This document has been prepared for **Jackson Environment and Planning Pty Ltd** on behalf of **Dial-A-Dump (EC) Pty Ltd**:

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Landfill Gas Collection Network and Flares – Eastern Creek Landfill

Air Quality Impact Assessment and Greenhouse Gas Assessment

Addressee(s):	Dial-A-Dump (EC) Pty Ltd
Site Address:	Kangaroo Avenue, Eastern Creek, NSW
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Quality Control

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THE PROPOSED DEVELOPMENT MODIFICATION	Final	Northstar Air Quality	GCG, MD	MD
LEGISLATION, REGULATION AND GUIDANCE	Final	Northstar Air Quality	GCG, MD	MD
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AIR QUALITY IMPACT ASSESSMENT	Final	Northstar Air Quality	GCG, MD	MD
GREENHOUSE GAS ASSESSMENT	Final	Northstar Air Quality	GCG, MD	MD
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Final Authority

This report must by regarded as draft until the above study components have been each marked as final, and the document has been signed and dated below.

Martin Doyle **30th November 2021**

Non-Technical Summary

Jackson Environment and Planning Pty Ltd has engaged Northstar Air Quality Pty Ltd on behalf of Dial-A-Dump (EC) Pty Ltd to perform an air quality impact assessment and greenhouse gas assessment for a proposed landfill gas collection network including flares (the Proposed Development Modification), at the Eastern Creek Recycling Ecology Park, located at Kangaroo Avenue, Eastern Creek, NSW, in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued for the Proposal.

Background

Prior to 2021, Dial-A-Dump (EC) Pty Ltd had historically received few odour complaints regarding operations at the Eastern Creek Recycling Ecology Park. An independent odour audit performed in 2020 concluded that the operation of the Eastern Creek Recycling Ecology Park was compliant with all conditions, except for two which were associated with the currency of the Air Quality, Odour and Greenhouse Gas Management Plan. That management plan was subsequently updated between February and July 2021 to reflect the identified non-compliances. The updated Air Quality, Odour and Greenhouse Gas Management Plan (Revision 5, July 2021) was approved by DPIE on 10 August 2021.

Between 1 April and 30 July 2021, the NSW Environment Protection Authority received more than 750 reports of odours described variously as 'rotten egg gas', 'sulphur smelling', and 'foul chemical smells' from residents and businesses in suburbs surrounding the Eastern Creek Recycling Ecology Park including Minchinbury, Mt Druitt, St Clair, Erskine Park, Horsley Park and Eastern Creek. The descriptors of odour used in numerous odour complaints, as briefly identified above, is consistent with the description of odour from hydrogen sulphide. The NSW Environment Protection Authority conducted a number of odour surveys and inspections of the Eastern Creek Recycling Ecology Park and surrounding areas and came to the conclusion that an odour was being emitted from the Eastern Creek Recycling Ecology Park.

As a result, on 23 April 2021 the Environment Protection Authority issued a Clean-Up Notice under section 91 of the *Protection of the Environment Operations Act* 1997 requiring Dial-A-Dump (EC) Pty Ltd to take reasonable immediate actions to manage gas emissions from the leachate riser and leachate vent pipe. Following the issue of the Clean-up Notice, Dial-A-Dump (EC) Pty Ltd took action to seal the leachate riser and leachate vent pipe.

The NSW Environment Protection Authority continued to receive odour complaints after the completion of these actions required through the Clean Up Notice.

The NSW Environment Protection Authority considered further actions were required to prevent the emission of offensive odours from the Eastern Creek Recycling Ecology Park. On 7 May 2021 the Environment Protection Authority issued Licence Variation Notice No. 1608782 to include a Special Condition in order to impose additional Licence requirements to prevent the emission of potentially offensive odours from the Premises.

Specifically, a condition was temporarily imposed which supported the installation of a temporary flare in the vicinity of the leachate riser in the south-east portion of the landfill to capture and treat landfill gas by high-temperature combustion. A number of additional temporary flares have since been installed, which have the aggregated capacity to treat up to 2 000 standard cubic metres per hour of landfill gas.

In a recent Senate estimates hearing, a representative of NSW EPA stated that a dramatic reduction in odour complaints was experienced following the installation of the temporary flare system, with monitoring of hydrogen sulphide around the premises indicating that concentrations were observed to "pretty much go to zero". Only two odour complaints relating to the Premises were received by NSW EPA in each of September and October 2021.

The Proposed Development Modification

The Proposed Development Modification seeks to build on the success of the temporary landfill gas collection and treatment system and provide a more permanent solution for management of landfill gas. A permanent flaring system is required by NSW Environment Protection Authority under Environment Protection Licence 13426, Condition U1.2 (b), as part of the broader landfill gas management plan for the Eastern Creek Recycling Ecology Park.

The Proposed Development Modification seeks to capture up to 85 percent of generated landfill gas, and combust this gas with 98 percent destruction efficiency within two permanent, enclosed flares at a rate of 3 000 standard cubic metres per hour.

The flares have been designed to be achieve the requirements as set out by NSW Environment Protection Authority, through the 'Environmental Guidelines for Solid Waste Landfills' (2016), the *Protection of the Environment Operations Act* 1997, and the *Protection of the Environment (Clean Air) Regulation* 2021. The flares would also be constructed, installed and operated in accordance with relevant Australian Standards.

Air Quality Impact Assessment

A quantitative assessment (dispersion modelling) has been performed, which seeks to assess the potential air quality impacts resulting from the operation of the permanent flares on the surrounding environment.

To appropriately assess the potential impacts in the area surrounding the Eastern Creek Recycling Ecology Park, the dispersion modelling has predicted air quality impacts at 4 900 individual locations, covering the residential areas of Minchinbury, Mt Druitt, Rooty Hill, Colyton, Erskine Park, and St Clair, and the industrial areas of Minchinbury, Erskine Park, Horsley Park and Eastern Creek.

The prevailing meteorology of the area has been assessed using observations made by the Australian Government Bureau of Meteorology, with a three-dimensional meteorological grid modelled to 'drive' the dispersion model.

Existing air quality conditions in the area have been characterised using data collected by NSW Department of Planning, Industry and Environment at the Prospect air quality monitoring station.

When landfill gas in combusted in a flare, hydrogen sulphide is converted (oxidised) to sulphur dioxide, with nitrogen dioxide, carbon monoxide, and particulate matter all being released. A small amount of hydrogen sulphide not converted (oxidised) to sulphur dioxide is also released. Given that the gas collection system will capture up to 85 percent of landfill gas generated, a small amount of hydrogen sulphide could still be emitted through the landfill surface. The air quality assessment considers all of these potential emission pathways, and pollutants noted above.

Emissions of each pollutant have been calculated, based on measured landfill gas data (for assessment of emissions through the flares), or based on research (for assessment of emissions through the landfill surface). In all cases, the emissions calculations represent potential worst-case impacts and are appropriate for comparison with short-term air quality criteria, and provided a more conservative approximation of emissions over the longer-term. Dial-A-Dump (EC) Pty Ltd continues to collect data associated with the operation of the currently operational temporary gas extraction and treatment trial, which will be used to confirm as appropriate, the data used in the air quality impact assessment.

The findings of the air quality impact assessment indicate that the concentrations of all pollutants assessed are below the NSW Environment Protection Authority air quality criteria, at all residential and industrial locations surrounding the Eastern Creek Recycling Ecology Park, even with the additional of existing air pollutant concentrations. In the case of fine particulate matter, exceedances of the air quality criteria are observed in the air quality record, even without the operation of the flares, and the operation of the Proposed Development Modification would not result in any additional exceedances of the relevant particulate criteria.

Importantly, the air quality impact assessment confirms that the operation of the Proposed Development Modification would result in no exceedances of the hydrogen sulphide criterion in any of the residential or industrial areas surrounding the Eastern Creek Recycling and Ecology Park, and the likelihood of odour impacts would be correspondingly low.

Greenhouse Gas Assessment

A greenhouse gas assessment has been performed which indicates that through the implementation of the Proposed Development Modification, approximately 265 000 tonnes of carbon dioxide equivalent could be avoided each year, which equates to an annual greenhouse gas emission reduction of 67 percent, when compared to a pre-flaring situation.

It is respectfully considered that the Proposed Development Modification provides a preferential environmental outcome, when compared with a pre-LFG capture and treatment scenario.

CONTENTS

Tables

Figures

1. INTRODUCTION

Jackson Environment and Planning Pty Ltd (JEP) has engaged Northstar Air Quality Pty Ltd (Northstar) on behalf of Dial-A-Dump (EC) Pty Ltd (DADEC) to perform an air quality impact assessment (AQIA) and greenhouse gas assessment (GHGA) for a proposed landfill gas collection network including flares (the Proposed Development Modification), at the Eastern Creek Recycling Ecology Park (the Premises), located at Kangaroo Avenue, Eastern Creek, NSW in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued for the Proposal.

