AIR QUALITY IMPACT ASSESSMENT

Macquarie Data Centre
17-23 Talavera Rd, North Ryde

Prepared for:

GIDDIS Project Management

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with GIDDIS Project Management (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30465-R02-v2.2	22 October 2021	Jason Shepherd	Ali Naghizadeh	Ali Naghizadeh
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EXECUTIVE SUMMARY

Background

This Air Quality Impact Assessment has been prepared by SLR Consulting Australia Pty Ltd on behalf of Macquarie Data Centres (MDC) C/- GIDDIS Project Management.

The following Air Quality Impact Assessment has been produced to support the Environmental Impact Statement (EIS) prepared by Willowtree Planning PTY Ltd (Willowtree Planning).

The EIS has been submitted to the New South Wales (NSW) Department of Planning, Industry and Environment (DPIE), in support of an application for State Significant Development (SSD), for the construction and operation of a data centre, involving earth works, provision of infrastructure and expansion of an existing data centre at 17 – 23 Talavera Road, Macquarie Park (Lot 527 DP 752035).

The proposal represents an extension to the approved data centre (LDA/2018/0322) to allow for additional data storage capacity at the Site, improving the overall operational efficiencies and provision of technology services to customers and the wider locality.

The proposal involves the construction and operation of an expansion to an existing data centre located at 17-23 Talavera Road, Macquarie Park (Lot 527 in DP 752035), comprising:

- a five-storey building
- ancillary office space and staff amenities
- a back-up power system
- associated infrastructure, car parking, loading docks and landscaping

The Site is located within the City of Ryde Local Government Area (LGA).

The Project seeks to operate 24 hours per day, seven (7) days per week, with the testing of back-up generators (generators) occurring between the hours of 9:00 am to 4:00 pm from Monday to Friday.

The particulars of this proposal are summarised below:

- Minor earthworks involving cut and fill works
- Infrastructure comprising civil works and utilities servicing
- Construction of a five (5) storey building extension, comprising up to:
  - 14 data halls
  - 18 generators
  - fitout of the building for use as a data centre (on an as-needs basis).

EXECUTIVE SUMMARY

Construction

The main potential sources of air emissions during the construction stage of the Project were identified as suspended particulate matter and deposited dust. The potential for off-site air quality impacts during the construction stage of the Project were assessed using a qualitative risk-based approach, concluding that given the nature of the operations proposed, the location of the Site and the local meteorological conditions, exceedances of the relevant air quality criteria are unlikely.

Operation

The potential for off-site air quality impacts during the operational stage of the Project were conservatively assessed quantitatively through the use of dispersion modelling techniques in accordance with the Approved Methods. The dispersion modelling study, which accounted for worst-case testing conditions predicted no exceedance of the relevant ambient air quality as a result of the operation of the Project.

The dispersion of emissions due to emergency conditions, where loss of all feeders to the Site requiring all generators to operate simultaneously, was conservatively modelled and predicted compliance with the PM_{10} and $PM_{2.5}$ 24-hour average criterion at all receptors with the exception of the nearest, which represented the potential rooftop air intakes of the neighbouring building. However, the predicted low likelihood of an exceedance coupled with the low likelihood of an emergency condition event happening was demonstrated to result in a vanishingly small chance of an exceedance occurring.

Conclusion

It is concluded that air quality issues do not pose a constraint for the Project.

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1 Introduction

1.1 Background

SLR Consulting Australia Pty Ltd (SLR) have been appointed by Macquarie Data Centres (MDC) to undertake the Air Quality Impact Assessment (AQIA) for the proposed development of the Macquarie Park Data Centre Campus IC3 Super West site at 17-23 Talavera Road, Macquarie Park (the Site).

This AQIA report serves to support the State Significant Development Application (SSDA) relating to the proposed development.

1.2 Relevant Policies, Guidelines and Plans

This assessment has been prepared with consideration of the following policies and guidelines:

- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA, 2017) (the Approved Methods)
- Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (NSW DEC, 2005)
- Protection of the Environment Operations Act 1997 (NSW Parliament, 1997)
- Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW Parliament, 2010)

The Approved Methods outlines the requirements for conducting an air quality impact assessment as follows (also indicated are the relevant sections of this report where the requirements are met):

- Description of local topographic features and sensitive receptor locations (Section 7.1 and Section 7.2 respectively)
- Establishment of air quality assessment criteria (Section 6.2)
- Analysis of climate and dispersion meteorology for the region (Section 7.3)
- Description of existing air quality environment (Section 7.4)
- Compilation of a comprehensive emissions inventory for the proposed activities (Section 8.3.6)
- Completion of atmospheric dispersion modelling and analysis of results (Section 9.2 and 9.3)
- Preparation of an air quality impact assessment report comprising the above.

1.3 Secretary's Environmental Assessment Requirements

This AQIA report is prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs). The SEARs for the proposal outline Key Issues to be addressed as part of this EIS and includes emissions to air associated with construction and operation.

SLR have been appointed by Macquarie Data Centres (MDC) to undertake the AQIA for the proposed development of the Macquarie Park Data Centre Campus IC3 Super West site.

The following SEARS are addressed within Table 1 of this report.

Table 1 SEARS Requirements

SEARs Items	Secretary's Environmental Assessment Requirements	Response

Key Issue	Air quality – including:
	• a quantitative assessment of the potential air quality, dust and odour impacts of the development, during construction and operation, in accordance with relevant Environment Protection Authority guidelines
	• The assessment must include:
	  ◦ scenarios for construction works, operations, and testing of the back-up power system or its considered alternatives and a justified worst-case scenario
	  ◦ assessment of emissions from the back-up power system against the standards of concentration outlined in the Protection of the Environment Operations (Clean Air) Regulation 2010 (including, but not limited to, polycyclic aromatic hydrocarbons (PAHs) and oxides of nitrogen (NOx) impacts)
	  ◦ assessment of criteria pollutants in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2016)
	• details of proposed mitigation, management and monitoring measures (including for the back-up power system) required to ensure compliance with section 128 of the Protection of the Environment Operations Act 1997.
		This report and specifically for construction:
		Sections 4.1, 6.1.1, 8.1, 9.1 and 11.1
		
		and for operation:
		Sections 4.2, 4.3, 6.1.2, 8.2, 8.3, 9.2 and 11.2.

2 Glossary and Abbreviations

Table 2 below shows the glossary of terms and their definitions used in this AQIA.

Table 2 Glossary

Term	Definition
The Site	Existing and proposed data centre at 17-23 Talavera Rd, North Ryde (Lot 527 DP 752035)
The Project	The construction of a new data centre (IC3W) and ancillary office space to expand the operation of the existing data centre (IC2 and IC3E).

Table 3 below shows the abbreviations and their definitions used in this AQIA.

Table 3 Abbreviations

Term	Definition
AQIA	Air Quality Impact Assessment
AQMS	Air Quality Monitoring Station
AWS	Automatic weather station
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
CO	Carbon Monoxide
DPIE	NSW Department of Planning, Industry and Environment
EES	DPIE's Environment, Energy and Science Group
EPA	NSW Environment Protection Authority
$g/m^2/month$	Grams per meter squared per month
IAQM	Institute of Air Quality Management
IN1	General industrial land (planning zone)
km	Kilometres
kW	Kilowatt
MW	Megawatt
MJ	Megajoule
m/s	Metres per second
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
O_3	Ozone
OEH	Office of Environment and Heritage
PM	Particulate matter
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
SO_2	Sulfur dioxide
SP2	Infrastructure (planning zone)
VOC	Volatile Organic Compounds

3 Project Description

3.1 Project Location

The Site is described as Lot 527 DP 752035, commonly known as 17 – 23 Talavera Road, Macquarie Park, located within the City of Ryde Local Government Area (LGA). The site has a total area of approximately 20,000 m^2, with access achieved via Talavera Road (Figure 1).

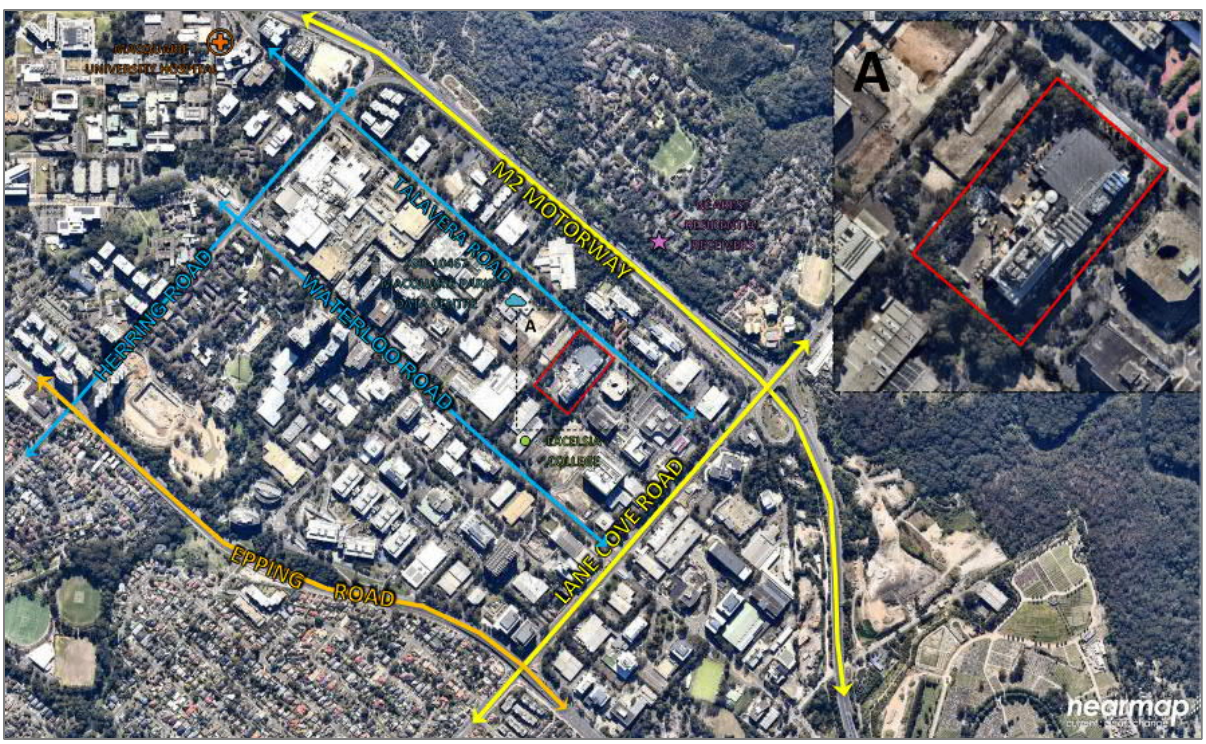
The Site forms part of the Macquarie Park Corridor, which is the strategic centre of Macquarie Park, being a health and education precinct and an important economic and employment powerhouse in Sydney's North District.

The Site is described through its current commercial setting as an existing Data Centre (LDA/2018/0322), adjoining surrounding commercial premises along Talavera Road, and forming part of the wider Macquarie Park Corridor.

The Site is situated approximately 12.5 km northwest of the Sydney CBD and 11.3 km northeast of Parramatta. It is within close proximity to transport infrastructure routes (predominantly the bus and rail networks), as well as sharing direct links with the wider regional road network, including Talavera Road, Lane Cove Road, Epping Road and the M2 Motorway.

These road networks provide enhanced connectivity to the Site and wider locality. Additionally, the Site is located within close proximity to active transport links, such as bicycle routes, providing an additional mode of accessible transport available to the Site.

Figure 1 The Site 17 – 23 Talavera Road, Macquarie Park, being Lot 527 DP 752035



3.2 Project Overview

The Site consists of an existing data centre buildings, IC2 and IC3E (Stage 1), to which the footprint is to be expanded by the construction of IC3W. The site includes administrative offices, internal roads and car parks.

IC2 is serviced by four diesel rotary uninterruptible power supply devices (DRUPS) and four standby diesel generators (generators) to provide power to the data centre in the event of an interruption of the mains grid electricity supply. The DRUPS are located on the ground floor and the generators are located on the roof, all exhausting from the roof level of IC2. IC3E is serviced by eight gensets on the ground floor, exhausting from the roof level of IC3E. IC3W is proposed to be serviced by 18 generators located on the roof of IC3W.

The proposal represents an extension to the approved data centre (LDA/2018/0322) to allow for additional data storage capacity, improving the overall operational efficiencies and provision of technology services to customers and the wider locality.

The proposal involves the construction and operation of an expansion to an existing data centre comprising:

- a five-storey building
- ancillary office space and staff amenities
- a back-up power system
- associated infrastructure, car parking, loading docks and landscaping

The proposal seeks to operate 24 hours per day, seven (7) days per week.

The particulars of this proposal are summarised below:

- Minor earthworks involving cut and fill works
- Infrastructure comprising civil works and utilities servicing
- Construction of a five (5) storey building extension, comprising up to:
  - 14 data halls
  - 18 generators
  - Fit out of the building for use as a data centre (on an as-needs basis).

Figure 2 Site Layout

4 Potential Sources of Air Emissions

4.1 Construction Phase

During the construction works, fugitive dust emissions are considered to be the primary emission type, which could give rise to nuisance and/or health impacts for the surrounding sensitive areas.

The main emissions to air during the construction phase are likely to be emissions of suspended particulate matter and nuisance dust from the movement of vehicles and construction equipment, excavation and rehabilitation, demolition, clearing and grading, truck loading and unloading and wind erosion.

4.2 Operational Phase

Generators are required to ensure ongoing operation if the mains grid electricity supply is interrupted for more than a few minutes. The function of the standby generators is to provide power when there is an unexpected interruption of mains grid electricity.

During the operational phase, the generators would be a source of products of combustion while undergoing testing and in the event of a power failure. In general, power interruptions last anything from a few seconds to a few hours and therefore even when required the generators would only operate for a short time.

Generator specifications are provided in Table 4. Full specifications are provided in Appendix C.

Table 4 Diesel Generator Specifications

Parameter	Units	IC3W
Model	-	20V4000G94F
Number	-	18
Electrical generation capacity: individual	kW	3,306
Electrical generation capacity: generators combined [a]	MW	59.5
Fuel rate: individual	L/h	ND
NO_x	g/kW	9.65
CO	g/kW	0.52
PM	g/kW	0.023
NO_x in-stack concentration	mg/Nm^3	2402 [b]
CO in-stack concentration	mg/Nm^3	127
PM in-stack concentration	mg/Nm^3	5.7
NO_x in-stack concentration	mg/Nm^3 @5% O_2	3430
CO in-stack concentration	mg/Nm^3 @5% O_2	181
PM in-stack concentration	mg/Nm^3 @5% O_2	8.2

ND No data

a Greater than the Protection of the Environment Operations (POEO) Act 1997 & Amendment Act 2011 (Refer Section 5.1.1) criteria used to define a scheduled activity under Clause 17 *Electricity Generation*. However, as the emergency standby plant is anticipated to operate less than 200 hours per year, this clause does not apply.

b It is noted that the anticipated maximum in-stack NO_X concentration exceeds the 450 mg/m^3 Protection of the Environment Operations (Clean Air) Regulation 2010 Group 6 limit (Refer Section 5.1.2). However, as the emergency standby plant is anticipated to operate less than 200 hours per year, it is exempt from these limits under the Regulation.

Table 5 provides the proposed testing regime for which this AQIA is based.

Table 5 Proposed Generator Testing Regime

Parameter	Value
No of generators	34 (inclusive of 16 existing and 18 proposed)
Test frequency per generator	Quarterly
Run time per test	60 minutes
No of generators per test	1 - 5
Number of tests per day	8
Testing schedule	Monday to Friday (9:00 am to 4:00 pm)
Total testing time for all generators	132 hours / annum (based on 1 generator per test)

As outlined in Table 5, testing of generators is proposed to be conducted for 60 minutes between 9:00 am to 4:00 pm, Monday to Friday. No more than five generators will be tested per day and the five generators will not necessarily be tested concurrently, noting that in previous discussions with the EPA on annual operating hours of diesel generators, they have indicated that time spent testing more than one generator concurrently will be counted once, i.e. not hours multiplied by number of generators running. The total test time for all generators (existing and proposed) is therefore estimated to be 132 hours or less per year.

In order to assess the worst-case scenario, the modelling undertaken for the operational scenario conservatively assumes that:

- Each generator would be tested for a period of 60 minutes.
- Five generators will be tested concurrently within the same hour.
- Testing of generators is conducted every hour of the year between 9:00 am and 5:00 pm, i.e. one additional hour to assess the operation of the generators under varying meteorological conditions and conservatively allow for potentially elevated evening background concentrations of NO_2.

4.3 Emergency Conditions

Major power interruptions requiring the simultaneous operation of all standby generators would only occur very infrequently and for a limited time period.

In order to assess the worst-case emergency conditions, the modelling undertaken for the operational scenario conservatively assumes that all 34 generators run concurrently within the same hour.

The emergency conditions are modelled for every hour of the year. This is an unrealistic situation only assumed such that the emergency operation of the generators under varying meteorological conditions can be conservatively assessed. The likelihood of the maximum predicted air quality impacts due to emergency conditions is discussed in Section 9.3.6.

Specifications for the existing 16 generators are provided in Table 4.

Table 6 Diesel Generator Specifications

Parameter	Units	IC2 (DRUPS)	IC2	IC3E
Model	-	20V400G63 EO	12V4000G23	20V400G63
Number	-	4	4	8
Electrical generation capacity: individual	kW	2,420	1,576	2,420
Electrical generation capacity: generators combined [a]	MW	9.7	6.3	19.4
Fuel rate: individual	L/h	554	ND	554 [b]
NO_x	g/kW	ND	ND	ND
CO	g/kW	ND	ND	ND
PM	g/kW	ND	ND	ND
NO_x in-stack concentration	mg/Nm^3	3675 [c]	4116 [c]	3675 [b,c]
CO in-stack concentration	mg/Nm^3	648	284	648 [b]
PM in-stack concentration	mg/Nm^3	108	20	108 [b]
NO_x in-stack concentration	mg/Nm^3 @5% O_2	ND	5202	ND
CO in-stack concentration	mg/Nm^3 @5% O_2	ND	359	ND
PM in-stack concentration	mg/Nm^3 @5% O_2	ND	25	ND

ND No data

a When all generators are combined, greater than the Protection of the Environment Operations (POEO) Act 1997 & Amendment Act 2011 (Refer Section 5.1.1) criteria used to define a scheduled activity under Clause 17 *Electricity Generation*. However, as the emergency standby plant is anticipated to operate less than 200 hours per year, this clause does not apply.

b No data: assume same specs as 20V400G63 EO.

c It is noted that the anticipated maximum in-stack NO_X concentration exceeds the 450 mg/m^3 Protection of the Environment Operations (Clean Air) Regulation 2010 Group 6 limit (Refer Section 5.1.2). However, as the emergency standby plant is anticipated to operate less than 200 hours per year, it is exempt from these limits under the Regulation.

d Based on emission factor for Cummins QSK95-G4 diesel fired generators (2560 kW).

5 Regulatory Framework

5.1 Relevant Legislation, Policy and Guidance

The following Air Quality Policy and Guidance documents have been referenced within this assessment and have been used to identify the relevant air quality criteria (see Section 6.2).

5.1.1 Protection of the Environment Operations (POEO) Act 1997 & Amendment Act 2011

The POEO Act (and Amendment Act 2011) is a key piece of environment protection legislation administered by the NSW Department of Planning, Industry and Environment's Environment, Energy and Science (EES) group which enables the Government to establish instruments for setting environmental standards, goals, protocols and guidelines.

The following sections of the POEO Act are of general relevance to the Project:

- Section 124 and 125 of the POEO Act states that any plant located at a premise (e.g. standby generators) should be maintained in an efficient condition and operated in a proper and efficient manner to reduce the potential for air pollution.
- Section 128 of the POEO Act states:
    1. The occupier of a premises must not carry out any activity or operate any plant in or on the premises in such a manner to cause or permit the emission at any point specified in or determined in accordance with the regulation of air impurities in excess of [the standard of concentration and/or the rate] prescribed by the regulations in respect of any such activity or any such plant.
    2. Where neither such a standard nor rate has been so prescribed, the occupier of any premises must carry on activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution.

Schedule 1 of the POEO, Scheduled Activities, defines those activities that require a licence for the premises for which the activity is carried out. Clause 17 *Electricity Generation* applies to electricity works (wind farms), general electricity works, metropolitan electricity works (gas turbines) and metropolitan electricity works (internal combustion engines). Clause 17 does not apply to the generation of electricity by means of electricity plant that is emergency stand-by plant operating for less than 200 hours per year. Given the total testing time of the stand by generators is less than 200 hours per year the proposal is not classified as a scheduled activity.

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

The POEO (Clean Air) Regulation 2010 (the Regulation) is the core regulatory instrument for air quality issues in NSW. In relation to industry, the Regulation:

- sets maximum limits on emissions from activities and plant for a number of substances
- deals with the transport and storage of volatile organic liquids
- restricts the use of high sulphur liquid fuel
- imposes operational requirements for certain afterburners, flares, vapour recovery units and other treatment plant.

Part 5 of the POEO (Clean Air) Regulation 2010 (the Regulation) also deals with emissions of air impurities from activities and plant, and sets maximum limits on emissions for a number of substances (including solid particles and visible smoke) as noted below in Table 7 and Table 8. The standards of concentrations prescribed by Part 5, Division 3 do not apply to plant during start-up and shutdown periods, however such emissions are still subject to the requirements of Section 128 (2) of the POEO Act in relation to the prevention and minimisation of air pollution.

Table 7 Schedule 6 Standards of Concentration for (Group C[1]) Non-Scheduled Premises

Air Impurity	Activity	Concentration [2]
Particles	Any activity/ plant	100 mg/m^3
Smoke	Solid fuel is burnt	Ringlemann 1 or 20% opacity
	Liquid fuel is burnt	Ringlemann 1 or 20% opacity

Note 1 Group C: Activity granted DA consent and commenced to operate after 1 September 2005.

Note 2 Reference conditions are: Dry, 273 K, 101.3 kPa for any activity.

Table 8 Schedule 4 Standards of Concentration for (Group 6[1]) Scheduled Premises

Air Impurity	Activity [2]	Concentration [3]
Solid Particles	Any activity/ plant	50 mg/m^3
NO_2 or NO or both, as NO_2 equivalent	Stationary reciprocating internal combustion engines	450 mg/m^3
VOCs as n-propane	Any stationary reciprocating internal combustion engine using a liquid fuel	1140 mg/m^3 VOCs or 5880 mg/m^3 CO
Smoke	An activity or plant in connection with which liquid or gaseous fuel is burnt	Ringlemann 1 or 20% opacity

Note 1 Group 6: Activity granted DA consent and commenced to operate after 1 September 2005.

Note 2 only concentration standards relevant to the operations at the Site have been listed.

Note 3 Reference conditions are: Dry, 273 K, 101.3 kPa for any activity.

The Regulation exempts emergency standby plant (comprising a stationary reciprocating internal combustion engine) for generating electricity from the air impurities standard for NO_2 and NO specified in Schedule 4 (see Table 8) relevant to that plant if the plant is used for a total of not more than 200 hours per year.

As outlined in Section 4.2, each generator (plant) is proposed to be operated for 12 hours per year for the purposes of testing. While generators will be required to operate for the purpose of electricity generation during major power interruptions. Such events would only occur very infrequently and for a limited time period. Therefore, it is anticipated that the plant would be required to operate for a total of less than 200 hours per year. As such the Project is exempt from the concentration limits outlined in Table 8.

5.1.3 NSW Environment Protection Authority Air Quality Policy and Guidance

The EPA is the NSW regulatory authority responsible for air quality regulation and associated activities.

The Approved Methods lists the statutory methods for modelling and assessing air pollutants from stationary sources and specifies criteria which reflect the environmental outcomes adopted by the EPA. The Approved Methods are referred to in the POEO (Clean Air) Regulation 2002 for assessment of impacts of air pollutants. The air quality criteria set out in the Approved Methods have been reproduced and discussed in Section 6.2.

5.1.4 Local Air Quality Toolkit

The Local Government Air Quality Toolkit (AQ Toolkit) has been developed by the EPA to assist local government in their management of air quality issues and provides guidelines for air quality management and for the use of air pollution control techniques. Relevant AQ Toolkit air quality guidance notes include:

- Dust from urban construction sites (NSW EPA, 2007-1)
- Construction sites (NSW EPA, 2007-2).

6 Relevant Pollutants and Air Quality Criteria

6.1 Pollutants of Concern

6.1.1 Construction

Potential air pollutants of interest for the construction of the Project are considered to be:

- Suspended particulate matter.
- Deposited dust.

