AIR QUALITY IMPACT ASSESSMENT

ORORA BOTANY MILL
WATER TREATMENT PLANT UPGRADE

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Job Number 16020537

Prepared by

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Air Quality Impact Assessment
Orora Botany Mill
Water Treatment Plant Upgrade

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1 INTRODUCTION

Todoroski Air Sciences has prepared this air quality impact assessment report for Orora (hereafter referred to as the Proponent). It provides an assessment of the potential air quality impacts associated with the proposed upgrades to the Orora Botany Mill Water Treatment Plant (WTP) (hereafter referred to as the Project).

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

- An outline of the local setting, background and description of the Project;
- A review of the existing meteorological and air quality environment surrounding the Project;
- A description of the dispersion modelling approach used to assess potential air quality impacts;
- An outline of the estimated potential air emissions associated with the Project; and,
- Presentation of the predicted results and discussion of the potential air quality impacts.

2 LOCAL SETTING

The Project is located approximately 5 kilometres (km) east-southeast of Sydney Airport and approximately 11km south-southeast of the Sydney Central Business District (CBD) (see **Figure 2-1**).

The land use in the surrounding area is characterised as urban residential areas to the east and northeast of the site. Commercial and industrial areas are identified in all directions with the nearest to the northwest and Port Botany to the south.

Figure 2-1 presents the location of the Project in relation to the potentially most affected sensitive receptors of relevance to this assessment.

Figure 2-2 presents a pseudo three-dimensional (3D) visualisation of the topography in the general vicinity of the Project area. The area can be characterised as relatively flat to the west and gently sloping towards higher ground towards the east, nearer the ocean coastline.

The local land use and terrain in this area would have an effect on wind patterns and dispersion of air emissions. The key effects relate to the proximity of the Project to the coastline, and the associated sea-breezes and other such coastal effects which would occur.

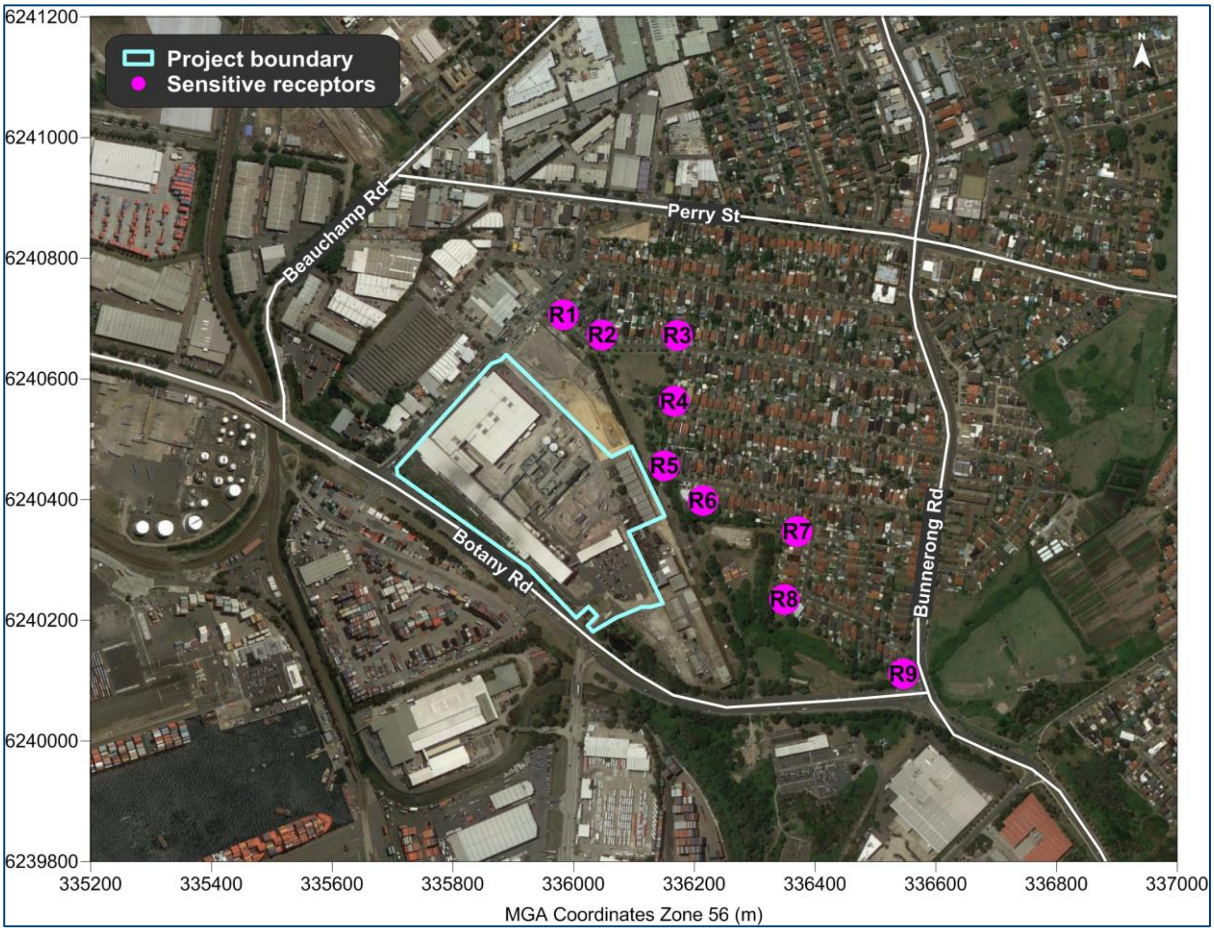

Figure 2-1: Project location

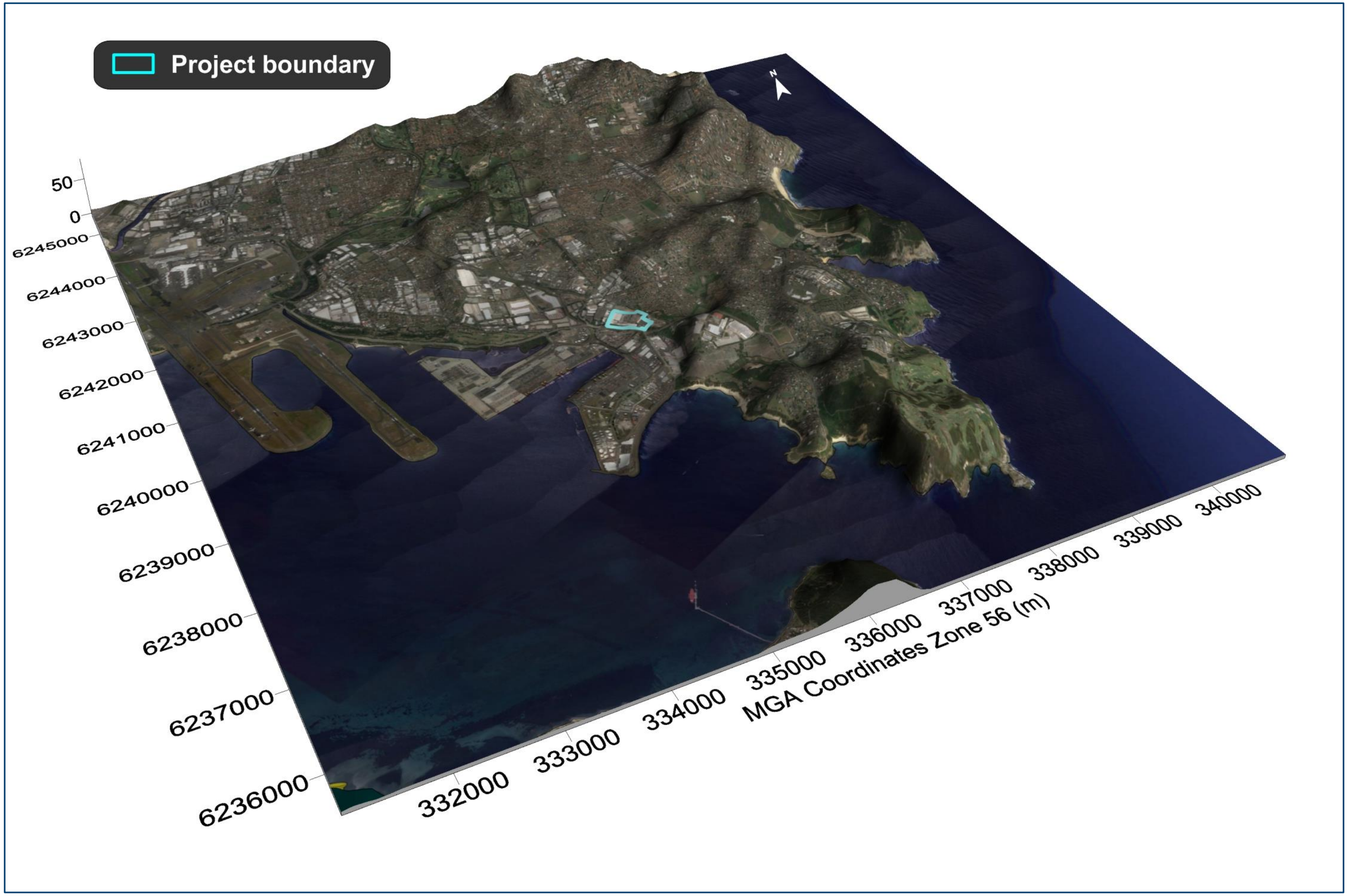

Figure 2-2: Representative view of the topography surrounding the Project location

3 PROJECT DESCRIPTION

Orora operates a paper mill at Botany Road, Matraville NSW. The paper mill utilises 100% recycled waste paper and requires significant quantities of water to process and manufacture finished paper products.

Process water generated at the site is currently treated at the on-site Primary Dissolved Air Flotation (DAF) Wastewater Treatment Plant WTP before being discharged to the Sydney Water sewerage system.

Orora is proposing to upgrade its WTP which involves the construction and operation of a secondary treatment process

3.1 Description of proposed WTP

The upgraded WTP would consist of the following components:

- Anaerobic water treatment
  - Anaerobic reactor & associated process equipment
  - Chemical storage & dosing
  - Biogas scrubbing, storage & emergency flare
  - Sulphur capture & removal process
  - Sludge storage & transport
- Aerobic water treatment
  - Aeration tank & clarifier
  - Various pumps and blowers
  - Associated process equipment
  - Sludge dewatering & storage
- Gas engine & electricity generation
- Odour control systems
- Internal maintenance road, stairways and other access facilities

The upgraded WTP would utilise the existing infrastructure to provide primary treatment of wastewater and also incorporate a two stage secondary treatment process. Anaerobic and aerobic treatment processes would be used to remove substances in the wastewater that generate high Biochemical Oxygen Demand (BOD).

Anaerobic digestion is a process by which specific microorganism bacteria break down biodegradable material in the absence of oxygen. Additional nutrients required by the anaerobic bacteria are supplied in the form of urea (nitrogen) and phosphate (phosphorus). The by-products of the anaerobic process are methane, hydrogen sulfide, other trace gases and excess microorganisms (known an anaerobic sludge). The volume of anaerobic sludge generated by the process is relatively small and would be either reused for re-seeding the anaerobic reactor, sold for use in another wastewater treatment plant or dewatered for disposal.

