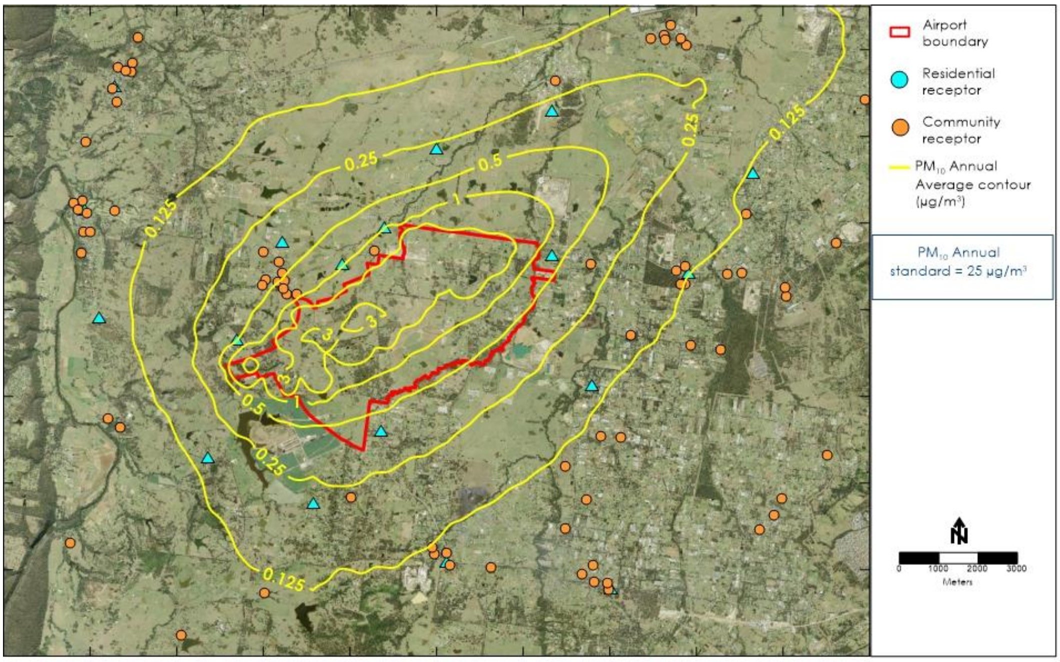


Figure G-3: Incremental PM2.5 24-hours Contour Plot during bulk earthworks

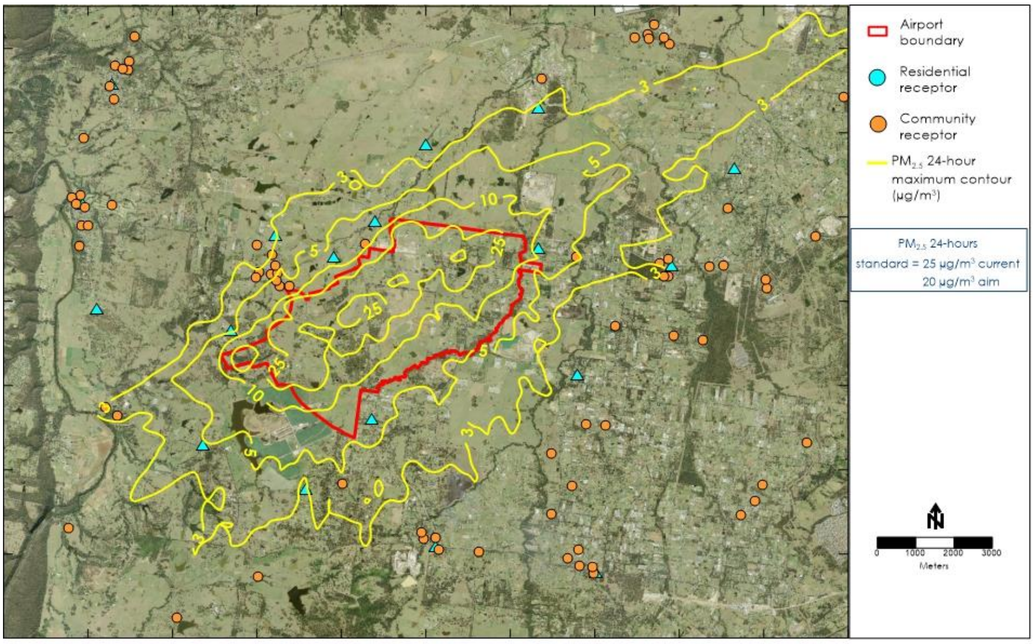


Figure G-4: Incremental $PM_{2.5}$ Annual Average Contour Plot during bulk earthworks

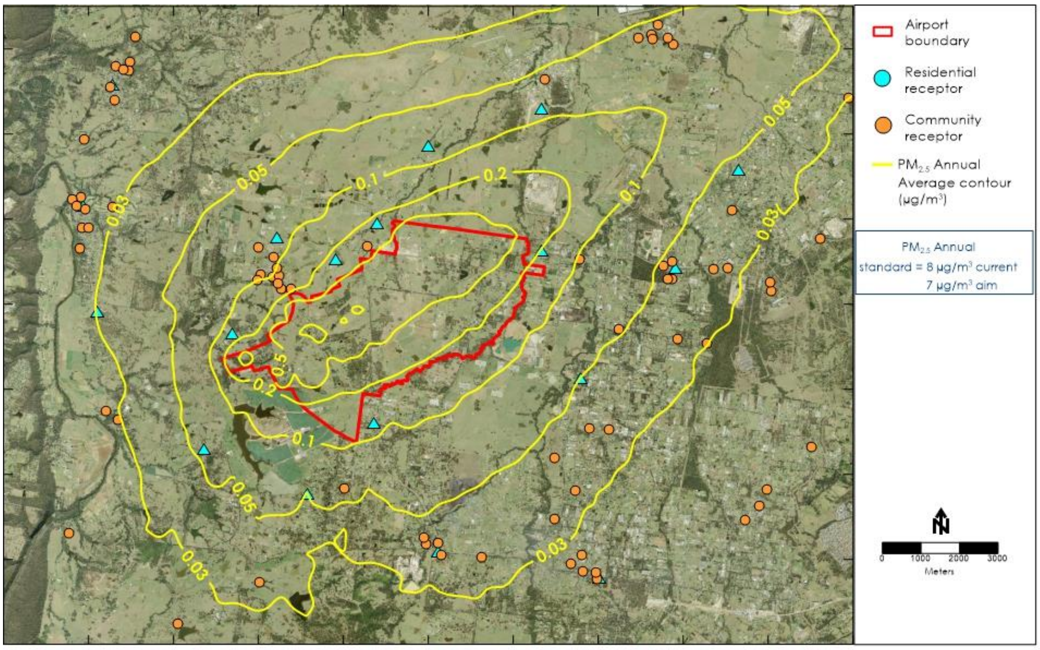


Figure G-5: Incremental Dust deposition Annual Average Contour Plot during bulk earthworks