Airborne contaminants that can be inhaled directly into the lungs can be classified on the basis of their physical properties as gases, vapours or particulate matter. In common usage, the terms "dust" and "particulates" are often used interchangeably. The health effects of particulate matter are strongly influenced by the size of the airborne particles. Smaller particles can penetrate further into the respiratory tract, with the smallest particles having a greater impact on human health as they penetrate to the gas exchange areas of the lungs. Larger particles primarily cause nuisance associated with coarse particles settling on surfaces and possessions (dust deposition), affecting visibility and contaminating tank water supplies. High rates of dust deposition can also adversely affect vegetation by blanketing leaf surfaces.

The term "particulate matter" refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm and is termed total suspended particulate (TSP). Epidemiological studies suggest a relationship between health impacts and exposure to concentrations of finer particulate matter, for example particulate matter with an aerodynamic diameter of 10 microns or less, which is referred to as PM_{10}. The PM_{10} size fraction is sufficiently small to penetrate the large airways of the lungs, while $PM_{2.5}$ (2.5 microns or less) particulates are generally small enough to be drawn in and deposited into the deepest portions of the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children. In an urban setting, the emission of $PM_{2.5}$ is primarily associated with vehicles exhausts resulting from the incomplete combustion of diesel. It is anticipated that the primary particle fraction associated with construction will be PM_{10}.

The key potential health and amenity issues associated with construction of Project are, respectively:

- Elevated PM_{10} concentrations
- Nuisance due to dust deposition and visible dust plumes.

6.1.2 Operation

Potential air pollutants of interest for the operation of the Project are considered to be emissions associated with the combustion of fuel in standby generators which include:

- carbon monoxide (CO)
- oxides of nitrogen (NO_x)
- PM_{10} and $PM_{2.5}$
- sulfur dioxide (SO_2)
- volatile organic compounds (VOCs)

- polycyclic aromatic hydrocarbons (PAHs).

CO is an odourless, colourless gas formed from the incomplete burning of fuels. It can be a common pollutant at the roadside and highest concentrations are typically found in the kerbside environments with concentrations decreasing rapidly with increasing distance from the road.

In atmospheric chemistry, NO_X generally refers to the total concentration of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a colourless and odourless gas that does not significantly affect human health. However, in the presence of oxygen, NO can be oxidised to NO_2 which can have significant health effects including damage to the respiratory tract and increased susceptibility to respiratory infections and asthma. NO will be converted to NO_2 after leaving the combustion source at a rate dependent on ambient and atmospheric conditions.

Sulfur in fuel converts to sulfur oxides during combustion, hence emissions of SO_2 are directly related to the concentration of sulfur in the fuel. Diesel contains more sulfur than gas, as there is negligible sulfur content in Australian natural gas and LPG.

VOCs have high vapour pressure at normal room-temperature conditions. Their high vapour pressure leads to evaporation from liquid or solid form and emission release to the atmosphere. VOCs are emitted by a variety of sources, including motor vehicles. VOCs that are often typical of these sources include benzene, toluene, ethylbenzene and xylenes (often referred to as 'BTEX'). Biogenic (natural) sources of VOC emissions are also significant (e.g. vegetation).

PAHs typically result from the incomplete combustion of organic material (such as coal, petrol, diesel, and wood). PAHs are toxic and carcinogenic, the degree to which is dependent on the type of PAH. PAHs typically occur in mixtures and it is therefore difficult to establish the risk that that the mixture may pose. The toxicity of a mixture of PAHs is therefore often expressed as a single number representing the equivalent concentration of the most toxic or carcinogenic congener, benzo(a)pyrene (B(a)P).

The rate and composition of air pollutant emissions from generators is a function of a number of factors, including the type and size of the generators, level of operation and fuel type.

Based on information provided to SLR, it is understood that the proposed backup generators will be Rolls Royce MTU 20V4000G94LF diesel fired generators. Refer to Appendix C for the specification sheet which includes details on the pollutant emission rates.

6.2 Ambient Air Quality Criteria

NSW EPA has established ground level air quality impact assessment criteria for air pollutants to achieve appropriate environmental outcomes and to minimise associated risks to human health as published in the Approved Methods. The criteria are the defining ambient air quality criteria for NSW, derived from a range of sources (including National Health and Medical Research Council (NHMRC), National Environment Protection Council (NEPC), World Health Organisation (WHO) and Australian and New Zealand Environment Conservation Council (ANZEEC)) and are considered appropriate for this AQIA.

It is noted that the criteria for PM_{10}, $PM_{2.5}$, CO, NO_2 and SO_2 are based on the ambient air quality standards set out in the National Environment Protection (Ambient Air Quality) Measure (the Air NEPM). On 15 April 2021, The National Environmental Protection Council agreed to vary the Air NEPM, and on 18 May 2021 the ambient air standards for NO_2 and SO_2 were amended. These changes to the standards for NO_2 and SO_2 include:

- NO_2:
  - The 1-hour standard for NO_2 in the Air NEPM is retained, however the numerical value of the standard has been reduced to 80 ppb (previously 120 ppb).
  - The annual standard for NO_2 in the Air NEPM is retained, however the numerical value of the standard has been reduced to 15 ppb (previously 30 ppb).
  - The form of both the 1-hour and annual NO_2 standards are as maximum values with no allowable exceedances.
- SO_2:
  - The 1-hour standard for SO_2 in the Air NEPM is retained, however the numerical value of the standard has been reduced to 100 ppb (previously 200 ppb).
  - A future 1-hour SO_2 standard of 75 ppb will be implemented from 2025.
  - The 24-hour standard for SO_2 in the Air NEPM will be retained, however the numerical value of the standard has been reduced to 20 ppb (previously 80 ppb).
  - No future target for 24-hour average SO_2 concentrations is proposed at this stage.
  - The current annual mean standard for SO_2 has been removed from the Air NEPM.
  - The form of both the revised 1-hour and 24-hour SO_2 standards are as maximum values with no allowable exceedances.

It is not yet known if or when the Approved Methods will be amended to reflect the recent changes to the Air NEPM and therefore this AQIA is based on the current ambient air quality criteria as published in the Approved Methods. The AQIA air quality criteria for the pollutants of concern during the operational phase of the Project, adopted from the Approved Methods, are provided in Table 9, referenced as mass concentrations.

Table 9 Project Air Quality Goals

Pollutant	Averaging Time	Criteria
PM_{10}	24 hours	50 µg/m³
	Annual	25 µg/m³
$PM_{2.5}$	24 hours	25 µg/m³
	Annual	8 µg/m³
Deposited dust	Annual	2 g/m²/month (maximum increase) 4 g/m²/month (maximum cumulative)
NO_2	1 hour	246 µg/m³
	Annual	62 µg/m³
CO	15 minutes	100 mg/m³
	1 hour	30 mg/m³
	8 hours	10 mg/m³
SO_2	10 minutes	712 µg/m³
	1 hour	570 µg/m³
	24 hours	228 µg/m³
	Annual	60 µg/m³

Pollutant	Averaging Time	Criteria
Toxic Pollutant	Averaging Time	Criteria (99.9th percentile)
Benzene	1 hour	0.029 mg/m^3
Toluene	1 hour	0.36 mg/m^3
Ethylbenzene	1 hour	8 mg/m^3
Xylene	1 hour	0.19 mg/m^3
PAHs (as benzo(a)pyrene	1 hour	0.0004 mg/m^3

In accordance with the Approved Methods, the impact assessment criteria are to be applied as follows:

- At the nearest existing or likely future off-site sensitive receptor.
- The incremental impact (predicted impacts due to the pollutant source alone) for each pollutant must be reported in units and averaging periods consistent with the impact assessment criteria.
- For individual toxic air pollutants, the incremental impact at and beyond the site boundary for each pollutant must be reported in concentration units consistent with the criteria (mg/m^3 or ppm), for an averaging period of 1 hour and as the 99.9th percentile of dispersion model predictions for Level 2 impact assessments.
- Background concentrations must be included using the procedures specified in Section 5 of the Approved Methods.
- Total cumulative impact (incremental impact plus background) must be reported as the 100th percentile (P=100) (or 99th percentile (P=99) for odour) in concentration or deposition units consistent with the impact assessment criteria and compared with the relevant impact assessment criteria.

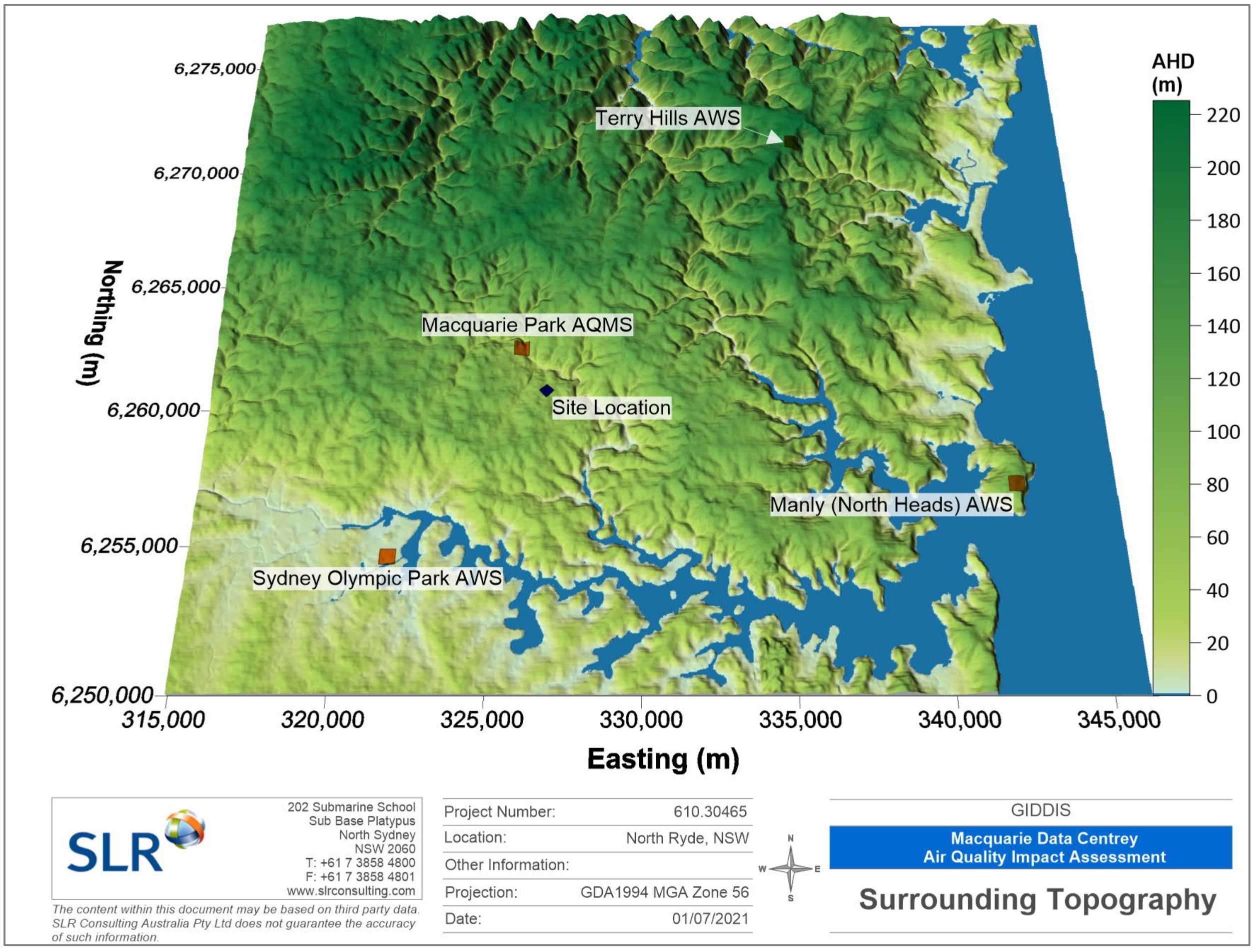
7 Existing Environment

7.1 Topography

Topography is important in air quality studies as local atmospheric dispersion can be influenced by terrain effects such as night-time katabatic (downhill) drainage flows from elevated terrain, channelling effects in valleys or gullies or plume interception at higher ground.

A three-dimensional representation of the area surrounding the Site is given in Figure 3. The topography of the local area generally ranges from an approximate elevation of 0 metres (m) to 220 m Australian Height Datum (AHD) with the area immediately surrounding the Site comprising of undulating terrain. The topography of the Site itself is relatively flat, gently sloping from the south to north.

Figure 3 Local Topographical Features



7.2 Land Use and Sensitive Receptors

The Site is zoned as B7 Business Park land (Ryde Local Environment Plan, 2014) as is the land immediately to the west, north and east (Figure 4). The land to the south is zoned B4 Commercial Core.

Based on available aerial images, SLR has identified nine representative sensitive receptors surrounding the Site. The nearest receptors consist of childcare centres located in Business Park areas, approximately 120 m and 170 m to the northeast and northwest of the Site respectively. Additionally, residential receptors have also been identified in areas zoned as High Density Residential approximately 310 m to the northeast of the Site, including 8-storey apartments approximately 400 m east of the Site. Locations of all identified receptors are provided in Table 10 and illustrated in Figure 5.

Figure 4 Planning Zones

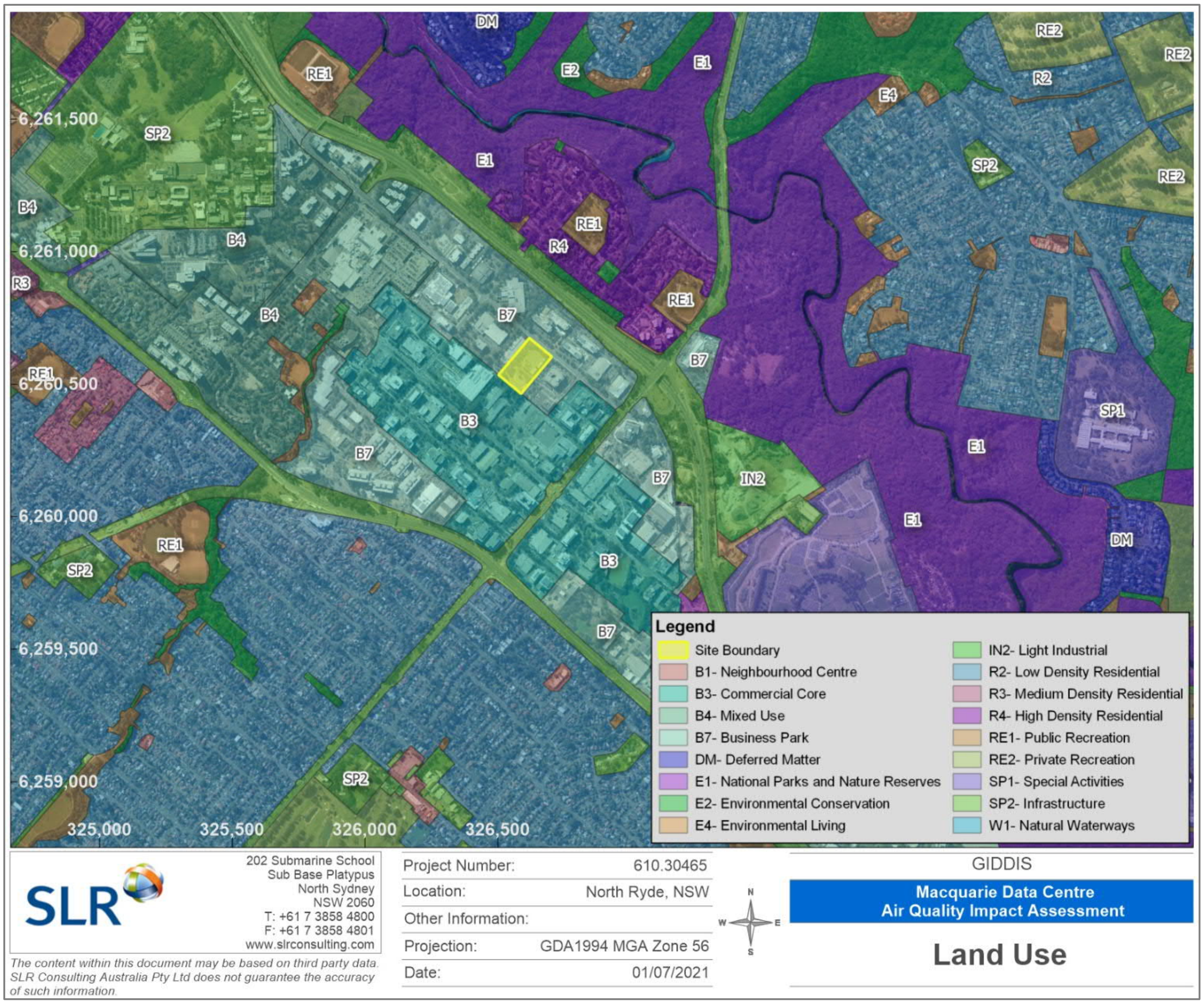
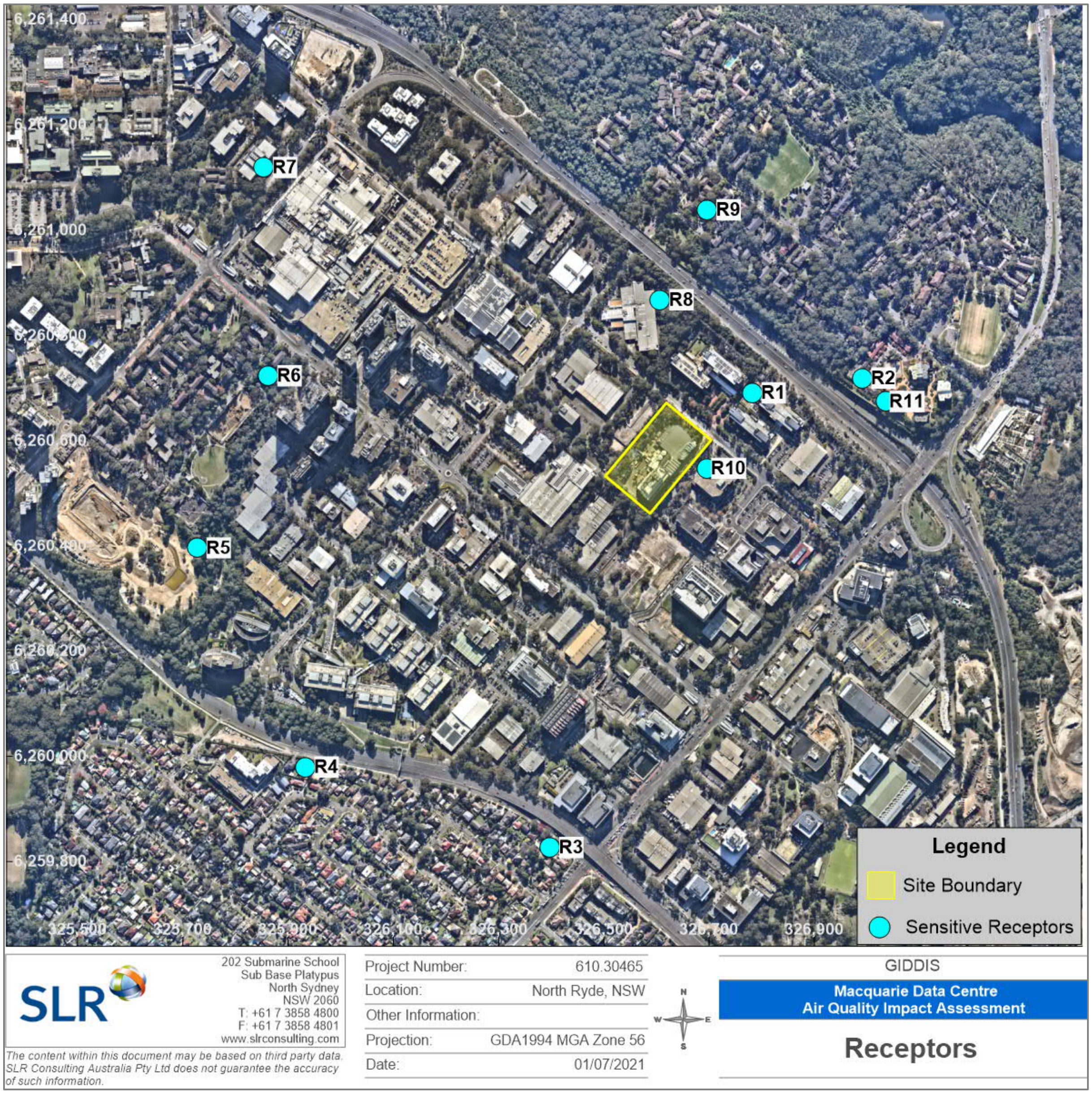


Table 10 Location of the Identified Sensitive Receptors

ID	Easting (m)	Northing (m)	Elevation ABGL (m)	Description	Approx. Distance from Source (m)
R_1	326781.44	6260691.2	0	Child care centre (outdoor area)	200
R_2	326990.23	6260719.08	0	Residence	400
R_3	326397.2	6259826.78	0	Residence	800
R_4	325932.06	6259979.75	0	Residence	900
R_5	325727.23	6260396.4	0	Residence	900
R_6	325861.53	6260723.61	0	Residence	750
R_7	325853.24	6261119	0	Residence	950
R_8	326606.49	6260867.77	0	Child care centre (outdoor area)	300
R_9	326695.88	6261038.63	0	Residence	500
R_10	326696.02	6260547.94	25	15 Talavera Rood Air Intakes	50
R_11-0	327034.98	6260674.77	0	Residence Ground Floor	450
R_11-1	327034.98	6260674.77	3	Residence 1st Floor	450
R_11-2	327034.98	6260674.77	6	Residence 2nd Floor	450
R_11-3	327034.98	6260674.77	9	Residence 3rd Floor	450
R_11-4	327034.98	6260674.77	12	Residence 4th Floor	450
R_11-5	327034.98	6260674.77	15	Residence 5th Floor	450
R_11-6	327034.98	6260674.77	18	Residence 6th Floor	450
R_11-7	327034.98	6260674.77	21	Residence 7th Floor	450

ABGL Above ground level

Figure 5 Surrounding Sensitive Receptors



7.3 Local Meteorology

The Bureau of Meteorology (BoM) maintains and publishes data from weather stations across Australia. The closest such station recording long term wind speed and wind direction data is the Sydney Olympic Park (Archery Centre) Automatic Weather Station (SOP AWS) (Station ID 66212), located approximately 8 kilometres (km) southwest of the Site. It is noted that considering the terrain between the Site and SOP AWS, wind conditions at the Site may be slightly different from those recorded at the AWS.

Wind

Local wind speed and direction influence the dispersion of air pollutants. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of 'plume' stretching. Wind direction, and the variability in wind direction, determines the general path pollutants will follow and the extent of crosswind spreading. Surface roughness (characterised by features such as the topography of the land and the presence of buildings, structures and trees) will also influence dispersion.

Annual and seasonal wind roses for the past five years, 2016 to 2020, compiled from data recorded by the SOP AWS are presented in Figure 6. Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from North). 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. Thus, it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

The annual wind rose indicates the predominant wind directions in the area are from the west-northwest and northwest. Calm wind conditions (wind speed less than 0.5 m/s) were predicted to occur 10.4% of the time throughout the investigated period. The average seasonal wind roses for the year 2016-2020 indicate that:

- In summer, winds are mostly gentle (between 3.0 m/s and 5.5 m/s) and blow predominantly from the southeast quadrant, with very few winds from other directions. Calms were predicted to occur 8.1% of the time during the summer months.
- In autumn and spring, winds are light to moderate (between 0.5 m/s and 8 m/s) blowing predominantly from the northwest and southeast quadrants , with lower frequency of winds from the southeast quadrant in autumn and a higher frequency of winds from the northwest quadrant in spring. Calms were predicted to occur 11.8% of the time during autumn and 9.3% of the time during the spring months.
- In winter, winds are mostly light to gentle (between 0.5 m/s and 5.5 m/s) and blow predominantly from the west-northwest and northwest directions, with very few winds blowing from the northeast and southeast quadrants. Calms were predicted to occur 12.5% of the time during the winter months.

As identified in Section 7.2, the closest existing sensitive receptors are located to the northeast and north of the Site. Winds from between the west-southwest and south-southeast directions, which would blow air emissions from the Site towards the closest receptors, occur approximately 22% of the time.

It is noted that given the topographical features between the Site and SOP AWS (see Figure 3), the actual winds experienced at the Site may be different to those recorded by the AWS.

Wind erosion of dust from exposed surfaces is usually initiated when wind speeds exceed the threshold friction velocity for a given surface or material, however a general rule of thumb is that wind erosion can be expected to occur above 5 m/s. The frequency of wind speeds for the period of 2016-2020 is presented in Figure 7. The plot shows that the frequency of wind speeds exceeding 5 m/s for the period 2016-2020 at SOP AWS was approximately 9%.