Following the anaerobic process, wastewater is then pumped to the aerobic treatment stage where it is mixed in with bacteria and a surplus of oxygen. The process further breaks down any remaining nutrients in the wastewater. The aerobic stage will further reduce the BOD load to domestic sewage levels. This stage occurs in a surplus of oxygen and generally would not generate excessive odour.

3.2 Proposed WTP layout

The WTP upgrades are proposed to be located in a central area of the site, adjacent to the existing WTP and the boiler house. Two indicative locations are available for the upgrade, as shown in **Figure 3-1**.

In this assessment it has been assumed that the Project would be positioned in the location closest to the nearest sensitive receptors. This would represent a potential worst-case for air quality impact and has been considered in this assessment to ensure conservatism (i.e. overestimation of potential impacts).

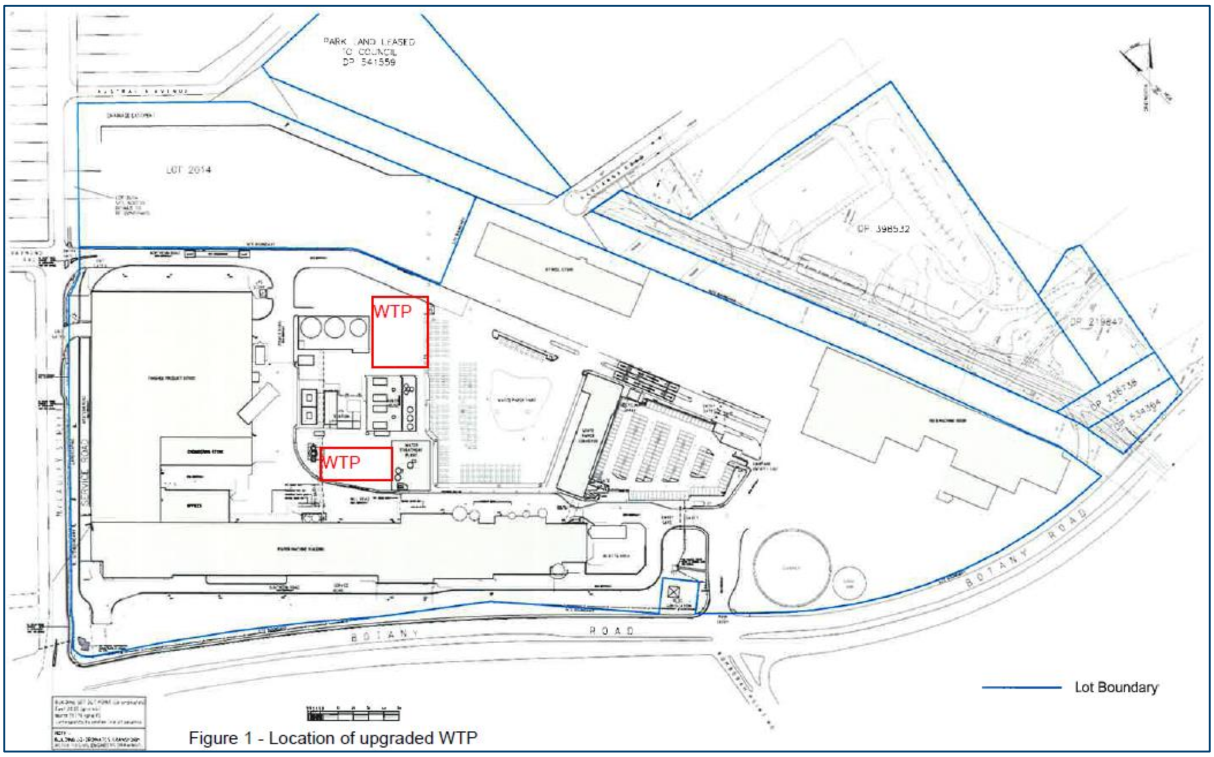

Figure 3-1: Indicative locations of proposed secondary WTP

Specific details for the upgraded WTP have not been finalised and the Proponent is currently choosing between two similar process designs. These are referred to as Option A and Option B.

An indicative layout of the process Option A is shown in **Figure 3-2**.

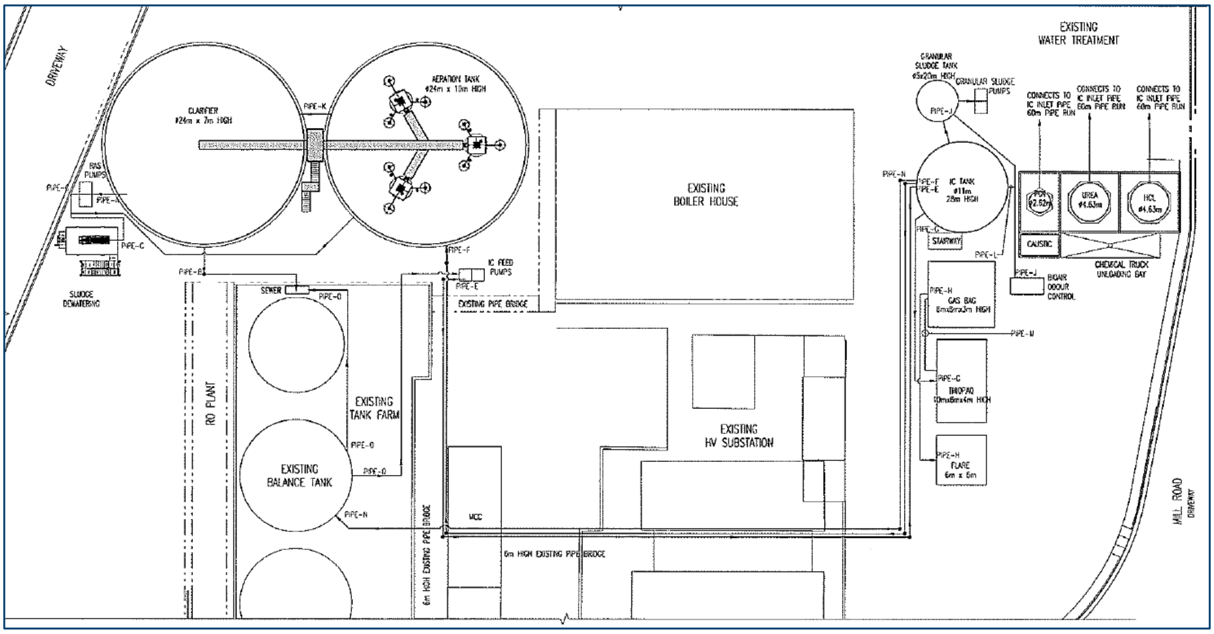

Figure 3-2: Indicative layout relative to other services (proposed Option A)

An indicative layout of the process Option B is shown in **Figure 3-3**.

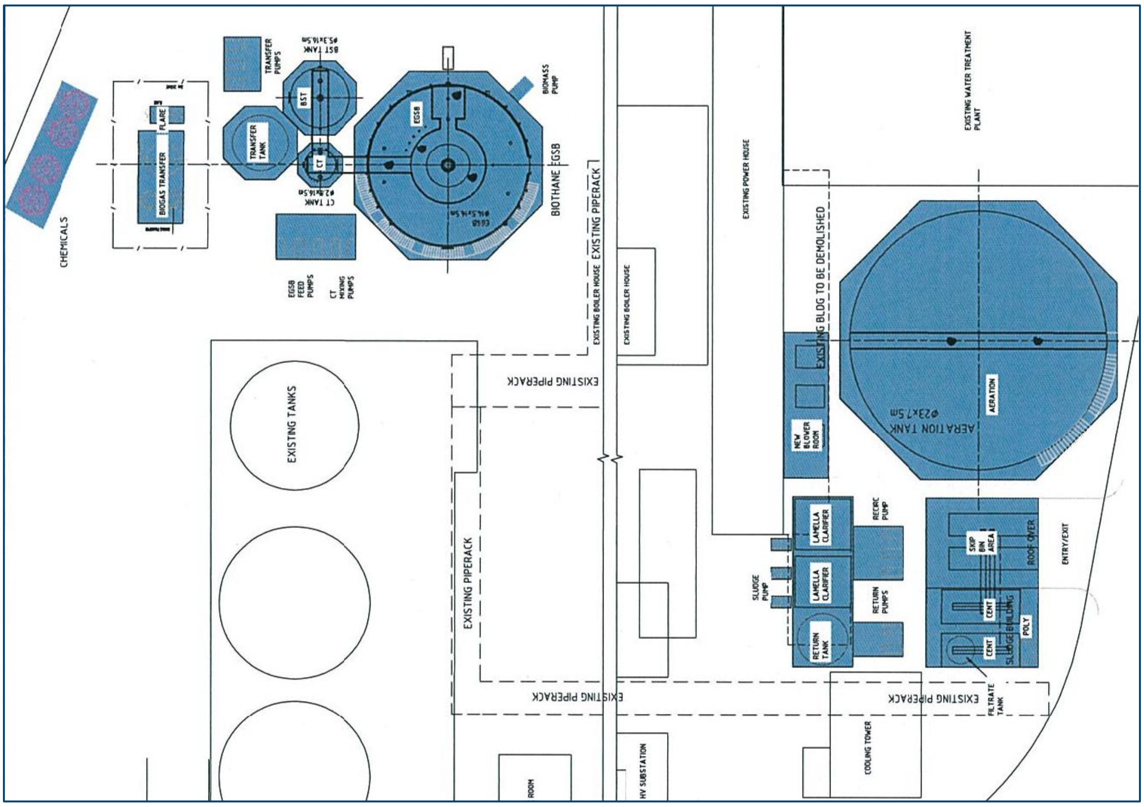

Figure 3-3: Indicative layout relative to other services (proposed Option B)

The key differences between the two process designs include:

- The positions of the aerobic and anaerobic processes are swapped between the options;
- The anaerobic tank of the Option B process would be fully sealed, while the some of the gas from the anaerobic tank of the Option A process would bleed through a biological odour control unit together with the gas from the granular sludge tank; and,
- Some differences in the different types of equipment including the clarifier and sludge dewatering equipment.

An important observation is that the proposed WTP would be sited as far as is practicable from receptors. The nearest element of the upgraded WTP (aeration tank and clarifier) would be approximately 160m from the nearest residence located on Partanna Avenue (Receptor R5 in **Figure 2-1**).

3.3 Proposed gas treatment and use

Wastewater from the paper making process generally contains sulphur compounds and during the anaerobic treatment process, some amount of this sulphur is converted to hydrogen sulphide (H_2S).

Gas generated from the anaerobic process will be scrubbed to remove H_2S, and then stored in a large bladder. This scrubbing process produces elemental sulphur which can be sold, and essentially eliminates H_2S odours (due to a removal efficiency of 99.9% of H_2S) and significantly reduces SO_X emissions by burning the remainder of the gases in an engine.

From the gas storage bladder, the captured biogas will be consumed in a gas engine to produce electricity for use by the site. When the generator isn't available, excess gas would be burnt in the emergency flare. The emergency flare would be operational infrequently and as a last resort measure. This would be a rare and exceptional circumstance as the electricity produced would be less than is needed for normal operations.

The gas from the headspace of the granular sludge tank and a portion of the gas from the anaerobic tank of the Option A process would pass through a biological packed bed odour control unit to ensure potential odours are managed.

4 AIR QUALITY ASSESSMENT CRITERIA

4.1 Preamble

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the Project and the applicable air quality criteria.

4.2 Odour

4.2.1 Introduction

Odour in a regulatory context needs to be considered in two similar, but different ways depending on the situation.