The Proposed Development Modification seeks to reduce the environmental impact of gases that would be otherwise discharged to the atmosphere from the landfill.

Activities at the Premises were originally approved (MP 06_0139) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2009 and commenced operations in 2012. Following the repeal of Part 3A of the EP&A Act on 1 October 2011, those activities were subject to the transitional arrangements provided by the Environmental Planning and Assessment Regulations 2000 (EP&A Regs). The transitional arrangements provided by EP&A Regs have now ceased, and the Premises was transitioned to a State Significant Development (SSD) on 2 October 2020. Consequently, MP 06_0139 is now considered to be SSD and this application has been prepared pursuant to Section 4.55 (1A) of the EP&A Act. This AQIA and GHGA form part of the Environmental Impact Statement (EIS) prepared to accompany the modification application for the Proposed Development Modification.

The AQIA has been performed with due reference to the following policies, guidelines and plans:

- *Protection of the Environment Operations Act* 1997.
- Protection of the Environment Operations (Clean Air) Regulation 2021.
- Approved Methods for the Modelling and Assessment of Air Quality in NSW (NSW EPA, 2017).
- Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (NSW DEC, 2006).
- Environmental Guidelines, Solid Waste Landfills (2nd edition) (NSW EPA, 2016).
- Bingo Industries, Landfill Gas Management Plan, Eastern Creek Recycling Ecology Park (& Landfill) (Bingo Industries, 2021a)
- Bingo Industries, Air Quality, Odour and Greenhouse Gas Management Plan (Bingo Industries, 2021b).
- Project Approval conditions (MP 06_0139) as modified.

The GHGA has been performed with due reference to the following policies, guidelines and plans:

- National Greenhouse Account Factors August 2021 (DISER, 2021).

- Bingo Industries, Landfill Gas Management Plan, Eastern Creek Recycling Ecology Park (& Landfill) (Bingo Industries, 2021a)
- Bingo Industries, Air Quality, Odour and Greenhouse Gas Management Plan (Bingo Industries, 2021b).
- Project Approval conditions (MP 06_0139) as modified.
- National Greenhouse and Energy Reporting (Measurement) Determination 2008.

NSW Department of Planning, Industry & Environment (DPIE) has provided requirements for the submission of the documentation to support the Proposed Development Modification. In relation to air quality and greenhouse gas, these requirements are presented in **Table 1**, including a reference to the section of this report where they have been addressed.

Table 1 Secretary's Environmental Assessment Requirements

Requirements	Addressed
5. Air quality, including: ▪ a quantitative Air Quality Impact Assessment (AQIA) of the potential air quality, dust and odour impacts of all stages of the modification (construction and operation) in accordance with the relevant Environment Protection Authority guidelines, including an assessment of cumulative impacts	Section 6
▪ a greenhouse gas assessment	Section 7
▪ details and results of the landfill gas extraction trial	Section 2.3
▪ details of proposed mitigation, management and monitoring measures	Section 8.2

2. THE PROPOSED DEVELOPMENT MODIFICATION

The following provides background to, and a description of, the Proposed Development Modification, and describes the potential sources of associated emissions to air, including greenhouse gas and odour.

2.1 Background

A detailed description of the project history, previous assessment, modifications, approved hours of operation is provided in the main Modification Report (JEP, 2021) and are not replicated here. Of relevance to this AQIA and GHGA, the following is noted.

The Premises operates under two Environment Protection Licences (EPL) issued by the Environment Protection Authority (EPA); EPL 20121 focusses on resource recovery and EPL 13426 covers landfill operations. The Premises has approval to:

- Accept up to two million tonnes per annum (Mtpa) of C&D (construction and demolition) and C&I (commercial and industrial) waste and landfilling of the quarry void of up to 1 million tpa of non-putrescible waste (including asbestos and other non-recyclable waste), excluding residual chute waste from the material processing centre;
- Crushing, grinding and separating works to process waste masonry material located in an area earmarked as the Segregated Materials Area (SMA);
- Stockpile up to 50 tonnes (t) of waste tyres; and
- Stockpile up to 20 000 t of green waste.

It is important to note that although the landfill is not licensed to, nor accepts putrescible wastes, the material which is permitted to be landfilled does contain organic material. This organic material can degrade to result in emissions of methane and other landfill gases (refer **Table 2**), which is consistent with emission calculations outlined in Australian Government, Clean Energy Regulator documentation for solid waste management (Clean Energy Regulator, 2021).

Furthermore, prior to June 2019, waste soils comprised more than 50 % of landfilled wastes. Soils are understood to have formed more than 60 % of waste from 2017 to 2019 and a higher percentage prior to 2017. During 2020 and 2021, mixed waste organic material (MWOO) was diverted to landfill and there were unseasonal influxes of fire debris from regional fires (2019 to 2020) and flood debris from regional flooding events (2021) (Bingo Industries, 2021a). This MWOO and flood waste is no longer permitted to be accepted at the Premises, in accordance with condition L3.7 of EPL 13426.

Due to the presence of organic waste in the landfill, and surface infiltration of precipitation being the primary water source for leachate generation at the Premises, there is the potential for landfill gas (LFG) to be produced and odours generated.

The volume of LFG generated at a landfill is directly proportional to the amount of waste within the landfill. The total volume of LFG that will be produced is dependent on the type of waste and its volume.

The rate at which LFG will be produced is influenced by:

- Moisture content and distribution
- Waste compaction
- Leachate management
- Waste composition changes over time
- pH and nutrient availability
- Temperature
- Presence of limiting factors (elevated temperatures or chemical inhibitors).

Typically, LFG contains (by volume) 45 % to 60 % methane, and 40 % to 60 % carbon dioxide. LFG can also contain small amounts of nitrogen, oxygen, ammonia, sulphides, hydrogen, carbon monoxide and non-methane organic compounds. **Table 2** lists 'typical' landfill gases, their percent by volume and characteristics. Note that the percentages of methane and carbon dioxide measured in LFG at the premises are consistent with these 'typical' values.

Table 2 Typical landfill gas components

Component	Percent by volume	Characteristics
Methane	45 – 60	Methane is a naturally occurring gas. It is colorless and odourless.
Carbon dioxide	40 -60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odourless, and slightly acidic.
Nitrogen	2- 5	Nitrogen comprises approximately 79% of the atmosphere. It is odourless, tasteless, and colourless.
Oxygen	0.1 – 1	Oxygen comprises approximately 21% of the atmosphere. It is odourless, tasteless, and colourless.
Ammonia	0.1 -1	Ammonia is a colourless gas with a pungent odour.
Non-methane organic compounds (NMOC)	0.01 – 06	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes.
Sulphides	0 – 1	Sulphides (e.g., hydrogen sulphide, dimethyl sulphide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulphides can cause unpleasant odours even at very low concentrations.
Hydrogen	0 – 0.2	Hydrogen is an odourless, colourless gas.
Carbon monoxide	0 – 0.2	Carbon monoxide is an odourless, colourless gas.

Reference: (Tchobanoglous, Theisen, & Vigil, 1993)

2.2 Odour Complaints History

Prior to 2021, the Premises had historically received few odour complaints that could be attributed to site operational activities. An independent odour audit was performed by Northstar in 2020, which included a site inspection and audit of project performance against relevant conditions outlined in Schedule 3 and Schedule 5 of the Project Approval for MP 06_0139, and associated Environment Protection Licences (EPL) 20121 and 13426 (Northstar Air Quality, 2020). That independent odour audit concluded that the operation of the Premises was compliant with all conditions, except for two which were associated with the currency of the Air Quality, Odour and Greenhouse Gas Management Plan for the Premises. That management plan was subsequently updated between February and July 2021 to reflect the identified non-compliances. The updated Air Quality, Odour and Greenhouse Gas Management Plan (Revision 5, July 2021) was approved by DPIE on August 10 2021.

In March 2021, record monthly rainfall totals were observed at two of the closest Bureau of Meteorology (BoM) automatic weather stations (AWS) to the Premises, where rainfall totals in March were 3.9 times the long-term monthly average at Horsley Park Equestrian Centre AWS, and 3.4 times the long-term monthly average at Badgerys Creek AWS[1]. This atypical rainfall event resulted in significant volumes of rainwater infiltrating the landfill, increasing the potential for the production of odour through various mechanisms, such as the microbial reduction of sulphate (present in the incoming waste stream) to hydrogen sulphide (H_2S). That rainfall event was widespread across NSW and resulted in significant flooding events. Similar odour issues have been experienced following that rainfall event at a number of landfills on the east coast of Australia, including the Coffs Harbour landfill, Bowral Waste Centre, Woodlawn Bioreactor, and Kembla Grange landfill[2].