Figure 6 Average Annual and Seasonal Wind Roses for Sydney Olympic Park AWS – 2016-2020

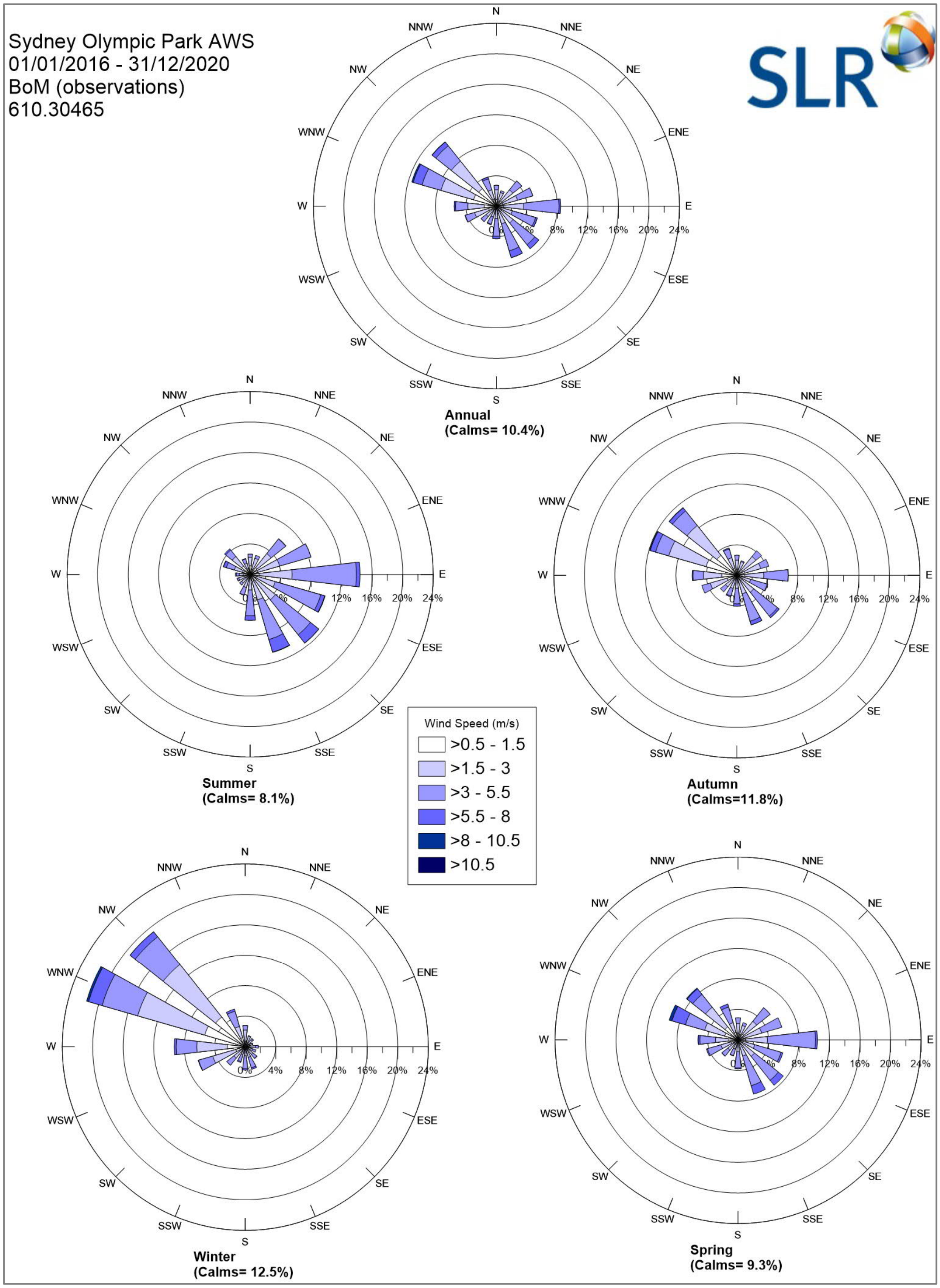
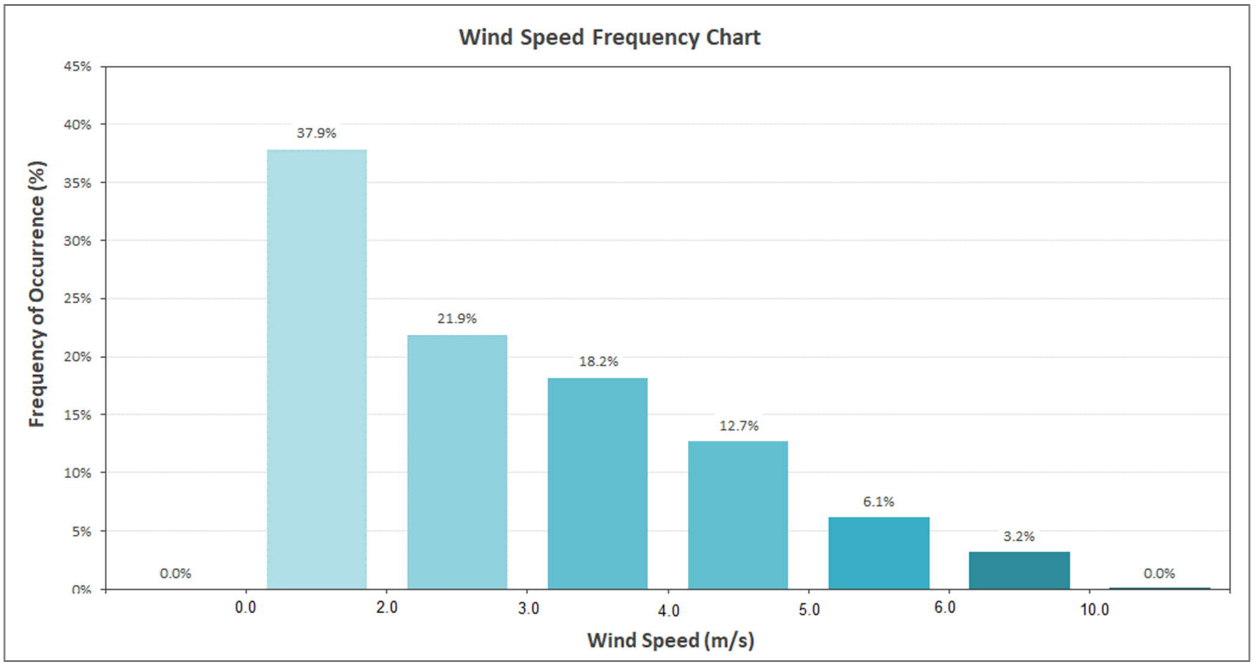


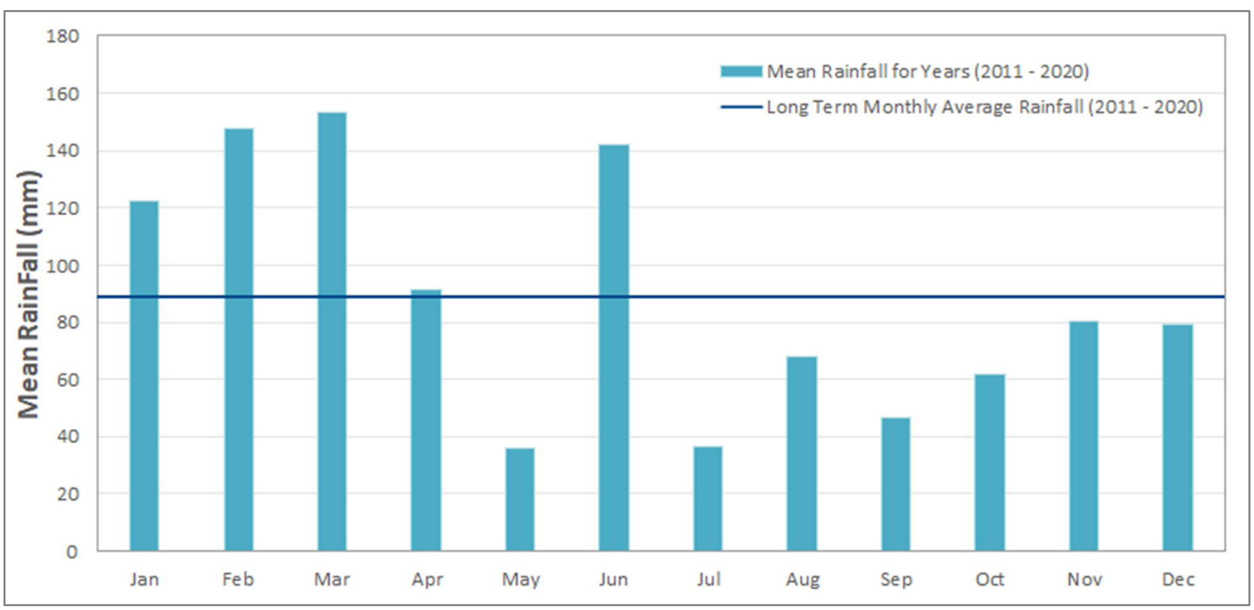
Figure 7 Wind Speed Frequency Chart for Sydney Olympic Park AWS – 2016-2020



Rainfall

Dry periods (no rainfall) have a greater risk of generating fugitive dust emissions during construction as moisture binds dust particles together. The long-term monthly rainfall averages recorded by the SOP AWS rain gauge are shown in Figure 8. Generally, rainfall is lowest in the mid-winter to mid spring period.

Figure 8 Long term Mean Rainfall for Sydney Olympic Park AWS – 2011-2020



7.4 Background Air Quality

Air quality monitoring is performed by the NSW EES at a number of monitoring stations across NSW. The closest such station is the Macquarie Park AQMS, located approximately 1.8 km northwest of the Site.

The Macquarie Park AQMS was commissioned in 2017 and is located at Macquarie University Sport Fields, Culloden Road in close proximity to vehicle activity along the M2 Motorway. It is situated at an elevation of 49 m. SLR considers air quality data from this station to be a reasonable representation of air quality conditions experienced at the Site (due to surrounding land use). The air pollutants currently measured by the Macquarie Park AQMS include:

- NO, NO_2 & NO_X
- PM_{10}
- $PM_{2.5}$
- O_3

Air quality monitoring data recorded by the Macquarie Park AQMS were obtained for the modelling year of 2018 (refer Section 8.2.2.1 for selection of representative year) and are summarised in Table 11. To be consistent with the NSW EES monitoring reports, the data for gaseous pollutants are presented in parts per hundred million (pphm) or parts per million (ppm), rather than µg/m^3 and mg/m^3 as used in Section 6.

A review of the data shows that exceedances of the 24-hour average PM_{10} criterion and 24-hour average $PM_{2.5}$ criterion were recorded by the Macquarie Park AQMS in 2018.

A review of the recorded exceedances during the calendar year of 2018 (NSW OEH, 2019) indicates that they were due to natural events such as bushfires or dust storms, or hazard reduction burns.

No exceedances of the annual average PM_{10} criterion and annual average $PM_{2.5}$ criterion were recorded by the Macquarie Park AQMS in 2018.

Ambient concentrations of SO_2, NO_2 and CO were below all relevant criteria for 2018.

Table 11 Summary of Macquarie Park AQMS Data (2018)

Pollutant	Averaging Period	Criteria	Macquarie Park AQMS		Units
			Maximum Concentration	Number of Exceedances	
SO_2	1-hour	20 pphm	4.4	0	pphm
	24-hour	8 pphm	0.7	0	pphm
	Annual	2 pphm	0.1	0	pphm
NO_2	1-hour	12 pphm	3.0	0	pphm
	Annual	3 pphm	0.6	0	pphm
CO	1-hour	25 ppm	4.4	0	ppm
	8-hour	9 ppm	2.5	0	ppm
PM_{10}	24-hour	50 µg/m³	85.6	4	µg/m³
	Annual	25 µg/m³	17.2	0	µg/m³
$PM_{2.5}$	24-hour	25 µg/m³	58.4	4	µg/m³
	Annual	8 µg/m³	7.0	0	µg/m³

Red fonts indicate exceedances of relevant criterion

8 Assessment Methodology

8.1 Construction Phase Qualitative Impact Assessment

Quantitatively assessing impacts of fugitive dust emissions from construction projects using predictive modelling is seldom considered appropriate, primarily due to the uncertainty in the details of the construction activities, including equipment type, number, location and scheduling, which are unlikely to be available at the time of the assessment. Furthermore, they are also likely to change as construction progresses.

Instead, it is considered appropriate to conduct a qualitative assessment of potential construction related air quality impacts. Potential impacts of dust emissions associated with proposed demolition and construction activities at the Site has been performed based on the methodology outlined in the Institute of Air Quality Management (UK) (IAQM) document, "*Assessment of dust from demolition and construction*" (Holman et al 2014). This guidance document provides a structured approach for classifying construction sites according to the risk of air quality impacts, to identify relevant mitigation measures appropriate to the risk (see Appendix A for full methodology).

The IAQM approach has been used widely in Australia for the assessment of air quality impacts from construction projects and the identification of appropriate mitigation measures and has been accepted by regulators across all states and territories for a variety of construction projects.

The IAQM method uses a four-step process for assessing dust impacts from construction activities:

- Step 1: Screening based on distance to the nearest sensitive receptor; whereby the sensitivity to dust deposition and human health impacts of the identified sensitive receptors is determined.
- Step 2: Assess risk of dust effects from activities based on:
    - the scale and nature of the works, which determines the potential dust emission magnitude; and
    - the sensitivity of the area surrounding dust-generating activities.
- Step 3: Determine site-specific mitigation for remaining activities with greater than negligible effects.
- Step 4: Assess significance of remaining activities after management measures have been considered.

It is noted that that accurate information regarding construction activities and equipment are not available at this stage, hence SLR has made conservative assumptions where necessary to assess impacts from construction activities. If these parameters were to be significantly modified, re-assessment of construction impacts is recommended.

8.2 Operational Phase Dispersion Modelling Study

The assessment of air emissions from the operational phase of the Project has been performed quantitatively through the use of dispersion modelling techniques.

8.2.1 Selection of Models

Emissions from the proposed quarry were modelled using a combination of the WRF, CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects "puffs" of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain hourly concentration evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

8.2.2 Meteorological Modelling

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke, 2002).

For this study, a site-representative three-dimensional meteorological dataset was compiled using a combination of the WRF and CALMET models, as discussed in the following sections.

8.2.2.1 Selection of Worst-Case Year

Meteorological data recorded over the five-year period 2016-2020 by the Sydney Olympic Dam AWS was analysed to select a worst-case meteorological year in order to provide a conservative air quality impact assessment. An analysis of the wind speed, wind direction, temperature and relative humidity recorded in each of the calendar years aligned well with the five-year average data with no particular years of note, however the year 2018 reported the worst-case combination of low average wind speed and greater number of calms, which generally results in reduced plume dispersion and consequently greater ground level impacts. For this reason, 2018 was chosen for the AQIA.

8.2.2.2 WRF

The Weather Research and Forecast (WRF) model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting needs. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometres.

For this assessment, the WRF modelling system was used to produce the meteorological field required to provide the 'initial guess' field for the CALMET meteorological model for a period of one year (1 January 2018 to 31 December 2018). Parameters used in the WRF model for this assessment are presented in Table 12.

Table 12 Meteorological Parameters – WRF

Parameter	Domain 1	Domain 2	Domain 3	Domain 4
Modelling domain (km)	1,890 x 1,890	171 x 171	66 x 66	22 x 22
Grid resolution (km)	27	9	3	1
Number of vertical levels	30	30	30	30
Parent Domain	-	1	2	3
Microphysics	WSM6	WSM6	WSM6	WSM6
Cumulus parametrization	Kain-Fritsch	Kain-Fritsch	Kain-Fritsch	Kain-Fritsch
Shortwave radiation physics	Dudhia	Dudhia	Dudhia	Dudhia
Longwave radiation physics	RRTM	RRTM	RRTM	RRTM
Planetary boundary layer	YSU	YSU	YSU	YSU

8.2.2.3 CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly-varying wind field thus reflects the influences of local topography and land uses.

The CALMET model was run for a 4 km by 4 km domain with a 30 m grid resolution. WRF-generated three-dimensional meteorological data were used as the ‘initial-guess’ wind field. Local topography and land use information were used to refine the wind field predetermined by the WRF output.

Any observed meteorological data required to refine the meteorological model predictions were not available at the Site or surrounding areas. Given this, both WRF and CALMET models were run in no observation mode to generate the three-dimensional representative meteorological dataset for the site and surrounding areas.

Table 13 details the parameters used in the meteorological modelling to drive the CALMET model.

Table 13 Meteorological Modelling Parameters - CALMET

Parameter	Data
Modelling period	1st January 2018 to 31st December 2018
Meteorological grid resolution	30 m
Initial guess filed	WRF output
Vertical resolution (cell heights)	10 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m)
Data assimilation	None

8.2.2.4 Site Representative Meteorological Data

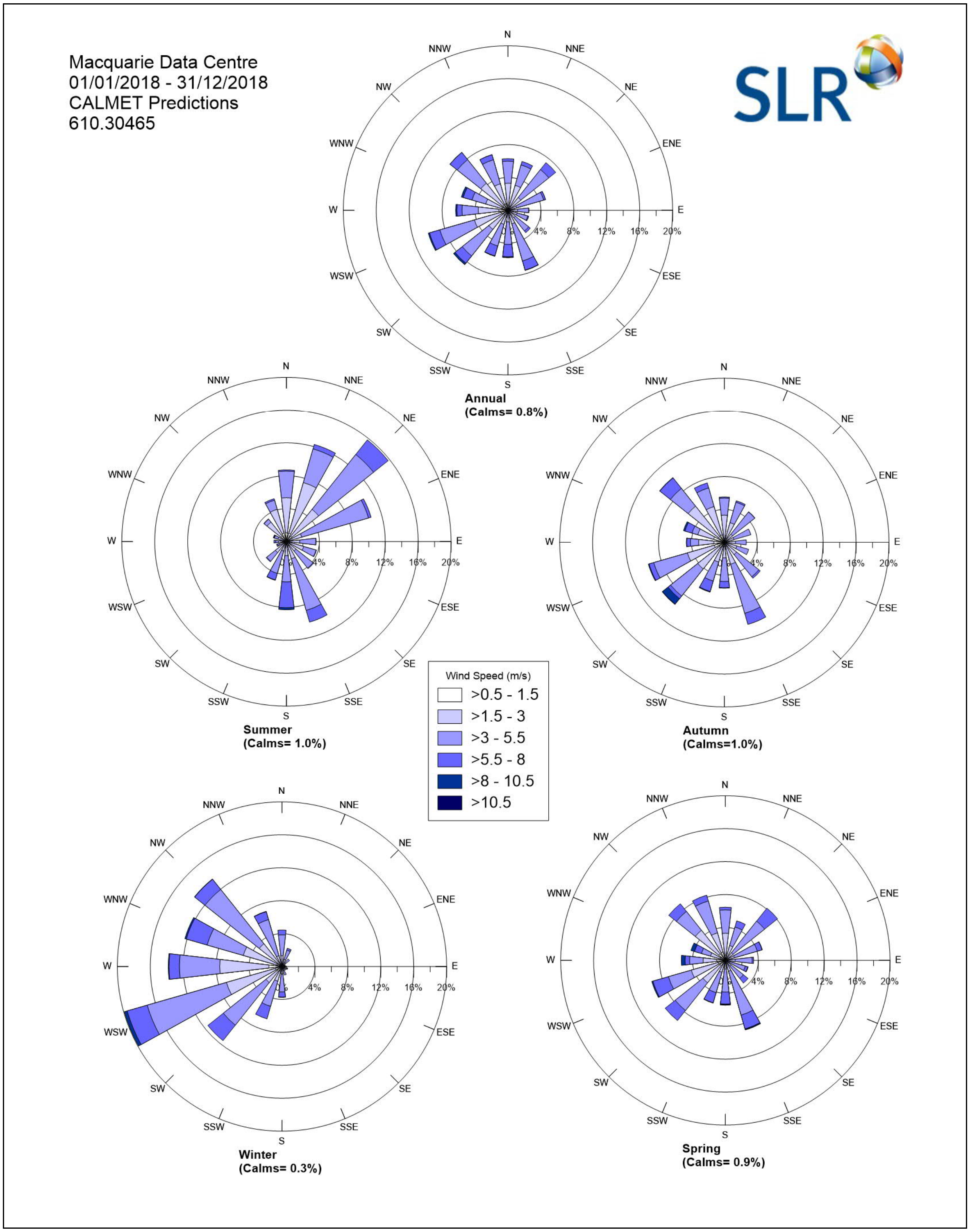
This section presents a summary of the key meteorological conditions predicted by CALMET at the Site.

8.2.2.4.1 Wind Speed and Direction

A summary of the annual wind behaviour predicted by WRF/CALMET for the Site is presented in Figure 9. Based on the model predictions, the site experienced light to strong winds (between 1.5 m/s and 13.6 m/s), from all directions but with fewer winds from the east-southeastern quadrant. There are few calm wind conditions (wind speeds less than 0.5 m/s), predicted to occur approximately 0.8% of the time.

The seasonal wind roses indicate that in summer and autumn, winds from the eastern quadrant are predominant, with summer experiencing more southeasterlies and autumn more northeasterlies. Winter sees a strong predominance from the north while spring sees a more even spread from all directions.

Figure 9 Wind Roses for the Site, as Predicted by WRF/CALMET



8.2.2.5 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in Table 14.

Table 14 Meteorological Conditions Defining PGT Stability Classes

Surface wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

Notes:

Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.

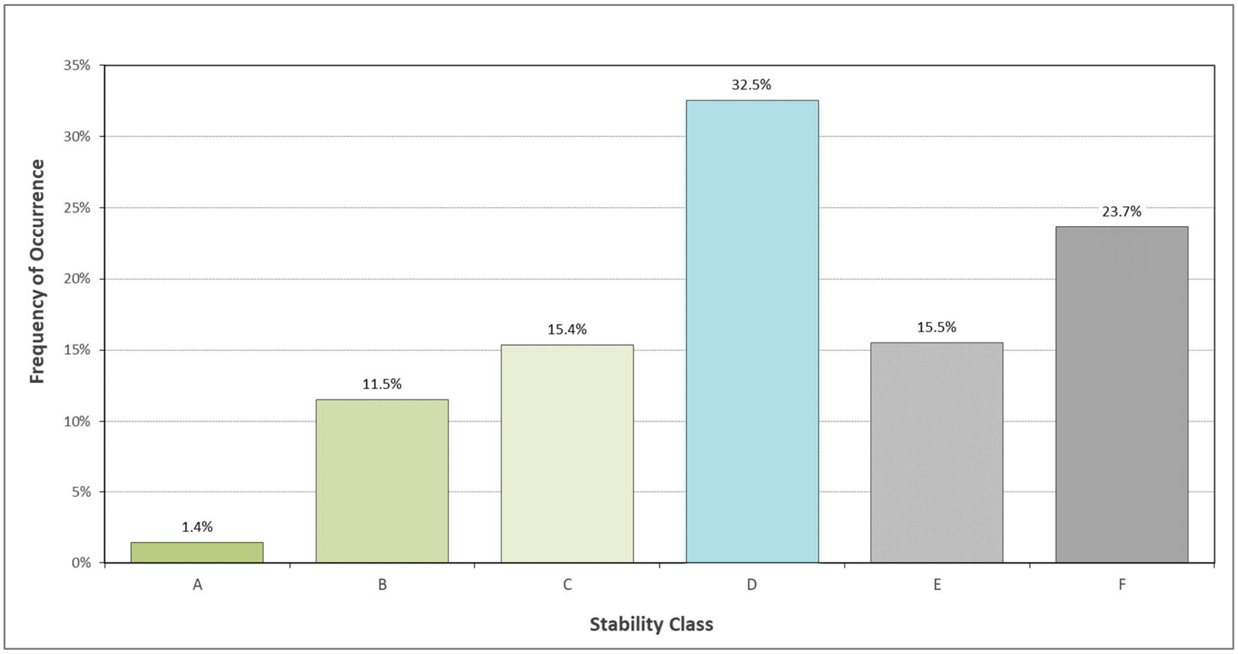
Night refers to the period from 1 hour before sunset to 1 hour after sunrise.

The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

Source: NOAA, 2018.

The predicted frequency of each stability class at the Site during 2018 is presented in Figure 10. The results indicate a high frequency of conditions typical to Stability Class D (Neutral), with a low frequency of very unstable conditions (Stability Class A). Stable conditions (Stability Classes E and F) also occur relatively frequently. Stable conditions occur during the night-time, under low wind speed conditions, which inhibit pollutant dispersion.