NSW legislation prohibits emissions that cause offensive odour to occur at any off-site receptor. Offensive odour is evaluated in the field by authorised officers, who are obliged to consider the odour in the context of its receiving environment, frequency, duration, character and so on and to determine whether the odour would interfere with the comfort and repose of the normal person unreasonably. In this context, the concept of offensive odour is applied to operational facilities and relates to actual emissions in the air.

However, in the approval and planning process for proposed new operations or modifications to existing projects, no actual odour exists and it is necessary to consider hypothetical odour. In this context, odour concentrations are used and are defined in odour units. The number of odour units represents the number of times that the odour would need to be diluted to reach a level that is just detectable to the human nose. Thus by definition, odour less than one odour unit (1 OU), would not be detectable to most people.

The range of a person's ability to detect odour varies greatly in the population, as does their sensitivity to the type of odour. The wide ranging response in how any particular odour is perceived by any individual poses specific challenges in the assessment of odour impacts and the application of specific air quality goals related to odour. The NSW Odour Policy (**NSW DEC, 2006**) sets out a framework specifically to deal with such issues.

It needs to be noted that the term odour refers to complex mixtures of odours, and not “pure” odour arising from a single chemical. Odour from a single, known chemical very rarely occurs (when it does, it is best to consider that specific chemical in terms of its concentration in the air). In most situations odour will be comprised of a cocktail of many substances that is referred to as a complex mixture of odour, or more simply odour.

For activities with potential to release significant odour it may be necessary to predict the likely odour impact that may arise. This is done by using air dispersion modelling which can calculate the level of dilution of odours emitted from the source at the point that such odour reaches surrounding receptors. This approach allows the air dispersion model to produce results in terms of odour units.

The NSW criteria for acceptable levels of odour range from 2 to 7 OU, with the more stringent 2 OU criteria applicable to densely populated urban areas and the 7 OU criteria applicable to sparsely populated rural areas, as outlined below.

4.2.2 Complex Mixtures of Odorous Air Pollutants

Table 4-1 presents the assessment criteria as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**). This criterion has been refined to take into account the population densities of specific areas and is based on a 99th percentile of dispersion model predictions calculated as 1-second averages (nose-response time).

Table 4-1: Impact assessment criteria for complex mixtures of odorous air pollutants (nose-response-time average, 99th percentile)

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (OU)
Urban (≥~2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

Source: **NSW DEC, 2005**

The NSW odour goals are based on the risk of odour impact within the general population of a given area. In sparsely populated areas the criteria assume there is a lower risk that some individuals within the community would find the odour unacceptable, hence higher criteria apply.

Peak-to-mean factors are applied to account for any odour fluctuation above and below the mean odour level of the 1-hour averaging time. The criteria in **Table 4-1** are compared with modelled results that include peaking factors to account for the time-averaging limitations of air dispersion models. The peak-to-mean factors developed by **Katestone Scientific Pty Ltd (1995, 1998)** for NSW EPA are applied to convert the modelled (1-hour) averaging time to 1-second peak concentrations which are appropriate.

A summary of the peak-to-mean values is provided in **Appendix A**.

4.2.3 Specific odour criteria for Orora

While 2OU may be the appropriate criterion to be applied for the Project based on **Table 4-1**, as the Project is located close to a densely populated residential area, the Technical Framework for the *Assessment and management of odour from stationary sources in NSW* **(DEC, 2006)** allows for a development of an acceptable odour performance of a facility. This would be agreed with the neighbours if appropriate mitigation strategies would not reduce the odour impacts at sensitive receptors to levels below the appropriate criteria. A site specific odour criterion was determined to be 6OU as analysed by **SKM (2006)** based on odour complaints data. Thus, a criterion of 6OU was applied in previous odour assessments for the site (**SKM, 2006** and **Benbow Environmental, 2010**) and is also applied in this assessment.

4.3 Particulate matter

Particulate matter consists of dust particles of varying size and composition. Air quality goals refer to measures of the total mass of all particles suspended in air defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (μm) as in practice particles larger than 30 to 50μm will settle out of the atmosphere too quickly to be regarded as air pollutants.

Two sub-classes of TSP are also included in the air quality goals, namely PM_{10}, particulate matter with equivalent aerodynamic diameters of 10μm or less, and $PM_{2.5}$, particulate matter with equivalent aerodynamic diameters of 2.5μm or less.

Particulate matter, typically in the upper size range, that settles from the atmosphere and deposit on surfaces is characterised as deposited dust. The deposition of dust on surfaces is considered a nuisance and can adversely affect the amenity of an area by soiling property in the vicinity.

4.3.1 New South Wales Environment Protection Authority impact assessment criteria

Table 4-2 summarises the air quality goals that are relevant to this study as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**).

The air quality goals for total impacts relate to the total dust burden in the air and not just the dust from the Project. Consideration of background dust levels needs to be made when using these goals to assess potential impacts.

Table 4-2: NSW EPA air quality impact assessment criteria

Pollutant	Averaging period	Impact	Criteria
TSP	Annual	Total	90µg/m³
PM_{10}	Annual	Total	30µg/m³
	24 hour	Total	50µg/m³
Deposited dust	Annual	Incremental	2g/m²/month
		Total	4g/m²/month

Source: **NSW DEC, 2005**
µg/m³ = micrograms per cubic metre
g/m²/month = grams per square metre per month

4.3.2 National Environment Protection (Ambient Air Quality) Measure

The National Environment Protection Council (NEPC) Act 1994 and subsequent amendments define the National Environment Protection Measures (NEPMs) as instruments for setting environmental objectives in Australia.

The Ambient Air Quality NEPM specifies national ambient air quality standards and goals for air pollutants including PM_{10} and $PM_{2.5}$. The standard for PM_{10} and $PM_{2.5}$ is outlined in **Table 4-3**. The Ambient Air Quality NEPM allows for exceedance above the 24-hour average criterion in exceptional events such as bush fires and regional dust storms, and included goals for $PM_{2.5}$ concentrations (see **Table 4-4**).

Table 4-3: Standard for PM_{10} and $PM_{2.5}$ concentrations

Pollutant	Averaging period	Maximum concentration
PM_{10}	24 hour	50µg/m³
	Annual	25µg/m³
$PM_{2.5}$	24 hour	25µg/m³
	Annual	8µg/m³

Source: **NEPC, 2016**

Table 4-4: Goal for $PM_{2.5}$ concentrations by 2025

Pollutant	Averaging period	Maximum concentration
$PM_{2.5}$	24 hour	20µg/m^3
	Annual	7µg/m^3

Source: **NEPC, 2016**

As with each of the NEPM goals, these apply to the average, or general exposure of a population, rather than to "hot spot" locations or to individual industry projects.

4.4 Combustion air pollutants

Emissions of air pollutants that arise from the operation of the natural gas fired equipment which may be relevant include sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO). Other combustion air pollutants are too low to be of any tangible risk to the environment, and are not considered further.

Table 4-5 outlines the applicable air quality assessment criteria, as outlined in the document *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**), for potential combustion air pollutants that are considered in this assessment.

Table 4-5: Applicable air quality impact assessment criteria for potential combustion air pollutants

Pollutant	Averaging period	Criterion
SO_2	10-minute	712µg/m^3
	1-hour	570µg/m^3
	24-hour	228µg/m^3
	Annual	60µg/m^3
NO_2	1-hour	246µg/m^3
	Annual	62µg/m^3
CO	15-minute	100mg/m^3
	1-hour	30mg/m^3
	8-hour	10mg/m^3

Source: **NSW DEC, 2005**

4.4.1 Protection of the Environment Operations (Clean Air) Regulation 2010

The Protection of the Environment Operations (Clean Air) Regulation 2010 (**POEO, 2010**) outlines standards of concentrations for air emissions emitted from various plant. The emission limits applicable to the Project are summarised in **Table 4-6**.

Table 4-6: Standards of concentration for schedule premises

Pollutant	Applicable plant	Standard of concentration
TSP	Boiler	50mg/m^3
	Gas engine	50mg/m^3
NO_x, as NO_2 equivalent	Boiler	300mg/m^3
	Gas engine	450mg/m^3
H_2S	Any activity or plant	5mg/m^3
CO	Boiler	125mg/m^3
	Gas engine	125mg/m^3

Source: **POEO, 2010**

5 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the general area surrounding the Project.

5.1 Local climate

Long-term climatic data from the closest Bureau of Meteorology (BoM) weather station at Sydney Airport Aeronautical Meteorological Office (AMO) (Site No. 066037) were analysed to characterise the local climate in the proximity of the Project. The Sydney Airport AMO weather station is located approximately 5km west-northwest of the Project.

Table 5-1 and **Figure 5-1** present a summary of data from the Sydney Airport AMO weather station collected over a 71 to 87-year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 26.5 degrees Celsius (ºC) and July is the coldest month with a mean minimum temperature of 7.2ºC.

Rainfall peaks during the first half of the year declines during the latter, with an annual average rainfall of 1083.7 millimetres (mm) over 96.0 days. The data indicate that June is the wettest month with an average rainfall of 122.5mm over 8.8 days and September is the driest month with an average rainfall of 60.3mm over 6.8 days.

Relative humidity exhibits little variability across the year. Mean 9am relative humidity ranges from 61% in October to 74% in June. Mean 3pm relative humidity levels range from 49% in August to 63% in February.

Wind speeds during the warmer months have a greater spread between the 9am and 3pm conditions compared to the cooler months. Mean 9am wind speeds range from 12.6 kilometres per hour (km/h) in May to 16.3km/h in October. Mean 3pm wind speeds range from 17.1km/h in May to 25.3km/h in November.

Table 5-1: Monthly climate statistics summary – Sydney Airport AMO

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temperature (ºC)	26.5	26.4	25.3	22.9	20.0	17.6	17.0	18.4	20.6	22.6	24.1	25.8	22.3
Mean min. temperature (ºC)	18.9	19.1	17.6	14.2	11.0	8.7	7.2	8.2	10.5	13.3	15.5	17.5	13.5
Rainfall													
Rainfall (mm)	95.9	111.1	115.7	109.3	98.6	122.5	69.6	76.8	60.3	70.3	81.5	74.0	1083.7
Mean No. of rain days (≥1mm)	8.1	8.5	9.2	8.6	8.5	8.8	6.7	6.8	6.8	7.8	8.4	7.8	96.0
9am conditions													
Mean temperature (ºC)	22.4	22.3	21.1	18.2	14.6	11.9	10.8	12.5	15.7	18.4	19.9	21.6	17.4
Mean relative humidity (%)	70	73	73	71	73	74	71	65	62	61	64	66	69
Mean wind speed (km/h)	14.4	13.8	12.9	12.9	12.6	13.4	13.3	14.4	15.5	16.3	16.0	14.8	14.2
3pm conditions													
Mean temperature (ºC)	24.8	24.8	23.9	21.7	19.0	16.6	16.1	17.2	19.0	20.7	22.1	23.9	20.8
Mean relative humidity (%)	60	63	61	59	58	57	52	49	51	54	56	58	57
Mean wind speed (km/h)	24.1	23.0	21.0	19.3	17.1	17.8	18.2	20.8	23.1	24.6	25.3	25.2	21.6