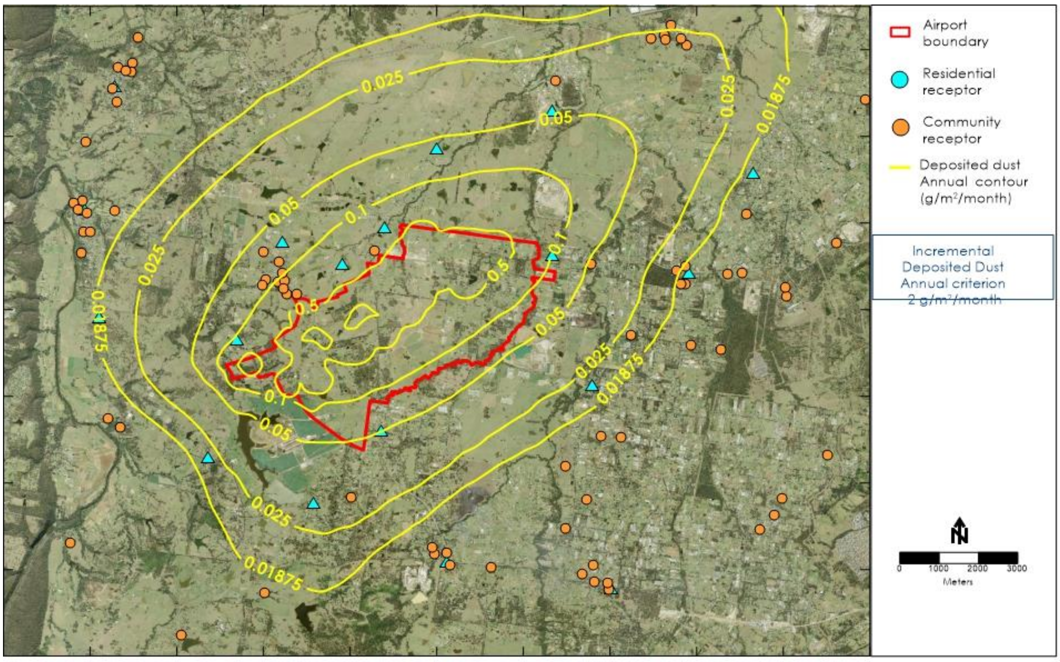


Table G-2: Predicted cumulative results during bulk earthworks

Receptor ID	Receptor location	PM_{10} ($\mu g/m^3$)		$PM_{2.5}$ ($\mu g/m^3$)		Dust deposition ($g/m^2/month$)
		24-hour	Annual	24-hour	Annual	Annual
	Criterion	*50*	*30*	*25*	*8*	*4*
R1	Bringelly	43.0	17.1	13.5	7.0	2.0
R2	Luddenham	42.7	17.3	13.3	7.1	2.1
R3	Greendale, Greendale Road	42.7	17.1	13.3	7.1	2.0
R4	Kemps Creek	42.6	17.1	13.3	7.0	2.0
R6	Mulgoa	42.6	17.1	13.3	7.0	2.0
R7	Wallacia	42.6	17.1	13.3	7.0	2.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	43.4	17.3	13.5	7.1	2.0
R14	Lawson Road, Badgerys Creek	43.0	17.6	13.4	7.2	2.1
R15	Mersey Rd, Greendale	44.6	17.4	14.0	7.1	2.1
R17	Luddenham Road	44.2	17.3	13.7	7.1	2.1
R18	Cnr Adams & Elizabeth Drive	44.2	18.0	13.7	7.2	2.2
R19	Cnr Adams & Anton Road	43.9	17.9	13.6	7.2	2.2
R21	Cnr Willowdene Ave and Vicar Park Lane	42.9	17.5	13.4	7.1	2.1
R22	Rossmore, Victor Ave	42.7	17.1	13.3	7.0	2.0
R23	Wallacia, Greendale Rd	42.6	17.1	13.3	7.0	2.0
R24	Badgerys Creek 1 NE	90.4	23.3	22.5	8.3	3.1
R25	Badgerys Creek 2 SW	60.2	20.8	14.9	7.6	2.8
R27	Greendale, Dwyer Rd	43.0	17.2	13.4	7.0	2.0
R30	Rossmore residential	42.7	17.1	13.4	7.0	2.0
R31	Mt Vernon residential	42.6	17.1	13.3	7.0	2.0
R34	Emmaus Residential Aged Care	42.6	17.2	13.3	7.1	2.0
R35	Mamre After School and Vacation Care	42.6	17.2	13.3	7.1	2.0
R36	Head Start After School Care	42.6	17.0	13.3	7.0	2.0
R37	Schoolies at Mulgoa	42.7	17.4	13.3	7.1	2.1
R38	Do-re-mi Day Care Centre	42.6	17.1	13.3	7.0	2.0
R39	Little Amigos Austral Early Learning Centre	42.6	17.0	13.3	7.0	2.0
R40	Little Smarties Childcare Centre	42.6	17.2	13.3	7.1	2.0
R41	The Grove Academy	42.6	17.1	13.3	7.0	2.0
R42	Horsley Kids	42.6	17.1	13.3	7.0	2.0
R44	Bringelly Child Care Centre	44.0	17.2	13.9	7.1	2.0
R46	Clementson Drive Early Educational Centre	42.6	17.1	13.3	7.0	2.0
R48	Kids Korner West Hoxton Early Learning Centre	42.6	17.0	13.3	7.0	2.0
R49	Luddenham Child Care Centre	42.7	17.4	13.3	7.1	2.1
R52	The Frogs Lodge	42.6	17.0	13.3	7.0	2.0
R53	Rossmore Community Preschool	42.7	17.1	13.4	7.0	2.0
R54	Mulgoa Preschool	42.6	17.1	13.3	7.0	2.0
R55	Jillys Educational Childcare Centre	42.7	17.1	13.4	7.0	2.0
R57	Wallacia Progress Hall	42.6	17.1	13.3	7.0	2.0
R59	Bringelly Community Centre	43.0	17.1	13.5	7.0	2.0
R63	Luddenham Progress Hall	43.2	17.5	13.4	7.1	2.1
R64	Mulgoa Hall	42.6	17.1	13.3	7.0	2.0
R65	Emmaus Catholic College	42.6	17.2	13.3	7.1	2.0
R66	University of Sydney Farms	42.8	17.1	13.5	7.0	2.0
R68	Christadelphian Heritage College Sydney	42.6	17.1	13.3	7.0	2.0
R69	Mamre Anglican School	42.6	17.2	13.3	7.1	2.0
R72	Irfan College	42.6	17.1	13.3	7.0	2.0

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*50*	*30*	*25*	*8*	*4*
R73	Luddenham Public School	44.7	17.5	13.6	7.1	2.1
R74	Kemps Creek Public School	42.6	17.1	13.3	7.0	2.0
R75	Trinity Catholic Primary School	42.6	17.2	13.3	7.1	2.0
R76	Bringelly Public School	43.0	17.1	13.5	7.0	2.0
R78	Mulgoa Public School	42.6	17.1	13.3	7.0	2.0
R79	Rossmore Public School	42.7	17.1	13.4	7.0	2.0
R80	Wallacia Public School	42.6	17.1	13.3	7.0	2.0
R82	Bellfield College - Junior Campus	42.9	17.1	13.5	7.0	2.0
R84	Bringelly Park	43.0	17.1	13.6	7.0	2.0
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	42.6	17.0	13.3	7.0	2.0
R86	Blaxland Crossing Reserve	42.6	17.1	13.3	7.0	2.0
R87	Bill Anderson Reserve	42.6	17.1	13.3	7.0	2.0
R88	Kemps Creek Nature Reserve	42.6	17.1	13.3	7.0	2.0
R91	Western Sydney Parklands	42.6	17.1	13.3	7.0	2.0
R93	Rossmore Grange	42.8	17.1	13.5	7.0	2.0
R94	Freeburn Park	43.4	17.4	13.4	7.1	2.1
R95	Overett Reserve	42.7	17.3	13.3	7.1	2.0
R97	Mulgoa Park	42.6	17.1	13.3	7.0	2.0
R98	Wallacia Bowling and Recreation Club	42.6	17.1	13.3	7.0	2.0
R99	Hubertus Country Club	44.6	18.4	13.7	7.3	2.3
R100	Sugarloaf Cobbitty Equestrian Club	42.6	17.1	13.3	7.0	2.0
R102	Panthers Wallacia	42.6	17.1	13.3	7.0	2.0
R103	Twin Creeks Golf and Country Club	43.2	17.2	13.5	7.1	2.0
R104	Sydney International Shooting Centre	42.6	17.1	13.3	7.0	2.0
R108	Luddenham Showground	42.7	17.3	13.3	7.1	2.1
R109	Kemps Creek Sporting and Bowling Club	42.6	17.1	13.3	7.0	2.0
R110	St James Luddenham	42.9	17.7	13.4	7.1	2.1
R111	Lin Ying temple	42.6	17.1	13.3	7.0	2.0
R112	Vat Ketanak Khmer Kampuchea Krom	42.7	17.1	13.4	7.0	2.0
R114	Anglican Church Sydney Diocese	42.6	17.1	13.3	7.0	2.0
R115	Anglican Parish of Mulgoa	42.6	17.1	13.3	7.0	2.0
R117	Bringelly Vineyard Church	42.9	17.1	13.6	7.0	2.0
R118	Free Church of Tonga	42.6	17.1	13.3	7.0	2.0
R120	Our Lady Queen of Peace	42.7	17.2	13.3	7.1	2.0
R122	St Anthony	42.6	17.0	13.3	7.0	2.0
R123	St Marys Church	42.6	17.1	13.3	7.0	2.0
R124	Wallacia Christian Church	42.6	17.1	13.3	7.0	2.0
R126	St Francis Xavier Church	42.6	17.1	13.3	7.0	2.0
R127	Luddenham Uniting Church	44.0	17.5	13.5	7.1	2.1
R130	Hopewood Health Retreat	42.6	17.1	13.3	7.0	2.0
R131	Science of the Soul Study Centre	42.6	17.1	13.3	7.0	2.0
R132	Bringelly shops	43.0	17.1	13.5	7.0	2.0
R134	Kemps Creek shops	42.6	17.1	13.3	7.0	2.0
R135	Luddenham shops	42.9	17.8	13.4	7.2	2.2
R136	Mulgoa shops	42.6	17.1	13.3	7.0	2.0
R137	Rossmore shops	42.7	17.1	13.4	7.0	2.0
R138	Wallacia Shops	42.6	17.1	13.3	7.0	2.0
R140	Holy Family Catholic Primary and Church	42.7	17.4	13.4	7.1	2.1
R141	Edmund Rice Retreat and Conference Centre	42.6	17.1	13.3	7.0	2.0

Figure G-6: Cumulative PM_{10} Annual Average Contour Plot during bulk earthworks

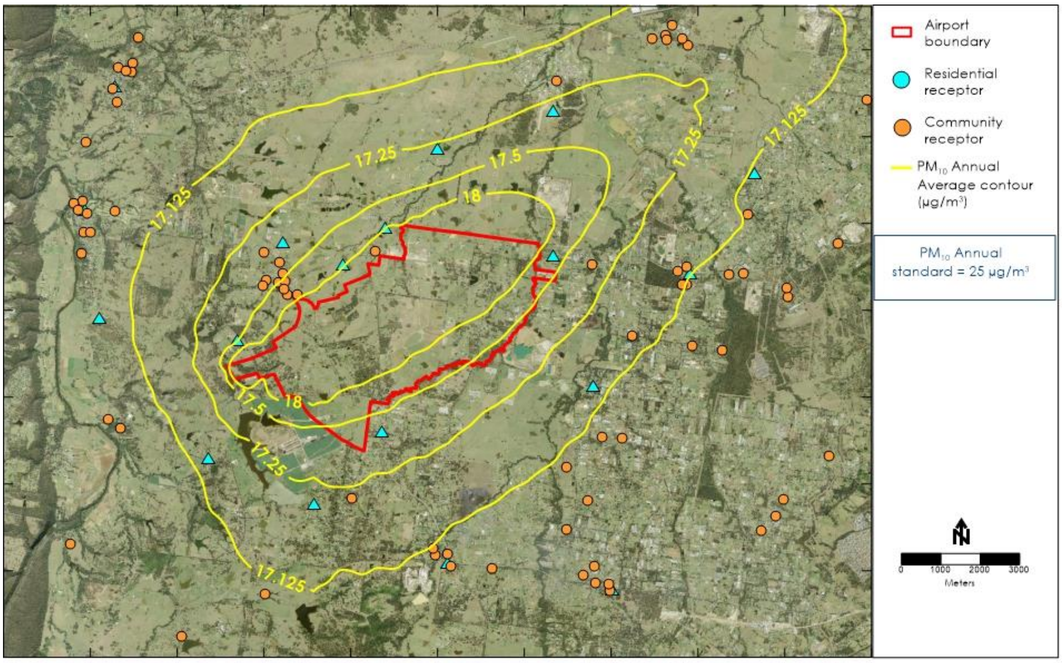


Figure G-7: Cumulative $PM_{2.5}$ Annual Average Contour Plot during during bulk earthworks