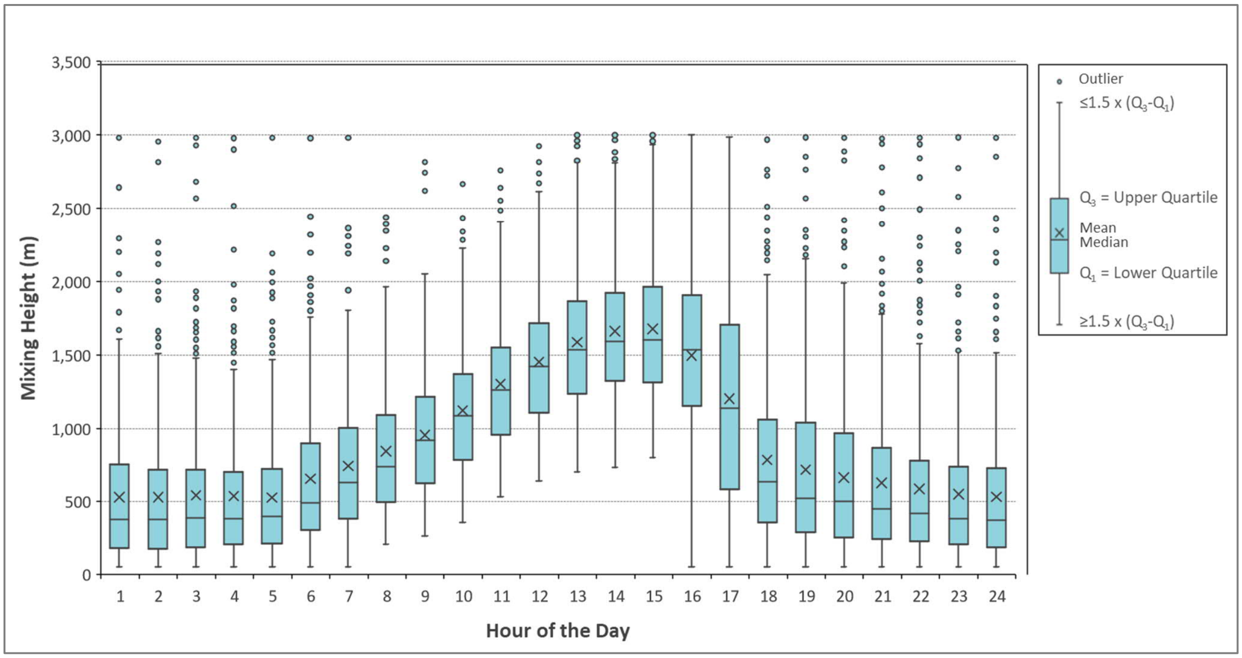
Figure 10 Stability Class Distribution Predicted by CALMET for the Site



8.2.2.6 Mixing Heights

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Site are illustrated in Figure 11. As would be expected, an increase in the mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

Figure 11 Mixing Heights Predicted by CALMET for the Site



8.3 Additional Model Parameters and Options

A summary of additional CALPUFF modelling options and parameters used for the assessment is provided in Table 15.

Table 15 Model Parameters

Parameter	Option
Calculation Type	Concentration
Plume Rise Method	Briggs
Building Downwash	BPIP-PRIME
Gridded Receptors	Cartesian 2 km x 2 km; 30 m spacing; 0 m AGL centred on Site
Discrete Receptors	Refer Section 7.2

AGL Above ground level

8.3.1.1 Background Pollutant Concentrations

Hourly varying air quality data recorded by the Macquarie Park AQMS during the modelling period were used for the contemporaneous analysis of cumulative ground level concentrations.

It is noted that in circumstances where the existing ambient air pollutant concentrations exceed the impact assessment criteria, the Approved Methods requires the AQIA to demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity.

8.3.1.2 Building Downwash

Building downwash is a phenomenon caused by structures near to pollutant emission sources influencing atmospheric turbulence. Airflow is rapidly mixed to the ground as frictional forces and pressure gradients cause stagnations and eddies to develop in the wake of buildings downwind of elevated sources.

The USEPA has established a Good Engineering Practice (GEP) stack height which is defined as the 'height necessary to ensure that emissions from the stack do not result in excessive concentrations of any air pollutants in the immediate vicinity of the source as a result of atmospheric downwash, eddies or wakes which may be created by the source itself, nearby structures or nearby terrain obstacles' (USEPA, 1985). The definition of GEP stack height is the building height plus 1.5 times the lesser of the building height or projected building width.

A stack is considered to be wake affected when the stack and building are located less than five times the lesser of the building height or project building width apart.

CALPUFF contains the *Prime* algorithm which was used to predict building downwash effects. Influencing building dimensions were calculated using the USEPA's Building Profile Input Program (BPIP).

For modelling purposes, proposed site buildings as well as enclosures for the proposed generators were included in the modelling to account for the potential the building wakes. Table 16 provides the buildings heights as input into the model, the relative locations of which are illustrated in Figure 13.

Table 16 Buildings Included in Model

ID	Height (m)
BLD_1 (IC2)	12.9
BLD_2 (IC3E and IC3W)	43.8
BLD_3	26
BLD_4	29
BLD_5	25
BLD_6	33
BLD_7	33
BLD_8	9.6
BLD_9	17.8
BLD_10	19.2
BLD_11	16
BLD_12	17.7

8.3.2 NO_x to NO_2 conversion

NO_x emitted from combustion processes mainly consist of NO with a small portion (approximately 10%) of NO_2. In the atmosphere however, NO emitted from the source oxidises to NO_2 in the presence of ozone (O_3) and sunlight as it travels further from the source. The rate of oxidation depends on a number of parameters including the ambient O_3 concentration. The Approved Methods lists the following methods that can be applied to take account the oxidation of NO to NO_2 in estimating downwind NO_2 concentrations at receptor locations.

Method 1 – 100% Conversion

This method is usually used as a screening level assessment and assumes 100% conversion of NO to NO_2 before the plume arrives at the receptor location. Use of this method can significantly over-predict NO_2 concentrations at nearfield receptors. Given the close proximity of sensitive receptors to the Site the use of Method 1 (100% conversion) is not appropriate.

Method 2 – Ambient Ozone Limiting Method (OLM)

This method assumes that all the available ozone in the atmosphere will react with NO in the plume until either all the O_3 or all the NO is used up. NO_2 concentrations can be estimated by this method using the following equation:

$[NO_2]_{total} = \{0.1 \times [NO_x]_{pred}\} + MIN\{(0.9) \times [NO_x]_{pred}$ or $(46/48) \times [O3]_{bkgd}\} + [NO_2]_{bkgd}$

Again, given the close proximity of sensitive receptors with short transport and duration periods from the Site, Method 2 could be deemed overly conservative as it assumes that the atmospheric reaction is instantaneous when in reality, the reaction takes place over a number of hours (NSW EPA, 2017).

Method 3 – NO to NO_2 conversion using empirical relationship

An empirical equation for estimating the oxidation rate of NO in power plant plumes dependent on distance downwind from the source and the parameters A and α and has the following form:

$$NO_2 = NO_x \times A(1 - e^{-\alpha x})$$

where *x* is the distance from the source and A and α are classified according to the O_3 concentration, wind speed and season (Janssen, van Wakeren, van Duuran, & Elshout, 1988) as provided in Table 17.

Table 17 Classification of Values for A and **α** by Season

Season	Ozone (ppb)	Wind Speed (m/s)		
		5	15	>15
Winter	40	A = 0.87 α = 0.07	A = 0.87 α = 0.07	A = 0.87 α = 0.15
	30	A = 0.82 α = 0.07	A = 0.83 α = 0.07	A = 0.83 α = 0.07
	20	A = 0.74 α = 0.07	A = 0.74 α = 0.07	A = 0.74 α = 0.07
	10	A = 0.49 α = 0.05	A = 0.49 α = 0.05	A = 0.49 α = 0.05
Spring/Autumn	60	A = 0.85 α = 0.10	A = 0.85 α = 0.15	A = 0.85 α = 0.30
	40	A = 0.80 α = 0.10	A = 0.80 α = 0.10	A = 0.80 α = 0.25
	30	A = 0.74 α = 0.10	A = 0.74 α = 0.10	A = 0.74 α = 0.15

Season	Ozone (ppb)	Wind Speed (m/s)		
		5	15	>15
	20	A = 0.635 α = 0.10	A = 0.635 α = 0.10	A = 0.635 α = 0.10
Summer	200	A = 0.93 α = 0.40	A = 0.93 α = 0.65	A = 0.93 α = 0.80
	120	A = 0.88 α = 0.20	A = 0.88 α = 0.35	A = 0.88 α = 0.45
	60	A = 0.81 α = 0.15	A = 0.81 α = 0.25	A = 0.81 α = 0.35
	40	A = 0.74 α = 0.10	A = 0.74 α = 0.15	A = 0.74 α = 0.25
	30	A = 0.67 α = 0.10	A = 0.67 α = 0.10	A = 0.67 α = 0.10

This assessment employs Method 3, adopting O_3 data from the Macquarie Park AQMS, presented in Figure 12 and summarised Table 18, to estimate the incremental and cumulative NO_2 impacts at nearby sensitive receptors as a result of the Project emissions. Additional conservatism is realised by using predicted hourly ground-level windspeeds (Section 8.2.2.4.1), rather than those predicted at the emission height (between 18 and 45 m above ground level) where windspeeds would be generally be greater.

Figure 12 Macquarie Park AQMS O_3 1-Hour Average Concentrations (2018)

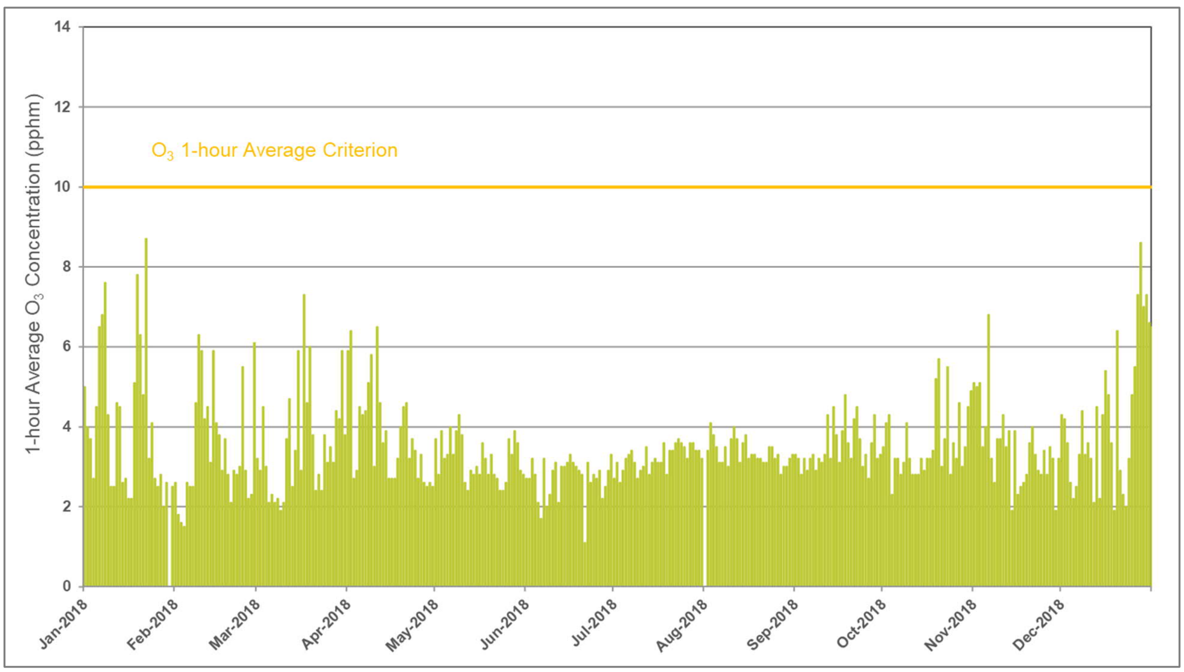


Table 18 O_3 Concentration Summary: Macquarie Park AQMS (2018)

Pollutant	Averaging Period	Units	Maximum Concentration	Criteria
O_3	1-hour	pphm	8.7	10
		µg/m³	171	196

8.3.3 SO_2

In the absence of SO_2 emission rates provided in the Rolls Royce MTU engine specifications (Appendix C), emission rates are adopted from the specification sheet for the Cummins QSK95-G4, a similar sized generator used for standby power generation (also provided in Appendix C). The Cummins QSK95-G4 SO_2 emission factor of 0.004 grams per break horsepower-hour (g/bhp-hr) is equal to 0.0054 grams per kilowatt-hour (g/kW-hr).

8.3.4 PAHs as Benzo(a)Pyrene

The Approved Methods requires that all PAHs be assessed as benzo(a)pyrene toxic equivalency quotient (B(a)PTEQ) using the potency equivalency factors (PEFs) provided in Table 19. The emission of PAHs as B(a)PTEQ is equal to the sum of the individual PAH emission factors multiplied by their PEFs:

$$EF_{B(a)PTEQ} = \sum_{i=1}^{n} EF_i \times PEF_i$$

Table 19 Approved Methods Potency Equivalency Factors for PAHs

PAH or Derivative	CAS Number	PEF
Benzo[a]pyrene	50-32-8	1
Benzo[a]anthracene	56-55-3	0.1
Benzo[b]fluoranthene	205-99-2	0.1
Benzo[j]fluoranthene	205-82-3	0.1
Benzo[k]fluoranthene	207-08-9	0.1
Bibenz[a,j]acridine	224-42-0	0.1
Bibenz[a,h]acridine	226-36-8	0.1
7h-dibenzo[c,g]carbazole	194-59-2	1
Dibenzo[a,e]pyrene	192-65-4	1
Dibenzo[a,h]pyrene	189-64-0	10
Dibenzo[a,i]pyrene	189-55-9	10
Dibenzo[a,l]pyrene	191-30-0	10
5-nitroacenaphthene	602-87-9	0.01
Indeno[1,2,3-cd]pyrene	193-39-5	0.1
5-methylchrysene	3697-24-3	1
1-nitropyrene	5522-43-0	0.1
4-nitropyrene	57835-92-4	0.1
1,6-dinitropyrene	42397-64-8	10
1,8-dinitropyrene	42397-65-9	1

PAH or Derivative	CAS Number	PEF
6-nitrocrysene	08-02-7496	10
2-nitrofluorene	607-57-8	0.01
Chrysene	218-01-9	0.01
Dibenz[a,h]anthracene	53-70-3	0.4
7,12-dimethylbenzanthracene	57-97-6	21.8
3-methylcholanthrene	56-49-5	1.9

In the absence of PAH emission rates provided in the engine specifications (Appendix C), emission rates are calculated from emission factors adopted from USEPA "*AP42: Compilation of Air Emission Factors, 3.3 Gasoline and Diesel Industrial Engines"* (USEPA, 2006 and Updates). Table 3.3-2 "Speciated Organic Compound Emission Factors for Diesel Engines" provides emission factors as a function of diesel fuel input for 16 PAHs. These are presented in Table 20 along with their PEFs, where provided, and the resultant PAH as B(a)PTEQ emission factor.

Table 20 PAH (as Benzo(a)pyrene) Emission Factor

PAH	AP42 Emission Factor (mg/MJ)	PEF ^
Benzo(a)anthracene	72.2	0.1
Chrysene	1.5	0.01
Benzo(b)fluoranthene	4.3	0.1
Benzo(k)fluoranthene	6.7	0.1
Benzo(a)pyrene	80.8	1
Indeno(1,2,3-cd)pyrene	16.1	0.1
Dibenz(a,h)anthracene	100.3	0.4
PAH as B(a)PTEQ	281.9	

^ Approved Methods Table 7.2c.

8.3.5 Conversion of Averaging Times

For pollutants with short-term (sub-hourly) air quality impact assessment criteria, in the absence of specific guidance in the Approved methods, the short term impacts have been estimated using the formula cited in the *Guidance notes for using the regulatory air pollution model AERMOD in Victoria* (EPAV, 2013) as follows:

$$C_t = C(t_0) \times ({}^{t_0}/_{t})^{0.2}$$

Where

C_t = concentration for the longer time-averaging period

C_0 = concentration for the shorter time-averaging period

t_0 = longer averaging time

t = shorter averaging time

8.3.6 Source Characteristics and Emission Rates

CALPUFF requires a range of inputs to describe the emissions to air as a result of the proposed activities.

Potential air emissions and relevant stack parameters for the generator stack were estimated based on the diesel engine technical specifications. Table 21 provides a summary of stack parameters and emission rates for each of the proposed generators. SLR understands that the generators will be operating in 'Full Continuous' mode during testing. Refer to Appendix C for the generator set specifications sheet and Appendix D for the general arrangement of the generators. The generator exhausts will be oriented vertically.

Table 21 Stack Parameters and Emission Rates – Proposed Generators

Parameter	Data	Unit	Reference/Base
Temperature	754	K	Calculated from engine specifications (Refer Appendix C)
Release height	45.1	m	Client drawings
Exhaust gas velocity	40.7	m/s	Calculated from engine specifications (Refer Appendix C)
Stack diameter	0.60	m	Client drawings
Stack orientation	Vertical	-	Client drawings
NO_x emission rate	8.9	g/s	Engine specifications (Refer Appendix C)
CO emission rate	0.48	g/s	
PM emission rate	0.021	g/s	
SO_2 emission rate	0.0049	g/s	In absence of data, based on Cummins QSK95-G4 engine specifications (Refer Appendix C), scaled for power output.
PAH (as B(a)P) emission rate	2.1×10^{-6}	g/s	Calculated using engine specifications (Full Continuous fuel consumption rate; Refer Appendix C) and AP42 3.3 PAH emission factors for uncontrolled diesel engines.

The generator set specifications sheet includes emission rates of the pollutants of concern with the exception of VOC. It is noted that VOC emissions from the combustion of diesel are low relative to their assessment criteria when compared with other products of combustion. Therefore, if no exceedances of other combustion gas criteria are predicted, it is considered appropriate to assume that VOC emissions from the operation of the Project are would also result in no exceedances of the relevant criteria. VOC emissions from the project have therefore not been considered further in this assessment.

To conservatively represent the testing regime (Section 4.2), the modelling assumes that five generators run continuously between 9:00 am and 5:00 pm, every day of the year. It is noted that the use of this approach is likely to significantly overestimate the 24-hour average and annual average downwind air pollutant concentrations as only 4 tests are to be conducted per year per generator.

The five generators closest to the location of the nearest identified sensitive receptors were modelled. Figure 13 illustrates the modelled sources and buildings for the worst-case testing scenario.

Figure 13 Modelled Buildings and Point Sources (Worst-case Testing Scenario)

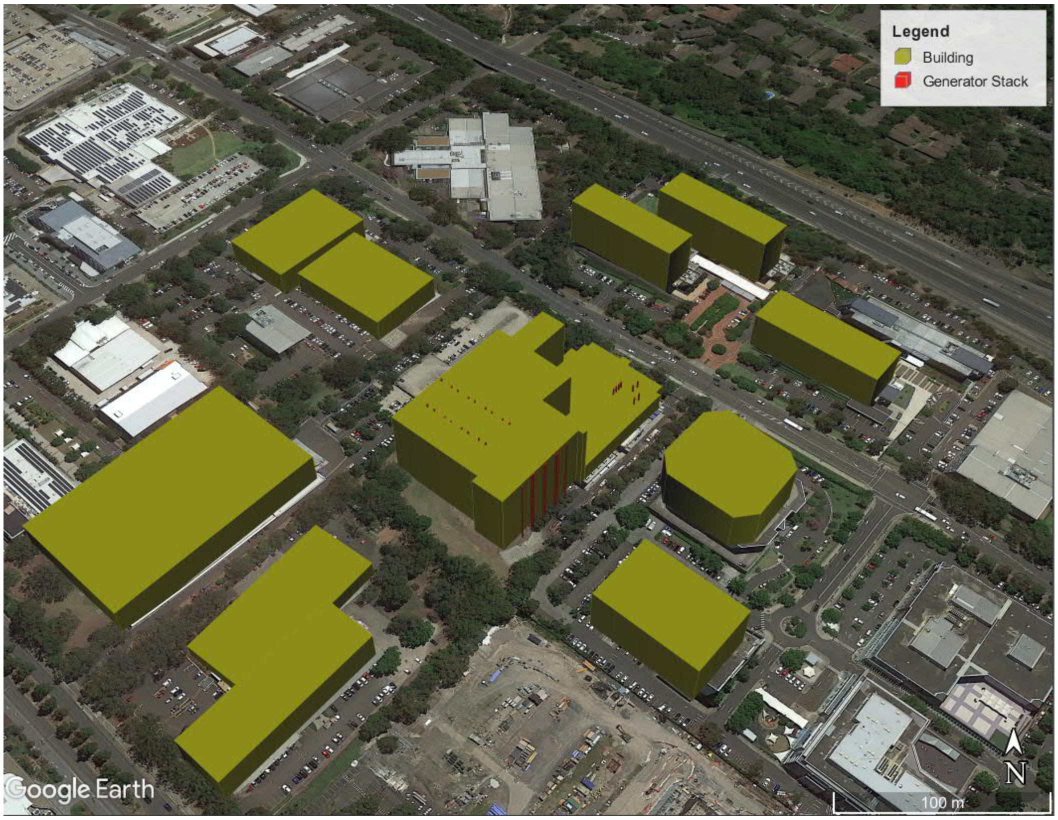
Table 22 provides a summary of stack parameters and emission rates for each of the existing generators as modelled. To conservatively represent emergency conditions (Section 4.3) the modelling assumes that all generators run continuously 24 hours per day, every day of the year. The buildings and stacks modelled for the emergency scenario are illustrated in Error! Not a valid bookmark self-reference..

Table 22 Stack Parameters and Emission Rates – Existing Generators

Parameter	Unit	IC2 (DRUPS)	IC2	IC3E
Temperature	K	763	763	733
Release height	m	17.9	17.9	34.0
Exhaust gas velocity	m/s	42.9	42.9	25.1
Stack diameter	m	0.51	0.51	0.60
Stack orientation	-	Vertical	Vertical	Horizontal
NO_x emission rate	g/s	14.8	5.6	14.8
CO emission rate	g/s	2.6	0.44	2.6
PM emission rate	g/s	0.43	0.035	0.43
SO_2 emission rate [a]	g/s	0.0036	0.0023	0.0036
PAH (as B(a)P) emission rate [b]	g/s	1.6×10^{-6}	1.0×10^{-6}	2.1×10^{-6}

a In absence of data, based on Cummins QSK95-G4 engine specifications (Refer Appendix C), scaled for power output.
b Calculated using engine specifications and AP42 3.3 PAH emission factors for uncontrolled diesel engines.

Figure 14 Modelled Buildings and Point Sources (Worst-case Emergency Scenario)



8.3.7 Accuracy of Modelling

All atmospheric dispersion models, including CALPUFF, represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below:

- Oversimplification of physics: This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Uncertainties are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
- Uncertainties in emission rates: Ground level concentrations are proportional to the pollutant emission rate. In addition, most modelling studies assume constant worst-case emission levels or are based on the results of a small number of stack tests, however operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.

- Uncertainties in wind direction and wind speed: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of plume. Uncertainties in these parameters can result in errors in the predicted distance from the source of the plume impact, and magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- Uncertainties in mixing height: If the plume elevation reaches 80% or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.
- Uncertainties in temperature: Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and magnitude of that impact.
- Uncertainties in stability estimates: Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, uncertainties in these parameters can cause either under-prediction or over-prediction of ground level concentrations. For example, if an error is made of one stability class, then the computed concentrations can be off by 50% or more.

The USEPA makes the following statement in its Modelling Guideline (US EPA, 2005) on the relative accuracy of models:

> *"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to 40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognised for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."*

9 Assessment of Air Quality Impacts

9.1 Construction Phase

9.1.1 Step 1 – Screening Based on Separation Distance

As noted in Section 7.2, the nearest sensitive receptor is located approximately 120 m from the nearest Site boundary.

The screening criteria for detailed assessment are:

- a '*human receptor*[1]' within:
  - 350 m of the boundary of the site; or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).
- an '*ecological receptor*[2]' within:
  - 50 m of the boundary of the site; or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

Since the nearest sensitive receptor has been identified to be 120 m northeast of the Site boundary, a detailed assessment is deemed necessary for construction impacts.

In relation to the wind roses presented in Section 7.1, it is apparent that winds that would blow fugitive dust emissions from the construction works towards the identified receptor are most likely to occur during the summer, autumn and spring months and least likely to occur during the winter months.

9.1.2 Step 2a – Assessment of Scale and Nature of the Works

Based on the IAQM definitions presented in Appendix A, dust emission magnitudes for the anticipated works have been categorised as presented in Table 23.

It is noted that no demolition works are anticipated to occur on site and hence impacts from these activities have not been considered further.

[1] A 'human receptor', refers to any location where a person or property may experience the adverse effects of airborne dust or dust soiling, or exposure to PM_{10} over a time period. In terms of annoyance effects, this will most commonly relate to dwellings, but may also refer to other premises such as buildings housing cultural heritage collections (e.g. museums and galleries), vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations (e.g. salad or soft-fruit production).