Source: **Bureau of Meteorology, 2016a (6 April 2016)**

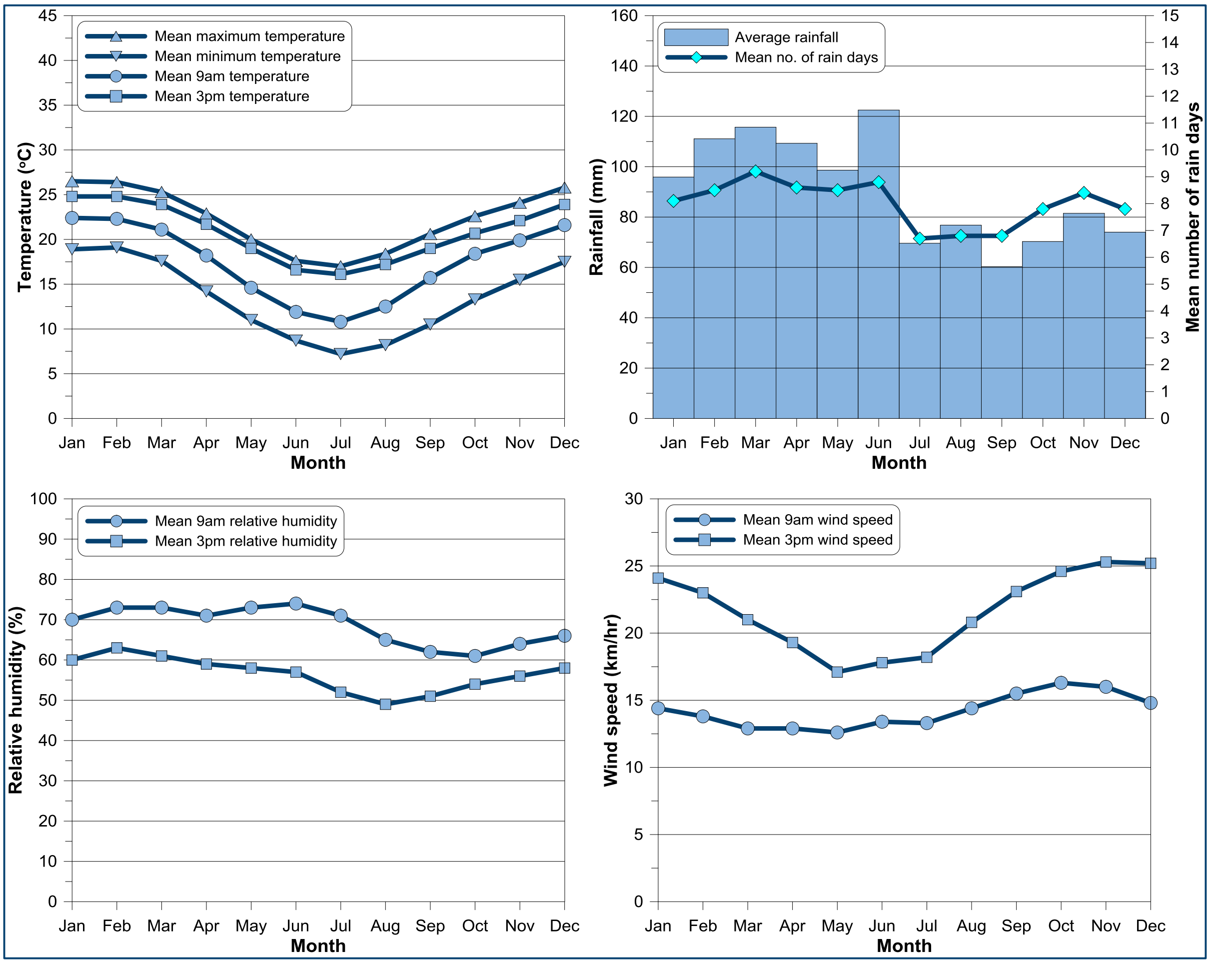

Figure 5-1: Monthly climate statistics summary – Sydney Airport AMO

5.2 Local meteorological conditions

Annual and seasonal windroses for the Sydney Airport AMO during the 2012 calendar period are presented in **Figure 5-2**.

Strong winds are generally experienced in the area due to its proximity to the coast. Winds from the northwest quadrant are typically weaker than winds from other directions. On an annual basis, the winds are varied with the highest portion originating from the northwest.

In summer, winds are typically from the northeast and southeast quadrants, with dominant winds from the northeast and south. The autumn distribution is similar to the annual distribution with a high portion of winds from the northwest. During winter, winds are typically from the southwest and northwest quadrants, with winds from the northeast most frequent. Spring has similar distribution to the annual distribution, however indicates a slightly higher portion of northeast winds.

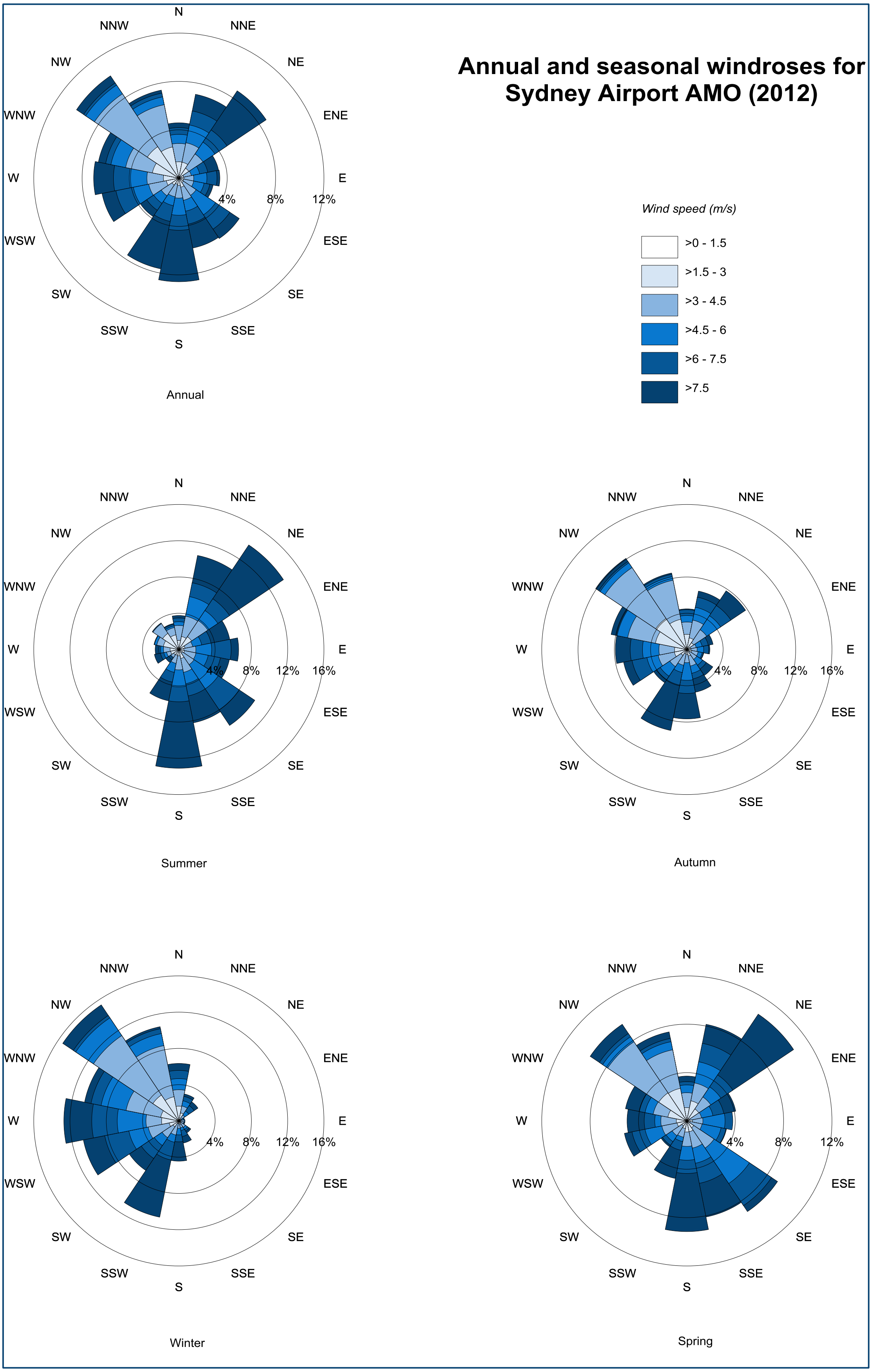

Figure 5-2: Annual and seasonal windroses for Sydney Airport AMO

5.3 Ambient air quality

The main sources of air pollutants in the area surrounding the Project include emissions from local anthropogenic activities such as various commercial or industrial activities, motor vehicle exhaust and domestic wood heaters.

Ambient air quality monitoring data from the Project site are not available. Therefore the available data from the nearest air quality monitors operated by the NSW Office of Environment and Heritage (OEH) were used to quantify the existing background level for assessed pollutants at the Project site.

The NSW OEH air quality monitors at Randwick, Earlwood and Rozelle (see **Figure 5-3**) are approximately 4 to 12km from the site and are considered to be generally representative of the background levels in the vicinity of the Project site. The data from these monitors have therefore been used to quantify the existing ambient levels of air pollutants in this study.

Figure 5-3: NSW EPA monitoring sites

5.3.1 PM_{10} monitoring

A summary of the available data from the NSW OEH monitoring stations is presented in **Table 5-2**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 5-4**.

A review of **Table 5-2** indicates that the annual average PM_{10} concentrations for each monitoring station were below the relevant criterion of 30µg/m³. The maximum 24-hour average PM_{10}

concentrations recorded at these stations were found to exceed the relevant criterion of 50µg/m³ at times during the review period (see **Figure 5-4**).

Table 5-2: Summary of PM_{10} levels from NSW OEH TEOM monitoring (µg/m³)

Station ID	Annual average					Maximum 24-hour average				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Randwick	15.9	18.0	18.8	18.2	18.6	40.1	43.7	55.3	46.1	77.4
Earlwood	18.1	19.6	19.9	18.3	17.2	124.9	44.2	63.1	45.2	66.5
Rozelle	16.6	16.9	18.3	17.8	16.7	39.4	40.7	58.5	43.8	60.3

The Ambient Air Quality NEPM standard for 24 hour average PM_{10} is a level of 50µg/m³ with an allowance for extraordinary events such as bushfires and dust storms that may produce dust levels above the standard (refer to **Table 4-3**).

It can be seen from **Figure 5-4** that PM_{10} concentrations are nominally highest in the spring and summer months with the warmer weather raising the potential for drier ground elevating the occurrence of windblown dust, bushfires and increased pollen levels.