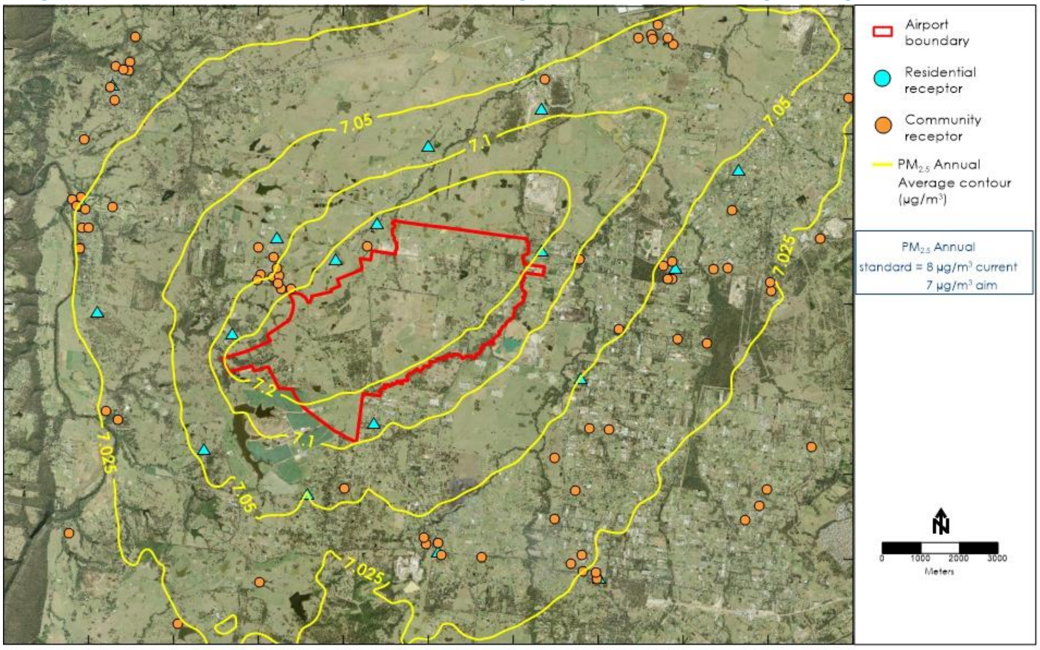
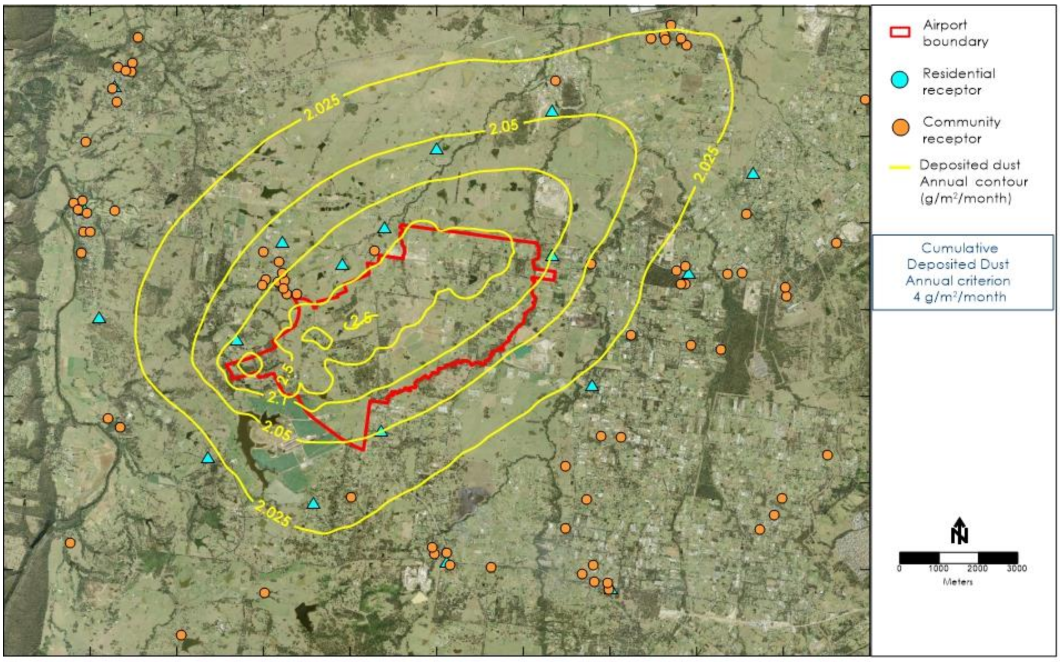


Figure G-8: Cumulative Dust deposition Annual Average Contour Plot during bulk earthworks



G.1.2 Aviation infrastructure

Table G-3: Predicted incremental results during aviation infrastructure works

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
	Criterion	*n/a*	*n/a*	*n/a*	*n/a*	2
R1	Bringelly	0.8	<0.0	0.5	<0.0	<0.0
R2	Luddenham	0.7	0.1	0.2	<0.0	<0.0
R3	Greendale, Greendale Road	1.2	0.1	0.7	<0.0	<0.0
R4	Kemps Creek	1.0	0.1	2.2	<0.0	<0.0
R6	Mulgoa	0.4	<0.0	0.3	<0.0	<0.0
R7	Wallacia	0.3	<0.0	0.2	<0.0	<0.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	1.7	0.1	0.8	<0.0	<0.0
R14	Lawson Road, Badgerys Creek	7.6	0.4	4.9	0.2	0.1
R15	Mersey Rd, Greendale	2.8	0.1	1.2	0.1	<0.0
R17	Luddenham Road	1.7	0.1	1.0	<0.0	<0.0
R18	Cnr Adams & Elizabeth Drive	3.6	0.3	2.1	0.1	0.1
R19	Cnr Adams & Anton Road	2.3	0.3	0.9	0.1	0.1
R21	Cnr Willowdene Ave and Vicar Park Lane	1.1	0.2	0.3	<0.0	0.1
R22	Rossmore, Victor Ave	1.4	0.1	1.3	<0.0	<0.0
R23	Wallacia, Greendale Rd	0.5	<0.0	0.3	<0.0	<0.0
R24	Badgerys Creek 1 NE	227.6	9.5	84.4	2.6	2.4
R25	Badgerys Creek 2 SW	11.7	1.8	1.7	0.3	0.7
R27	Greendale, Dwyer Rd	0.6	0.1	0.2	<0.0	<0.0
R30	Rossmore residential	0.6	<0.0	0.5	<0.0	<0.0
R31	Mt Vernon residential	1.6	0.1	0.6	<0.0	<0.0
R34	Emmaus Residential Aged Care	0.9	0.1	0.5	<0.0	<0.0

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		n/a	n/a	n/a	n/a	2
R35	Mamre After School and Vacation Care	0.7	0.1	0.4	<0.0	<0.0
R36	Head Start After School Care	0.3	<0.0	0.6	<0.0	<0.0
R37	Schoolies at Mulgoa	1.3	0.2	0.3	<0.0	<0.0
R38	Do-re-mi Day Care Centre	1.3	0.1	0.7	<0.0	<0.0
R39	Little Amigos Austral Early Learning Centre	0.6	<0.0	0.5	<0.0	<0.0
R40	Little Smarties Childcare Centre	0.7	0.1	0.8	<0.0	<0.0
R41	The Grove Academy	0.8	<0.0	1.4	<0.0	<0.0
R42	Horsley Kids	0.4	<0.0	0.3	<0.0	<0.0
R44	Bringelly Child Care Centre	0.9	0.1	0.3	<0.0	<0.0
R46	Clementson Drive Early Educational Centre	0.9	<0.0	0.5	<0.0	<0.0
R48	Kids Korner West Hoxton Early Learning Centre	0.5	<0.0	0.6	<0.0	<0.0
R49	Luddenham Child Care Centre	0.7	0.1	0.2	<0.0	<0.0
R52	The Frogs Lodge	0.3	<0.0	0.7	<0.0	<0.0
R53	Rossmore Community Preschool	0.5	<0.0	0.4	<0.0	<0.0
R54	Mulgoa Preschool	0.4	<0.0	0.2	<0.0	<0.0
R55	Jillys Educational Childcare Centre	1.6	<0.0	0.9	<0.0	<0.0
R57	Wallacia Progress Hall	0.3	<0.0	0.2	<0.0	<0.0
R59	Bringelly Community Centre	1.3	0.1	0.7	<0.0	<0.0
R63	Luddenham Progress Hall	1.3	0.2	0.3	<0.0	0.1
R64	Mulgoa Hall	0.6	<0.0	0.3	<0.0	<0.0
R65	Emmaus Catholic College	0.9	0.1	1.1	<0.0	<0.0
R66	University of Sydney Farms	0.7	<0.0	0.4	<0.0	<0.0
R68	Christadelphian Heritage College Sydney	2.5	0.1	1.5	<0.0	<0.0
R69	Mamre Anglican School	0.9	0.1	0.7	<0.0	<0.0
R72	Irfan College	0.5	<0.0	0.1	<0.0	<0.0
R73	Luddenham Public School	1.3	0.2	0.3	<0.0	0.1
R74	Kemps Creek Public School	3.0	0.1	1.1	<0.0	<0.0
R75	Trinity Catholic Primary School	0.6	0.1	0.4	<0.0	<0.0
R76	Bringelly Public School	0.7	<0.0	0.4	<0.0	<0.0
R78	Mulgoa Public School	0.5	<0.0	0.3	<0.0	<0.0
R79	Rossmore Public School	0.9	<0.0	0.6	<0.0	<0.0
R80	Wallacia Public School	0.3	<0.0	0.2	<0.0	<0.0
R82	Bellfield College - Junior Campus	0.8	<0.0	0.7	<0.0	<0.0
R84	Bringelly Park	1.5	0.1	1.0	<0.0	<0.0
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.3	<0.0	0.2	<0.0	<0.0
R86	Blaxland Crossing Reserve	0.3	<0.0	0.2	<0.0	<0.0
R87	Bill Anderson Reserve	1.6	0.1	2.7	<0.0	<0.0
R88	Kemps Creek Nature Reserve	0.6	<0.0	0.5	<0.0	<0.0
R91	Western Sydney Parklands	1.1	<0.0	0.5	<0.0	<0.0
R93	Rossmore Grange	0.6	<0.0	0.9	<0.0	<0.0
R94	Freeburn Park	1.5	0.2	0.4	<0.0	0.1