[2] An 'ecological receptor' refers to any sensitive habitat affected by dust soiling. This includes the direct impacts on vegetation or aquatic ecosystems of dust deposition, and the indirect impacts on fauna (e.g. on foraging habitats).

Table 23 Categorisation of Dust Emission Magnitude

Activity	Dust Emission Magnitude	Basis
Earthworks	Medium	Total site area 2,500 m^2 to 10,000 m^2, moderately dusty soil type (e.g. silt), 5 to 10 heavy earth moving vehicles active at any one time, formation of bunds 4 m to 8 m in height, total material moved 20,000 t to 100,000 t. *Total area where the earthworks will be undertaken for the Project, including removal of carparks and internal roads is estimated to be greater than 3,000 m^2.*
Construction	Medium	Total building volume 25,000 m^3 to 100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching. *The total building area is estimated to be greater than 3,000 m^2. Therefore, the total volume is likely to be greater than 25,000 m^3.*
Trackout	Medium	Between 10 and 50 heavy vehicle movements per day, surface materials with a moderate potential for dust generation, between 50 m and 100 m of unpaved road length. *The unpaved road length is estimated to be less than 50 m.*

9.1.3 Step 2b – Risk Assessment

Receptor Sensitivity

Based on the criteria listed in Table A1 in Appendix A, the sensitivity of the identified receptor in this study is conservatively classified *high* for dust soiling and *high* for health impacts.

Sensitivity of an Area

Based on the classifications shown in Table A2 and Table A3 in Appendix A, the sensitivity of the area to dust soiling may be classified as *medium* while the sensitivity of the area for health effects may able be classified as *low,* based on an annual average PM_{10} concertation of 17.2 µg/m^3.

Risk Assessment

Table 24 presents the preliminary risk of air quality impacts from uncontrolled construction activities determined using the risk matrix provided in Table A4 and Table A5 in Appendix A, based on the identified receptor sensitivity and sensitivity of the area.

Table 24 Preliminary Risk of Air Quality Impacts from Construction Activities (Uncontrolled)

Impact	Sensitivity of Area	Dust Emission Magnitude			Preliminary Risk		
		Earthworks	Construction	Trackout	Earthworks	Construction	Trackout
Dust Soiling	Medium	Medium	Medium	Medium	Medium	Medium	Low
Health Effects	Low	Medium	Medium	Medium	Low	Low	Low

The results indicate that there is a low risk of adverse dust soiling and health effects occurring at the off-site sensitive receptor locations if no mitigation measures were to be applied to control emissions during the works.

9.1.4 Step 3 - Mitigation Measures

For almost all construction activity, the IAQM Methods notes that the aim should be to prevent significant effects on receptors through the use of effective mitigation and experience shows that this is normally possible.

The IAQM document provides guidance on appropriate mitigation measures for construction activities determined to have low, medium and high preliminary risk of adverse air quality impacts. Table 25 lists the relevant mitigation measures by the IAQM methodology for a project shown to have a low risk of adverse impacts. Not all these measures would be practical or relevant for the Project, hence a detailed review of the recommendations should be performed as part of the development of the Construction Environmental Management Plan (CEMP) and the most appropriate measures adopted.

Table 25 Proactive Dust Mitigation Measures

#	Mitigation Measure
1	Communications
1.1	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.
1.2	Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the Site Manager.
1.3	Display the head or regional office contact information.
2	Site Management
2.1	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.
2.2	Make the complaints log available to the Local Authority when requested.
2.3	Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.

#	Mitigation Measure
3	Preparing and Maintaining the Site
3.1	Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.
3.2	Erect solid screens or barriers around dusty activities or the site boundary that they are at least as high as any stockpiles on site.
3.3	Fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period.
3.4	Avoid site runoff of water or mud.
3.5	Keep site fencing, barriers and scaffolding clean using wet methods.
3.6	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below.
3.7	Cover, seed or fence stockpiles to prevent wind erosion.
4	Operating Vehicle/Machinery and Sustainable Travel
4.1	Ensure all on-road vehicles comply with relevant vehicle emission standards, where applicable.
4.2	Stationary trucks will switch off engines if idling time on-site is likely to exceed 2 minutes.
4.3	Avoid using the local road network during peak traffic periods, where possible.
4.4	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.
4.5	Minimise truck queuing and unnecessary trips through logistical planning.
5	Operations
5.1	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.
5.2	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/ mitigation, using non-potable water where possible and appropriate.
5.3	Use enclosed chutes and conveyors and covered skips.
5.4	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.
6	Waste Management
6.1	No on-site burning of waste materials.
7	Excavation
7.1	Only the minimum area necessary is disturbed at any one time.
7.2	Where applicable, rehabilitation of disturbed areas will be undertaken as soon as practicable.
7.2	If unanticipated strong odours are encountered or significant dust emissions are noted on site, stop related work and seek advice from the Environmental Coordinator or equivalent role.
7.3	Carry out excavation works and vehicle loading/unloading when weather conditions are favourable (i.e. receptors are upwind from the works).
8	Construction
8.1	Avoid scabbling (roughening of concrete surfaces) if possible.
8.2	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.

#	Mitigation Measure
9	Trackout
9.1	Use water-assisted dust sweeper(s) on the access and local roads to remove, as necessary, any material tracked out of the site.
9.2	Avoid dry sweeping of large areas.
9.3	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.
9.4	Record all inspections of haul routes and any subsequent action in a site log book.
9.5	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site).
10	Contingency Plan for Prolonged Dust Events
10.1	Deployment of additional water sprays where practicable
10.2	Relocation or modification of dust-generating sources, where possible
10.3	Temporary halting of activities and resuming when conditions have improved

In addition to the mitigation measures proposed in Table 25, daily site inspections should be carried out during construction works. Daily environmental inspections will include, but not be limited to:

- Visual inspection of any airborne dust being generated on-site or being observed blowing off-site
- Ensuring roads leaving the Site are free of soil, and that there is no observable soil tracking onto the road network
- Inspection of the erosion and sediment control systems for silt build-up
- Inspection of stockpiles and waste storage areas to ensure no significant wind erosion is observable.

Any environmental inspection reports should include the above observations, with remedial or corrective actions noted (as appropriate). Any remedial or corrective actions must be reported to the Site Manager as soon as is practicable.

9.1.5 Step 4 - Residual Impacts

A reappraisal of the predicted unmitigated air quality impacts on sensitive receptors has been performed to demonstrate the opportunity for minimising risks associated with the use of mitigation strategies. These are termed 'residual impacts'. The results of the reappraisal are presented below in Table 26.

Table 26 Residual Risk of Air Quality Impacts from Construction

Impact	Sensitivity of Area	Residual Risk		
		Earthworks	Construction	Trackout
Dust Soiling	Low	Low	Low	Negligible
Health Impacts	Medium	Negligible	Negligible	Negligible

The dust deposition impacts for mitigated activities are anticipated to be *low* for earthworks and construction activities and *negligible* for trackout activities, while health impacts for all mitigated activities are anticipated to be *negligible.*

9.2 Operational Phase

9.2.1 Particulates

Table 27 presents maximum 24-hour and annual average incremental particulate matter concentrations at surrounding sensitive receptor locations. Given the insignificant incremental increase of particulate matter predicted at the identified receptors, additional exceedances of PM_{10} and $PM_{2.5}$ criteria due to the operation of the Project are considered unlikely.

Table 27 Maximum Predicted PM Concentrations at Sensitive Receptors

Receptor ID	Increment (µg/m³)	
	Maximum 24-Hour	Annual
R1	0.37	0.038
R2	0.18	0.019
R3	0.073	0.0059
R4	0.068	0.0104
R5	0.069	0.0079
R6	0.082	0.0064
R7	0.075	0.0051
R8	0.26	0.035
R9	0.16	0.017
R10	0.54	0.076
R11-0	0.16	0.016
R11-1	0.16	0.016
R11-2	0.16	0.016
R11-3	0.16	0.016
R11-4	0.15	0.016
R11-5	0.15	0.016
R11-6	0.15	0.016
R11-7	0.15	0.016

9.2.2 NO_2

Table 28 presents the incremental and cumulative maximum 1-hour and annual average NO_2 concentrations predicted at identified sensitive receptor locations. Contour plots of the predicted incremental NO_x concentrations are presented in Figure 15 and Figure 16.

The modelling results show that the predicted cumulative maximum 1-hour and annual average NO_2 concentrations are below the relevant ambient air quality criteria at all receptor locations modelled.

Table 28 Maximum Predicted NO_2 Concentrations at Sensitive Receptors

Receptor ID	Incremental (µg/m³)							Cumulative (µg/m³)	
	Maximum 1-Hour	*Corresponding 1-Hour* [a]					Annual	1-Hour	Annual
		NO_X (µg/m³)	*O_3 (ppb)*	*Wind Speed (m/s)*	*Transport Time (s)* [b]	*NO_2 (µg/m³)*			
R1	7.6	517	35	5.3	38	1.9	0.18	56	11
R2	7.4	237	42	3.6	111	9.4	0.18	57	11
R3	16	112	60	5.9	136	9.4	0.13	56	11
R4	14	87	69	6.1	148	7.5	0.28	56	11
R5	9.1	85	60	6.2	145	7.5	0.21	56	11
R6	8.2	95	78	2.3	326	11	0.14	56	11
R7	9.0	134	34	5.9	161	7.5	0.13	56	11
R8	7.2	331	31	4.1	73	3.8	0.26	62	11
R9	8.4	329	24	4.8	104	13	0.20	61	11
R10	4.0	716	42	6.6	7.6	1.9	0.10	56	11
R11-0	7.4	133	60	6.6	68	7.5	0.18	57	11
R11-1	7.4	133	60	6.6	68	7.5	0.18	57	11
R11-2	7.4	133	60	6.6	68	7.5	0.18	57	11
R11-3	7.4	133	60	6.6	68	7.5	0.18	57	11
R11-4	7.4	133	60	6.6	68	7.5	0.18	57	11
R11-5	7.4	133	60	6.6	68	7.5	0.17	57	11
R11-6	7.4	133	60	6.6	68	7.5	0.17	57	11
R11-7	7.4	133	60	6.6	68	7.5	0.17	57	11
Criteria								246	62

a Used to calculate 1-hour incremental NO_2 concentration using the Method 3 (Section 8.3.2).

b Approximate plume transport time from source to receptor based on windspeed and separation distance.

Figure 15 Predicted 1-hour Average Incremental NO_X Isopleths – Operations

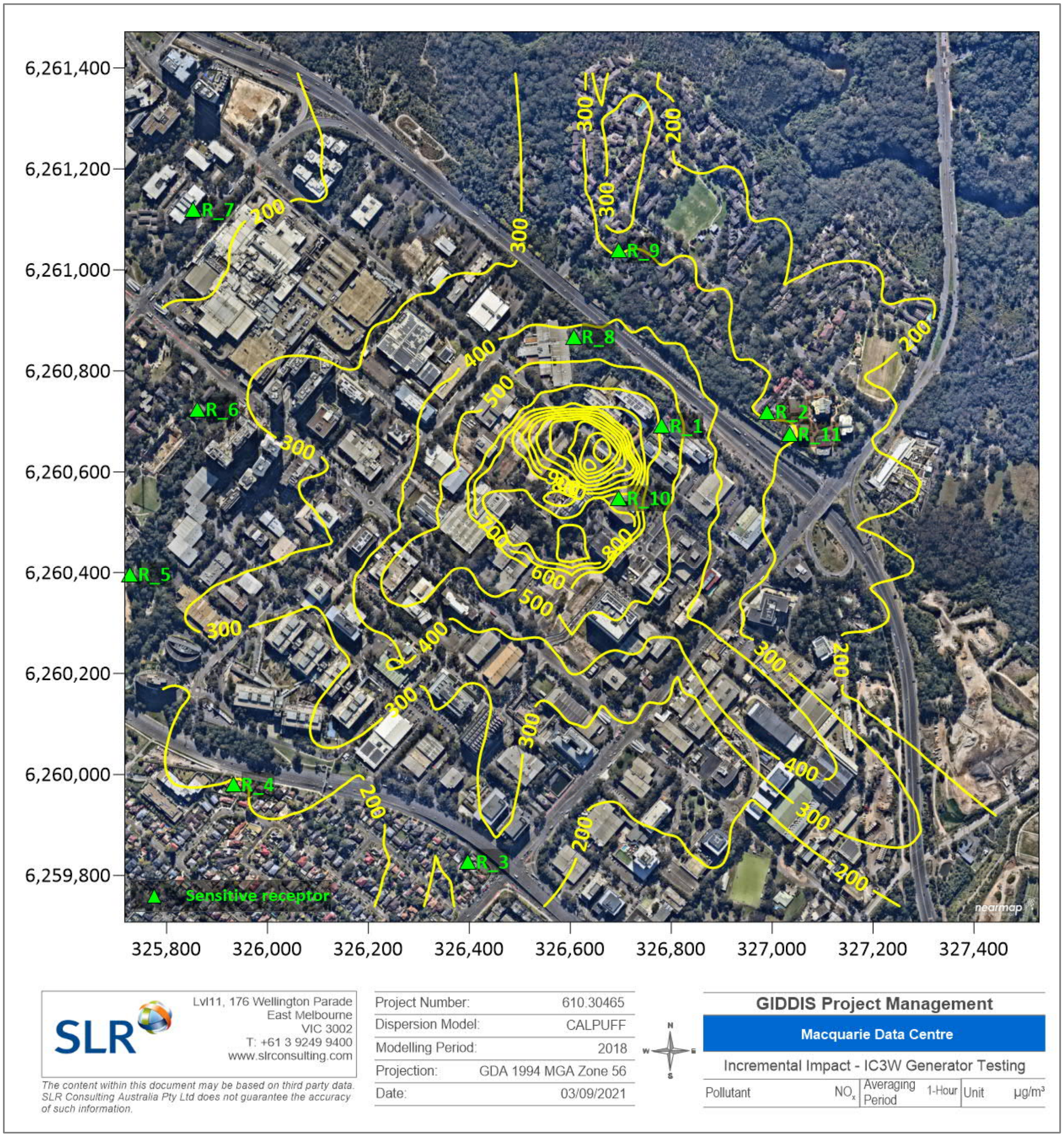
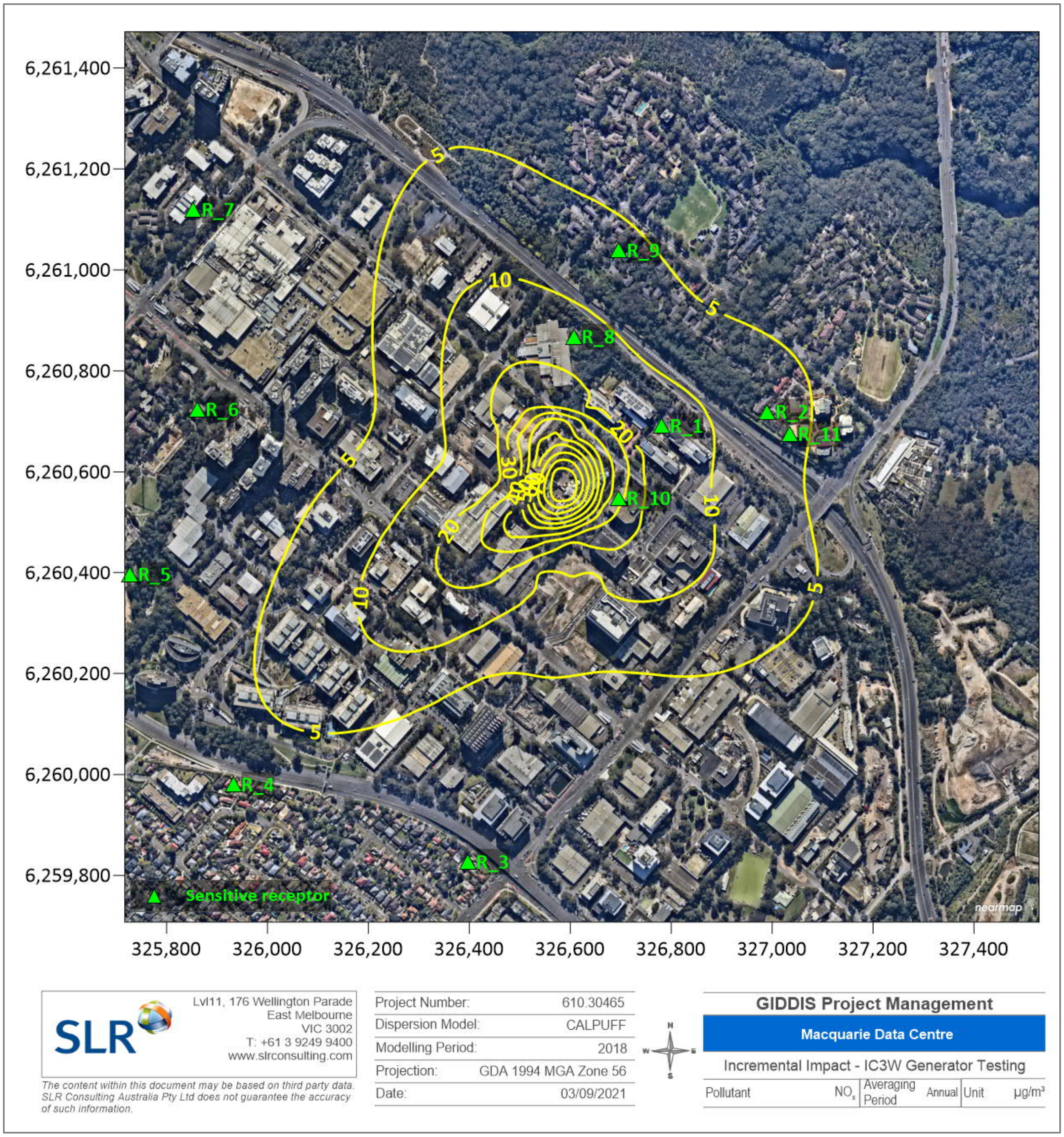


Figure 16 Predicted Annual Average Incremental NO_X Isopleths – Operations



9.2.3 CO

Table 29 presents the maximum incremental 15-minute, 1-hour and 8-hour average CO concentrations predicted at surrounding sensitive receptor locations. Given the insignificant incremental increase of CO predicted at the identified receptors, exceedances of the relevant CO criteria due to the operation of the Project are considered unlikely.

Table 29 Maximum Predicted CO Concentrations at Sensitive Receptors

Receptor ID	Increment (mg/m³)		
	15-Minute*	1-Hour	8-Hour
R1	0.039	0.030	0.026
R2	0.020	0.015	0.012
R3	0.019	0.015	0.005
R4	0.019	0.014	0.005
R5	0.010	0.008	0.005
R6	0.014	0.011	0.006
R7	0.010	0.007	0.005
R8	0.028	0.022	0.018
R9	0.024	0.018	0.011
R10	0.052	0.040	0.037
R11-0	0.020	0.015	0.011
R11-1	0.020	0.015	0.011
R11-2	0.020	0.015	0.011
R11-3	0.020	0.015	0.011
R11-4	0.020	0.015	0.011
R11-5	0.020	0.015	0.010
R11-6	0.020	0.015	0.010
R11-7	0.020	0.015	0.010
Criteria	100	30	10

* The 1-hour average CO concentrations predicted by the modelling were converted to 15-minute averages using the power law formula.

9.2.4 SO_2

Table 30 presents the incremental maximum 10-minute, 1-hour, 24-hour and annual average SO_2 concentrations predicted at surrounding sensitive receptor locations Given the insignificant incremental increase of SO_2 predicted at the identified receptors, exceedances of the relevant SO_2 criteria due to the operation of the Project are considered unlikely.

Table 30 Maximum Predicted SO_2 Concentrations at Residential Receptors

Receptor ID	Increment (µg /m³)			
	10-Minute*	1-Hour	24-Hour	Annual
R1	0.43	0.30	0.087	0.0089
R2	0.23	0.16	0.042	0.0043
R3	0.22	0.15	0.017	0.0014
R4	0.21	0.15	0.016	0.0024
R5	0.11	0.08	0.016	0.0018
R6	0.15	0.11	0.019	0.0015
R7	0.11	0.07	0.018	0.0012

Receptor ID	Increment (µg /m³)			
	10-Minute*	1-Hour	24-Hour	Annual
R8	0.31	0.22	0.061	0.0082
R9	0.26	0.18	0.038	0.0040
R10	0.58	0.40	0.13	0.018
R11-0	0.22	0.16	0.036	0.0038
R11-1	0.22	0.16	0.036	0.0038
R11-2	0.22	0.16	0.036	0.0038
R11-3	0.22	0.16	0.036	0.0038
R11-4	0.22	0.16	0.036	0.0038
R11-5	0.22	0.16	0.036	0.0038
R11-6	0.22	0.16	0.036	0.0038
R11-7	0.22	0.16	0.035	0.0037
Criteria	712	570	228	60

* The 1-hour average SO_2 concentrations predicted by the modelling were converted to 10-minute averages using the power law formula.

9.2.5 PAHs

The maximum (99.9th percentile) incremental 1-hour average PAH concentrations predicted beyond the Site boundary was <0.0000004 mg/m³ significantly less (<0.1%) than the criterion of 0.0004 mg/m³. For the purposes of modelling, background PAH concentrations were assumed to be negligible. Regardless, it is unlikely that the addition of the incremental impacts to a background concentration would cause an exceedance.

Table 31 presents the incremental maximum 1-hour average PAH concentrations predicted at surrounding sensitive receptor locations.

Table 31 Maximum Predicted PAH Concentrations at Residential Receptors

Receptor ID	Increment 1-Hour (mg/m³) ^
R1	0.00000013
R2	<0.0000001
R3	<0.0000001
R4	<0.0000001
R5	<0.0000001
R6	<0.0000001
R7	<0.0000001
R8	<0.0000001
R9	<0.0000001
R10	0.00000017
R11-0	<0.0000001
R11-1	<0.0000001
R11-2	<0.0000001
R11-3	<0.0000001

Receptor ID	Increment 1-Hour (mg/m³) ^
R11-4	<0.0000001
R11-5	<0.0000001
R11-6	<0.0000001
R11-7	<0.0000001
Criteria	0.0004

^ 99.9th percentile.

9.2.6 Summary

The dispersion modelling study, which accounted for worst-case testing conditions (Section 4.2) predicted no exceedances of the relevant ambient air quality criteria as a result of the operation of the Project. It is noted that given the insignificant incremental increase in ground level concentrations of particulate matter, CO and SO_2 at the modelled sensitive receptor locations, a contemporaneous cumulative assessment was not undertaken.

9.3 Emergency Conditions

9.3.1 Particulates

The left-hand columns of Table 32 present the incremental and cumulative maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted at identified sensitive receptor locations. The exceedances of the 24-hour PM_{10} and $PM_{2.5}$ criteria are primarily due to elevated background concentrations, however, the incremental impacts of the Project result in several additional exceedances of the 24-hour PM_{10} or $PM_{2.5}$ criterion at all receptors except R5, R6 and R7. These results assume that all generators are running for 24 hours every day of the year and are therefore considered very conservative. It is considered more realistic, while retaining a high degree of conservatism, to calculate the daily cumulative concentrations based on one 1-hour emergency event occurring every day of the year. The daily predicted 1-hour maximum incremental concentration, divided by 24 (24 hours), and added to the 24-hour average background concentration gives the equivalent cumulative 24-hour average concentration as provided in the right-hand columns of Table 32.

Isopleth plots of the predicted maximum 24-hour average incremental PM concentrations based on maximum 1-hour daily emergency operations are presented in Figure 17.