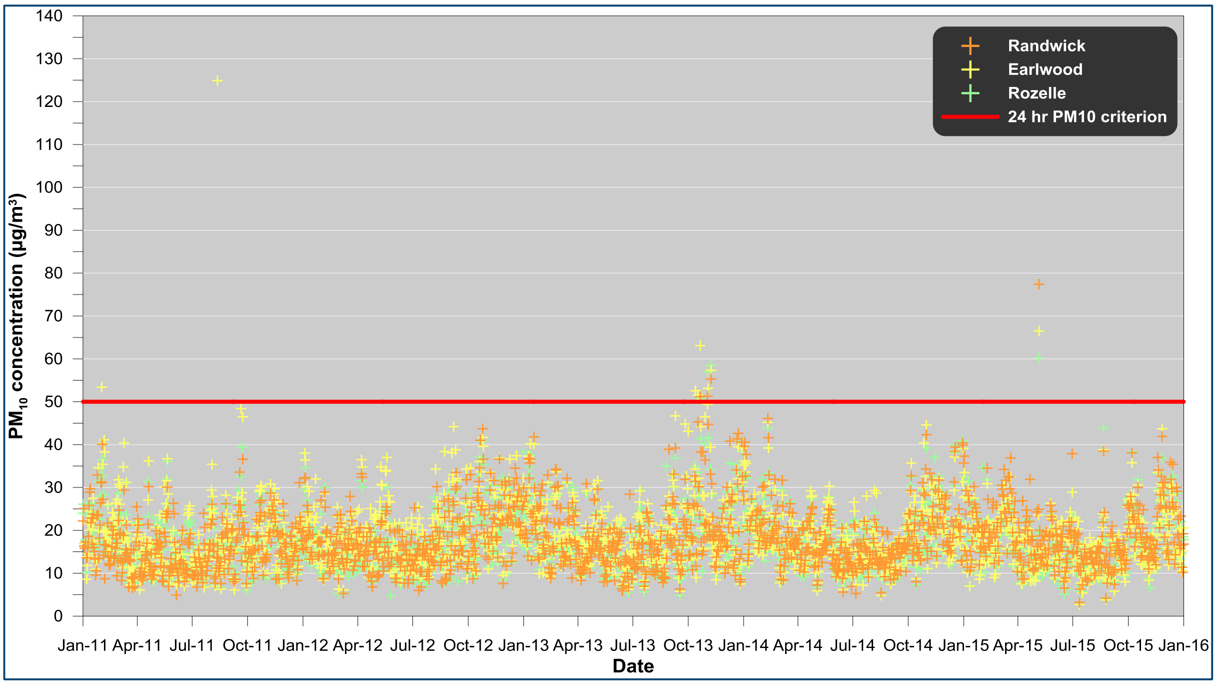

Figure 5-4: 24-hour average PM_{10} concentrations

5.3.2 $PM_{2.5}$ monitoring

A summary of the $PM_{2.5}$ readings from the NSW EPA monitoring stations is presented in **Table 5-3**. The recorded 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 5-5**.

Table 5-3 indicates that the annual average $PM_{2.5}$ concentration for the Earlwood monitoring station was 0.7µg/m³ above the NEPM standard of 8µg/m³ in 2015. For all other periods the annual average $PM_{2.5}$ concentrations were below standard. The Rozelle monitoring station indicated levels below the standard in 2015.

The lower $PM_{2.5}$ levels recorded in 2011 and 2012 may be due to La Niña experienced in Australia which brought heavy rainfalls (**BOM, 2016b**).

Table 5-3: Summary of $PM_{2.5}$ levels from NSW EPA BAM monitoring (µg/m³)

Station ID	Annual average					Maximum 24-hour average				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Earlwood	5.4	5.6	7.9	7.8	8.7	23.6	20.7	37.3	22.7	28.0
Rozelle(1)	-	-	-	-	7.2	-	-	-	-	33.4

(1)Data available from March 2015

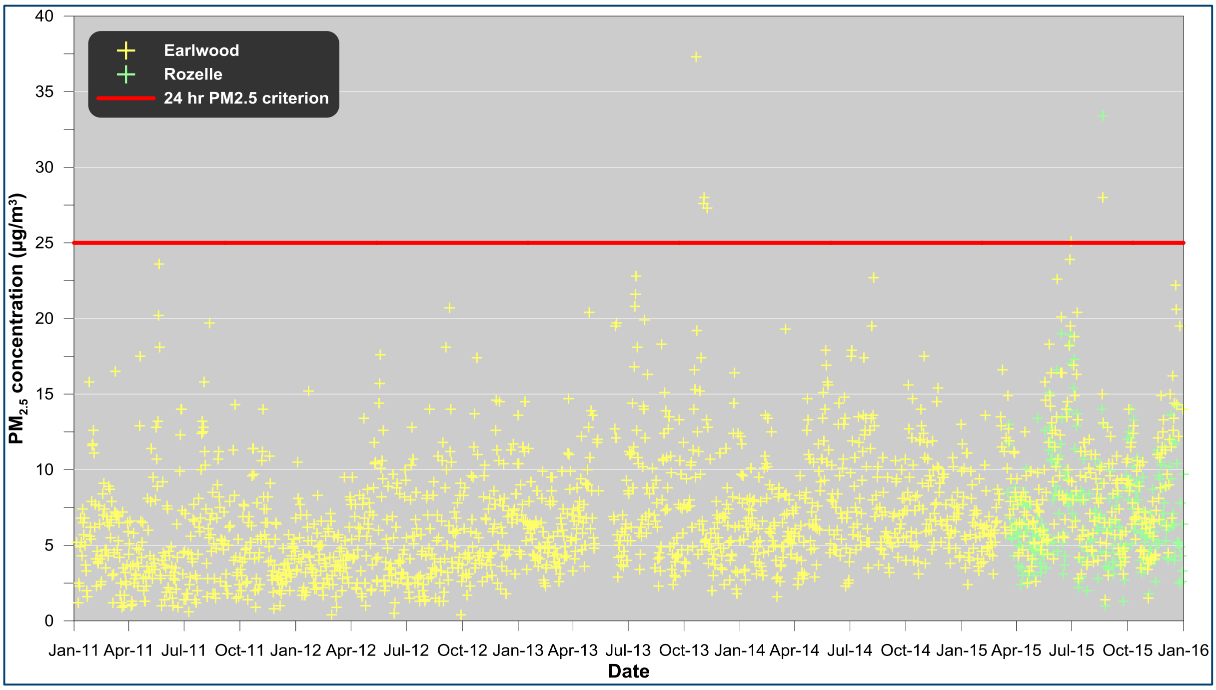

Figure 5-5: 24-hour average $PM_{2.5}$ concentrations

5.3.3 SO_2 monitoring

Table 5-5 presents a summary of the SO_2 monitoring data and shows that the maximum 1-hour average SO_2 level during the 2011 to 2015 period at these monitors was 88.66µg/m^3 recorded at Randwick. The annual average levels recorded at both Randwick and Rozelle during the period were a uniform level of 2.86µg/m^3 which is the equivalent to the resolution of the recorded SO_2 levels of 0.1 parts per hundred million (pphm).

Table 5-4: Summary of SO_2 levels from NSW EPA monitoring sites (µg/m³)

Station ID	2011	2012	2013	2014	2015
	Annual Average				
Randwick	2.86	2.86	2.86	2.86	2.86
Rozelle(1)	-	-	-	-	2.86
	Maximum 1-hour average				
Randwick	65.8	65.8	77.2	74.4	88.7
Rozelle(1)	-	-	-	-	80.1

(1)Data available from February 2015

Figure 5-7 presents the maximum daily 1-hour average SO_2 concentrations recorded at the NSW EPA monitoring sites from 2011 to 2015. The monitoring data reviewed indicate that there were no exceedances of the NSW EPA 1-hour average goal of 570µg/m^3 during this period at the monitors. The data in **Figure 5-6** indicate that levels of SO_2 are relatively low compared to the criterion level and show no clear seasonal variation.

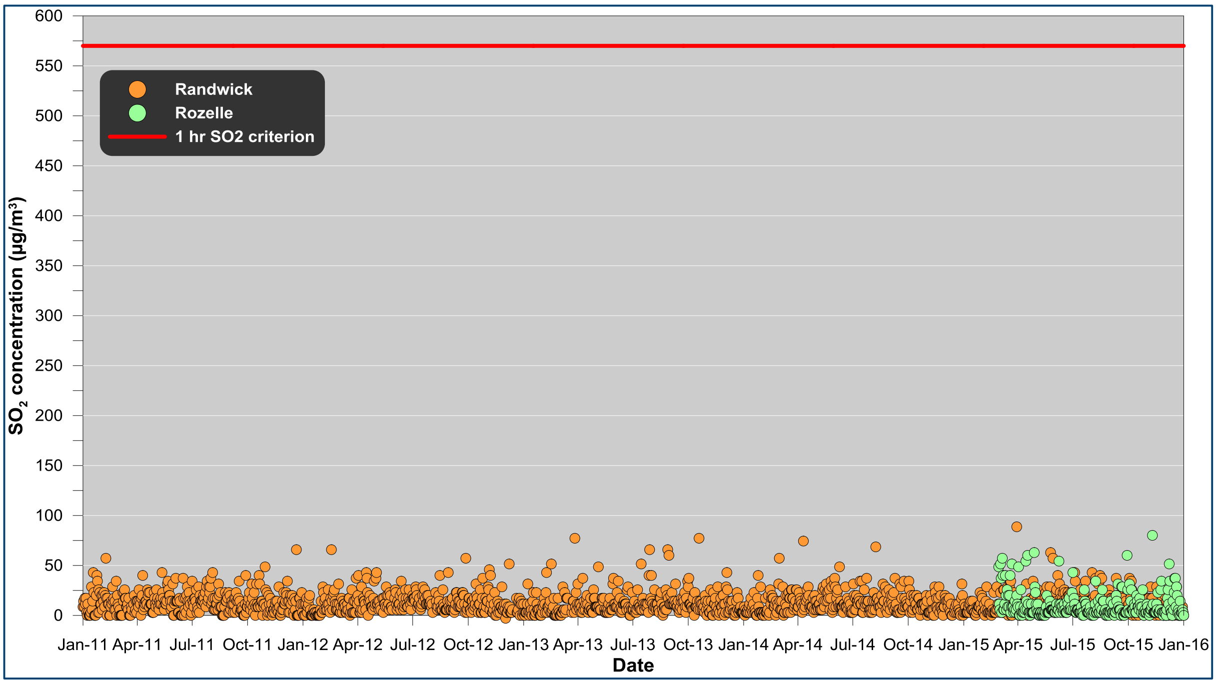

Figure 5-6: Maximum daily 1 hour average SO_2 concentrations

5.3.4 NO_2 monitoring

Table 5-5 presents a summary of the NO_2 monitoring data and shows that the maximum 1-hour average NO_2 level during the 2011 to 2015 period at these monitors was 143.5µg/m^3 recorded at Rozelle. The maximum annual average level during the period was also recorded at Rozelle with a level of 24.6µg/m^3.

Table 5-5: Summary of NO_2 levels from NSW EPA monitoring sites (µg/m³)

Station ID	2011	2012	2013	2014	2015
	Annual Average				
Randwick	14.4	12.3	14.4	12.3	16.4
Earlwood	18.5	18.5	20.5	16.4	16.4
Rozelle	22.6	24.6	22.6	22.6	22.6
	Maximum 1-hour average				
Randwick	108.7	84.1	94.3	96.4	88.2
Earlwood	94.3	104.6	98.4	82.0	108.7
Rozelle	102.5	127.1	143.5	112.8	123.0

Figure 5-7 presents the maximum daily 1-hour average NO_2 concentrations recorded at the NSW EPA monitoring sites from 2011 to 2015. The monitoring data reviewed indicate that there were no exceedances of the NSW EPA 1-hour average goal of 246µg/m^3 during this period at the monitors.

The data in **Figure 5-7** indicate that levels of NO_2 are relatively low compared to the criterion level and show a clear trend of seasonal fluctuation. Higher NO_2 concentrations occur during the cooler months with the low temperatures and less sunlight which makes the NO_2 less readily consumed in the formation of ozone **(DECCW, 2010)**.