Receptor ID	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		*n/a*	*n/a*	*n/a*	*n/a*	*2*
R95	Overett Reserve	3.3	0.2	4.3	0.1	<0.0
R97	Mulgoa Park	0.6	<0.0	0.3	<0.0	<0.0
R98	Wallacia Bowling and Recreation Club	0.3	<0.0	0.2	<0.0	<0.0
R99	Hubertus Country Club	3.7	0.4	1.5	0.1	0.1
R100	Sugarloaf Cobbitty Equestrian Club	0.2	<0.0	0.2	<0.0	<0.0
R102	Panthers Wallacia	0.3	<0.0	0.2	<0.0	<0.0
R103	Twin Creeks Golf and Country Club	0.9	0.1	0.4	<0.0	<0.0
R104	Sydney International Shooting Centre	0.8	<0.0	0.8	<0.0	<0.0
R108	Luddenham Showground	0.8	0.1	0.2	<0.0	<0.0
R109	Kemps Creek Sporting and Bowling Club	0.7	<0.0	1.0	<0.0	<0.0
R110	St James Luddenham	2.1	0.3	0.4	0.1	0.1
R111	Lin Ying temple	1.6	0.1	1.1	<0.0	<0.0
R112	Vat Ketanak Khmer Kampuchea Krom	1.0	<0.0	1.1	<0.0	<0.0
R114	Anglican Church Sydney Diocese	1.3	<0.0	0.5	<0.0	<0.0
R115	Anglican Parish of Mulgoa	0.2	<0.0	0.4	<0.0	<0.0
R117	Bringelly Vineyard Church	0.4	<0.0	0.3	<0.0	<0.0
R118	Free Church of Tonga	0.8	<0.0	0.4	<0.0	<0.0
R120	Our Lady Queen of Peace	1.4	0.1	1.8	<0.0	<0.0
R122	St Anthony	0.2	<0.0	0.2	<0.0	<0.0
R123	St Marys Church	0.4	<0.0	0.1	<0.0	<0.0
R124	Wallacia Christian Church	0.3	<0.0	0.2	<0.0	<0.0
R126	St Francis Xavier Church	0.8	<0.0	0.4	<0.0	<0.0
R127	Luddenham Uniting Church	1.3	0.2	0.3	<0.0	0.1
R130	Hopewood Health Retreat	0.3	<0.0	0.2	<0.0	<0.0
R131	Science of the Soul Study Centre	0.7	<0.0	1.2	<0.0	<0.0
R132	Bringelly shops	1.0	<0.0	0.5	<0.0	<0.0
R134	Kemps Creek shops	1.2	0.1	2.2	<0.0	<0.0
R135	Luddenham shops	1.7	0.3	0.3	0.1	0.1
R136	Mulgoa shops	0.4	<0.0	0.3	<0.0	<0.0
R137	Rossmore shops	0.6	<0.0	0.5	<0.0	<0.0
R138	Wallacia Shops	0.3	<0.0	0.2	<0.0	<0.0
R140	Holy Family Catholic Primary and Church	1.6	0.2	0.4	<0.0	0.1
R141	Edmund Rice Retreat and Conference Centre	0.2	<0.0	0.3	<0.0	<0.0

Figure G-9: Incremental PM_{10} 24-hours Contour Plot during aviation infrastructure works.

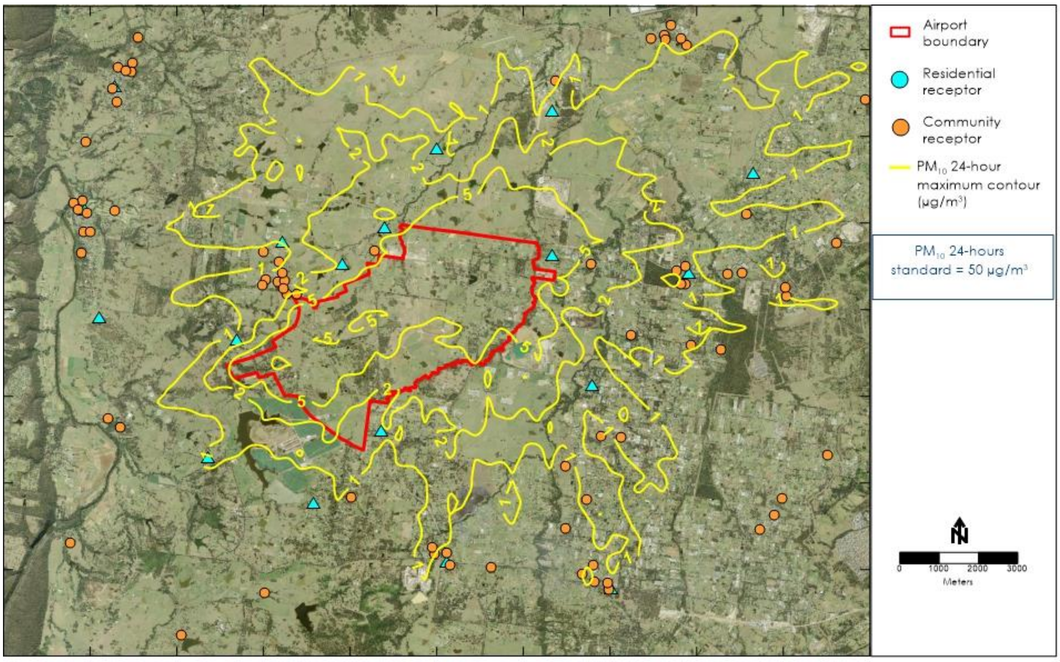


Figure G-10: Incremental PM_{10} Annual Average Contour Plot during aviation infrastructure works

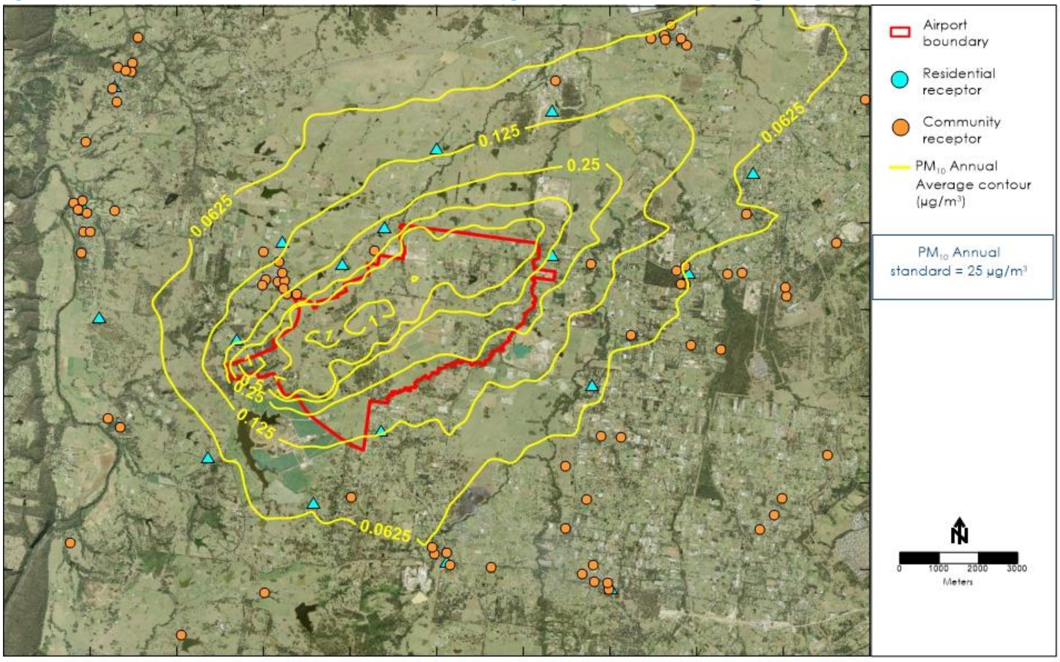


Figure G-11: Incremental $PM_{2.5}$ 24-hours Contour Plot during aviation infrastructure works

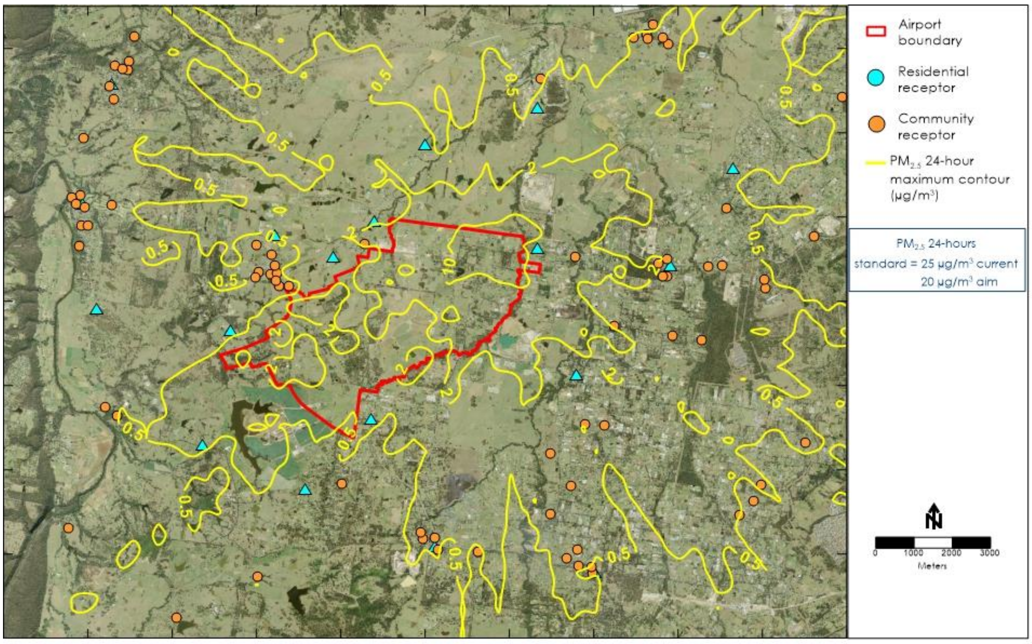


Figure G-12: Incremental $PM_{2.5}$ Annual Average Contour Plot during aviation infrastructure works