Between 1 April and 30 July 2021, the NSW Environment Protection Authority (EPA) received more than 750 reports of odours described variously as 'rotten egg gas', 'sulphur smelling', and 'foul chemical smells' from residents and businesses in suburbs surrounding the REP including Minchinbury, Mt Druitt, St Clair, Erskine Park, Horsley Park and Eastern Creek. The NSW Environment Protection Authority conducted a number of odour surveys and inspections of the Eastern Creek Recycling Ecology Park and surrounding areas and came to the conclusion that an odour was being emitted from the Eastern Creek Recycling Ecology Park.

As a result, on 23 April 2021 the EPA issued a Clean-Up Notice under section 91 of the POEO Act (Notice No. 3500173) requiring DADEC to take reasonable immediate actions to manage gas emissions from the leachate riser and leachate vent pipe. Following the issue of the Clean-up Notice, DADEC took action to seal the leachate riser and leachate vent pipe.

[1] http://www.bom.gov.au/climate/current/month/nsw/archive/202103.summary.shtml

2 https://www.epa.nsw.gov.au/news/news/2021/community-news-updates

The NSW EPA continued to receive complaints of odours after the completion of these actions. The NSW EPA considered further actions were required to prevent the emission of offensive odours from the Premises. On 7 May 2021 the EPA issued Licence Variation Notice No. 1608782 to include a Special Condition in order to impose additional Licence requirements (Condition E5) to prevent the emission of potentially offensive odours from the Premises.

Specifically, Condition E5.11 was temporarily imposed which supported the installation of a temporary flare in the vicinity of the leachate riser in the south-east of the landfill to capture and treat LFG by high-temperature combustion.

In response to odour complaints, NSW EPA installed a network of monitors to measure H_2S concentrations, with four of the monitors located in the Eastern Creek industrial area and three in the Minchinbury residential area. The seven monitors have been reporting H_2S concentrations since 9 June 2021 (and ongoing) providing concentrations every 10 minutes[3].

The dataset, which covers an approximate five-month period, suggests that the frequency of H_2S concentrations above the odour detection threshold (ODT, i.e. the concentration at which H_2S odour can be detected by the human nose) is low, with a low frequency of odour complaints being received by the NSW EPA in September and October 2021. This indicates that the temporary gas extraction trial and treatment by flaring (refer **Section 2.3**) is acting to manage offsite impacts of H_2S, and consequently, odour.

2.3 Temporary Gas Extraction Trial and Treatment by Flaring

The installation of the current temporary infrastructure for the extraction of LFG at the Premises commenced on 15 May 2021, with an LFG pumping trial commencing on 17 May 2021 at the Premises. The pumping trial required the progressive installation and operation of an LFG extraction system, initially with 15 LFG extraction wells and a single flare (extracting and treating by combustion 500 standardised cubic metres per hour (gas volume standardised to 15 °C) ($Sm^3 \cdot hr^{-1}$) of LFG). A second flare (treating by combustion 800 $Sm^3 \cdot hr^{-1}$ of LFG) was commissioned on 26 May 2021 with an additional six LFG wells in operation, plus a connection to the leachate riser.

The pumping trial LFG extraction system was expanded with the installation of another six LFG wells and a horizontal well at the leachate riser, which was completed on 29 May 2021. A third flare (treating by combustion 500 $Sm^3 \cdot hr^{-1}$ of LFG) was commissioned on 11 June 2021 and a fourth flare (treating by combustion 500 $Sm^3 \cdot hr^{-1}$ of LFG) became operational in October 2021 with an additional four wells, totalling 31 gas wells. One temporary flare was offsite for servicing in October 2021 and is now back on site and expected to return to operation on 29 November 2021.

[3] https://www.epa.nsw.gov.au/working-together/community-engagement/community-news/minchinbury-odours

2.4 Proposed Gas Extraction and Treatment by Flaring

The Proposed Development Modification seeks approval to install and operate two permanent enclosed LFG flares at the Premises to allow the ongoing extraction and treatment by combustion of LFG. The temporary flares are located within the landfill void and would be required to be sequentially relocated as the landfill surface is raised through the placement of waste materials. The Proposed Development Modification would provide a more sustainable long-term solution as it would locate larger LFG flares in a permanent position, outside of the landfill void. The proposed location of these flares is presented in **Figure 1**.

Key advantages associated with the Proposed Development Modification include:

- The capture of a large proportion of LFG from the landfill;
- Allows the treatment by combustion of the captured LFG, which:
  - oxidises methane (CH_4) to carbon dioxide (CO_2), thereby reducing the greenhouse gas impact of those emissions (refer **Section 7**); and
  - oxidises odorous gases (such as H_2S) to less-odorous compounds.
- Responding to community and regulatory requirements for the treatment of LFG emissions ;
- Providing an opportunity for future expansion to providing energy via a cogeneration system through the use of non-renewable energy resources, avoiding greenhouse gas emissions and supporting contribution to the NSW government Net Zero commitments.

In NSW, the operation of flares to treat LFG emissions is controlled through the *Protection of the Environment (Operations) Act* 1997 (the POEO Act), and the *Protection of the Environment (Clean Air) Regulations* 2021 (the Clean Air Regulations). The requirements of the POEO Act and Clean Air Regulations in relation to the flaring of LFG are outlined in detail in **Section 3**. The requirements of Australian Standard (AS) 3814-2018 (Industrial and commercial gas fired appliances) would also be relevant. The proposed flares have been designed to meet all requirements, and a summary of compliance is provided in **Section 8.1.2**.

The Proposed Development Modification involves the installation of two (2) high temperature, fully enclosed ground flares (model OEF-300), each treating 1 500 $Sm^3 \cdot hr^{-1}$ [4] at the Premises.

[4] at 15°C, 101.325 kPa (1 atm), and 0 % moisture content

Figure 1 Premises location and proposed permanent flare location

The enclosed flares would have an enclosure surrounding the burner head with a refractory shell that is internally insulated. The shell helps to reduce noise, luminosity and heat radiation and promotes more efficient combustion by maintaining temperature, air flow and more stable combustion conditions. Enclosed flares are therefore significantly more efficient than open flares. An example of the flare design is provided in **Figure 2**.

Figure 2 Example of the model OEF-300 flare

The flares will be approximately 8 metres (m) high and located approximately 50 m northeast of the site office (refer to **Figure 1**).

The flares are designed to combust LFG with a CH_4 composition of between 10-60 %(v/v). Ignition is established using an LPG gas pilot. The flares will be connected to an existing three phase power source which eliminates the need to use diesel fuel in a portable generator and the use of non-compliant elevated flares (non-high temperature).

The flares will be connected to the existing gas collection system via a 450 millimetre (mm) main header line. LFG enters the flares via a stainless-steel condensate knock-out pot and is drawn into the blower. Electric motors, with direct-drive arrangement to a gas booster, will be capable of delivering 1 500 $Sm^3 \cdot hr^{-1}$ to each flare.

The flare will be automatically and remotely controlled using the Horner flare Programmable Logic Controller (PLC) and will have automatic shutdown and restart with remote dial in telemetry. The flare unit provides industry best practice control over combustion air to facilitate elevated temperatures, whilst promoting high efficiency combustion. All flaring equipment on site will be compliant with the relevant Australian and international standards, including AS3814/AG 501-Industrial and Commercial Gas-fired Appliances.

Key elements of the construction of the Proposed Development Modification would include:

- Engineered hardstand areas for supporting the LFG flares;
- A 1.8 m palisade security fence will be installed around the flare unit;
- In-line barometric condensate traps installed to remove any condensate build up within the main header line close to the flare;
- Remedial works to re-seal compacted clay cap over pipe trenching;
- Commissioning and pressure testing of the gas collection system and a permanent LFG flare to ensure performance requirements are met.

Condensate will be removed passively using barometric 'traps' at low points of the header lines. In-line barometric condensate traps will be installed to remove any condensate build up within the main header line close to the flare. The flow lines will be laid so that condensate can gravity drain back to the wells or to a condensate trap. The length of the lines will be minimised to reduce the likelihood of introducing low points, friction loss and build-up of condensate.

Subject to final staging and any weather delays, it is anticipated that installation works will be completed over a period of approximately three to four months, which is expected to include mobilisation and demobilisation at commencement and completion respectively.

Information provided by the flare contractor indicates that the system gas collection efficiency is likely to be up to 85 % over the life of the project (Run Energy, 2021a), although for the purposes of this assessment a conservative value of 70 % has been adopted Given that the collection efficiency is less than 100 %, a proportion of gas generated within the landfill may be emitted from the landfill surface in a passive manner (which would be managed in accordance with the Landfill Gas Management Plan (Bingo Industries, 2021a), refer to **Section 8.2**). This has been subject to quantitative assessment (refer to **Section 5.1.2** and **Section 6**).