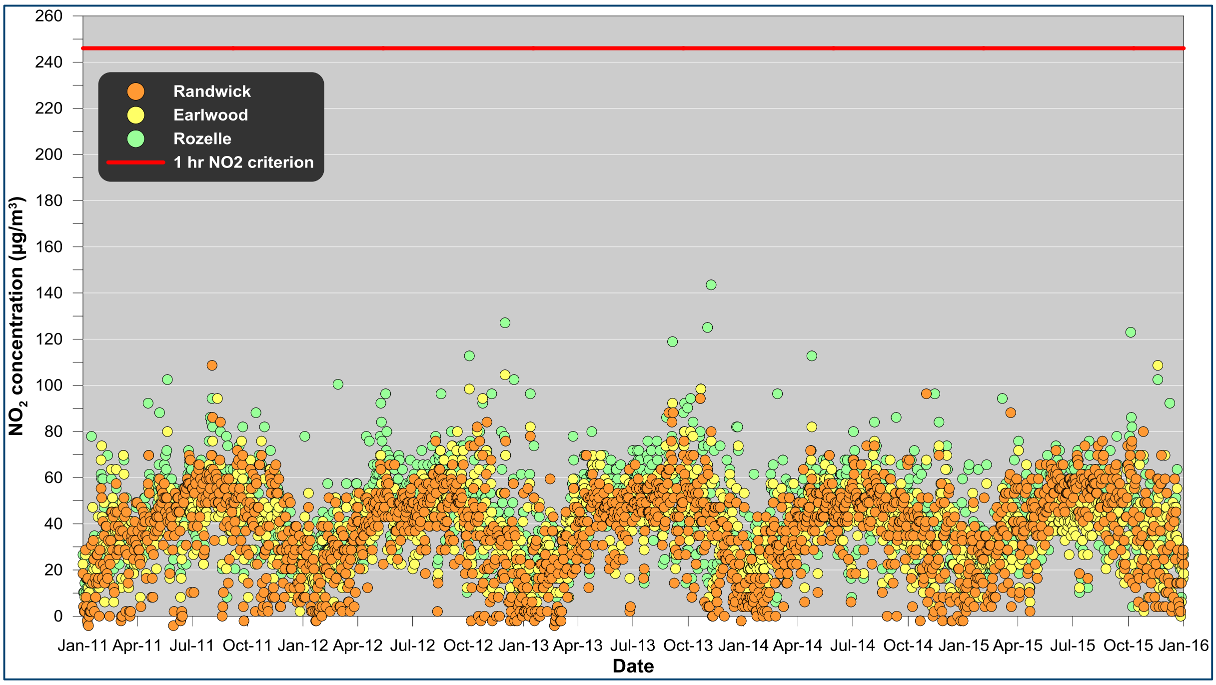

Figure 5-7: Maximum daily 1 hour average NO_2 concentrations

5.3.5 CO monitoring

Table 5-6 presents a summary of the CO monitoring data and shows that the maximum 8-hour rolling average CO level during the 2011 to 2015 period recorded at Rozelle was 2.8mg/m³. Based on the 8-hour rolling average CO monitoring data which are low compared to the goal, it is likely that the CO levels of other averaging times would also be below the applicable air quality goals.

Table 5-6: Summary of CO levels from NSW EPA monitoring sites (mg/m³)

Station ID	2011	2012	2013	2014	2015
	Maximum 8-hour rolling average				
Rozelle	1.8	2.8	2.3	1.4	1.4

Figure 5-8 presents the maximum daily rolling 8-hour average CO concentrations recorded at the NSW EPA monitoring sites from 2011 to 2015. The monitoring data reviewed indicate that there were no exceedances of the NSW EPA 8-hour average goal of 10mg/m³ during this period at the monitors.

The data in **Figure 5-8** indicate that measured levels of CO are low compared to the criterion level and show a similar but less pronounced seasonal fluctuation trend relative to the trends in NO_2 concentrations. Similar to the NO_2, the CO is a precursor to the formation of ozone (**Saini et al, 2008**) and with less available sunlight in the cooler months, it is less readily consumed in the formation of ozone.

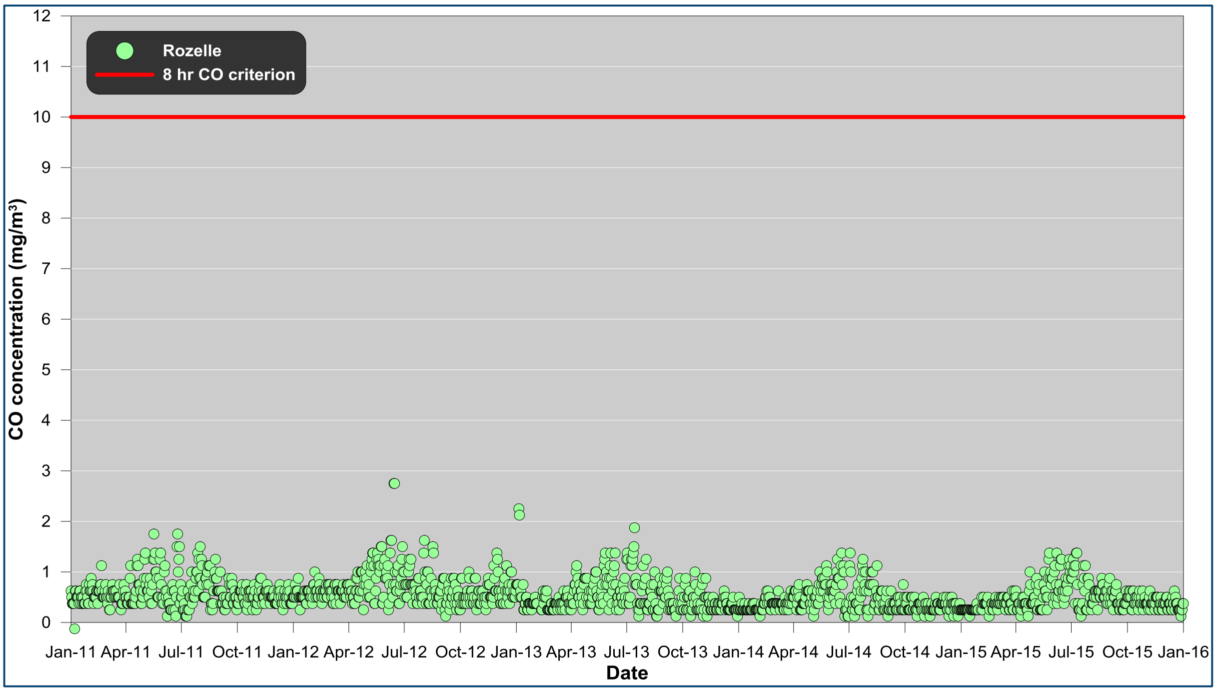

Figure 5-8: Maximum daily rolling 8 hour average CO concentrations

6 DISPERSION MODELLING APPROACH

6.1 Introduction

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

For this assessment the CALPUFF modelling suite is applied to dispersion modelling. The CALPUFF model is an advanced "puff" model that can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a three dimensional, sub-hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC Environmental Corporation**, **2011**).

6.2 Modelling methodology

Modelling was undertaken using a combination of The Air Pollution Model (TAPM) and the CALPUFF Modelling System. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

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

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

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

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

6.2.1 Meteorological modelling

TAPM was applied to the available data to generate a 3D upper air data file for use in CALMET. The centre of analysis for TAPM was 33.84deg south and 151.11deg east (325100mE, 6254000mN). The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

CALMET modelling used a nested approach where the 3D wind field from the coarser grid outer domain is used as the initial guess (or starting) field for the finer grid inner domain. This approach has several advantages over modelling a single domain. Observed surface wind field data from the near field as well as from far field monitoring sites can be included in the model to generate a more representative 3D wind field for the modelled area. Off domain terrain features for the finer grid domain can be allowed to take effect within the finer domain, as would occur in reality. Also, the coarse scale wind flow fields give a better set of starting conditions with which to operate the finer grid run.

The CALMET initial domain was run on a 50 x 50km area with a 1km grid resolution and refined for a second domain on a 10 x 10km area with a 0.1km grid resolution.

The 2012 calendar year was selected as the meteorological year for the dispersion modelling based on analysis of long-term data trends in meteorological data recorded for the area. **Table 6-1** outlines the parameters used from each station.

Table 6-1: Surface observation stations

Weather stations	Parameters						
	WS	WD	CH	CC	T	RH	SLP
Sydney Olympic Park (BoM) (Station No. 66195)	✓	✓			✓	✓	
Canterbury Racecourse AWS (BoM) (Station No. 66194)	✓	✓			✓	✓	
Bankstown Airport AWS (BoM) (Station No. 66137)	✓	✓	✓	✓	✓	✓	✓
Sydney Airport AMO (BoM) (Station No. 66037)	✓	✓	✓	✓	✓	✓	✓
Sydney Harbour (Wedding Cake West) (BoM) (Station No. 66196)	✓	✓			✓		
Fort Denison (BoM) (Station No. 66022)	✓	✓					
Terrey Hills AWS (BoM) (Station No. 66059)	✓	✓			✓	✓	
Horsley Park Equestrian Centre AWS (BoM) (Station No. 67119)	✓	✓			✓	✓	
Kurnell AWS (BoM) (Station No. 66043)	✓	✓					
Little Bay (The Coast Golf Club) (BoM) (Station No. 66051)	✓	✓					
Port Botany (Molineux Point AWS) (BoM) (Station No. 66100)	✓	✓					

WS = wind speed, WD = wind direction, CH = cloud height, CC = cloud cover, T = temperature, RH = relative humidity, SLP = station level pressure

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

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 6-1** and **Figure 6-2**.

Figure 6-1 presents the annual and seasonal windroses from the CALMET data. The figure shows similar annual and seasonal windroses for the Sydney Airport AMO during the 2012 calendar period presented in **Figure 5-2**.

Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds. **Figure 6-2** includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and show sensible trends considered to be representative of the area.