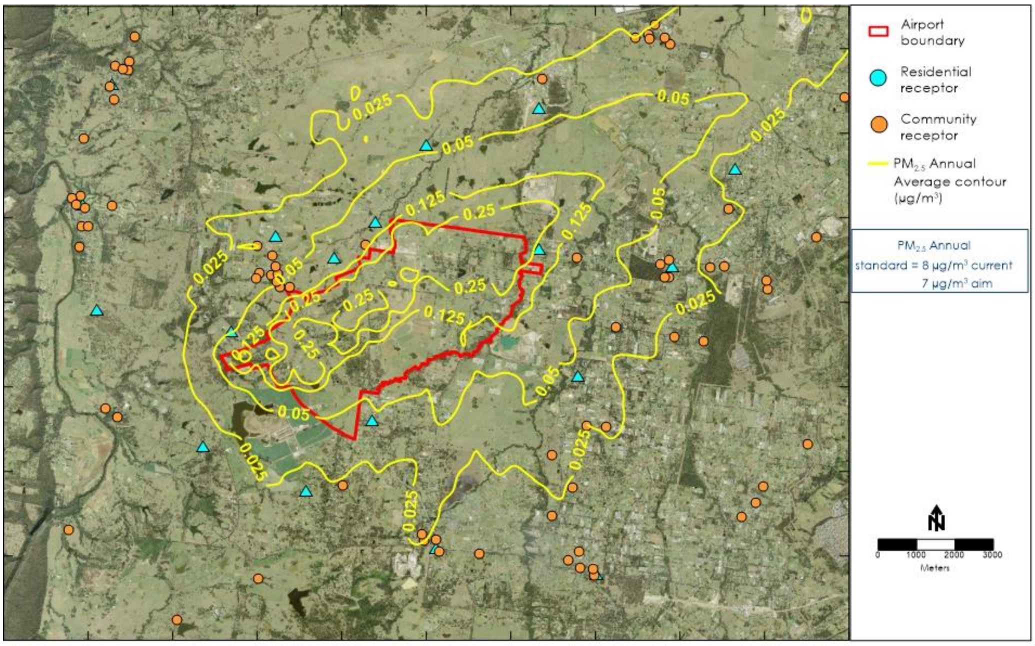


Figure G-13: Incremental Dust deposition Annual Average Contour Plot during aviation infrastructure works

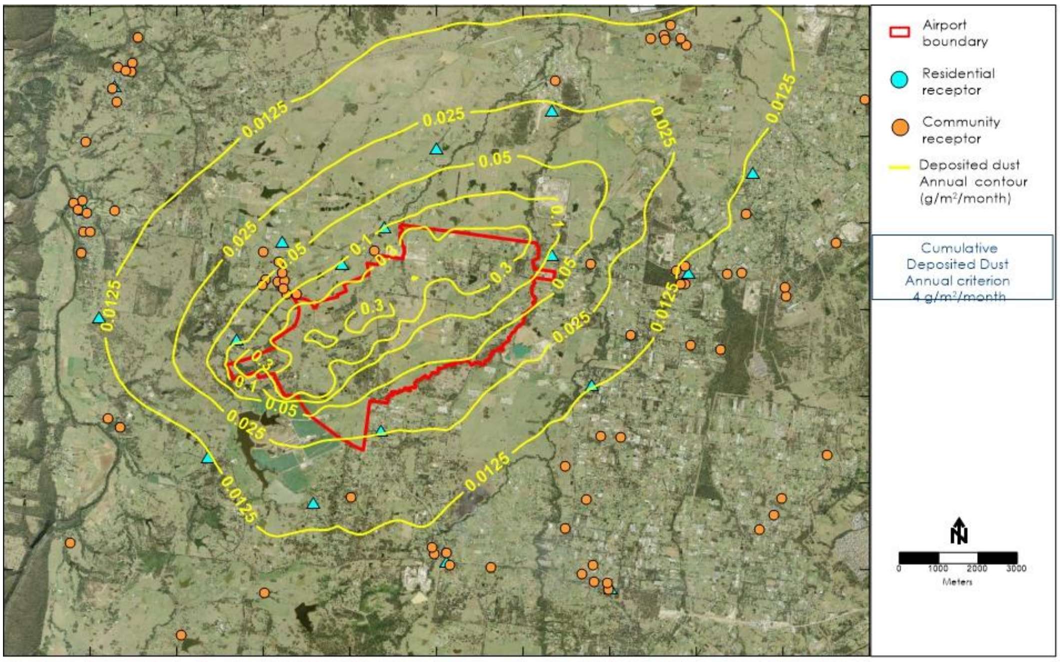


Table G-4: Predicted cumulative results during aviation infrastructure works

Receptor	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
Criterion		50	30	25	8	4
R1	Bringelly	42.6	17.0	13.8	7.0	2.0
R2	Luddenham	42.6	17.1	13.3	7.0	2.0
R3	Greendale, Greendale Road	42.6	17.1	13.3	7.0	2.0
R4	Kemps Creek	42.6	17.1	13.3	7.0	2.0
R6	Mulgoa	42.6	17.0	13.3	7.0	2.0
R7	Wallacia	42.6	17.0	13.3	7.0	2.0
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	43.2	17.1	14.1	7.0	2.0
R14	Lawson Road, Badgerys Creek	42.6	17.4	13.7	7.2	2.1
R15	Mersey Rd, Greendale	43.4	17.1	13.5	7.1	2.0
R17	Luddenham Road	42.7	17.1	13.4	7.0	2.0
R18	Cnr Adams & Elizabeth Drive	42.6	17.3	13.4	7.1	2.1
R19	Cnr Adams & Anton Road	42.6	17.3	13.4	7.1	2.1
R21	Cnr Willowdene Ave and Vicar Park Lane	42.6	17.2	13.3	7.0	2.1
R22	Rossmore, Victor Ave	42.6	17.1	13.3	7.0	2.0
R23	Wallacia, Greendale Rd	42.9	17.0	13.3	7.0	2.0
R24	Badgerys Creek 1 NE	42.6	26.5	91.3	9.6	4.4
R25	Badgerys Creek 2 SW	42.6	18.8	14.1	7.3	2.7
R27	Greendale, Dwyer Rd	43.1	17.1	13.4	7.0	2.0
R30	Rossmore residential	42.6	17.0	13.5	7.0	2.0

Recepto r	Receptor location	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
	Criterion	*50*	*30*	*25*	*8*	*4*
R31	Mt Vernon residential	42.6	17.1	13.3	7.0	2.0
R34	Emmaus Residential Aged Care	43.4	17.1	13.3	7.0	2.0
R35	Mamre After School and Vacation Care	42.6	17.1	13.3	7.0	2.0
R36	Head Start After School Care	42.6	17.0	13.3	7.0	2.0
R37	Schoolies at Mulgoa	42.6	17.2	13.3	7.0	2.0
R38	Do-re-mi Day Care Centre	42.6	17.1	13.3	7.0	2.0
R39	Little Amigos Austral Early Learning Centre	43.4	17.0	13.3	7.0	2.0
R40	Little Smarties Childcare Centre	42.6	17.1	13.3	7.0	2.0
R41	The Grove Academy	42.6	17.0	13.3	7.0	2.0
R42	Horsley Kids	42.6	17.0	13.3	7.0	2.0
R44	Bringelly Child Care Centre	42.6	17.1	13.5	7.0	2.0
R46	Clementson Drive Early Educational Centre	42.6	17.0	13.3	7.0	2.0
R48	Kids Korner West Hoxton Early Learning Centre	42.6	17.0	13.3	7.0	2.0
R49	Luddenham Child Care Centre	42.6	17.1	13.3	7.0	2.0
R52	The Frogs Lodge	42.6	17.0	13.3	7.0	2.0
R53	Rossmore Community Preschool	42.6	17.0	13.6	7.0	2.0
R54	Mulgoa Preschool	42.7	17.0	13.3	7.0	2.0
R55	Jillys Educational Childcare Centre	42.6	17.0	13.5	7.0	2.0
R57	Wallacia Progress Hall	42.6	17.0	13.3	7.0	2.0
R59	Bringelly Community Centre	42.6	17.1	13.4	7.0	2.0
R63	Luddenham Progress Hall	42.6	17.2	13.3	7.0	2.1
R64	Mulgoa Hall	42.6	17.0	13.3	7.0	2.0
R65	Emmaus Catholic College	43.0	17.1	13.3	7.0	2.0
R66	University of Sydney Farms	42.6	17.0	13.4	7.0	2.0
R68	Christadelphian Heritage College Sydney	42.6	17.1	13.3	7.0	2.0
R69	Mamre Anglican School	42.6	17.1	13.3	7.0	2.0
R72	Irfan College	42.6	17.0	13.3	7.0	2.0
R73	Luddenham Public School	42.6	17.2	13.4	7.0	2.1
R74	Kemps Creek Public School	42.7	17.1	13.3	7.0	2.0
R75	Trinity Catholic Primary School	42.6	17.1	13.3	7.0	2.0
R76	Bringelly Public School	43.0	17.0	13.7	7.0	2.0
R78	Mulgoa Public School	42.6	17.0	13.3	7.0	2.0
R79	Rossmore Public School	42.8	17.0	13.6	7.0	2.0
R80	Wallacia Public School	42.6	17.0	13.3	7.0	2.0
R82	Bellfield College - Junior Campus	42.6	17.0	14.0	7.0	2.0
R84	Bringelly Park	43.1	17.1	13.4	7.0	2.0
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	42.6	17.0	13.3	7.0	2.0