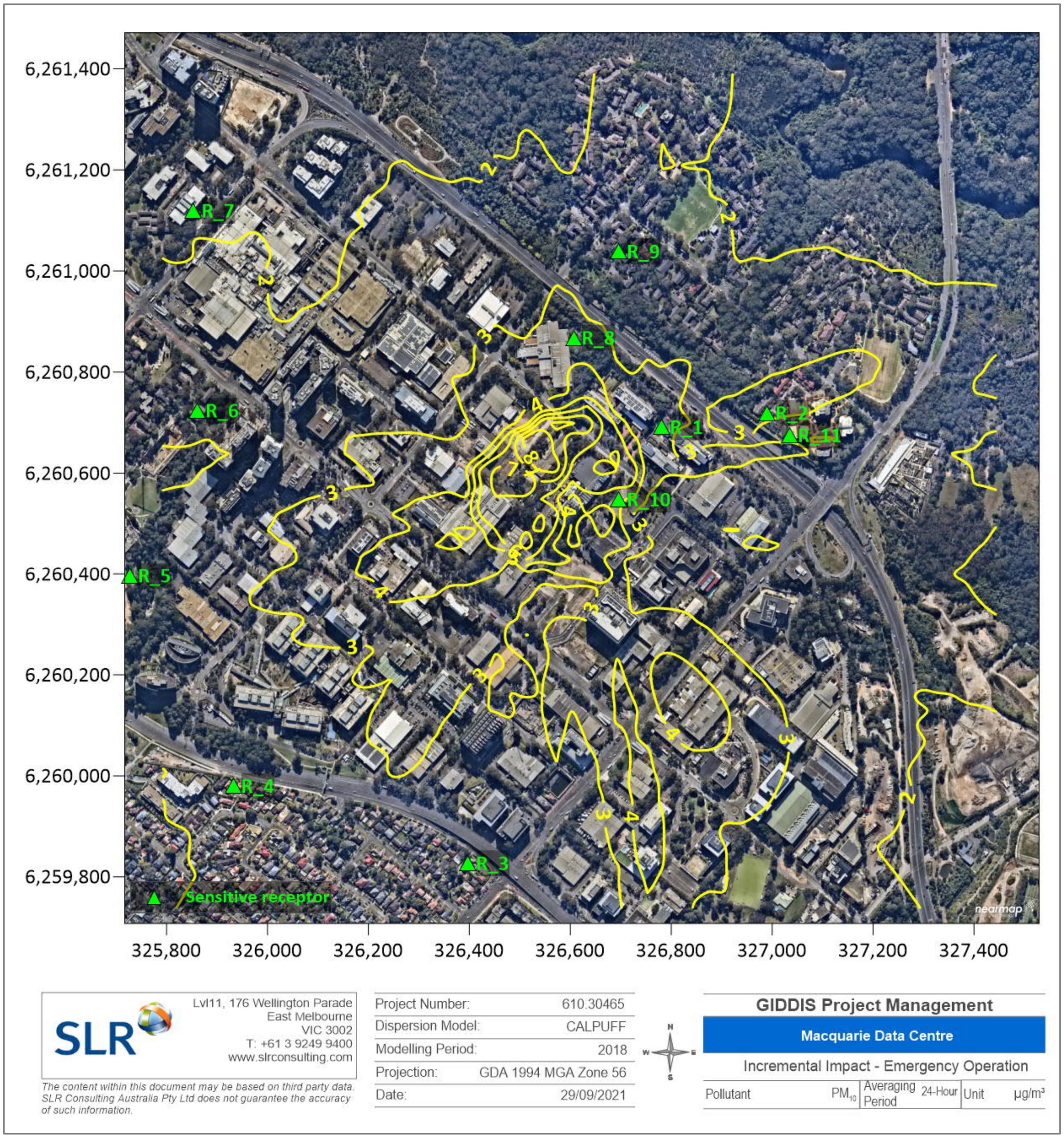
Table 32 Maximum Predicted 24-Hour PM Concentrations at Sensitive Receptors

Receptor ID	Daily 24-Hour Emergency Operation					Daily 1-Hour Emergency Operation				
	Maximum 24-Hour Average Incremental Concentration (µg/m³)	Maximum Cumulative 24-Hour Average Concentration (µg/m³)		Additional Exceedances as Result of Project [a]		Maximum 1-Hour Incremental Concentration (µg/m³)	Maximum Cumulative 24-Hour Average Concentration (µg/m³) [b]		Additional Exceedances as Result of Project [a]	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
R1	47	86	66	18	74	84	86	60	0	0
R2	36	87	67	3	40	104	86	60	0	0
R3	23	86	62	0	2	67	86	60	0	0
R4	20	86	62	0	0	63	86	61	0	0
R5	10	86	59	0	0	48	86	59	0	0
R6	13	86	59	0	0	55	86	59	0	0
R7	12	86	58	0	0	46	86	58	0	0
R8	44	86	59	9	45	90	86	59	0	0
R9	18	86	60	0	2	59	86	59	0	0
R10	71	137	78	54	136	168	90	60	2	1
R11-0	34	88	68	2	27	77	87	60	0	0
R11-1	34	88	68	2	27	77	87	60	0	0
R11-2	34	88	68	2	27	77	87	60	0	0
R11-3	35	88	68	2	27	78	87	60	0	0
R11-4	35	88	68	2	28	79	87	60	0	0
R11-5	35	88	68	3	28	80	87	60	0	0
R11-6	35	88	68	4	28	82	87	60	0	0
R11-7	36	87	68	4	28	83	87	60	0	0
Criteria		50	25			Criteria	50	25		

a Over and above background, for which four exceedances are recorded.

b Equal to the maximum 1-hour incremental concentration divided by 24, plus corresponding background 24-hour average on that day.

Figure 17 Predicted 24-Hour Maximum Incremental PM Concentrations Based on Daily 1-Hour Emergency Condition



A contemporaneous analysis of the highest 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted at the worst impacted receptor, R10 (roof air intakes on nearby commercial building rooftop), based on daily 1-hour emergency operation is presented in Table 33.

Table 33 Ten Highest Contemporaneous 24-Hour Average PM_{10} and $PM_{2.5}$ Predictions at Receptor R10

Date	24-Hour Average Concentration (µg/m³)			Date	24-Hour Average Concentration (µg/m³)		
	Background	Predicted Increment [a]	Cumulative Impact		Background	Predicted Increment [a]	Cumulative Impact
PM_{10}							
Ten Highest Maximum Background Hours				Ten Highest Maximum Incremental Impact Hours			
22-11-2018	86	4.4	90	28-03-2018	22	6.9	29
21-11-2018	70	4.0	74	20-01-2018	14	6.7	21
19-03-2018	60	0.41	60	02-05-2018	14	6.3	21
15-02-2018	52	0.012	52	02-12-2018	33	6.2	39
18-07-2018	48	4.1	52	11-02-2018	14	6.2	27
13-04-2018	46	3.6	50	04-07-2018	16	6.2	22
08-08-2018	46	4.9	51	28-09-2018	21	6.1	20
09-08-2018	43	1.7	45	05-07-2018	10	6.1	16
19-07-2018	41	3.9	44	06-02-2018	14	6.0	14
20-03-2018	36	0.21	36	30-12-2018	21	6.0	34
Criterion			50				50
$PM_{2.5}$							
Ten Highest Maximum Background Hours				Ten Highest Maximum Incremental Impact Hours			
09-08-2018	58	1.7	60	28-03-2018	6.3	6.9	13
08-08-2018	42	4.9	47	20-01-2018	3.4	6.7	10
13-04-2018	29	3.6	32	02-05-2018	5.7	6.3	12
26-05-2018	28	0.55	28	02-12-2018	7.9	6.2	14
27-05-2018	22	5.6	28	11-02-2018	5.9	6.2	14
28-05-2018	19	2.8	21	04-07-2018	9.6	6.2	16
21-11-2018	17	4.0	21	28-09-2018	7.4	6.1	12
15-07-2018	17	2.5	20	05-07-2018	5.9	6.1	12
17-09-2018	17	2.5	19	06-02-2018	6.4	6.0	9.2
19-03-2018	15	0.41	16	30-12-2018	10	6.0	17
Criterion			25				25

Red font indicates exceedance of criterion (background or cumulative).

a Equal to the maximum 1-hour incremental concentration divided by 24.

Figure 18 and Figure 19 present plots of the predicted cumulative PM_{10} and $PM_{2.5}$ impacts at the sensitive receptors during one year in descending order and illustrate the relatively small increase in exceedances at Receptor R10 over those caused by elevated background concentrations when an emergency operation of all generators is assumed one hour every day of the year.

The actual likelihood of emergency operation events and therefore exceedances of the PM_{10} and $PM_{2.5}$ criteria due to emergency conditions are discussed in the summary below (Section 9.3.6).

Figure 18 Predicted 24-Hour PM_{10} Cumulative Concentrations at Sensitive Receptors by Rank

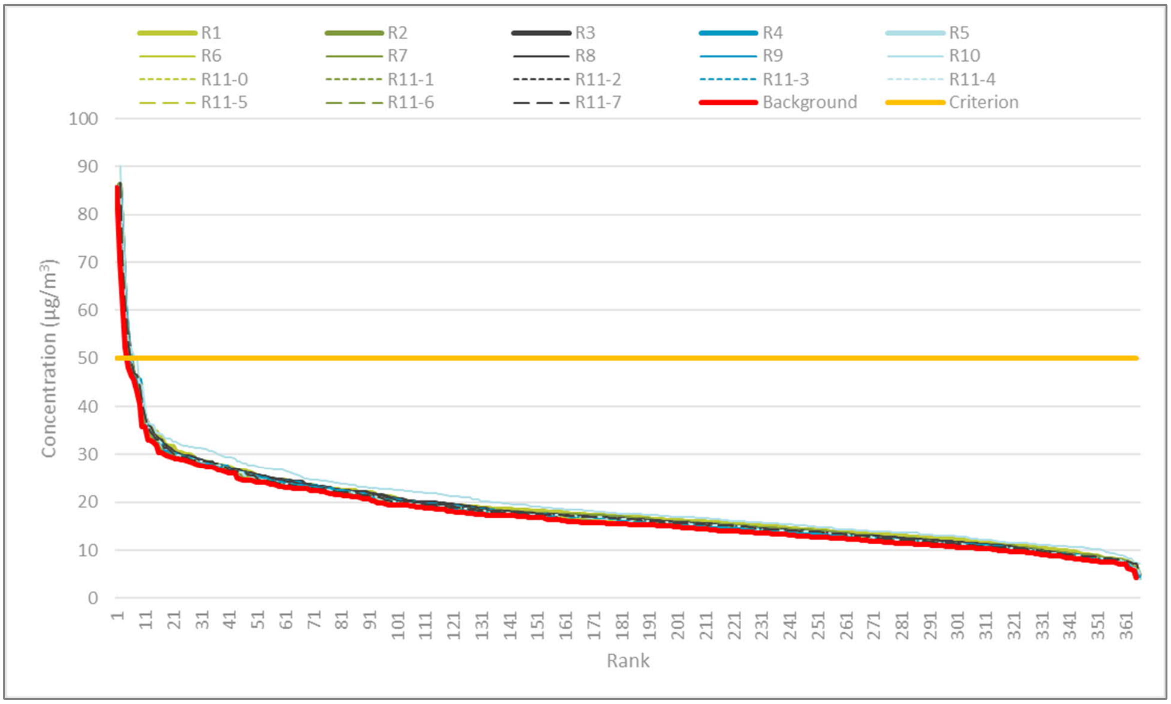
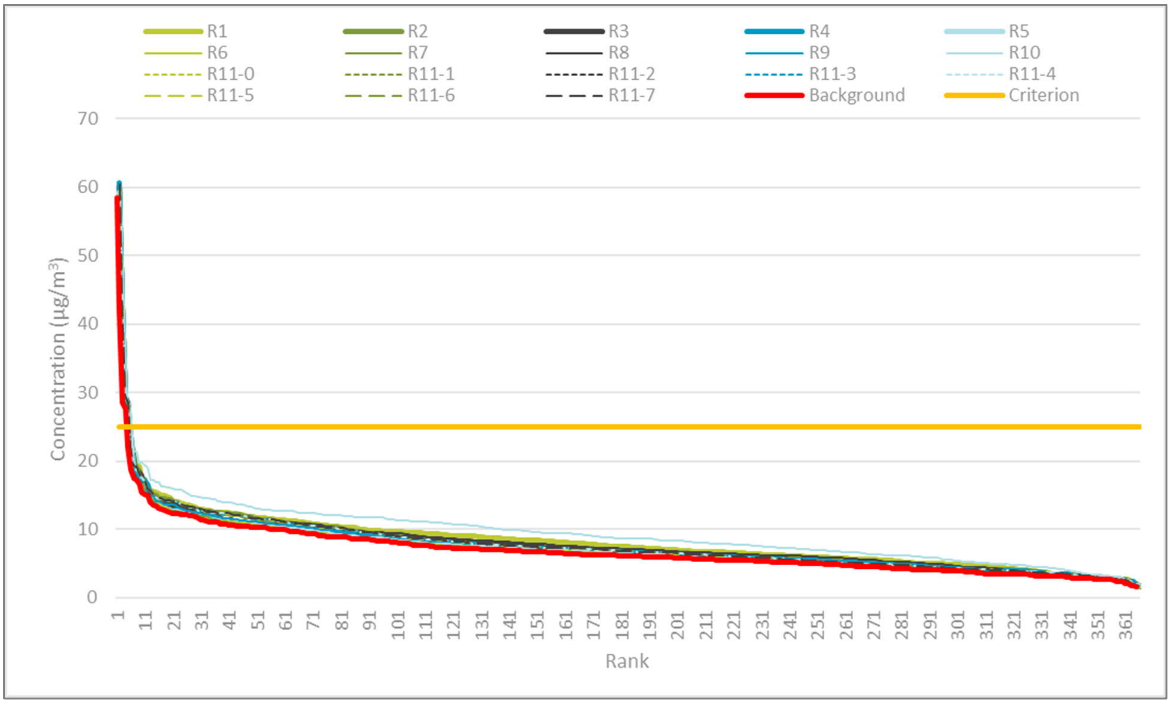


Figure 19 Predicted 24-Hour $PM_{2.5}$ Cumulative Concentrations at Sensitive Receptors by Rank



9.3.2 NO_2

Figure 20 presents the incremental and cumulative maximum 1-hour average NO_2 concentrations predicted at identified sensitive receptor locations. Isopleth plots of the predicted incremental NO_x concentrations are presented in Figure 21.

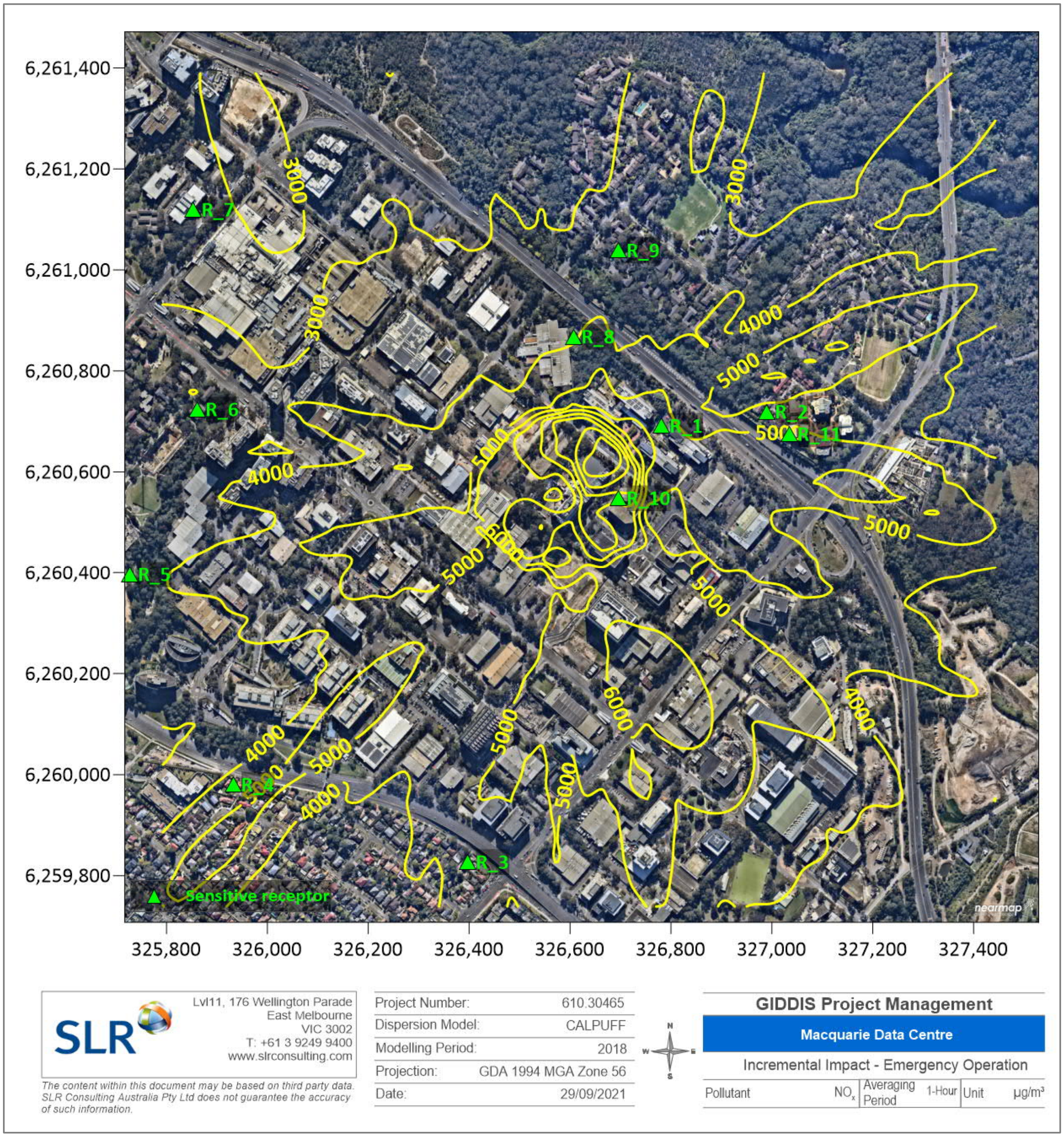
The modelling results show that the predicted cumulative maximum 1-hour and annual average NO_2 concentrations are below the relevant ambient air quality criteria at all receptor locations modelled.

Figure 20 Maximum Predicted NO_2 Concentrations at Sensitive Receptors

Receptor ID	Incremental (µg/m³)							Cumulative (µg/m³)	
	Maximum 1-Hour	*Corresponding 1-Hour* [a]					Annual	1-Hour	Annual
		NO_X (µg/m³)	*O_3 (ppb)*	*Wind Speed (m/s)*	*Transport Time (s)* [b]	*NO_2 (µg/m³)*			
R1	62	4232	30	4.6	44	1.9	6.0	87	16
R2	88	3331	18	2.5	160	7.5	6.2	107	17
R3	183	3556	3.0	2.2	367	1.9	6.1	195	17
R4	171	2479	44	2.9	310	3.8	5.8	174	16
R5	150	2606	19	2.1	425	10	2.5	161	13
R6	128	2654	39	2.1	355	0.0	2.1	150	13
R7	128	2103	29	2.9	333	1.9	2.6	130	13
R8	87	3979	36	3.7	81	3.8	6.2	116	17
R9	90	2480	35	4.5	112	13	5.2	118	16
R10	35	6364	42	6.2	8.0	1.9	3.0	64	13
R11-0	128	4332	19	3.2	140	7.5	6.0	135	16
R11-1	128	4330	19	3.2	140	7.5	6.0	135	16
R11-2	128	4325	19	3.2	140	7.5	6.0	135	16
R11-3	127	4316	19	3.2	140	7.5	6.0	135	16
R11-4	127	4302	19	3.2	140	7.5	6.0	134	16
R11-5	126	4285	19	3.2	140	7.5	6.1	134	17
R11-6	126	4264	19	3.2	140	7.5	6.1	133	17
R11-7	125	4237	19	3.2	140	7.5	6.1	132	17
Criteria								246	62

a Used to calculate 1-hour incremental NO_2 concentration using Method 3 (Section 8.3.2).
b Approximate plume transport time from source to receptor based on windspeed and separation distance.

Figure 21 Predicted 1-hour Average Incremental NO_X Isopleth Plot – Emergency Conditions



9.3.3 CO

Table 34 presents the maximum incremental 15-minute, 1-hour and 8-hour average CO concentrations predicted at surrounding sensitive receptor locations. Given the insignificant incremental increase of CO predicted at the identified receptors, exceedances of the relevant CO criteria due to the operation of the Project are considered unlikely.

Table 34 Predicted CO Concentrations at Sensitive Receptors

Receptor ID	Increment (mg/m³)		
	Maximum 15-Minute*	Maximum 1-Hour	Maximum 8-Hour
R1	0.75	0.57	0.53
R2	0.71	0.53	0.39
R3	0.59	0.44	0.34
R4	0.48	0.36	0.20
R5	0.44	0.33	0.21
R6	0.46	0.35	0.24
R7	0.37	0.28	0.19
R8	0.74	0.56	0.49
R9	0.53	0.40	0.28
R10	1.4	1.0	0.72
R11-0	0.67	0.51	0.39
R11-1	0.67	0.51	0.39
R11-2	0.67	0.51	0.39
R11-3	0.67	0.51	0.39
R11-4	0.67	0.51	0.39
R11-5	0.67	0.51	0.40
R11-6	0.67	0.51	0.40
R11-7	0.66	0.50	0.41
Criteria	100	30	10

* The 1-hour average CO concentrations predicted by the modelling were converted to 15-minute averages using the power law formula.

9.3.4 SO_2

Table 35 presents the incremental maximum 10-minute, 1-hour, 24-hour and annual average SO_2 concentrations predicted at surrounding sensitive receptor locations Given the insignificant incremental increase of SO_2 predicted at the identified receptors, exceedances of the relevant SO_2 criteria due to the operation of the Project are considered unlikely.

Table 35 Predicted SO_2 Concentrations at Residential Receptors

Receptor ID	Increment (µg/m³)		
	Maximum 10-Minute*	Maximum 1-Hour	Maximum 24-Hour
R1	2.7	1.9	1.3
R2	2.2	1.5	0.92
R3	1.9	1.3	0.52
R4	1.5	1.1	0.42
R5	1.5	1.1	0.21
R6	1.3	0.9	0.26
R7	1.2	0.8	0.30
R8	1.9	1.3	0.83
R9	1.6	1.1	0.52
R10	3.7	2.6	2.1
R11-0	2.4	1.7	0.83
R11-1	2.4	1.7	0.83
R11-2	2.4	1.7	0.84
R11-3	2.4	1.7	0.84
R11-4	2.4	1.7	0.84
R11-5	2.4	1.7	0.84
R11-6	2.4	1.6	0.85
R11-7	2.3	1.6	0.85
Criteria	712	570	228

* The 1-hour average SO_2 concentrations predicted by the modelling were converted to 10-minute averages using the power law formula.

9.3.5 PAHs

The maximum (99.9th percentile) incremental 1-hour average PAH concentrations predicted beyond the Site boundary was 0.0000011 mg/m^3 significantly less (<03%) than the criterion of 0.0004 mg/m^3. For the purposes of modelling, background PAH concentrations were assumed to be negligible. Regardless, it is unlikely that the addition of the incremental impacts to a background concentration would cause an exceedance.

Table 36 presents the incremental maximum 1-hour average PAH concentrations predicted at surrounding sensitive receptor locations.

Table 36 Predicted PAH Concentrations at Residential Receptors

Receptor ID	Maximum^ Increment 1-Hour (mg /m³)
R1	<0.000001
R2	<0.000001
R3	<0.000001
R4	<0.000001
R5	<0.000001

Receptor ID	Maximum^ Increment 1-Hour (mg /m³)
R6	<0.000001
R7	<0.000001
R8	<0.000001
R9	<0.000001
R10	0.0000011
R11-0	<0.000001
R11-1	<0.000001
R11-2	<0.000001
R11-3	<0.000001
R11-4	<0.000001
R11-5	<0.000001
R11-6	<0.000001
R11-7	<0.000001
Criteria	0.0004

^ 99.9th percentile.

9.3.6 Summary

The dispersion modelling study, which accounted for the emergency conditions (all generators running) every hour of the year predicted no exceedances of the NO_2, CO, SO_2 or PAH ambient air quality criteria.

No additional exceedances (over background) of the PM_{10} and PM_{25} 24-hour average criteria were predicted due to the Project for any of the receptors with the exception of R10 for which two additional exceedances of the PM_{10} criterion and one additional exceedance of the $PM_{2.5}$ criterion were predicted.

A comprehensive worst-case assessment was achieved by modelling the emergency conditions (operation of all backup generators) for every hour of the year to account for all meteorological and background air quality conditions. From these predictions the daily 1-hour maximum incremental concentrations, divided by 24, were added to the daily 24-hour average background concentration representing 1-hour emergency operation every day of the year. This assessment conservatively assumes that the emergency operation would occur on the hour associated with the meteorological conditions that result in the maximum 1-hour average concentration for that day. The likelihood of exceedances under these assumptions is the equivalent of:

- 1 exceedance every 0.5 years for PM_{10}
- 1 exceedance every year for $PM_{2.5}$.

However, if more realistically, an emergency condition event lasting 1 hour was conservatively assumed to occur once per year, rather than every day, and conservatively occurred on the hour of day that resulted in the maximum 1-hour average concentration for that day, the likelihood of this resulting in an exceedance would be equal to 1/365th of the predicted likelihoods above, equivalent to:

- 1 exceedance every 183 years for PM_{10}
- 1 exceedance every 365 years for $PM_{2.5}$.

At the time of writing, information on the historical power interruptions at the site was unavailable. A recent study conducted by SLR for a similar facility in Eastern Creek observed the following for that site:

- The site had had two power interruptions in the past ten years.
- Each interruption consisted of the loss of one of four feeder supplies.
- The two interruptions lasted for 13 minutes and 21 minutes, respectively.
- Loss of one feeder to that site did not require all generators to be used to provide emergency power.