Figure 6-1: Windroses from CALMET extract at 10m height (Cell Ref 5050)

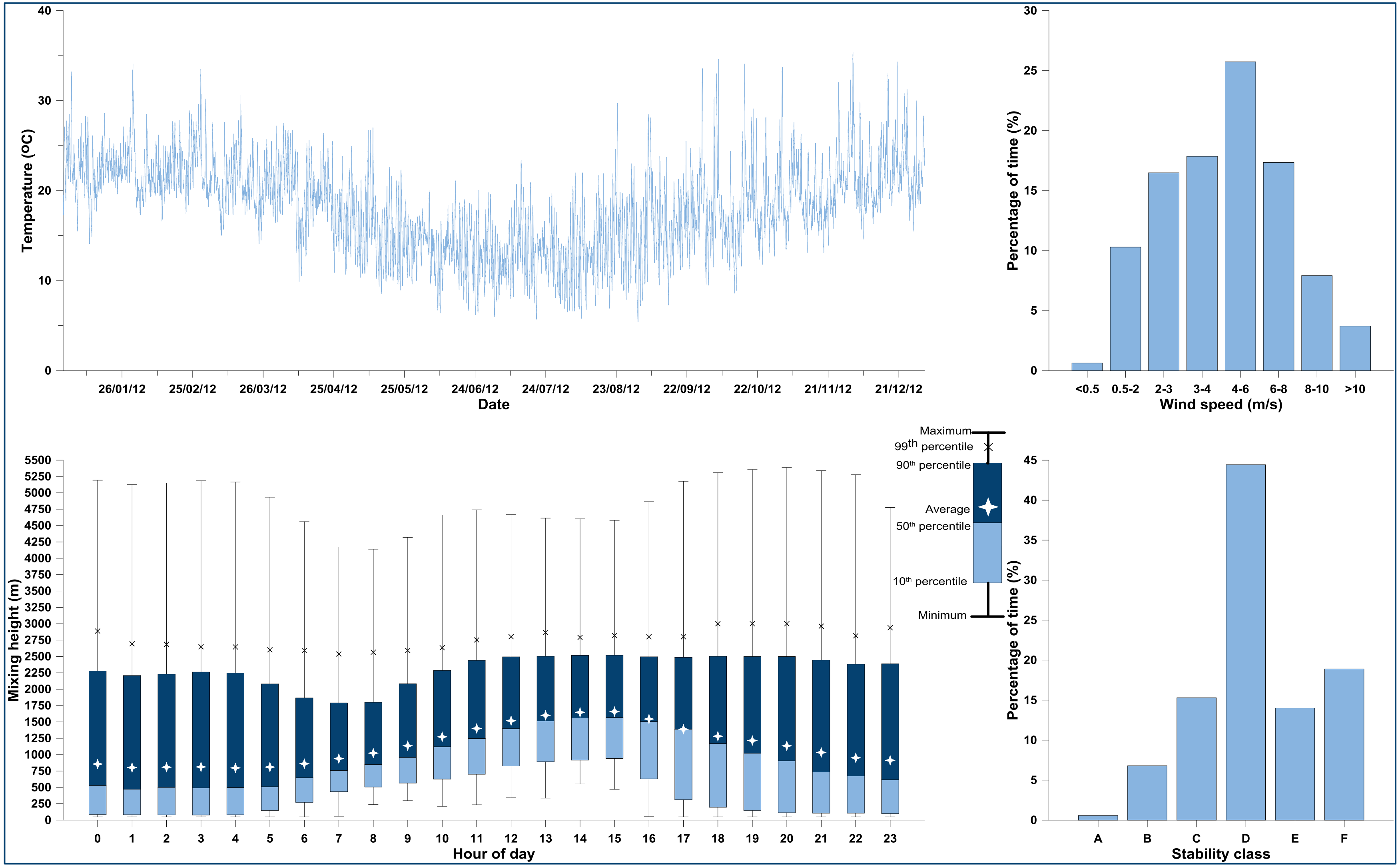

Figure 6-2: Meteorological analyses of CALMET extract (Cell Ref 5050)

6.2.2 Dispersion modelling

6.2.2.1 Odour modelling

For this assessment two scenarios were modelled, representing the existing situation and the proposed situation including the upgraded WTP.

The emission parameters for the existing scenario were approximated in consideration of the data in the latest odour assessment report prepared for the site (**Benbow Environmental, 2010**). The odour emission inventory for the existing scenario is presented in **Table 6-2**. The locations of the odour sources are presented in **Figure 6-3**.

Due to the large similarities and minor differences between the two potential designs for the upgraded WTP (Option A or B), it is anticipated that there would be minor differences between the odour impacts of the two designs at the sensitive receptors.

To be conservative, the worst-case design was modelled. This was considered to be Option A as there would be more odour sources and the significant sources would be slightly closer to the sensitive receptors compared with the Option B layout.

With the Option B design, the anaerobic tank would be closest to the sensitive receptors but would be fully sealed and thus would not have any significant emissions. With the Option A design, the aerobic tank, clarifier and sludge dewatering would be closest to the sensitive receptors. Although the emissions from the anaerobic tank would be captured and used as fuel to produce electricity, some odour emissions would pass through a biological packed bed odour control unit together with the emissions from the granular sludge tank, before they are emitted to the atmosphere.

Table 6-3 presents the odour emission inventory of the proposed WTP. The locations of the modelled sources are shown in **Figure 6-3.** The emission parameters are either assumed or based on the indicative site plan, unless otherwise stated. The location of the sludge storage area was assumed to be next to the sludge dewatering area.

For conservatism in the assessment, all sources were assumed to emit odours continuously for 24 hours including those from the sludge dewatering and sludge storage which are planned to occur only during daytime.

Table 6-2: Odour emission inventory of the existing scenario

Source ID	Description	Easting (m)	Northing (m)	Stack height (m)	Discharge Temperature (°C)	Stack Diameter (m)	Exit Velocity (m/s)	Odour Strength at STP (OU/m³)	Odour Emission Rate (OU/s)
Building Ventilation									
BV01	Roof Exhaust Fan No. 1	335834	6240404	19.5	30	1.60	14.10	300	8,109
BV02	Roof Exhaust Fan No. 2	335885	6240345	21.5	30	1.60	14.10	300	8,109
BV03	Roof Exhaust Fan No. 3	335893	6240337	21.5	30	1.60	14.10	300	8,109
BV04	Roof Exhaust Fan No. 4	335898	6240334	21.5	30	1.60	14.10	300	8,109
BV05	Roof Exhaust Fan No. 5	335957	6240283	19.5	30	1.60	14.10	300	8,109
Process Ventilation									
PV01	Optiformer Exhaust Fan No.1	335915	6240319	30.5	40	1.62	14.10	500	13,520
PV02	Mist Collector and Vac. Fabric	335904	6240329	30.5	40	1.15	14.10	500	6,804
PV03	Optiformer Exhaust Fan No.2	335907	6240336	30.5	40	1.62	14.10	500	13,520
PV04	Vacuum Blower No.1+ No. 2	335881	6240358	19.5	105.6	1.50	14.10	700	13,328
PV05	Vacuum System Fan No.1	335931	6240312	30.5	86	0.57	14.10	700	2,071
PV06	Vacuum System Fan No.2	335925	6240318	30.5	99	0.38	14.10	700	884
PV07	Vac Roll Exhaust Air No.1 Fan	335874	6240366	19.5	47.7	1.34	14.10	350	6,287
PV08	Hood Exhaust Air No.1 Fan	335858	6240381	19.5	51.4	1.92	14.10	350	12,843
PV09	Vac Roll Exhaust Air No.2 Fan	335843	6240395	19.5	51.6	1.32	14.10	350	6,006
PV10	Vac Roll Exhaust Air No.3 Fan	335822	6240415	19.5	47.7	2.06	14.10	300	12,770
PV11	Winder Pulper Exhaust Fan	335769	6240464	16.5	30	0.90	14.10	500	4,280
PV13	Vent	335851	6240430	15	30	0.11	2.07	5250	77
PV14	Pulper Exhaust Fan	335986	6240295	28.5	30	0.46	14.10	500	1,126

Source: **Benbow Environmental (2010)**

Table 6-3: Odour emission inventory of the proposed WTP

Point source									
Source ID	**Description**	**Easting (m)**	**Northing (m)**	**Stack height (m)**	**Discharge temperature (°C)**	**Stack diameter (m)**	**Exit velocity (m/s)**	**Odour strength at STP (OU/m^3)**	**Odour emission rate (OU/s)**
OC	Bioair odour control	335928	6240408	5	25	0.1	15 [a]	500 [a]	67 [a]

Area source						
Source ID	**Description**	**Corner easting (m)**	**Corner northing (m)**	**Effective height (m)**	**Initial sigma z (m)**	**Odour emission rate ($OU/m^2/s$)**
AT	Aeration tank	335985	6240466	10	2	0.3 [b]
		336001	6240451			
		335987	6240435			
		335971	6240450			
C	Clarifier	336002	6240485	7	2	0.1 [b]
		336018	6240472			
		336004	6240455			
		335988	6240469			

Volume source							
Source ID	**Description**	**Easting (m)**	**Northing (m)**	**Effective height (m)**	**Initial sigma y (m)**	**Initial sigma z (m)**	**Odour emission rate (OU/s)**
SD	Sludge dewatering	336003	6240489	1	1	1	500 [c]
SS	Sludge storage	335998	6240495	1	1	1	200 [d]

STP – standard temperature and pressure (at 0°C and 1 atm)

[a] The dimension of the odour control unit would be 2m x 2m x 3m. Based on a lower removal efficiency of 80% (**Salmon, 2016**), a minimum residence of 90 seconds (**Salmon, 2016**) of a biological odour control, and assuming 10% of emission from the anaerobic tank with an odour emission rate 1.5OU/m^2/s (**SKM, 2013**), and the odour emission from the granular sludge tank at the rate of 8.41OU/m^2/s (**Naddeo et al, 2012**), the calculated odour emission rate is 36OU/s. The maximum limit of 500OU based from the standard specification of the odour control unit of **Sydney Water (2011)**, the odour emission rate would be 67OU/s. To be conservative, the higher odour emission rate was used in this assessment. Assuming a stack diameter of 0.1m, the calculated velocity is 17m/s. To be conservative, the minimum velocity of 15m/s as specified in **Sydney Water (2011)** was used.

[b] Source: **Naddeo et al (2012)**

[c] Source: **SKM (2013)**

[d] Based from the sludge dewatering odour emission rate (500OU/s) **(SKM (2013)** scaled down to emission rate for sludge storage based from **Naddeo et al (2012)**

Figure 6-3: Locations of modelled emission sources

6.2.2.2 Combustion pollutant modelling

Air pollutants from the existing boiler stacks and a proposed gas engine for electricity generation were also modelled. **Figure 6-3** shows the location of these sources. There are two existing boiler stacks located next to each other. For conservatism, the proposed gas engine was assumed to be located on the eastern portion of the site closer to the sensitive receptor locations.

Table 6-4 shows the model parameters for the existing boiler stacks and proposed gas engine. The parameters for the boiler stacks were based from the results of the stack emissions testing from 2010 to 2015. Conservative parameters were used in the model such as the lowest discharge temperature, lowest exit velocity, and highest available pollutant emission rates measured via the stack testing.

The proposed gas engine would produce approximately 1.5 megawatt (MW) of power. For conservatism, exhaust gas heat recovery was assumed which would result in a lower exhaust gas exit temperature of approximately 180°C. Although the Proponent has not decided whether to include exhaust gas heat recovery, this assumption would represent a worst-case scenario for air quality impacts as it means the exhaust temperature is significantly lower and air dispersion is reduced.

The CO emission rate from the gas engine was assumed to be at the **POEO (Clean Air) Regulation (2010)** emission limit of 125 milligram per normal cubic metre (mg/Nm^3).

The NSW EPA has a policy to minimise NO_x emissions for new NO_x sources (**NSW DECC, 2009**). This would require a low NO_x engine with an emission limit of $250 mg/Nm^3$ for NO_x commensurate with best available techniques (BAT) for the combustion of biogasses (containing some residual levels of sulfur). Therefore, in this assessment, the NO_x and CO emission rates were calculated based on emission limit concentrations of $250\ mg/Nm^3$, respectively.

The emission flowrate from the gas engine was calculated assuming;

- The biogas contains 70% methane and 30% carbon dioxide **(NPI, 2008)**;
- Methane energy content of approximately 35.9 megajoule per normal cubic metre (MJ/Nm^3) **(NPI, 2008)**;
- Fuel energy to power rate of 10,000 kilojoule per kilowatt-hour (kJ/kWh) **(NPI, 2008)**; and,
- 10% excess air, consistent with low NO_x engines.