Receptor	Receptor location	PM10 (µg/m³)		PM2.5 (µg/m³)		Dust deposition (g/m²/month)
		24-hour	Annual	24-hour	Annual	Annual
	Criterion	*50*	*30*	*25*	*8*	*4*
R86	Blaxland Crossing Reserve	42.9	17.0	13.3	7.0	2.0
R87	Bill Anderson Reserve	43.0	17.1	13.3	7.0	2.0
R88	Kemps Creek Nature Reserve	43.0	17.0	13.3	7.0	2.0
R91	Western Sydney Parklands	42.7	17.0	13.3	7.0	2.0
R93	Rossmore Grange	42.6	17.0	14.0	7.0	2.0
R94	Freeburn Park	249.6	17.2	13.4	7.0	2.1
R95	Overett Reserve	46.2	17.2	13.3	7.1	2.0
R97	Mulgoa Park	42.7	17.0	13.3	7.0	2.0
R98	Wallacia Bowling and Recreation Club	42.6	17.0	13.3	7.0	2.0
R99	Hubertus Country Club	42.6	17.4	13.5	7.1	2.1
R100	Sugarloaf Cobbitty Equestrian Club	42.6	17.0	13.3	7.0	2.0
R102	Panthers Wallacia	42.6	17.0	13.3	7.0	2.0
R103	Twin Creeks Golf and Country Club	42.6	17.1	13.7	7.0	2.0
R104	Sydney International Shooting Centre	42.6	17.0	13.3	7.0	2.0
R108	Luddenham Showground	42.6	17.1	13.3	7.0	2.0
R109	Kemps Creek Sporting and Bowling Club	42.6	17.0	13.3	7.0	2.0
R110	St James Luddenham	42.6	17.3	13.3	7.1	2.1
R111	Lin Ying temple	42.6	17.1	13.3	7.0	2.0
R112	Vat Ketanak Khmer Kampuchea Krom	42.6	17.0	13.4	7.0	2.0
R114	Anglican Church Sydney Diocese	42.6	17.0	13.3	7.0	2.0
R115	Anglican Parish of Mulgoa	42.6	17.0	13.3	7.0	2.0
R117	Bringelly Vineyard Church	42.6	17.0	13.4	7.0	2.0
R118	Free Church of Tonga	42.6	17.0	13.3	7.0	2.0
R120	Our Lady Queen of Peace	42.6	17.1	13.3	7.0	2.0
R122	St Anthony	42.6	17.0	13.3	7.0	2.0
R123	St Marys Church	42.6	17.0	13.3	7.0	2.0
R124	Wallacia Christian Church	42.6	17.0	13.3	7.0	2.0
R126	St Francis Xavier Church	43.0	17.0	13.3	7.0	2.0
R127	Luddenham Uniting Church	42.6	17.2	13.4	7.0	2.1
R130	Hopewood Health Retreat	42.6	17.0	13.3	7.0	2.0
R131	Science of the Soul Study Centre	42.6	17.0	13.3	7.0	2.0
R132	Bringelly shops	42.7	17.0	13.8	7.0	2.0
R134	Kemps Creek shops	42.6	17.1	13.3	7.0	2.0
R135	Luddenham shops	42.6	17.3	13.3	7.1	2.1
R136	Mulgoa shops	42.6	17.0	13.3	7.0	2.0
R137	Rossmore shops	42.7	17.0	13.6	7.0	2.0
R138	Wallacia Shops	42.6	17.0	13.3	7.0	2.0
R140	Holy Family Catholic Primary and Church	42.7	17.2	13.3	7.0	2.1
R141	Edmund Rice Retreat and Conference Centre	42.6	17.0	13.3	7.0	2.0

Figure G-14: Cumulative PM_{10} Annual Average Contour Plot during aviation infrastructure works.

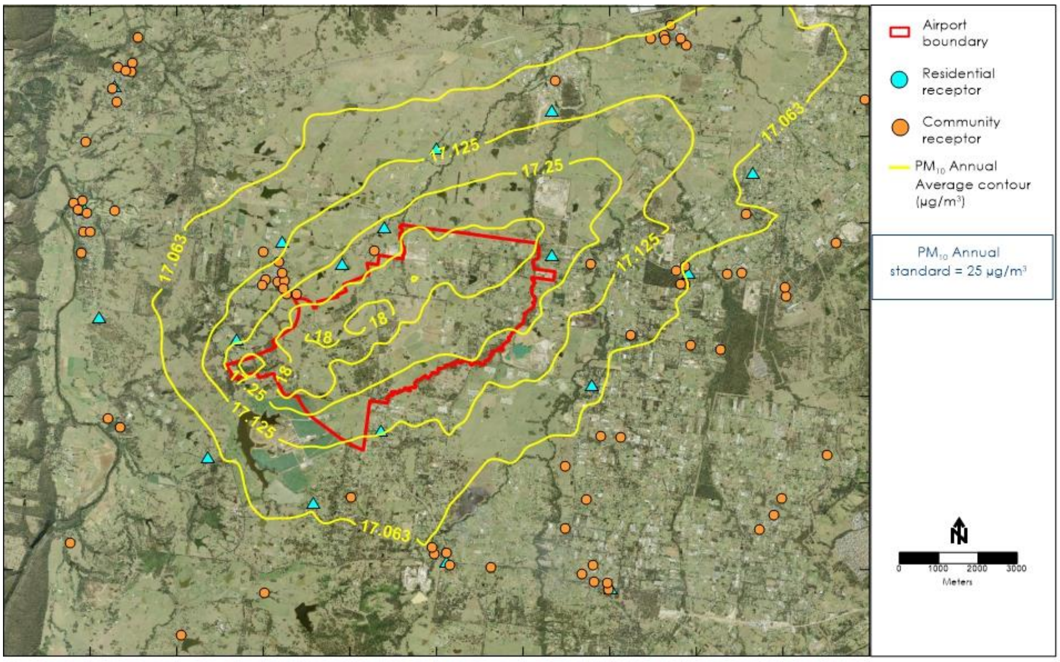


Figure G-15: Cumulative $PM_{2.5}$ Annual Average Contour Plot during aviation infrastructure works

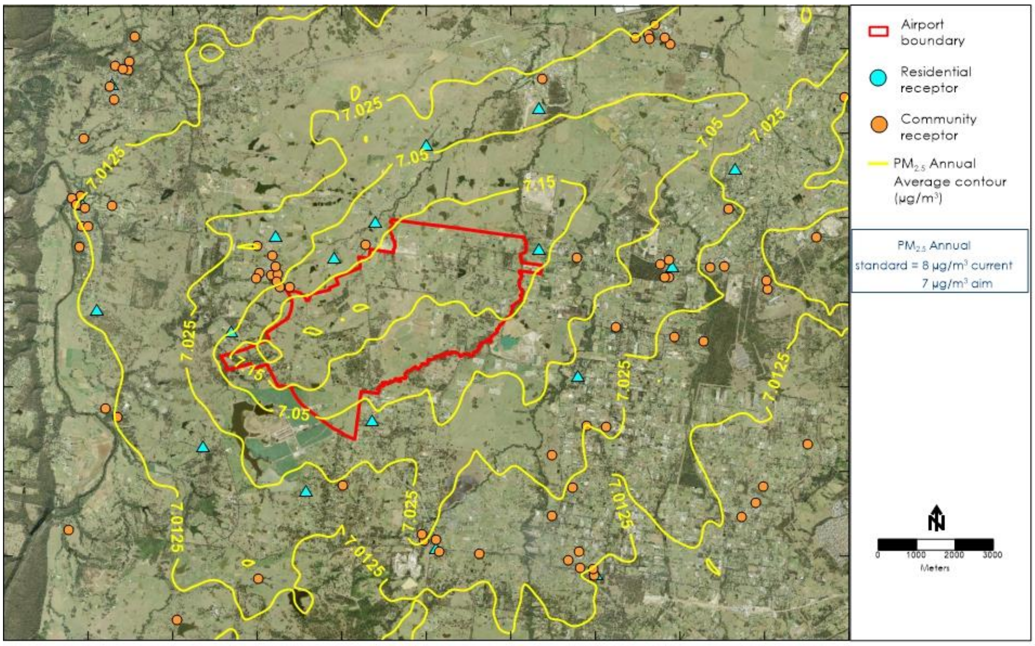
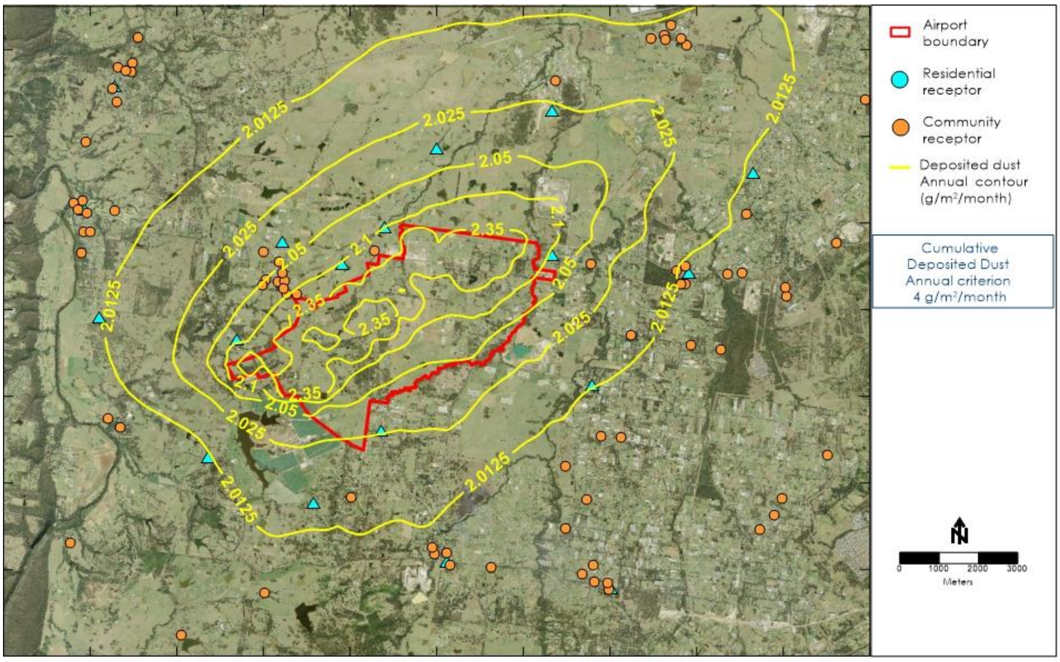


Figure G-16: Cumulative Dust deposition annual Average Contour Plot during aviation infrastructure works.