As previously discussed in **Section 2.2**, the frequency of H_2S concentrations measured by the NSW EPA above the odour detection threshold in the Minchinbury residential area is demonstrated to be low. This provides confidence that the temporary gas collection and treatment system (currently operating at up to 2 000 $Sm^3 \cdot s^{-1}$) is acting to reduce offsite H_2S impacts. The proposed permanent gas extraction and flaring system (operating at 3 000 $Sm^3 \cdot s^{-1}$) would be expected to further improve that situation.

2.5 Identified Potential for Emissions to Air

Operation of the two permanent LFG flares may result in the following pollutant emissions:

- Carbon monoxide (CO)

  Formed through potential incomplete combustion of LFG resulting from 'quenching' of the hydrocarbon oxidation reactions by, for example, cool flare walls or dilution air.
- Oxides of nitrogen (NO_X)

  There are three mechanisms for the formation of NO_X:
  - thermal NO_X results from the nitrogen in the combustion air and only becomes significant at flame temperatures above 1 200 °C;
  - fuel NO_X is formed from the oxidation of nitrogenous compounds in LFG;
  - prompt NO_X occurs early in the flame and is caused by the attack of small hydrocarbon radicals (mainly CH) on nitrogen.
- Sulphur dioxide (SO_2)

  Formed through the oxidation of the sulphur compounds present in the LFG.
- Hydrogen sulphide (H_2S)

  Resulting from the incomplete oxidation of H_2S in LFG.
- Particulate matter (as total suspended particulate (TSP), particulate matter with an aerodynamic diameter of 10 microns (PM_{10}) and particulate matter with an aerodynamic diameter of 2.5 microns ($PM_{2.5}$))

  Formed through the incomplete combustion of LFG.

Passive gaseous emissions through the landfill surface may also occur, both with and without the flares being operational, and the specific pollutant of interest associated with passive gaseous emissions is hydrogen sulphide (H_2S).

Air pollutant emissions during construction of the permanent flares and installation of gas wells and LFG collection network are anticipated to be minimal and have not been subject to assessment. A range of standard emissions control measures would be applied as required to manage any potential minor impacts during construction.

3. LEGISLATION, REGULATION AND GUIDANCE

The following sections provide a summary of the relevant legislative guidelines and regulations applicable to air quality and greenhouse gas factors resulting from the operation of the Premises.

3.1 NSW EPA Approved Methods

3.1.1 Criteria Air Pollutants

State air quality guidelines adopted by the NSW EPA are published in the *'Approved Methods for the Modelling and Assessment of Air Quality in NSW'* (the Approved Methods (NSW EPA, 2016)) which has been consulted during the preparation of this assessment report.

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

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

The criteria specified in the Approved Methods are the defining ambient air quality criteria for NSW. The standards adopted to protect members of the community from health impacts in NSW, are presented in **Table 3** for the pollutants identified in **Section 2.5**.

Table 3 NSW EPA air quality standards and goals

Pollutant	Averaging period	Units	Criterion
Sulphur dioxide (SO_2)	10 minutes	$\mu g{\cdot}m^{-3}$ (a)	712
	1 hour	$\mu g{\cdot}m^{-3}$	570
	24 hours	$\mu g{\cdot}m^{-3}$	228
	Annual	$\mu g{\cdot}m^{-3}$	60
Nitrogen dioxide (NO_2)	1 hour	$\mu g{\cdot}m^{-3}$	246
	Annual	$\mu g{\cdot}m^{-3}$	62
Particulates (as PM_{10})	24 hours	$\mu g{\cdot}m^{-3}$	50
	1 year	$\mu g{\cdot}m^{-3}$	25
Particulates (as $PM_{2.5}$)	24 hours	$\mu g{\cdot}m^{-3}$	25
	1 year	$\mu g{\cdot}m^{-3}$	8
Particulates (as total suspended particulate [TSP])	1 year	$\mu g{\cdot}m^{-3}$	90

Pollutant	Averaging period	Units	Criterion
Carbon monoxide (CO)	15 minutes	$mg{\cdot}m^{-3}$ (d)	100
	1 hour	$mg{\cdot}m^{-3}$	30
	8 hours	$mg{\cdot}m^{-3}$	10

Notes: (a): micrograms per cubic metre of air (b): Maximum increase in deposited dust level
(c): Maximum total deposited dust level (d): milligrams per cubic metre of air

Section 7.1.2 of the Approved Methods (NSW EPA, 2016) clearly states how the air quality criteria outlined in **Table 3** are to be applied:

1. At the nearest existing or likely future off-site sensitive receptor.
2. 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.
3. Background concentrations must be included.
4. Total impact (incremental impact plus background) must be reported as the 100^{th} percentile in concentration or deposition units consistent with the impact assessment criteria and compared with the relevant impact assessment criteria.

3.1.2 Odorous Air Pollutants

Section 7.4 of the Approved Methods lists criteria for individual odorous air pollutants. The criterion for H_2S is population density specific, as presented in table 7.4b of the Approved Methods and reproduced in **Table 4**. Given the largely urbanised nature of the area surrounding the Premises (refer **Section 4.1**), an H_2S criterion of 1.38 $\mu g{\cdot}m^{-3}$ is applicable (which is equivalent to 2 odour units (OU)).

Table 4 NSW EPA impact assessment criteria for H_2S

Population of Affected Community	Impact Assessment Criteria ($\mu g{\cdot}m^{-3}$) nose response time, 99^{th} percentile
Urban area (≥2000)	1.38
500 – 2000	2.07
125 – 500	2.76
30 – 125	3.45
10 – 30	4.14
Single residence (≤2)	4.83

Based on the landfill gas monitoring performed on behalf of DADEC, trace compounds of other odorous gases have not been detected and are not subject to assessment.

Section 7.4.2 of the Approved Methods (NSW EPA, 2016) clearly state how the H_2S criteria outlined in **Table 4** are to be applied:

1. At the nearest existing or likely future off-site sensitive receptor.
2. The incremental impact must be reported in concentration units consistent with the impact assessment criteria ($\mu g \cdot m^{-3}$) and which must be reported as peak concentrations (i.e. approximately one second average) in accordance with the requirements of the Approved Methods, and as the 99th percentile of dispersion model predictions.

Peak (approximately one second average) concentrations can be determined through the application of peak to mean (P/M60) factors as outlined in table 6.1 of the Approved Methods. Refer to **Section 5.1.3** for a description of how these factors have been applied within this assessment.

3.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations* (POEO) *Act* 1997 sets the statutory framework for managing air quality in NSW, including establishing the licensing scheme for major industrial premises and a range of air pollution offences and penalties.

Clause 129 is associated with emissions of odours from premises licensed for scheduled activities, and is relevant to the Proposed Development Modification site:

(1) The occupier of any premises at which scheduled activities are carried on under the authority conferred by a licence must not cause or permit the emission of any offensive odour from the premises to which the licence applies.

(2) It is a defence in proceedings against a person for an offence against this section if the person establishes that—

(a) the emission is identified in the relevant environment protection licence as a potentially offensive odour and the odour was emitted in accordance with the conditions of the licence directed at minimising the odour, or

(b) the only persons affected by the odour were persons engaged in the management or operation of the premises.

(3) A person who contravenes this section is guilty of an offence.

The POEO Act 1997 defines offensive odour as an odour:

(a) that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances—

(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or

(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or

(b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations.

3.3 Protection of the Environment (Clean Air) Regulation 2021

The Protection of the Environment Operations (POEO) (Clean Air) Regulation (2021) sets requirements and standards of concentration for emissions to air associated with the flaring of LFG.

The relevant requirements are outlined in the following sections. A summary of how the Proposed Development Modification has been designed to meet these requirements is presented in **Section 8.1.2**.

3.3.1 Operation of Group 6 Treatment Plant

Relevant requirements of Clause 50 of the POEO (Clean Air) Regulation 2021 (Operation of Group 6 treatment plant) state:

An occupier of premises on which any Group 6 treatment plant is operated must ensure that—

(a) any flare operated for the treatment of air impurities is operated in such a way that a flame is present at all times while air impurities are required to be treated, and

(b) either or both of the following requirements relating to the operation of any such plant are complied with—

(i) the requirements in clauses 51 and 52,

(ii) the requirements in clause 53.

3.3.2 Residence Time

Relevant requirements of Clause 51 of the POEO (Clean Air) Regulation 2021 (Residence time) state:

(2) An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the time between landfill gas entering and exiting the flare is more than 0.6 seconds.

(3) For the purposes of this clause, the time elapsing between an air impurity, including landfill gas, entering and exiting an afterburner or flare is to be calculated—

(a) using the volumetric flow rate for the air impurity, as determined in accordance with TM-2 or CEM-6, and

(b) using a 1 hour rolling averaging period.