Assuming similar network performance supplying the Project, it can be concluded that the actual likelihood of an exceedance of the air quality criteria at nearby sensitive receptors due to the emergency operation of the Project is negligible.

10 Air Quality Monitoring Program

10.1 Construction Phase

The AQIA concluded that the risk of construction dust emissions causing nuisance impacts at off-site sensitive receptor locations is low. It is also noted that any impacts will be temporary and managed through the implementation of appropriate mitigation measures.

Considering the low risk from the construction dust emissions to cause nuisance at off-site sensitive receptor locations, dust monitoring at the nearest sensitive receptors is not considered necessary.

However utilising static dust gauge(s) for the duration of Project construction, started at least one month before commencement of construction work, would be an inexpensive monitoring method that could be used to demonstrate that dust emissions are being managed effectively.

A summary of the proposed nuisance dust monitoring program is shown in Table 37.

Table 37 Nuisance Dust Monitoring Program

Parameter	Methodology	Duration	Location	Frequency
Deposited dust	AS/NZS 3580.1.1:2016 - *Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment*	During Site preparation, earthworks, construction	Site boundary (to be confirmed by monitoring subconsultant)	Monthly

An air quality contingency management plan for the Project construction, based on the monitoring approach outlined above, is provided in Table 38.

Table 38 Nuisance Dust Contingency Management Plan for Project

Trigger	Dust Deposition Rate <4 g/m²/month	Dust Deposition Rate >4 g/m²/month
Response	No response required. Continue monitoring program	Review and investigate construction activities and respective control measures, where appropriate. Implement additional remedial measures, such as: • Deployment of additional water sprays. • Relocation or modification of dust-generating sources. • Temporary halting of activities and resuming when conditions have improved.

10.2 Operational Phase

Given the nature and scale of the proposed standard operation test activities, with predicted ground level concentrations within the assessment criteria limits it is not anticipated that any impacts upon human health or amenity values would be experienced during the operational phase. Therefore, monitoring of air quality is not considered to be required during the operational phase.

The emergency conditions scenario, based on a number of cumulative assumptions, does show exceedances, however, considering the nature of these results and the conclusion regarding the normal operations above the results from the worst-case operations scenario does not justify the need for any monitoring.

11 Mitigation measures

11.1 Construction Phase

The SEARs require an environmental risk analysis to identify potential environmental impacts associated with the Project. The following represents the way in which risks, impacts and mitigation measures are identified and quantified in relation to dust management at the Project.

This analysis comprises a qualitative assessment consistent with AS/NZS ISO 31000:2009 *Risk Management–Principles and Guidelines* (Standards Australia 2009). The level of risk was assessed by considering the potential impacts of the Project prior to application of any mitigation or management measures.

Risk comprises the likelihood of an event occurring and the consequences of that event. For the Project, the descriptors shown in Table 39 were adopted for 'likelihood' and 'consequence'.

Table 39 Risk Descriptors

Likelihood		Consequence	
A	Almost certain	1	Widespread and/or irreversible impact
B	Likely	2	Extensive but reversible (within 2 years) impact or irreversible local impact
C	Possible	3	Local, acceptable or reversible impact
D	Unlikely	4	Local, reversible, short term (<3 months) impact
E	Rare	5	Local, reversible, short term (<1 month) impact

The risk levels for likely and potential impacts were derived using the risk matrix shown in Table 40.

Table 40 Risk Matrix

		Likelihood				
Consequence		A	B	C	D	E
	1	High	High	Medium	Low	Very Low
	2	High	High	Medium	Low	Very Low
	3	Medium	Medium	Medium	Low	Very Low
	4	Low	Low	Low	Low	Very Low
	5	Very Low	Very Low	Very Low	Very Low	Very Low

The risk assessment and mitigations measures are shown in Table 41.

Table 41 Risk Assessment and Mitigation Measures

Matter	Potential Impact	Likelihood	Consequence	Risk Level	Proposed Mitigation Measures
Air Quality	PM_{10} health impacts on nearby sensitive receptors from construction phase	E	4	Very Low	No mitigation required for PM_{10} specifically. Note that measures for dust soiling (below) will likely also reduce the potential impact of PM_{10}.
	Dust soiling (nuisance) impacts on nearby receptors from construction phase	D	4	Low	Develop a Construction Environmental Management Plan (CEMP) adopting appropriate and relevant measures from Section 9.1.4 of the AQIA, including monitoring as proposed in Section 10 of the AQIA.

11.2 Operation Phase

Given the worst-case operating scenario modelled predicted compliance with all relevant air quality impact assessment criteria, and the extremely low probability of the exceedances due to emergency conditions, installation of pollution control devices on generators at this initial stage is not deemed necessary. However, retrofittable pollution control devices capable of significantly reducing pollutant levels from the generators are available and should be installed at a later stage if change in circumstances mean generators require to be operated on a more frequent basis than has been assumed by this air quality impact assessment.

12 Conclusions

The main potential sources of air emissions were identified as suspended particulate matter and deposited dust during the construction stage and combustion gases and particulate matter during the operational stage of the Project.

The potential for off-site air quality impacts during the construction stage of the Project were assessed using a qualitative risk-based approach, concluding that given the nature of the operations proposed, the location of the Site and the local meteorological conditions, exceedances of the relevant air quality criteria are unlikely.

The potential for off-site air quality impacts during the operational stage of the Project were conservatively assessed quantitatively through the use of dispersion modelling techniques in general accordance with the Approved Methods. The dispersion modelling study, which accounted for worst-case testing conditions predicted no exceedance of the relevant ambient air quality as a result of the operation of the Project.

The dispersion of emissions due to emergency conditions, where loss of all feeders to the Site requiring all generators to operate simultaneously, was conservatively modelled and predicted compliance with the PM_{10} and $PM_{2.5}$ 24-hour average criterion at all receptors with the exception of the nearest, which represented the potential rooftop air intakes of the neighbouring building. However, the predicted likelihood of an exceedance coupled with the likelihood of an emergency condition event happening was demonstrated to result in a vanishingly small chance of an exceedance occurring.

Nevertheless, it is recommended that retrofittable pollution control devices capable of significantly reducing pollutant levels from the generators should be available to be installed at a later stage if a change in operating conditions deems this necessary.

It is concluded that air quality issues do not pose a constraint for the Project.

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APPENDIX A

IAQM Construction Assessment Methodology

Step 1 – Screening Based on Separation Distance

The Step 1 screening criteria provided by the IAQM guidance suggests screening out any assessment of impacts from construction activities where sensitive receptors are located more than 350 m from the boundary of the Site, more than 50 m from the route used by construction vehicles on public roads and more than 500 m from the Site entrance. This step is noted as having deliberately been chosen to be conservative, and will require assessments for most projects.

Step 2a – Assessment of Scale and Nature of the Works

Step 2a of the assessment provides "dust emissions magnitudes" for each of four dust generating activities; demolition, earthworks, construction, and track-out (the movement of soils and dusty materials onto public roads by vehicles). The magnitudes are: *Large*; *Medium*; or *Small*, with suggested definitions for each category. The definitions given in the IAQM guidance for earthworks, construction activities and track-out, which are most relevant to this Project, are as follows:

Demolition *(Any activity involved with the removal of an existing structure [or structures]. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time)*:

- *Large*: Total 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;
- *Medium*: Total building volume 20,000 m^3 – 50,000 m^3, potentially dusty construction material, demolition activities 10-20 m above ground level; and
- *Small*: Total building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities <10m above ground, demolition during wetter months.

Earthworks *(Covers the processes of soil-stripping, ground-levelling, excavation and landscaping)*:

- *Large*: Total site area greater than 10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), more than 10 heavy earth moving vehicles active at any one time, formation of bunds greater than 8 m in height, total material moved more than 100,000 t.
- *Medium*: Total site area 2,500 m^2 to 10,000 m^2, moderately dusty soil type (e.g. silt), 5 to 10 heavy earth moving vehicles active at any one time, formation of bunds 4 m to 8 m in height, total material moved 20,000 t to 100,000 t.
- *Small*: Total site area less than 2,500 m^2, soil type with large grain size (e.g. sand), less than five heavy earth moving vehicles active at any one time, formation of bunds less than 4 m in height, total material moved less than 20,000 t, earthworks during wetter months.

Construction *(Any activity involved with the provision of a new structure (or structures), its modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, etc)*:

- *Large*: Total building volume greater than 100,000 m^3, piling, on site concrete batching; sandblasting.
- *Medium*: Total building volume 25,000 m^3 to 100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching.
- *Small*: Total building volume less than 25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).

Track-out *(The transport of dust and dirt from the construction / demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network)*:

- *Large*: More than 50 heavy vehicle movements per day, surface materials with a high potential for dust generation, greater than 100 m of unpaved road length.
- *Medium*: Between 10 and 50 heavy vehicle movements per day, surface materials with a moderate potential for dust generation, between 50 m and 100 m of unpaved road length.
- *Small*: Less than 10 heavy vehicle movements per day, surface materials with a low potential for dust generation, less than 50 m of unpaved road length.

In order to provide a conservative assessment of potential impacts, it has been assumed that if at least one of the parameters specified in the 'large' definition is satisfied, the works are classified as large, and so on.

Step 2b – Risk Assessment

Assessment of the Sensitivity of the Area

- Step 2b of the assessment process requires the sensitivity of the area to be defined. The sensitivity of the area takes into account:
- The specific sensitivities that identified sensitive receptors have to dust deposition and human health impacts
- The proximity and number of those receptors
- In the case of PM_{10}, the local background concentration
- Other site-specific factors, such as whether there are natural shelters such as trees to reduce the risk of wind-blown dust.

Individual receptors are classified as having *high*, *medium* or *low* sensitivity to dust deposition and human health impacts (ecological receptors are not addressed using this approach). The IAQM method provides guidance on the sensitivity of different receptor types to dust soiling and health effects as summarised in Table A-1. It is noted that user expectations of amenity levels (dust soiling) is dependent on existing deposition levels.

Table A-1 IAQM Guidance for Categorising Receptor Sensitivity

Value	High Sensitivity Receptor	Medium Sensitivity Receptor	Low Sensitivity Receptor
Dust soiling	Users can reasonably expect a high level of amenity; or The appearance, aesthetics or value of their property would be diminished by soiling, and the people or property would reasonably be expected to be present continuously, or at least regularly for extended periods as part of the normal pattern of use of the land.	Users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or The appearance, aesthetics or value of their property could be diminished by soiling; or The people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land.	The enjoyment of amenity would not reasonably be expected; or Property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or There is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land.
	Examples: Dwellings, museums, medium and long term car parks and car showrooms.	*Examples: Parks and places of work.*	*Examples: Playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads.*
Health effects	Locations where the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day).	Locations where human exposure is transient.
	Examples: Residential properties, hospitals, schools and residential care homes.	*Examples: Office and shop workers, but will generally not include workers occupationally exposed to PM_{10}.*	*Examples: Public footpaths, playing fields, parks and shopping street.*

According to the IAQM methods, the sensitivity of the identified individual receptors (as described above) is then used to assess the *sensitivity of the area* surrounding the active construction area, taking into account the proximity and number of those receptors, and the local background PM_{10} concentration (in the case of potential health impacts) and other site-specific factors. Additional factors to consider when determining the sensitivity of the area include:

- Any history of dust generating activities in the area
- The likelihood of concurrent dust generating activity on nearby sites

- Any pre-existing screening between the source and the receptors
- Any conclusions drawn from analysing local meteorological data which accurately represent the area and if relevant, the season during which the works will take place
- Any conclusions drawn from local topography
- The duration of the potential impact (as a receptor may be willing to accept elevated dust levels for a known short duration, or may become more sensitive or less sensitive (acclimatised) over time for long-term impacts)
- Any known specific receptor sensitivities which go beyond the classifications given in the IAQM document.

The IAQM guidance for assessing the sensitivity of an area to dust soiling is shown in Table A-2. The sensitivity of the area should be derived for each of activity relevant to the project (i.e. construction and earthworks).

Table A-2 IAQM Guidance for Categorising the Sensitivity of an Area to Dust Soiling Effects

Receptor sensitivity	Number of receptors	Distance from the source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

Note: Estimate the total number of receptors within the stated distance. Only the *highest level* of area sensitivity from the table needs to be considered. For example, if there are 7 high sensitivity receptors < 20m of the source and 95 high sensitivity receptors between 20 and 50 m, then the total of number of receptors < 50 m is 102. The sensitivity of the area in this case would be high.

A modified version of the IAQM guidance for assessing the *sensitivity of an area* to health impacts is shown in Table A-3. For high sensitivity receptors, the IAQM methods takes the existing background concentrations of PM_{10} (as an annual average) experienced in the area of interest into account and is based on the air quality objectives for PM_{10} in the UK. As these objectives differ from the ambient air quality criteria adopted for use in this assessment (i.e. an annual average of 25 µg/m^3 for PM_{10}) the IAQM method has been modified slightly.

- This approach is consistent with the IAQM guidance, which notes that in using the tables to define the *sensitivity of an area*, professional judgement may be used to determine alternative sensitivity categories, taking into account the following factors:
- Any history of dust generating activities in the area
- The likelihood of concurrent dust generating activity on nearby sites
- Any pre-existing screening between the source and the receptors
- Any conclusions drawn from analysing local meteorological data which accurately represent the area, and if relevant the season during which the works will take place
- Any conclusions drawn from local topography
- Duration of the potential impact
- Any known specific receptor sensitivities which go beyond the classifications given in this document.

Table A-3 IAQM Guidance for Categorising the Sensitivity of an Area to Dust Health Effects

Receptor sensitivity	Annual mean PM_{10} conc.	Number of receptors [a,b]	Distance from the source (m)				
			<20	<50	<100	<200	<350
High	>25 µg/m^3	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	21-25 µg/m^3	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	17-21 µg/m^3	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<17 µg/m^3	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>25 µg/m^3	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	21-25 µg/m^3	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	17-21 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<17 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Notes: (a) Estimate the total within the stated distance (e.g. the total within 350 m and not the number between 200 and 350 m); noting that only the highest level of area sensitivity from the table needs to be considered.

(b) In the case of high sensitivity receptors with high occupancy (such as schools or hospitals) approximate the number of people likely to be present. In the case of residential dwellings, just include the number of properties.

Risk Assessment

The dust emission magnitude from Step 2a and the receptor sensitivity from Step 2b are then used in the matrices shown in Table A-4 (demolition), Table A-5 (earthworks and construction) and Table A-6 (track-out) to determine the risk category with no mitigation applied.

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Table A-4 Risk Category from Demolition Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible

Table A-5 Risk Category from Earthworks and Construction Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table A-6 Risk Category from Track-out Activities

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

Step 3 - Site-Specific Mitigation

Once the risk categories are determined for each of the relevant activities, site-specific management measures can be identified based on whether the Site is a low, medium or high risk site.

Step 4 – Residual Impacts

Following Step 3, the residual impact is then determined after management measures have been considered.

APPENDIX B

SELECTION OF REPRESENTATIVE METEOROLOGICAL DATA

Once emitted to atmosphere, the emissions will:

- Rise according to the momentum and buoyancy of the emission at the discharge point relative to the prevailing atmospheric conditions;
- Be advected from the source according to the strength and direction of the wind at the height which the plume has risen in the atmosphere;
- Be diluted due to mixing with the ambient air, according to the intensity of turbulence; and
- (Potentially) be chemically transformed and/or depleted by deposition processes.

Dispersion is the combined effect of these processes. Dispersion modelling is used as a tool to simulate the air quality effects of specific emission sources, given the meteorology typical for a local area together with the expected emissions. Selection of a year when the meteorological data is atypical means that the resultant predictions may not appropriately represent the most likely air quality impacts. Therefore, in dispersion modelling, one of the key considerations is the representative nature of the meteorological data used.

The year of meteorological data used for the dispersion modelling was selected by reviewing the most recent five years of historical surface observations at Sydney Olympic Park AWS (2016 to 2020 inclusive) to determine the year that is most representative of average conditions. Wind direction, wind speed and ambient temperature were compared to 5-year averages for the region to determine the most representative year.

Data collected from 2016 to 2020 is summarised in Figure A1 to Figure A3. Examination of the data indicates the following:

- Figure A1 indicates all years are generally similar with a higher frequency of winds from the north, northwest and west-northwest.
- Figure A2 indicates that average monthly wind speeds during 2018 typically representative of the 5-year average wind speeds.

Analysis of the average windspeeds and frequency of calms indicates that the years 2019 and 2020 generally have lower windspeeds that the five-year average, however, background PM_{10} and $PM_{2.5}$ concentrations for these years is known to be heavily impacted by summer bushfire events. For this reason, 2018 was selected as the representative year of meteorology with which to conduct the plume dispersion modelling.

Figure A1 Frequency of Winds at Sydney Olympic Park AWS 2016 – 2020

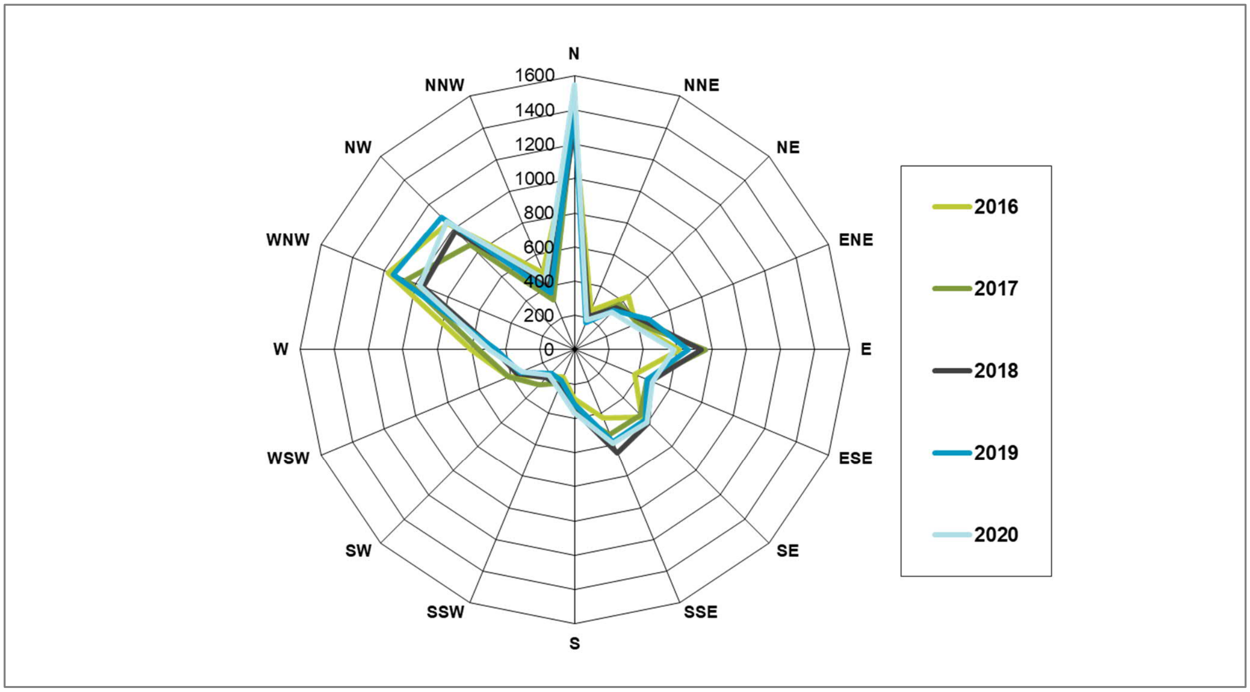
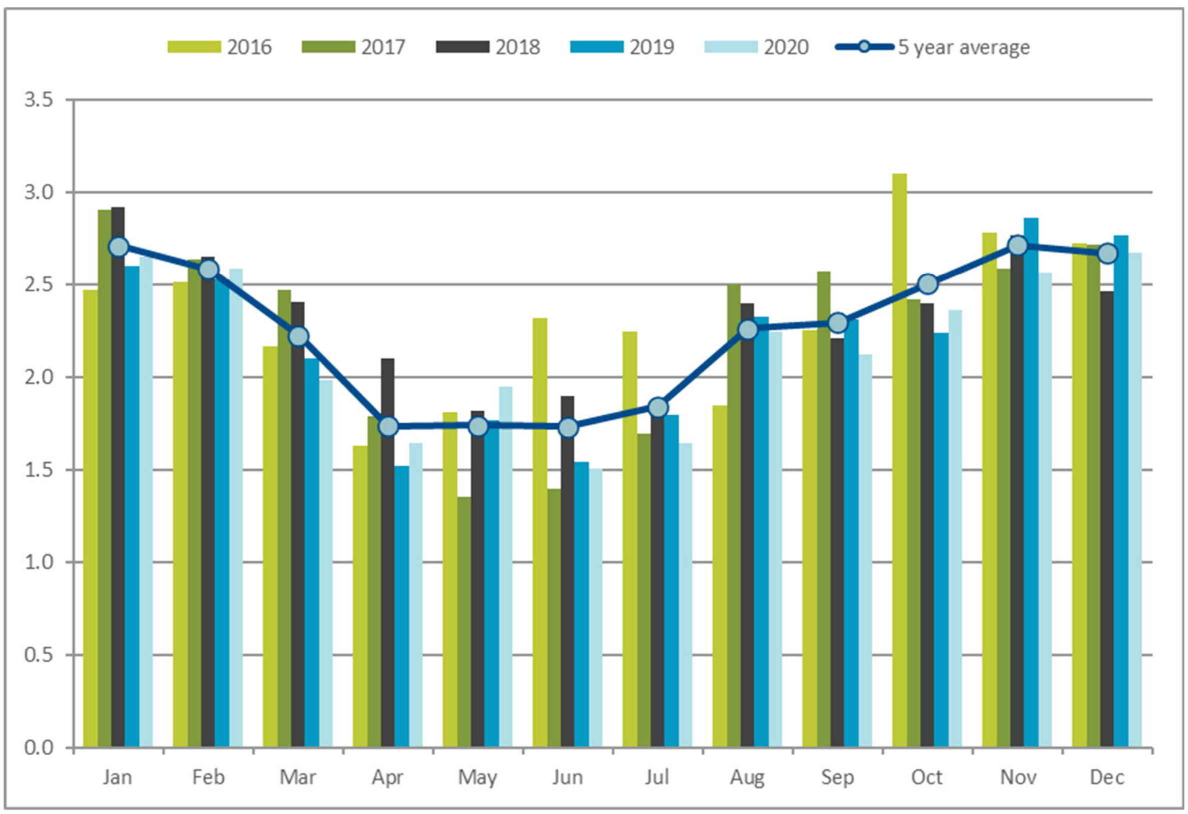


Figure A2 Monthly Average Wind Speed at Sydney Olympic Park AWS 2016 – 2020



APPENDIX C

Diesel Generator Specifications Sheets

20V4000G94LF – IC3W

Edition 8/10/2021
Page 5/26

Technical Sales Document

- Product Data -

A Rolls-Royce solution

Name	20V4000G94LF	**Speed [rpm]**	1500
Application Group	3D	**Nominal power [kW]**	3308
Dataset	Ref. 25°C/45°C	**Nominal power [bhp]**	4436
		Nominal power [kVA]	-
		Nominal power [kWel]	-
		Frequency [Hz]	50

Exhaust Regulations Fuel-consumption optimized;

3. Consumption

No.	Description	Index	Value	Unit
56	Specific fuel consumption (be) - 100 % FSP (+ 5 %; EN 590; 42.8 MJ/kg)	R	202	g/kWh
57	Specific fuel consumption (be) - 75 % FSP (+ 5 %; EN 590; 42.8 MJ/kg)	R	189	g/kWh
58	Specific fuel consumption (be) - 50 % FSP (+ 5 %; EN 590; 42.8 MJ/kg)	R	202	g/kWh
59	Specific fuel consumption (be) - 25 % FSP (+ 5 %; EN 590; 42.8 MJ/kg)	R	226	g/kWh
73	No-load fuel consumption	R	50	kg/h
92	Lube oil consumption after 100 h of operation (B = fuel consumption per hour) Guideline value does not apply for the design of EGAT systems. Please consult the Applications Center with regard to the layout of EGA systems.	R	0.2	% of B
62	Lube oil consumption after 100 h of operation, max. (B = fuel consumption per hour)	L	0.5	% of B

RL Reference value: fuel stop power
Maximum engine power that cannot be run continuously on some applications (stabilization reserve)
DL Reference value: continuous power
Engine power that can be run continuously under standard conditions

> Actual value must be greater than specified value
< Actual value must be less than specified value

X Applicable
The module is valid for this product type
- Non-applicable
The module is not valid for this product type
N Value not named
The value has not yet been named or will not be named