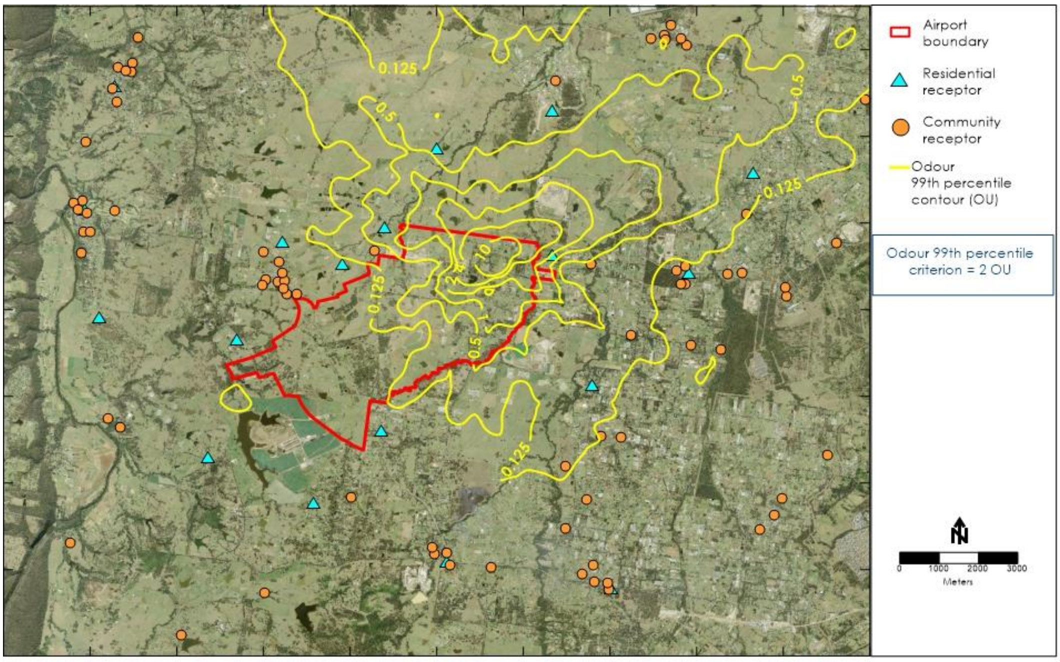
G.1.3 Asphalt plant

Table G-5: Predicted 99th percentile odour concentration from asphalt plant

Receptor	Receptor location	1-hour 99th percentile
	Criterion	2
R1	Bringelly	<0.1
R2	Luddenham	<0.1
R3	Greendale, Greendale Road	<0.1
R4	Kemps Creek	<0.1
R6	Mulgoa	<0.1
R7	Wallacia	<0.1
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	<0.1
R14	Lawson Road, Badgerys Creek	1.7
R15	Mersey Rd, Greendale	0.1
R17	Luddenham Road	0.4
R18	Cnr Adams & Elizabeth Drive	0.5
R19	Cnr Adams & Anton Road	0.1
R21	Cnr Willowdene Ave and Vicar Park Lane	<0.1
R22	Rossmore, Victor Ave	0.2
R23	Wallacia, Greendale Rd	<0.1
R24	Badgerys Creek 1 NE	41.4
R25	Badgerys Creek 2 SW	<0.1
R27	Greendale, Dwyer Rd	<0.1
R30	Rossmore residential	0.0
R31	Mt Vernon residential	0.2
R34	Emmaus Residential Aged Care	0.4
R38	Do-re-mi Day Care Centre	0.2
R39	Little Amigos Austral Early Learning Centre	<0.1
R40	Little Smarties Childcare Centre	0.3
R41	The Grove Academy	<0.1
R44	Bringelly Child Care Centre	<0.1
R46	Clementson Drive Early Educational Centre	0.1
R48	Kids Korner West Hoxton Early Learning Centre	<0.1
R57	Wallacia Progress Hall	<0.1
R59	Bringelly Community Centre	<0.1

R64	Mulgoa Hall	0.1
R65	Emmaus Catholic College	0.4
R66	University of Sydney Farms	<0.1
R69	Mamre Anglican School	0.6
R72	Irfan College	<0.1
R73	Luddenham Public School	<0.1
R74	Kemps Creek Public School	<0.1
R75	Trinity Catholic Primary School	0.4
R78	Mulgoa Public School	0.1
R82	Bellfield College - Junior Campus	<0.1
R84	Bringelly Park	<0.1
R87	Bill Anderson Reserve	0.1
R88	Kemps Creek Nature Reserve	0.1
R92	Eugenie Byrne Park	<0.1
R94	Freeburn Park	<0.1
R95	Overett Reserve	0.3
R96	Horsley Park Reserve	0.4
R98	Wallacia Bowling and Recreation Club	<0.1
R99	Hubertus Country Club	0.4
R101	Treetop Adventure Park	<0.1
R104	Sydney International Shooting Centre	<0.1
R109	Kemps Creek Sporting and Bowling Club	0.1
R110	St James Luddenham	<0.1
R113	All Saints Anglican Church	<0.1
R115	Anglican Parish of Mulgoa	0.1
R116	Baptist Union Church and Manse	<0.1
R118	Free Church of Tonga	<0.1
R121	Sacred Heart Catholic Church Warragamba	<0.1
R124	Wallacia Christian Church	<0.1
R131	Science of the Soul Study Centre	0.1
R132	Bringelly shops	<0.1
R133	Horsley Park Shops	0.1
R135	Luddenham shops	<0.1
R137	Rossmore shops	<0.1
R138	Wallacia Shops	<0.1
R142	Mount Druitt Public School	<0.1

Figure G-17: Predicted 99th percentile odour from asphalt plant contour Plot



Appendix H IMPACTS FROM DIESEL EMISSIONS

H.1 DIESEL EMISSIONS DURING CONSTRUCTION

H.1.1 Emissions calculations

A detailed description of the construction activities is presented in the *Construction Planning Report* **(GHD, 2015)**. Construction activities during the site preparation and aviation infrastructure works have been analysed and estimates of $PM_{2.5}$ emissions from diesel powered equipment. Emission factors have been sourced from available literature **(ASK Consulting Engineers 2013, Seabridge Gold 2012, ESA 2014, Heggies 2007, GHD 2011, CAT 2015)**. Where emissions were not available for $PM_{2.5}$ size particle fraction PM_{10} was used in place. This is considered a conservative assumption. It has been assumed that equipment will operate for 3,744 hours per year (6am – 6pm Monday to Saturday). The annual diesel emissions during construction are presented in **Table I1**.

Table H-1: Diesel emissions during construction

ACTIVITY	Annual $PM_{2.5}$ emissions (kg/yr)	
	Site preparation works	Av Infrastructure works
D11	3.5	-
D8	-	0.8
D6	0.1	-
657 Scraper	35.3	8.8
200t Excavator	26.4	-
30t Excavator	-	0.4
20,000L Water Cart	1.1	0.3
16' Grader	2.3	0.6
14' Grader	0.0	-
825 Compactor	3.1	0.9
Multi Tyre Roller	-	0.1
Smooth Drum Roller	0.4	0.3
Pad Foot Roller	0.4	0.1
966 Loader	-	1.1
Gravel Paver	-	0.2
Asphalt Paver	-	0.1
Concrete Placer Spreader	-	8.8
Concrete Slip Form Paver	-	8.8
Concrete Texture Cure Machine	-	8.8
50t dump truck	7.0	1.4
Dump truck (concrete and asphalt plants)	-	6.4
Total	*79.7*	*47.9*

H.1.2 Results

Table H-2: Predicted diesel $PM_{2.5}$ concentrations during bulk earthworks

Receptor	Receptor location	Diesel $PM_{2.5}$ (µg/m³) Annual average
R1	Bringelly	0.00023
R2	Luddenham	0.00041
R3	Greendale, Greendale Road	0.00041
R4	Kemps Creek	0.00022
R6	Mulgoa	0.00012
R7	Wallacia	0.00015
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.00035
R14	Lawson Road, Badgerys Creek	0.00078
R15	Mersey Rd, Greendale	0.00073