3.3.3 Combustion Temperature

Relevant requirements of Clause 52 of the POEO (Clean Air) Regulation 2021 (Combustion temperature) state:

(2) An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the temperature for the combustion of landfill gas by the flare is more than 760°C.

(3) A reference in this clause to the temperature for the combustion of an air impurity, including landfill gas, is a reference to that temperature as determined in accordance with TM-2, using a 1 hour rolling averaging period.

3.3.4 Destruction Efficiency

Relevant requirements of Clause 53 of the POEO (Clean Air) Regulation 2021 (Destruction efficiency) state:

(2) An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the destruction efficiency of the flare, in relation to landfill gas entering the flare, is more than 98%.

(3) A reference in this clause to the destruction efficiency of Group 6 treatment plant in relation to an air impurity, including landfill gas, is a reference to the destruction efficiency of the plant, in relation to the air impurity, calculated by using the following equation—

$$DE = [1 - (MW_{out}/MW_{in})] \times 100$$

where—

DE *is the destruction efficiency, expressed as a percentage.*

MW_{out} *is the mass emission rate of the air impurity in exhaust emissions prior to its release to the atmosphere using a 1 hour rolling averaging period.*

MW_{in} *is the mass feed rate of the air impurity in a waste feedstream using a 1 hour rolling averaging period.*

3.3.5 Standards of Concentration

Schedule 2 of the POEO (Clean Air) Regulation 2021 provides standards of concentration for flares premises are presented in **Table 5**.

Table 5 POEO (Clean Air) Regulation – General standards of concentration

Air Impurity	Activity	Standard of Concentration (Group 6)[1]
Volatile organic compounds (VOCs) as *n*-propane	Any enclosed ground-level flare treating landfill gas	40 $mg \cdot m^{-3}$
Smoke	Any flare	No visible emission other than for a total period of no more than 5 minutes in any 2 hours

Note: (1) Group 6 – pursuant to application made on or after 1 September 2005

3.4 NSW EPA Environmental Guidelines, Solid Waste Landfills

Section 5.5 of the NSW EPA Environmental Guidelines for Solid Waste Landfills (NSW EPA, 2016) outlines guidelines for landfill gas management and monitoring, and specifically emissions from the combustion of landfill gas. The relevant guidelines state:

Flares for treating landfill gas must be enclosed and at ground level. They must meet the operating requirements in the Protection of the Environment Operations (Clean Air) Regulation 2010, namely gas residence time >0.6 seconds, combustion temperature >760℃, destruction efficiency >98%, and flame present at all times while air impurities are required to be treated. Regular monitoring is required of temperature (in ℃) and volumetric flow rate (in cubic metres/second).

The discharge point(s) from any landfill gas combustion source should be designed to promote good dispersion (i.e. by means of such factors as stack height, diameter and discharge velocity) and ensure that the ground level concentration criteria are not exceeded. Further information about the design of discharge points can be obtained from Local Government Air Quality Toolkit, Module 3: Guidelines for Managing Air Pollution, Part 1: Air pollution control techniques (chapter 3): www.epa.nsw.gov.au/air/lgaqt.htm (NSW DECC, 2007).

Any liquid condensed from the landfill gas should be handled in the same manner as leachate. Because of the low pH and the potential odour it should not be spray-irrigated.

A summary of how the Proposed Development Modification has been designed to meet these requirements is presented in **Section 8.1.2**

3.5 Project Approval Conditions

The relevant project approval conditions as imposed on the Premises under Section 75J of the *Environmental Planning and Assessment Act 1979* relating to odour and greenhouse gas management state that:

The Proponent shall not cause or permit the emission of offensive odours from the site, as defined under Section 129 of the POEO Act.

The Proponent shall implement all reasonable and feasible measures to minimise the scope 1, 2 and 3 greenhouse gas emissions produced on site, to the satisfaction of the Secretary.

The Proponent shall prepare and implement an Air Quality, Odour and Greenhouse Gas Management Plan for the project to the satisfaction of the Secretary… of which requires a protocol for remediating uncontrolled landfill gas emissions

A summary of how the Proposed Development Modification has been designed to meet these requirements is presented in **Section 8.1.2**.

4. EXISTING CONDITIONS

4.1 Surrounding Land Sensitivity

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

To ensure that the selection of discrete receptors for the AQIA are reflective of the locations in which the population of the area surrounding the Premises reside, population density data has been examined. Population density data based on the 2016 census have been obtained from the Australian Bureau of Statistics (ABS) for a 1 square kilometre (km^2) grid, covering mainland Australia (ABS, 2017). Using a Geographical Information System (GIS), the locations of sensitive receptor locations have been confirmed with reference to their population densities.

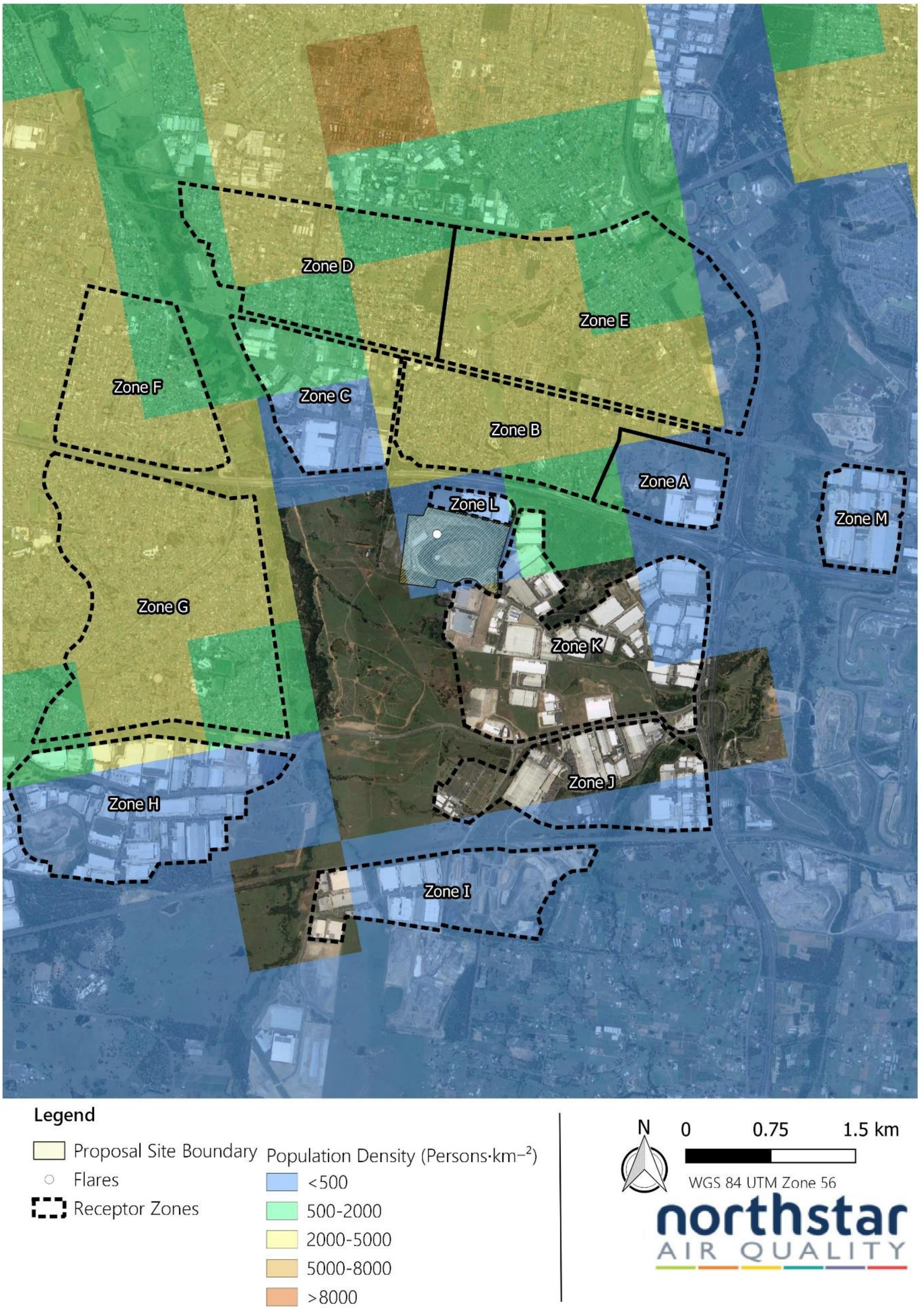
For clarity, the ABS use the following categories to analyse population density (persons·km^{-2}):

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

Using ABS data in a GIS, the population density of the area surrounding the Premises are presented in **Figure 3**. The Premises is located in an area of lower residential population densities to the south and east (between 0 and 500 persons·km^{-2}), with higher population densities (between 500 and 8 000 persons·km^{-2}) to the west and north. Given the higher population densities to the west and north of the Premises, identification of specific sensitive receptor locations is not practical, in quantitative modelling terms. For the purposes of this assessment, 13 'receptor zones' have been identified, which correspond to the areas outlined in **Figure 3** and **Table 6**. A uniform receptor grid covering all receptor zones presented in **Figure 3** at 100 m spacing, allows the output of the maximum predicted air quality impact within each zone. In addition, the maximum predicted concentrations outside the boundary of the Premises have also been assessed and reported. For clarity, this approach ensures that all sensitive receptors within each receptor zone, and any off-site location, are considered within the assessment.