The SO_2 emission rate was calculated on the basis of the assumed post-scrubber H_2S gas concentration of 10ppm (from the manufacturer's specification) and 100% conversion of H_2S to SO_2.

Table 6-4: Model parameters for the boiler stacks and gas engine

Sources	Easting (m)	Northing (m)	Stack height (m)	Discharge temperature (°C)	Stack diameter (m)	Exit velocity (m/s)	TSP (g/s)	PM_{10} (g/s)	SO_2 (g/s)	NO_x (g/s)	CO (g/s)
Boiler Stack 1	335956	6240417	43	120.6	1.69	6.2	0.021	0.015	-	0.5	1.1
Boiler Stack 2	335969	6240431	43	120.6	1.69	6.2					
Gas Engine	335992	6240514	6	180.0	0.3	32.4	-	-	0.039	0.35	0.17

- Not available and/or too low and was not considered in this assessment

7 DISPERSION MODELLING RESULTS

7.1 Odour

The spatial distribution of the dispersion modelling predictions for the existing and proposed scenarios is presented as isopleth diagrams showing the 99th percentile nose-response ground level odour concentrations in **Figure 7-1**.

As shown, the predicted odour impacts for the two scenarios are similar and the odour impacts from the proposed scenario would be insignificantly higher than those of the existing scenario.

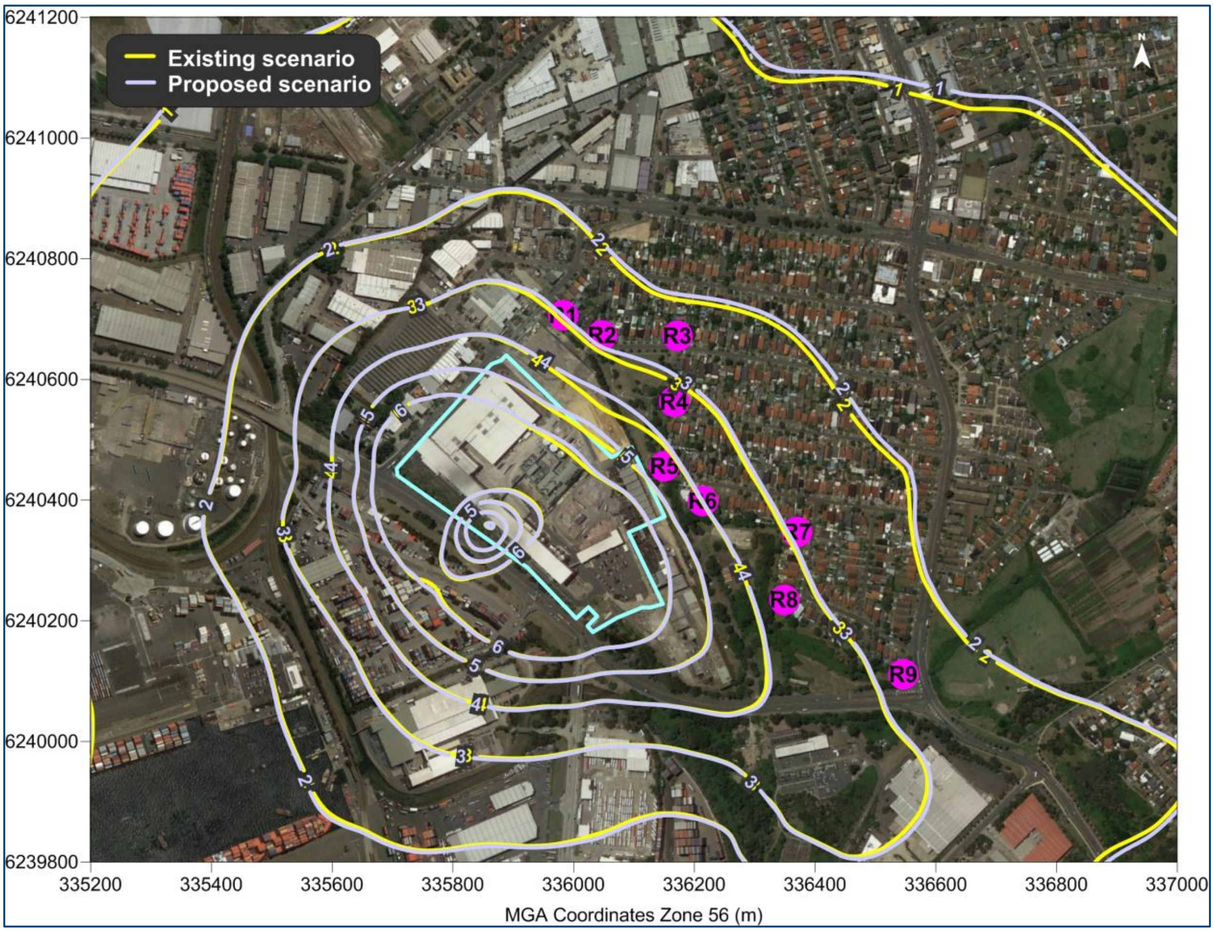

Figure 7-1: Predicted 99th percentile nose-response odour concentration (OU) for the existing and the proposed scenarios

Table 7-1 presents the predicted odour concentrations at each of the sensitive receptors for the existing and proposed scenarios, and the incremental change.

Table 7-1: Predicted 99th percentile nose-response odour concentrations at the sensitive receptors (OU)

	R1	R2	R3	R4	R5	R6	R7	R8	R9
Existing scenario	2.91	2.70	2.40	3.27	4.32	3.94	2.86	3.38	2.77
Proposed scenario	2.98	2.79	2.46	3.36	4.34	3.95	2.90	3.42	2.78
Incremental change	0.07	0.10	0.07	0.09	0.02	0.01	0.04	0.03	0.02

The highest predicted odour concentration is 4.3OU at receptor R5 for both the existing and the proposed scenarios.

The highest change of odour levels at the sensitive receptors would up to 0.1 OU. This would not be detectable or measurable in actual practice.

7.2 Combustion products

The predicted maximum incremental impact (i.e. due to the operation in isolation) and cumulative impact (i.e. due to the operation and background level) at the sensitive receptors arising from the Project is presented in **Table 7-2**.

With the exception of NO_2, the incremental impacts are low in comparison to the background concentrations. A total (100%) instantaneous conversion of the predicted NO_x levels to NO_2 was assumed in the estimation of the NO_2 incremental impacts. Even with this conservative assumption, the predicted maximum cumulative NO_2 impacts, as with the other pollutant impacts, would remain below the criteria. In actual practice the impacts would be significantly less than presented.

In the absence of background or source data for some of the assessable pollutants, several conservative assumptions were necessary as follows;

- All of the PM_{10} is comprised of $PM_{2.5}$, and hence the maximum $PM_{2.5}$ impacts are assessed based on the maximum PM_{10} impacts; and,
- Without background data and predictions for specific averaging periods, the required values are estimated based on the available shorter-term averaging period for SO_2 and CO.

Using these assumptions, the maximum cumulative impacts of all the assessed pollutants are below their relevant criteria at the sensitive receptors.

Table 7-2: Predicted incremental impact at the sensitive receptors

Pollutant	Averaging period	Unit	Background	Maximum incremental impact at the receptors	Maximum cumulative impact at the receptors	Criterion
TSP	Annual	µg/m³	-	0.02	-	90
PM_{10}	24-hour	µg/m³	43.7	0.12	43.82	50
	Annual	µg/m³	18.0	0.02	18.02	25
$PM_{2.5}$	24-hour	µg/m³	20.7	≤0.12[a]	≤20.82[a]	25
	Annual	µg/m³	5.6	≤0.02[a]	≤5.62[a]	8
SO_2	10-minute	µg/m³	-	7.47	-	712
	1-hour	µg/m³	65.8	5.52	71.3	570
	24-hour	µg/m³	-	1.38	<71.3[b]	228
	Annual	µg/m³	2.86	0.27	3.13	60
NO_2	1-hour	µg/m³	84.1	48.5	132.6	246
	Annual	µg/m³	12.3	2.9	15.2	62
CO	10-minute	mg/m³	-	0.044	-	-
	15-minute	mg/m³	-	<0.044[b]	-	100
	1-hour	mg/m³	-	0.032	-	30
	8-hour	mg/m³	2.8	<0.032[b]	<2.83[b]	10

- Not available

[a] Estimated based from PM_{10} results

[b] Estimated based from the results of a lower-averaging time of the same pollutant

8 DISCUSSION

It is observed that without the proposed wastewater treatment processes, the wastewater would still undergo similar processes at Sydney Water's sewage treatment facility; and without the proposed engine, electricity would still need to be purchased and thus generated by a power plant elsewhere. However there would be some energy lost through transmission, and thus more greenhouse gas and air pollution impacts due to this and also the likely production of coal-fired electricity instead of gas fired electricity.

The combination of the upgraded wastewater treatment and the treatment, recovery and combustion of the emissions, the Project would thus have a net positive air quality outcome from a total emissions perspective. The improvements would arise from:

- Reduction of methane emissions;
- Reduction of sulfur emissions in the form of H_2S and SO_2;
- Reduction of greenhouse gas emissions; and,
- The generation of electricity locally from biogas.

It is also noted that a low emissions engine is proposed, commensurate with best practice for the combustion of biogas. It is noted that the presence of residual levels of sulfur in the biogas poses a limit on how low the engine NO_x emissions can be, in this case not above 250mg/Nm^3. The presence of sulfur in the gas stream must necessarily be kept low otherwise it is costly to the operator in terms of maintenance and shortened life for an expensive asset. Thus the proponent has an inherent incentive to maintain the gas scrubbing equipment operating efficiently.

As shown in **Section 7.2**, even the highest levels of emissions from the engine would not cause any impact at the surrounding residences. As shown in **Section 7.1**, the effect of the Project on odour is unlikely to be discernible to any person off-site, and the Project has a positive effect on greenhouse gas emissions and some air emissions.

Overall, the study finds that the Project would not lead to any unacceptable level of air pollutants.

9 SUMMARY AND CONCLUSIONS

This study has examined the potential air quality impacts that may arise from the Project.

The study applies conservative calculations and assumptions which would overestimate the likely impacts for example, higher pollutant emission rates, lower stack temperature and velocity, total conversion of NO_x to NO_2, (amongst others).

The results indicate that the Project would lead to an insignificant change in odour concentrations and relative to the current situation, no discernible change in the levels of odour at the sensitive receptors are predicted due to the Project.

The results also show that the Project would not cause any exceedance of the air quality criteria at the sensitive receptors for all of the relevant air pollutants.

Overall, the Project would have a net positive effect on greenhouse gas emissions, and some air pollutants.

The study shows that the Project could operate either Option A or Option B without any unacceptable level of impact in the locality in regard to the applicable air quality and odour criteria.

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Appendix A
Peak-to-mean ratios

Peak-to-mean ratios

The following table shows the recommended factors to be applied for estimating peak concentrations from different source types, stabilities and distances.

Source Type	Pasquill-Gifford stability class	Near field P/M 60*	Far field P/M 60*
Area	A, B, C, D	2.5	2.5
	E, F	2.3	1.9
Line	A-F	6	6
Surface point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A-F	2.3	2.3
Volume	A-F	2.3	2.3

*Ratio of peak 1-second average concentrations