Receptor	Receptor location	Diesel $PM_{2.5}$ (µg/m³) Annual average
R17	Luddenham Road	0.00038
R18	Cnr Adams & Elizabeth Drive	0.00114
R19	Cnr Adams & Anton Road	0.00124
R21	Cnr Willowdene Ave and Vicar Park Lane	0.00085
R22	Rossmore, Victor Ave	0.00025
R23	Wallacia, Greendale Rd	0.00019
R24	Badgerys Creek 1 NE	0.00443
R25	Badgerys Creek 2 SW	0.00450
R27	Greendale, Dwyer Rd	0.00031
R30	Rossmore residential	0.00012
R31	Mt Vernon residential	0.00020
R34	Emmaus Residential Aged Care	0.00026
R35	Mamre After School and Vacation Care	0.00024
R36	Head Start After School Care	0.00009
R37	Schoolies at Mulgoa	0.00061
R38	Do-re-mi Day Care Centre	0.00020
R39	Little Amigos Austral Early Learning Centre	0.00009
R40	Little Smarties Childcare Centre	0.00023
R41	The Grove Academy	0.00018
R42	Horsley Kids	0.00013
R44	Bringelly Child Care Centre	0.00040
R46	Clementson Drive Early Educational Centre	0.00022
R48	Kids Korner West Hoxton Early Learning Centre	0.00009
R49	Luddenham Child Care Centre	0.00048
R52	The Frogs Lodge	0.00009
R53	Rossmore Community Preschool	0.00012
R54	Mulgoa Preschool	0.00012
R55	Jillys Educational Childcare Centre	0.00018
R57	Wallacia Progress Hall	0.00016
R59	Bringelly Community Centre	0.00025
R63	Luddenham Progress Hall	0.00061
R64	Mulgoa Hall	0.00012
R65	Emmaus Catholic College	0.00025
R66	University of Sydney Farms	0.00023
R68	Christadelphian Heritage College Sydney	0.00023
R69	Mamre Anglican School	0.00025
R72	Irfan College	0.00011
R73	Luddenham Public School	0.00068
R74	Kemps Creek Public School	0.00023
R75	Trinity Catholic Primary School	0.00022
R76	Bringelly Public School	0.00024
R78	Mulgoa Public School	0.00011
R79	Rossmore Public School	0.00014
R80	Wallacia Public School	0.00015
R82	Bellfield College - Junior Campus	0.00015
R84	Bringelly Park	0.00026
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.00012
R86	Blaxland Crossing Reserve	0.00014
R87	Bill Anderson Reserve	0.00024
R88	Kemps Creek Nature Reserve	0.00015
R91	Western Sydney Parklands	0.00014
R93	Rossmore Grange	0.00023

Receptor	Receptor location	Diesel $PM_{2.5}$ (µg/m³) Annual average
R94	Freeburn Park	0.00058
R95	Overett Reserve	0.00043
R97	Mulgoa Park	0.00012
R98	Wallacia Bowling and Recreation Club	0.00016
R99	Hubertus Country Club	0.00155
R100	Sugarloaf Cobbitty Equestrian Club	0.00016
R102	Panthers Wallacia	0.00017
R103	Twin Creeks Golf and Country Club	0.00026
R104	Sydney International Shooting Centre	0.00014
R108	Luddenham Showground	0.00043
R109	Kemps Creek Sporting and Bowling Club	0.00016
R110	St James Luddenham	0.00090
R111	Lin Ying temple	0.00020
R112	Vat Ketanak Khmer Kampuchea Krom	0.00019
R114	Anglican Church Sydney Diocese	0.00015
R115	Anglican Parish of Mulgoa	0.00011
R117	Bringelly Vineyard Church	0.00020
R118	Free Church of Tonga	0.00017
R120	Our Lady Queen of Peace	0.00025
R122	St Anthony	0.00009
R123	St Marys Church	0.00012
R124	Wallacia Christian Church	0.00016
R126	St Francis Xavier Church	0.00018
R127	Luddenham Uniting Church	0.00060
R130	Hopewood Health Retreat	0.00016
R131	Science of the Soul Study Centre	0.00017
R132	Bringelly shops	0.00022
R134	Kemps Creek shops	0.00023
R135	Luddenham shops	0.00107
R136	Mulgoa shops	0.00012
R137	Rossmore shops	0.00013
R138	Wallacia Shops	0.00015
R140	Holy Family Catholic Primary and Church	0.00064
R141	Edmund Rice Retreat and Conference Centre	0.00013

It is acknowledged that predicting model results for $PM_{2.5}$ in excess of one decimal place provides an unrealistic representation of model accuracy. However, results are provided above to demonstrate the spatial variation in prediction, and to provide the health risk assessment with inputs that are not effectively zero.

H.2 DIESEL EMISSIONS DURING OPERATION

H.2.1 Emissions calculations

Emission for diesel $PM_{2.5}$ were calculated by isolating the diesel emissions in EDMS.

H.2.2 Results

Table H-3: Predicted diesel $PM_{2.5}$ concentrations during stage 1 and longer term development

Receptor	Receptor location	Diesel $PM_{2.5}$ (µg/m³) Annual average Stage 1	Diesel $PM_{2.5}$ (µg/m³) Annual average Longer term
R1	Bringelly	0.3	0.4
R2	Luddenham	0.1	0.5
R3	Greendale, Greendale Road	0.1	0.3
R4	Kemps Creek	0.2	0.5
R6	Mulgoa	0.1	0.2
R7	Wallacia	0.1	0.2
R8	Twin Creeks, Cnr Twin Ck Drive & Humewood Place	0.2	0.4
R14	Lawson Road, Badgerys Creek	0.3	0.9
R15	Mersey Rd, Greendale	0.2	0.6
R17	Luddenham Road	0.2	0.4
R18	Cnr Adams & Elizabeth Drive	0.2	0.9
R19	Cnr Adams & Anton Road	0.3	0.8
R21	Cnr Willowdene Ave and Vicar Park Lane	0.1	0.5
R22	Rossmore, Victor Ave	0.2	0.4
R23	Wallacia, Greendale Rd	0.1	0.1
R24	Badgerys Creek 1 NE	0.6	2.0
R25	Badgerys Creek 2 SW	0.6	0.6
R27	Greendale, Dwyer Rd	0.1	0.2
R30	Rossmore residential	0.3	0.3
R31	Mt Vernon residential	0.2	0.4
R34	Emmaus Residential Aged Care	0.3	0.5
R35	Mamre After School and Vacation Care	0.3	0.5
R36	Head Start After School Care	0.4	0.5
R37	Schoolies at Mulgoa	0.1	0.3
R38	Do-re-mi Day Care Centre	0.3	0.5
R39	Little Amigos Austral Early Learning Centre	0.2	0.3
R40	Little Smarties Childcare Centre	0.3	0.4
R41	The Grove Academy	0.2	0.3
R42	Horsley Kids	0.2	0.3
R44	Bringelly Child Care Centre	0.1	0.3
R46	Clementson Drive Early Educational Centre	0.2	0.5
R48	Kids Korner West Hoxton Early Learning Centre	0.3	0.3
R49	Luddenham Child Care Centre	0.1	0.3
R52	The Frogs Lodge	0.2	0.3
R53	Rossmore Community Preschool	0.2	0.3
R54	Mulgoa Preschool	0.1	0.2
R55	Jillys Educational Childcare Centre	0.1	0.3
R57	Wallacia Progress Hall	0.1	0.2
R59	Bringelly Community Centre	0.2	0.4
R63	Luddenham Progress Hall	0.1	0.3
R64	Mulgoa Hall	0.1	0.2
R65	Emmaus Catholic College	0.3	0.5
R66	University of Sydney Farms	0.1	0.2
R68	Christadelphian Heritage College Sydney	0.2	0.4
R69	Mamre Anglican School	0.4	0.5
R72	Irfan College	0.6	0.8
R73	Luddenham Public School	0.1	0.5
R74	Kemps Creek Public School	0.2	0.4
R75	Trinity Catholic Primary School	0.3	0.5

Receptor	Receptor location	Diesel $PM_{2.5}$ (µg/m³) Annual average	
		Stage 1	Longer term
R76	Bringelly Public School	0.5	0.4
R78	Mulgoa Public School	0.1	0.2
R79	Rossmore Public School	0.5	0.5
R80	Wallacia Public School	0.1	0.2
R82	Bellfield College - Junior Campus	0.2	0.4
R84	Bringelly Park	0.2	0.4
R85	Bents Basin State Conservation Reserve and Gulguer Nature Reserve	0.0	0.1
R86	Blaxland Crossing Reserve	0.1	0.1
R87	Bill Anderson Reserve	0.2	0.5
R88	Kemps Creek Nature Reserve	0.2	0.3
R91	Western Sydney Parklands	0.2	0.5
R93	Rossmore Grange	0.1	0.3
R94	Freeburn Park	0.1	0.4
R95	Overett Reserve	0.2	0.8
R97	Mulgoa Park	0.1	0.2
R98	Wallacia Bowling and Recreation Club	0.1	0.2
R99	Hubertus Country Club	0.2	0.8
R100	Sugarloaf Cobbitty Equestrian Club	0.1	0.1
R102	Panthers Wallacia	0.1	0.2
R103	Twin Creeks Golf and Country Club	0.2	0.4
R104	Sydney International Shooting Centre	0.2	0.6
R108	Luddenham Showground	0.1	0.3
R109	Kemps Creek Sporting and Bowling Club	0.3	0.6
R110	St James Luddenham	0.2	0.5
R111	Lin Ying temple	0.2	0.4
R112	Vat Ketanak Khmer Kampuchea Krom	0.2	0.3
R114	Anglican Church Sydney Diocese	0.2	0.3
R115	Anglican Parish of Mulgoa	0.1	0.2
R117	Bringelly Vineyard Church	0.2	0.3
R118	Free Church of Tonga	0.1	0.1
R120	Our Lady Queen of Peace	0.2	0.4
R122	St Anthony	0.3	0.3
R123	St Marys Church	0.1	0.2
R124	Wallacia Christian Church	0.1	0.2
R126	St Francis Xavier Church	0.1	0.2
R127	Luddenham Uniting Church	0.1	0.3
R130	Hopewood Health Retreat	0.1	0.2
R131	Science of the Soul Study Centre	0.3	0.6
R132	Bringelly shops	0.3	0.4
R134	Kemps Creek shops	0.3	0.6
R135	Luddenham shops	0.2	0.4
R136	Mulgoa shops	0.1	0.2
R137	Rossmore shops	0.4	0.3
R138	Wallacia Shops	0.1	0.1
R140	Holy Family Catholic Primary and Church	0.1	0.4
R141	Edmund Rice Retreat and Conference Centre	0.1	0.2