A total of 4 900 receptor locations have been included in the modelling assessment.

Figure 3   Population density and sensitive receptors surrounding the Premises



Note: Areas with no colour represents a 1 km² grid cell with zero population

Table 6 Sensitive receptor zones adopted in the study

Zone	Suburb	Dominant land use	Distance to flares (m) (A)	Approximate area (km^2)	Centre of zone location (m, UTM 56)	
					Eastings	Northings
A	Minchinbury	Crematorium, Industrial	1 409	0.7	300 800	6 258 785
B	Minchinbury	Residential	587	1.7	299 491	6 259 263
C	Minchinbury	Industrial	755	1.3	297 811	6 259 593
D	Mount Druitt	Residential	1 537	2.4	297 857	6 260 740
E	Rooty Hill	Residential	1 491	3.8	300 295	6 260 216
F	Colyton	Residential	1 949	1.7	296 155	6 259 699
G	Erskine Park / St Clair	Residential	1 553	4.0	296 349	6 257 755
H	Erskine Park	Industrial	2 335	2.3	296 059	6 256 016
I	Horsley Park	Industrial	2 805	1.4	298 817	6 255 196
J	Eastern Creek	Industrial	2 009	1.6	300 113	6 256 134
K	Eastern Creek	Industrial	479	3.0	299 999	6 257 344
L	Eastern Creek	Industrial	229	0.2	299 113	6 258 612
M	Eastern Creek	Industrial	3 366	0.6	302 541	6 258 425

Note: (A) Measured from the closest edge of each zone boundary to the flares

4.2 Meteorology

In accordance with the requirements of the NSW EPA Approved Methods, the AQIA is required to describe and account for the influence of the prevailing meteorological conditions.

The meteorology experienced within an area can govern the generation (in the case of wind dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. The meteorology of the area surrounding the Premises has been examined using data collected by the Australian Government Bureau of Meteorology (BoM) at the Horsley Park Equestrian Centre Automatic Weather Station (AWS), which is located approximately 6 km northwest of the Proposed Development Modification site. This AWS is considered the most representative station for the area surrounding the Premises. Meteorological data is also collected by DADEC at an on-site weather station, although the primary source of data selected for use in this study is fully validated via independent sources of data to avoid any perceived bias.

To provide a characterisation of the meteorology which would be expected at the Premises, a meteorological modelling exercise has been performed.

Data from the year 2017 have been selected for use in the AQIA to provide an approximation of 'representative' conditions surrounding the Premises. This year has been selected through examination of meteorology and background air quality conditions for the five-year period 2016 to 2020. The year 2017 was selected as being most representative as wind speed and direction measured at Horsley Park Equestrian Centre AWS in 2017 were considered to be most representative of the five-year period examined, in meteorological terms.

A summary of the inputs and outputs of the meteorological modelling assessment, including model validation, is presented in **Appendix B**. This analysis includes a discussion of data availability and variability.

4.3 Air Quality

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

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

The locations of the nearest air quality monitoring stations (AQMS) to the Premises, operated by NSW DPIE are briefly summarised in **Table 7** (listed by proximity) and presented in **Appendix C**. The year 2017 is indicated in **Table 7** as this is the year selected for assessment (see **Section 4.2**).

Table 7 Closest DPIE AQMS to the Premises

AQMS Location	Approximate distance to Premises (km)	2017 Data	Measurement						
			PM_{10}	$PM_{2.5}$	TSP	NO_2	SO_2	CO	H_2S
St Marys	5.3	✓	✓	✓	×	✓	×	×	×
Blacktown	7.0	×	×	×	×	×	×	×	×
Prospect	7.3	✓	✓	✓	×	✓	✓	✓	×

The AQMS measuring the greatest number of parameters relevant to this AQIA in the assessment year of 2017 is located at Prospect and is considered to be reflective of the conditions at the Premises and surrounding area. Although data is available from the marginally closer AQMS at St Marys, that AQMS is located in a less urbanised location and concentrations of PM_{10} and NO_2 are lower than measured at Prospect, as confirmed in **Table 8**.

Table 8 Comparison of particulate and NO_2 measurements, St Marys and Prospect, 2017

Pollutant	Ave Period	Measured Value, 2017	
		Prospect (adopted)	St Marys
Particles (as PM_{10})	Annual $\mu g \cdot m^{-3}$	18.9	16.2
Particles (as $PM_{2.5}$)	Annual $\mu g \cdot m^{-3}$	7.7	7.0
Nitrogen dioxide (NO_2)	Annual $\mu g \cdot m^{-3}$	18.4	8.0

Data from the year 2017 have been selected for use in the AQIA to provide an approximation of 'representative' conditions surrounding the Premises (see **Section 4.2**). This year has been selected through examination of meteorology and air quality for the five-year period 2016 to 2020. Although significant bushfire activity was not observed in the particulate monitoring record in 2017, the selection of that year is still considered to be representative of the longer term period of data examined.

Appendix C provides a detailed assessment of the background air quality monitoring data collected at the Prospect AQMS. A summary of the air quality monitoring data used in this assessment to represent background conditions is presented in **Table 9**.

Table 9 Summary of background air quality used in the AQIA

Pollutant	Ave Period	Measured Value	Notes
Particles (as TSP) (derived from PM_{10})	Annual µg·m^{-3}	38.9	Estimated on a TSP:PM_{10} ratio of 2.0551:1
Particles (as PM_{10})	24-hour µg·m^{-3}	Daily Varying	The 24-hour maximum for PM_{10} in 2017 was 61.1 µg·m^{-3} (exceeding the criterion)
	Annual µg·m^{-3}	18.9	
Particles (as $PM_{2.5}$)	24-hour µg·m^{-3}	Daily Varying	The 24-hour maximum for $PM_{2.5}$ in 2017 was 30.1 µg·m^{-3} (exceeding the criterion)
	Annual µg·m^{-3}	7.7	
Nitrogen dioxide (NO_2)	1-hour µg·m^{-3}	112.8	Hourly maximum 1-hr average in 2017
	Annual µg·m^{-3}	18.4	Annual average in 2017
Sulphur dioxide (SO_2)	10-minute µg·m^{-3}	86.2	Calculated from hourly data (refer **Section 5.1.3** and **Appendix C**)
	1-hour µg·m^{-3}	60.3	Hourly maximum 1-hr average in 2017
	24-hour µg·m^{-3}	Daily Varying	The 24-hour maximum for SO_2 in 2017 was 26.2 µg·m^{-3}
	Annual µg·m^{-3}	1.8	Annual average in 2017
Carbon monoxide (CO)	15-minute mg·m^{-3}	2.4	Calculated from hourly data (refer **Section 5.1.3** and **Appendix C**)
	1-hour mg·m^{-3}	1.8	Hourly maximum 1-hr average in 2017
	8-hour mg·m^{-3}	1.3	Maximum 8-hr rolling average in 2017
Hydrogen sulphide (H_2S)	1 hour 99th percentile µg·m^{-3}	-	Assumed to be negligible

Note: Reference should be made to **Appendix C**

The AQIA has been performed to assess the contribution of the operations of the Proposed Development Modification to the air quality of the surrounding area. A full discussion of how the Proposed Development Modification may impact upon air quality is presented in **Section 6**.

4.4 Topography

The elevation of the Proposed Development Modification site is between approximately 0 m (at the base of the landfill void) and 80 m Australian Height Datum (AHD). The elevation at the proposed location of the flares is approximately 70 m AHD (refer to **Figure 4**).