* Adequate verification not yet available (tolerance +/- 10%)
** Adequate verification not yet available (tolerance +/- 5%)

A Design value
Value required for the design of an external system (plant)
R Guideline value
Typical average value as information – only suitable for design purposes to a limited extent
L Limit value
A value representing the lower limit/maximum value or upper limit/maximum value that may not be exceeded. Not suitable for design purposes

Technical Sales Document

- Product Data -

A Rolls-Royce solution

Name	20V4000G94LF	**Speed [rpm]**	1500
Application Group	3D	**Nominal power [kW]**	3308
Dataset	Ref. 25°C/45°C	**Nominal power [bhp]**	4436
		Nominal power [kVA]	-
		Nominal power [kWel]	-
		Frequency [Hz]	50

Exhaust Regulations Fuel-consumption optimized;

5. Combustion air / exhaust gas

No.	Description	Index	Value	Unit
27	Charge-air pressure before cylinder - FSP	R	3.84	bar abs
10	Combustion air volume flow - FSP	R	4.5	m^3/s
12	Exhaust volume flow (at exhaust temperature) - FSP	R	11.5	m^3/s
14	Exhaust temperature before turbocharger - FSP	R	693	°C
4083	Exhaust temperature after engine - FSP (Position of interface according to installation drawing)	R	481	°C

[BL] Reference value: fuel stop power
Maximum engine power that cannot be run continuously on some applications (stabilization reserve)
[DL] Reference value: continuous power
Engine power that can be run continuously under standard conditions

[>] Actual value must be greater than specified value
[<] Actual value must be less than specified value

[X] Applicable
The module is valid for this product type
[-] Non-applicable
The module is not valid for this product type
[N] Value not named
The value has not yet been named or will not be named

[*] Adequate verification not yet available (tolerance +/- 10%)
[**] Adequate verification not yet available (tolerance +/- 5%)

[A] Design value
Value required for the design of an external system (plant)
[R] Guideline value
Typical average value as information – only suitable for design purposes to a limited extent
[L] Limit value
A value representing the lower limit/minimum value or upper limit/maximum value that may not be exceeded. Not suitable for design purposes

SLR

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	20V4000G94LF				
Application Group	3D				
Legislative body	Fuel-consumption optimized				
Test cycle	D2				
Fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	Measured				

Not to exceed emission values*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	3306	2479	1653	827	331
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1499	1499	1499	1499	1499
Engine speed relative	[-]	1	1	1	1	1
NOX+HC1 mass flow	kg/h	32.2	31.35	16.85	7.86	
NOX-Emissions specific	g/kWh	9.65	12.54	10.04	9.2	
CO-Emissions specific	g/kWh	0.52	0.51	0.91	1.35	
HC1-Emissions specific	g/kWh	0.08	0.1	0.15	0.31	
NOX+HC1-Emissions specific	g/kWh	9.74	12.64	10.19	9.51	
PM-Emissions specific (Meas.)	g/kWh	0.023	0.033	0.058	0.131	
NOX-Emissions (based on O2 meas)	mg/m3N	2402	3129	2247	1534	
NOX+HC1-Emissions (based on O2 meas)	mg/m3N	2422	3153	2279	1584	
CO-Emissions (based on O2 meas)	mg/m3N	126.7	124.3	198.8	220.2	
HC1-Emissions (based on O2 meas)	mg/m3N	20.6	24.3	32	50	
PM-Emissions (based on O2 meas)	mg/m3N	5.7	8.1	12.7	21.5	

PDF	Name	Project no. MT IC3w	Size A4
Configurator		Order no. MT IC3w	
Approver1	Kneifel, Alexander (TSLE)	EDS-ID 603-10.08.2021	
Approver2	Buecheler, Otto (TVM)		
Approver3			
Approver4			
User	APACichange	Title Emission data sheet	
Engine model 20V4000G94LF			

Description of Revision | Frequency

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 420122_366_G94LF_FCO.nc for 1119 in EDS platfrom.

		Emissionstage: Fuel-consumption optimized	Sheet
Configuration-ID: 1119	Documentation: Penske - MT IC3w	Emissionstage basis: Fuel-consumption optimized	of

SLR

Engine data

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	20V4000G94LF				
Application Group	3D				
Legislative body	Fuel-consumption optimized				
Test cycle	D2				
Fuel sulphur content [ppm]	5				
mg/mN^3 values base on residual oxygen value of [%]	5				

Not to exceed emission values*

Cycle point	[-]	n1	n2	n3	n4	n5
Power	kW	3306	2479	1653	827	331
Power relative	[-]	1	0.75	0.5	0.25	0.1
Engine speed	1/min	1499	1499	1499	1499	1499
Engine speed relative	[-]	1	1	1	1	1
NOX+HC1 mass flow	kg/h	32.2	31.35	16.85	7.86	
NOX-Emissions specific	g/kWh	9.65	12.54	10.04	9.2	
CO-Emissions specific	g/kWh	0.52	0.51	0.91	1.35	
HC1-Emissions specific	g/kWh	0.08	0.1	0.15	0.31	
NOX+HC1-Emissions specific	g/kWh	9.74	12.64	10.19	9.51	
PM-Emissions specific (Meas.)	g/kWh	0.023	0.033	0.058	0.131	
NOX-Emissions (based on 5% O2)	mg/m3N	3430	4775	3653	3011	
NOX+HC1-Emissions (based on 5% O2)	mg/m3N	3460	4812	3705	3110	
CO-Emissions (based on 5% O2)	mg/m3N	181	189.7	323.2	432.3	
HC1-Emissions (based on 5% O2)	mg/m3N	29.4	37	52.1	98.2	
PM-Emissions (based on 5% O2)	mg/m3N	8.2	12.4	20.6	42.1	

PDF	Name
Configurator	
Approver1	Kneifel, Alexander (TSLE)
Approver2	Buecheler, Otto (TVM)
Approver3	
Approver4	
User	APAC\change
Project no.	MT IC3w
Order no.	MT IC3w
Size	A4
EDS-ID	604-10.08.2021
Engine model	20V4000G94LF
Title	Emission data sheet
Description of Revision	
Frequency	
Emissionstage	Fuel-consumption optimized
Emissionstage basis	Fuel-consumption optimized
Configuration-ID	1119
Documentation	Penske - MT IC3w
Sheet	
of	

Data generated by EDS Creator version 1.0 and uniplot.
Ref.-dataset: 420122_366_G94LF_FCO.nc for 1119 in EDS platfrom.

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Revision Change index	b				

Motordaten
engine data

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	12V4000G23				
Application group	3D				
Emission Stage/Optimisation	fuel-optimised				
Test cycle	D2				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Not to exceed Werte*
*not to exceed values**

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1,00	0,75	0,50	0,25				
Power	[kW]	1576	1181	788	397				
Speed (n/nN)	[-]	1	1	1	1				
Speed	[rpm]	1501	1500	1500	1500				
Exhaust back pressure	[mbar]	27	16	9	5				
NOx	[g/kWh]	12,9	13,4	11,4	9,3				
	[mg/mN³]	4116	4040	2894	1520				
CO	[g/kWh]	1,0	0,8	0,9	2,2				
	[mg/mN³]	284	218	206	328				
HC	[g/kWh]	0,19	0,24	0,44	1,01				
	[mg/mN³]	56	66	104	152				
O2	[%]	8,3	8,9	10,5	13,3				
Particulate calculated	[g/kWh]	0,08	0,09	0,13	0,26				
	[mg/mN³]	20	23	27	35				

* Calculated values are not proven by tests and therefore the accuracy cannot be guaranteed.
Emissions data measurement procedures are consistent with those described in the applicable rules and standards.
The NOx, CO, HC and PM emission data tabulated here were taken from a single new engine under the test conditions shown above and are valid for the following conditions:

- Ambient air pressure 1 bar
- Air intake temperature approx. 25°C
- Rel. Humidity 30%-60%
- New Engine
- New standard- air filter
- Exhaust gas back pressure according the given value in this EDS
- Fuel according to EN 590 or US EPA 40CFR89
- Coolant and Lubricants according MTU Fuels and Lubricants Specification

The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on single operating points and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle. Emissions data may vary depending on the type of exhaust gas aftertreatment that may be installed on the engine, therefore it is suggested that the engine manufacturer be contacted directly for further information.

Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures, and instrumentation. Over time deterioration may occur which may have an impact on emission levels. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

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Aenderungsbeschreibung/Description of Revision | Kommt von/Frequency
EDS Datenblätter im Windchill werden im Zuge der neuen EDS-Datenbank ungültig gesetzt.

MTU
Friedrichshafen GmbH

WORD	Datum/ Date	Name
Erstell. Drawn	16.12.2020 15:22:54	link
Bearb. Change	16.12.2020 15:23:53	link
Inhalt Content	30.03.2017	Khakholk
Gepr. Checked		

Motortyp / Engine Type: **12V4000G23**

Projekt-/Auftrags-Nr. Project/Order No.
Verwendbar f.Typ Applicable to Model
Format/Size: **A3**
Material-Nr./Material No.: **EDS 4000 0174**
Benennung/ Title: **EMISSIONSDATENBLATT**
EMISSION DATA SHEET

Zeichnungs-Nr./Drawing No. **FDH00000000000435498**
Blatt/ Sheet
von/of
Beschreibung/Description

Buchst./Rev. Ltr.	Aenderungs-Nr./Revision Notice No.	Bearbeitungsstatus/Lifecycle
d.1		In Arbeit

SLR

Revision *Change index*	b				

Motordaten
engine data

	Genset	Marine	O & G	Rail	C & I
Application	x				
Engine model	12V4000G23				
Application group	3D				
Emission Stage/Optimisation	fuel-optimised				
Test cycle	D2				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	5				

Not to exceed Werte*
*not to exceed values**

Cycle point	[-]	n1	n2	n3	n4	n5	n6	n7	n8
Power (P/PN)	[-]	1,00	0,75	0,50	0,25				
Power	[kW]	1576	1181	788	397				
Speed (n/nN)	[-]	1	1	1	1				
Speed	[rpm]	1501	1500	1500	1500				
Exhaust back pressure	[mbar]	27	16	9	5				
NOx	[g/kWh]	12,9	13,4	11,4	9,3				
	[mg/mN³]	5202	5355	4397	3148				
CO	[g/kWh]	1,0	0,8	0,9	2,2				
	[mg/mN³]	359	290	313	679				
HC	[g/kWh]	0,19	0,24	0,44	1,01				
	[mg/mN³]	70	88	158	316				
O2	[%]	5,0	5,0	5,0	5,0				
Particulate calculated	[g/kWh]	0,08	0,09	0,13	0,26				
	[mg/mN³]	25	31	41	73				

* Calculated values are not proven by tests and therefore the accuracy cannot be guaranteed.

Emissions data measurement procedures are consistent with those described in the applicable rules and standards.

The NOx, CO, HC and PM emission data tabulated here were taken from a single new engine under the test conditions shown above and are valid for the following conditions:

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Verwendbar f.Typ Applicable to Model
Format/Size: **A3**

Material-Nr./Material No.: **EDS 4000 0174**

Benennung/ Title:
EMISSIONSDATENBLATT
EMISSION DATA SHEET

Zeichnungs-Nr./Drawing No.: **FDH0000000000435498**

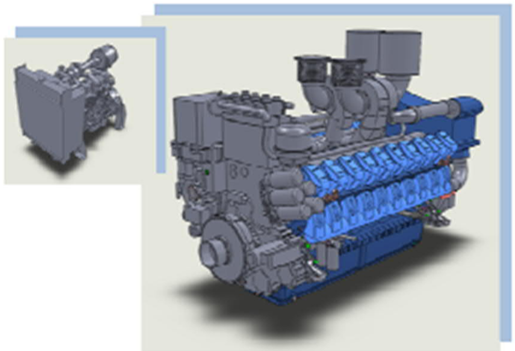
Blatt/ Sheet
von/of

Buchst./Rev. Ltr.	Aenderungs-Nr./Revision Notice No.	Bearbeitungsstatus/Lifecycle
d.1		In Arbeit

Beschreibung/Description

SLR

2 DIESEL ENGINE



2.1 MAIN FEATURES

Characteristic	Value	Unit	Remark
Brand	MTU		
Model	20V4000G63 EO		
Rated speed	1500	RPM	
Displacement	95.4	L	
Number of cylinders	20		
Electrical system	24	V DC	
Prime power rating (PRP)	2420	kW	At 40°C and 100kPa according to ISO 3046
Standby power (ESP)	2662	kW	

2.3 FLUIDS CAPACITIES

Fluid type	Quantity	Unit
Lubricating oil capacity (total)	390	l
Lubricating oil consumption at rated power		l/h
Coolant capacity in engine circuit (radiator not included)	205	l
Coolant capacity in aftercooler circuit (if applicable and radiator not included)	55	l

2.4 FUEL

Fuel consumption (Admissible tolerance : +/-5%)	g/kWh	L/h
at 25% PRP	236	168
at 50% PRP	215	306
at 75% PRP	213	455
at 100% PRP	213	606
at rated output power	213	545

Other characteristics	Value	Unit
Fuel maximum inlet temperature	55	°C
Maximum fuel flow	1020	L/h

2.5 EXHAUST

Characteristics	Value	Unit
Exhaust gas flow	31300	m^3/h
Exhaust gas temperature	590	°C
Heat rejection to exhaust	NA	kW
Exhaust back pressure (Design value)	30	mbar
Maximum exhaust back pressure	85	mbar

Exhaust emissions (PRP)	Value	Unit
Complies with	TA-Luft	
NOx	1700	mg/m^3
CO	300	mg/m^3
Unburned hydrocarbons	150	mg/m^3
Particulate matter (Dust)	50	mg/m^3

20V400G63 – IC3E

DIESEL GENERATOR SET
MTU 20V4000 DS3100

380V – 11 kV/50 Hz/Data Center Continuous Power/Fuel Consumption Optimized
MTU 20V4000G63/Water Charge Air Cooling

Optional equipment and finishing shown. Standard may vary.

mtu onsite energy

PRODUCT HIGHLIGHTS

// **Benefits**
- Low fuel consumption
- Optimized system integration ability
- High reliability
- High availability of power
- Long maintenance intervals

// **MTU Onsite Energy is a single-source supplier**

// **Support**
- Global product support offered

// **Standards**
- Engine-generator set is designed and manufactured in facilities certified to standards ISO 2008:9001 and ISO 2004:14001
- Generator set complies to ISO 8528
- Generator meets NEMA MG1, BS5000, ISO, DIN EN and IEC standards
- NFPA 110

// **Power Rating**
- System ratings: 2900 kVA - 2910 kVA
- Accepts rated load in one step per NFPA 110
- Generator set complies to G3 according to ISO 8528-5
- Generator set exceeds load steps according to ISO 8528-5

// **Performance Assurance Certification (PAC)**
- Engine-generator set tested to ISO 8528-5 for transient response
- 100% load factor
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Complete range of accessories available**
- Control panel
- Power panel
- Circuit breaker/power distribution
- Fuel system
- Fuel connections with shut-off valve mounted to base frame
- Starting/charging system
- Exhaust system
- Mechanical and electrical driven radiators
- Medium and oversized voltage alternators

// **Emissions**
- Fuel consumption optimized

// **Certifications**
- CE certification option
- Unit certificate acc. to BDEW (German Grid-Code)

APPLICATION DATA[1]

// Engine

Manufacturer	MTU
Model	20V4000G63
Type	4-cycle
Arrangement	20V
Displacement: l	95.4
Bore: mm	170
Stroke: mm	210
Compression ratio	16.4
Rated speed: rpm	1500
Engine governor	ADEC (ECU 7)
Max power: kWm	2420
Air cleaner	Dry

// Fuel System

Maximum fuel lift: m	5
Total fuel flow: l/min	27

// Fuel Consumption[2]

	l/hr	g/kwh
At 100% of power rating:	554	190
At 75% of power rating:	422	193
At 50% of power rating:	294.5	202

// Liquid Capacity (Lubrication)

Total oil system capacity: l	390
Engine jacket water capacity: l	205
Intercooler coolant capacity: l	50

// Combustion Air Requirements

Combustion air volume: m^3/s	2.7
Max. air intake restriction: mbar	50

// Cooling/Radiator System

Coolant flow rate (HT circuit): m^3/h	80
Coolant flow rate (LT circuit): m^3/h	32.5
Heat rejection to coolant: kW	890
Heat radiated to charge air cooling: kW	350
Heat radiated to ambient: kW	105
Fan power for electr. radiator (40°C): kW	70

// Exhaust System

Exhaust gas temp. (after turbocharger): °C	560
Exhaust gas volume: m^3/s	7.1
Maximum allowable back pressure: mbar	85
Minimum allowable back pressure: mbar	30

CUMMINS – For approximate SO_2 Emissions

Exhaust emission data sheet
C3750 D5
50 Hz Diesel generator set

Engine Information:

Model:	Cummins Inc. QSK95-G4	Bore:	7.48 in. (190 mm)
Type:	4 Cycle, VEE, 16 cylinder diesel	Stroke:	8.27 in. (210 mm)
Aspiration:	Turbocharged and Aftercooled	Displacement:	5816 cu. in. (95.3 liters)
Compression Ratio:	15.5:1		
Emission Control Device:	Turbocharged and Aftercooled		
Emission Level:	Stationary emergency		

Performance Data	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime	Full Continuous
Engine BHP @ 1500 RPM (50 Hz)	1145	2185	3225	4308	3822	3433
Fuel Consumption L/Hr (US Gal/Hr)	216 (57)	371 (98)	537 (142)	723 (191)	636 (168)	575 (152)
Exhaust Gas Flow m³/min (CFM)	205 (7251)	317 (11195)	443 (15664)	560 (19765)	510 (18022)	473 (16705)
Exhaust Gas Temperature °C (°F)	331 (627)	378 (713)	383 (722)	413 (776)	391 (763)	384 (723)
Exhaust Emission Data						
HC (Total Unburned Hydrocarbons)	0.19 (81)	0.09 (46)	0.08 (40)	0.06 (31)	0.06 (33)	0.08 (41)
NOx (Oxides of Nitrogen as NO_2)	9.1 (3990)	9.3 (4540)	7.6 (3800)	7.4 (3700)	7.3 (3670)	7 (3500)
CO (Carbon Monoxide)	0.3 (150)	0.2 (110)	0.1 (30)	0.1 (40)	0.1 (30)	0.1 (30)
PM (Particulate Matter)	0.05 (18)	0.01 (6)	0.01 (3)	0.01 (4)	0.01 (3)	0.01 (3)
SO_2 (Sulfur Dioxide)	0.005 (1.8)	0.004 (1.8)	0.004 (1.8)	0.004 (1.7)	0.004 (1.7)	0.004 (1.8)
Smoke (FSN)	0.35	0.16	0.08	0.11	0.08	0.08

All values (except smoke) are cited: g/BHP-hr (mg/Nm³ @ 5% O_2)

Test Conditions

Steady-state emissions recorded per ISO8178-1 during operation at rated engine speed (+/-2%) and stated constant load (+/-2%) with engine temperatures, pressures and emission rates stabilized.

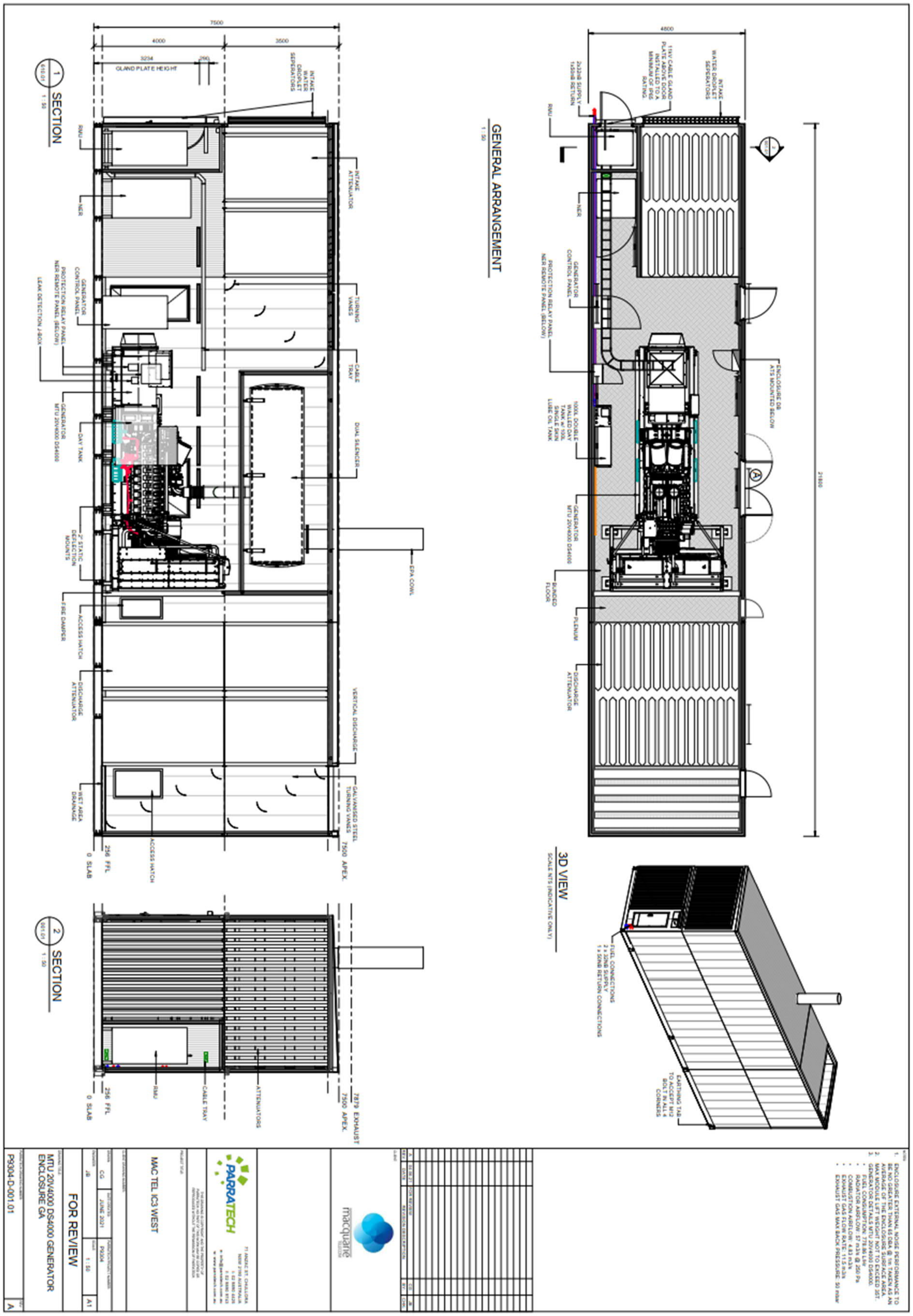
Fuel Specification:	40-48 Cetane Number, 0.0015 Wt.% Sulfur; Reference ISO8178-5, 40 CFR 86, 1313—98 Type 2-D and ASTM D975 No. 2-D. Fuel Density at 0.85 Kg/L (7.1 lbs/US Gal)
Air Inlet Temperature	25 °C (77 °F)
Fuel Inlet Temperature:	40 °C (104 °F)
Barometric Pressure:	100 kPa (29.53 in Hg)
Humidity:	NOx measurement corrected to 10.7 g/kg (75 grains H_2O/lb) of dry air
Intake Restriction:	Set to 18 in of H_2O as measured from compressor inlet
Exhaust Back Pressure:	Set to 1.5 in Hg
Note:	mg/m³ values are measured dry, corrected to 5% O_2 and normalized to standard temperature and pressure (0°C, 101.325 kPa)

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

Cummins Inc. Data and specification subject to change without notice EDS-1209b (1/18)

APPENDIX D

Generator Enclosure – General Arrangement


GENERAL ARRANGEMENT
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SECTION
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SECTION
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3D VIEW
SCALE NTS (INDICATIVE ONLY)
7500
4000
3500
4800
21800
INTAKE ATTENUATOR
TURNING VANES
CABLE TRAY
DUAL SILENCER
EPA COWL
VERTICAL DISCHARGE
GALVANISED STEEL TURNING VANES
RMU
NER
GENERATOR CONTROL PANEL
PROTECTION RELAY PANEL
NER REMOTE PANEL (BELOW)
LEAK DETECTION J-BOX
GENERATOR MTU 20V4000 DS4000
DAY TANK
FIRE DAMPER
ACCESS HATCH
DISCHARGE ATTENUATOR
WET AREA DRAINAGE
PLENUM
BUNDED FLOOR
ATTENUATORS
CABLE TRAY
FUEL CONNECTIONS
EARTHING TAB
MAC TEL IC3 WEST
FOR REVIEW
MTU 20V4000 DS4000 GENERATOR ENCLOSURE GA
JUNE 2021
1:50
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P9304-D-001.01
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