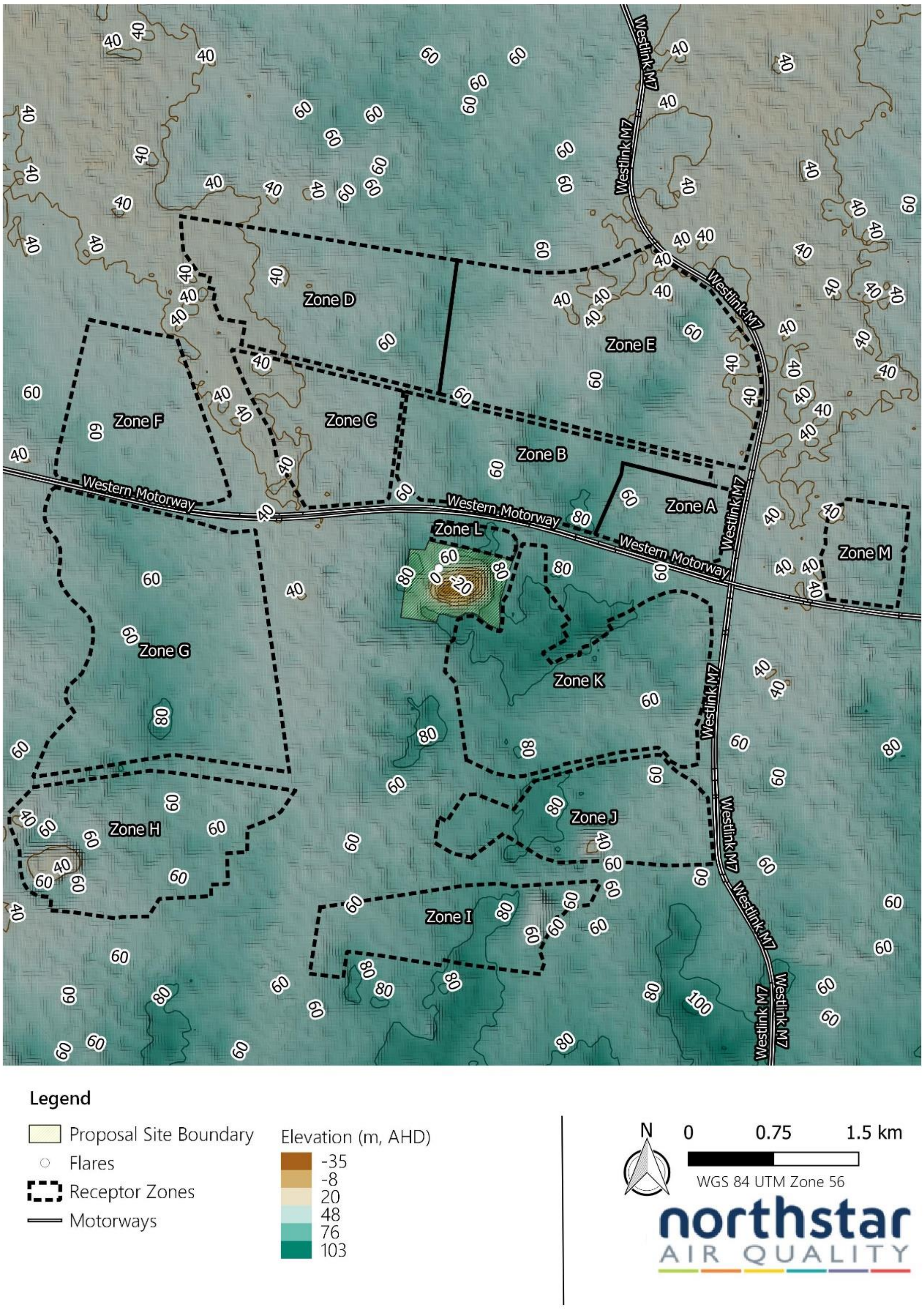
The topography of the area, and the locations of surrounding receptors in relation to the Premises and surrounding topography has informed the approach to meteorological and dispersion modelling (refer **Section 5.1**).

The influence of topography has been included within the dispersion modelling assessment.

4.5 Potential for Cumulative Impacts

The air quality data discussed in **Section 4.3** is appropriate to provide a representation of all other activities in the area surrounding the Premises. There are no other sources of relevant air pollutants in the area that are likely to impact cumulatively with the Proposed Development Modification.

Figure 4 Representation of topography surrounding the Premises



Source: Northstar Air Quality

5. APPROACH TO ASSESSMENT

5.1 Air Quality Impact Assessment

5.1.1 Dispersion Modelling

A dispersion modelling assessment has been performed using the NSW EPA approved CALPUFF atmospheric dispersion model. The modelling has been performed in CALPUFF 3-dimensional (3-D) mode, adopting a 'No-Obs' meteorological modelling simulation, in accordance with NSW DPIE guidance (Barclay & Scire, 2011) (please refer to **Appendix B** for further information). This approach allows the inclusion of topographical features which are present in the area surrounding the Premises, as discussed in **Section 4.4**.

An assessment of the impacts of the operation of activities of the Proposed Development Modification has been performed which characterises the likely day-to-day operation, approximating operational characteristics which are appropriate to assess against long- and short-term air quality criteria as presented in **Section 3**.

The modelling scenarios provides an indication of the air quality impacts of the operation of activities associated with the Proposed Development Modification. Added to these impacts are background air quality concentrations (where available and discussed in **Section 4.2** and **Appendix C**) which represent the air quality which may be expected within the area surrounding the Premises, without the impacts of the Proposed Development Modification itself.

The following provides a description of the determination of appropriate emissions of air pollutants resulting from the operation of the Proposed Development Modification.

5.1.2 Emissions Estimation - Flares

A significant quantity of information has been provided by DADEC relating to the operation of the LFG flares. A summary of this information as it relates to air pollutant emissions is presented in **Table 11**. These values have been adopted in the dispersion modelling assessment.

Reference should be made to **Appendix A** for a summary of reported units, however for clarity the following unit prefixes are adopted to denote the gas conditions of reported gas volumes:

- **Nm^3**: normalised gas volume at 0 °C;
- **Sm^3**: standardised gas volume at 15 °C; and
- **Am^3**: actual gas volume at the relevant (stated) temperature.

Gas flow rates to the flares and the associated estimate of LFG capture rates from the landfill have been provided by DADEC as 1 500 $Sm^3 \cdot hr^{-1}$ (per flare) and up to 85 %, respectively. although for the purposes of this assessment a conservative gas capture rate of 70 % has been adopted. Based upon this information, the total landfill gas generation rate has been estimated to be 4 286 $Sm^3 \cdot hr^{-1}$ (15 °C), or 4 063 $Nm^3 \cdot hr^{-1}$ (0 °C).

$$2 \times \left(1500 \frac{Sm^3}{hr}\right) \times \left(\frac{100\ \%}{70\ \%}\right) = 4\,286\ Sm^3 \cdot hr^{-1}$$

$$4\,286 \frac{Sm^3}{hr} \times \left(\frac{273\ ℃}{273\ ℃ + 15\ ℃}\right) = 4\,063\ Nm^3 \cdot hr^{-1}$$

With the flares operating and drawing 1 500 $Sm^3 \cdot hr^{-1}$ (per flare) of the total estimated generation rate of 4 286 $Sm^3 \cdot hr^{-1}$, the potential surface LFG volumetric rate is reduced to 1 286 $Sm^3 \cdot hr^{-1}$ (i.e. the difference between those two values).

The approach to estimation of surface H_2S emissions is presented in **Section 5.1.3**.

In regard to the emission rates from the flares, an LFG volumetric inflow rate to each flare is estimated as 1 500 $Sm^3 \cdot hr^{-1}$ (15 °C) or 1 422 $Nm^3 \cdot hr^{-1}$ (0 °C).

$$1\,500 \frac{Sm^3}{hr} \times \left(\frac{273\ ℃}{273\ ℃ + 15\ ℃}\right) = 1\,422\ Nm^3 \cdot hr^{-1}$$

Using an measured CH_4 composition of 53.7 %(v/v) and an excess air factor of ×24.85 (volume air per volume CH_4) at 900 °C (the design combustion temperature) (SEPA, 1997), a combustion air requirement of 18 974 $Nm^3 \cdot hr^{-1}$ is estimated.

$$1\,422 \frac{Nm^3}{hr} \times \frac{53.7}{100} \times 24.85 \frac{vol\ air}{vol\ CH_4} = 18\,974\ Nm^3 \cdot hr^{-1}$$

The total gaseous discharge is therefore estimated as the sum of LFG volume of 1 422 $Nm^3 \cdot hr^{-1}$ and a combustion air requirement of 18 974 $Nm^3 \cdot hr^{-1}$ as 20 396 $Nm^3 \cdot hr^{-1}$ (0 °C) or 87 636 $Am^3 \cdot hr^{-1}$ (900 °C).

$$1\,422 \frac{Nm^3}{hr} + 18\,974 \frac{Nm^3}{hr} = 20\,396\ Nm^3 \cdot hr^{-1}$$

$$20\,396 \frac{Nm^3}{hr} \times \left(\frac{273\ ℃ + 900\ ℃}{273\ ℃}\right) = 87\,636\ Am^3 \cdot hr^{-1}$$

With an internal diameter of 2.452 m (cross sectional area of 4.72 m^2), this equates to a discharge velocity of 5.16 $m \cdot s^{-1}$, and at a discharge height of 8 m AGL, a gas retention time of 1.55 s is estimated.

$$87\,636 \frac{Am^3}{hr} \times \frac{1}{3600} \times \frac{1}{4.72 m^2} = 5.16\ m \cdot s^{-1}$$

$$8\ m \times \frac{1}{5.16\ m \cdot s^{-1}} = 1.55\ s$$

With reference to supplied monitoring data, an LFG H_2S concentration of 967 parts per million (ppm) (equivalent to 1 472 mg·Nm^{-3}) has been taken to represent peak measured H_2S LFG concentrations (ALS Environmental, 2021).

At an influent landfill gas concentration of 967 ppm, H_2S emissions (post combustion) are estimated as 0.012 g·s^{-1} based on a landfill gas flow of 1 422 Nm^3·hr^{-1} per flare (combustion air will not generate H_2S) and a 98 % destruction efficiency.

$$1\,472\,\frac{mg}{Nm^3}\times\left(\frac{100\,\%-98\,\%}{100\,\%}\right)\times\frac{1}{1\,000}\times 1\,422\,\frac{Nm^3}{hr}\times\frac{1}{3\,600}=0.012\ g\cdot s^{-1}$$

Emissions of SO_2 have been estimated from H_2S inflow concentrations and can be calculated stoichiometrically by a molecular weight correction of (64.066 / 34.1). 1 472 mg$_{(H2S)}$·Nm^{-3} equates to 2 766 mg$_{(SO2)}$·Nm^{-3} and an emission rate of 1.09 g·s^{-1} assuming 967 ppm H_2S in LFG:

$$1\,472\,\frac{mg}{Nm^3}\times\left(\frac{64.066g\cdot mol^{-1}}{34.1g\cdot mol^{-1}}\right)\times\frac{1}{1000}\times 1\,422\,\frac{Nm^3}{hr}\times\frac{1}{3\,600}=1.09\ g\cdot s^{-1}$$

Enclosed flare emission factors for NO_X, CO and PM have been sourced from US EPA AP-42 (US EPA, 2008) as 6.31×10^{-04} kg·Sm$^3_{(CH4)}$, 7.37×10^{-04} kg·Sm$^3_{(CH4)}$ and 2.38×10^{-04} kg·Sm$^3_{(CH4)}$ respectively. The flares are rated to take 1 500 Sm^3·hr^{-1} LFG, which is comprised of 53.7 % CH_4, which equates to 805.5 Sm^3·hr^{-1} CH_4.

$$6.31^{-04}\,\frac{kg_{NOX}}{Sm^3(CH_4)}\times\left(1\,500\,\frac{Sm^3}{hr(LFG)}\times\frac{53.7\,\%}{100\,\%}\right)=0.141\ g_{NOX}\cdot s^{-1}$$

$$7.37^{-04}\,\frac{kg_{CO}}{Sm^3(CH_4)}\times\left(1\,500\,\frac{Sm^3}{hr(LFG)}\times\frac{53.7\,\%}{100\,\%}\right)=0.165\ g_{CO}\cdot s^{-1}$$

$$2.38^{-04}\,\frac{kg_{PM}}{Sm^3(CH_4)}\times\left(1\,500\,\frac{Sm^3}{hr(LFG)}\times\frac{53.7\,\%}{100\,\%}\right)=0.053\ g_{PM}\cdot s^{-1}$$

For the purposes of this assessment, 100 % of PM has been assessed as $PM_{2.5}$.

5.1.3 Emissions Estimation – Landfill Surface

As previously discussed in **Section 5.1.2**, with the flares operating and drawing 1 500 Sm^3·hr^{-1} (per flare) of the total estimated generation rate of 4 286 Sm^3·hr^{-1}, the potential surface LFG volumetric rate (at a conservative 70 % LFG capture rate) is reduced to 1 286 Sm^3·hr^{-1} (i.e. the difference between those two values). This section examines the potential emissions of H_2S which might be experienced through the landfill surface, once the permanent flares are operational, resulting from that potential flow rate.

The surface concentration of H_2S would be subject to ongoing monitoring, in accordance with the Landfill Gas Management Plan (Bingo Industries, 2021a). Surface monitoring under that plan is a current and ongoing commitment, and data collected over a sufficient length of time is not currently available to allow a full characterisation of that potential emission.

In lieu of that pending data, surface flux measurements of H_2S taken at five construction and demolition landfills have been reviewed (Eun, Reinhart, Cooper, Townsend, & Faour, 2007). That study indicated that across all five C&D landfills at which measurements were taken, surface flux of H_2S was variable (see **Table 10**) and for the purposes of this assessment, the average surface H_2S flux of 1.17 $mg{\cdot}m^{-2}{\cdot}day^{-1}$ has been adopted.

Table 10 Summary of surface H_2S flux at five C&D landfills

Site	Site A	Site B	Site C	Site D	Site E	Average
Number of flux measurements	20	20	20	20	19	-
Arithmetic mean ($mg{\cdot}m^{-2}{\cdot}day^{-1}$)	0.179	1.94	1.54	1.47	0.716	1.17
Gypsum drywall content (vol %)	4 %	10 %	N/A	N/A	N/A	-

Reference: from (Eun, Reinhart, Cooper, Townsend, & Faour, 2007)

It is acknowledged that the surface flux of H_2S will be variable across a landfill surface, and would be a function of, for example, the type, volume, and saturation rate of waste below the measurement point. For the purposes of this assessment, the value selected for adoption in further assessment (1.17 $mg{\cdot}m^{-2}{\cdot}day^{-1}$) is considered to represent a reasonable assumption, based on measured data at C&D landfills. It should be noted that the implementation of a gas collection system acts to create a vacuum within the landfill itself, and passive emissions through the landfill surface may be lower than those assumed within this assessment. However, to provide an approximation of the potential impacts, the data above have been adopted (an H_2S surface flux of 1.17 $mg{\cdot}m^{-2}{\cdot}day^{-1}$ which corresponds to a H_2S flux rate of $1.36{\times}10^{-08}$ $g{\cdot}m^{-2}{\cdot}s^{-1}$)

5.1.4 Emissions Estimation – Summary

A summary of the estimated emissions adopted in the modelling assessment is presented in **Table 11** below.

Table 11 Characteristics of the Proposed Development Modification operation

Parameter	Value	Source
Landfill gas flare		
Number	2 no.	Supplied
Operating hours	24 hours / 7 days	Assumed
Unit	OEF-300	Supplied
Fuel	Landfill gas	Supplied
Methane content	53.7 %(v/v)	Supplied
LFG flow rate	1 422 $Nm^3 \cdot hr^{-1}$ (at 0 °C) (per unit)	Supplied
Combustion air flow rate	18 974 $Nm^3 \cdot hr^{-1}$ (at 0 °C) (per unit)	Calculated
Exhaust gas flow rate	20 396 $Nm^3 \cdot hr^{-1}$ (dry, at 0 °C)	Calculated
Exhaust gas flow rate	87 636 $Am^3 \cdot hr^{-1}$ (dry, at 900 °C)	Calculated
Methane flow rate	805.5 $Sm^3 \cdot hr^{-1}$ (at 15 °C) (per unit)	Supplied
Exhaust stack height	8 m AGL	Supplied
Exhaust stack diameter	2.452 m (internal diameter)	Supplied
Exhaust gas exit velocity	5.16 $m \cdot s^{-1}$	Calculated
Emission temperature	900 °C	Supplied
Residence time	1.55 s	Calculated
Destruction efficiency	98 %	Supplied
Emission concentration (NO_X)	0.631 $g \cdot Sm^3$ CH_4	From (US EPA, 2008)
Emission concentration (CO)	0.737 $g \cdot Sm^3$ CH_4	
Emission concentration (PM)	0.238 $g \cdot Sm^3$ CH_4	
Emission concentration (H_2S) at 967 ppm LFG	29.4 $mg \cdot Nm^{-3}$ at 98% destruction efficiency	Supplied from measured data
Emission concentration (SO_2) at 967ppm H_2S LFG	2 766 $mg \cdot Nm^{-3}$	Calculated
Emission rate (NO_X)	0.141 $g \cdot s^{-1}$	Calculated
Emission rate (CO)	0.165 $g \cdot s^{-1}$	Calculated
Emission rate (PM)[(a)]	0.053 $g \cdot s^{-1}$	Calculated
Emission rate (H_2S) at 967 ppm LFG	0.012 $g \cdot s^{-1}$	Calculated
Emission rate (SO_2) at 967 ppm H_2S LFG	1.09 $g \cdot s^{-1}$	Calculated
Landfill surface		
Current area	96 000 m^2	Assumed
Surface average emission rate (H_2S)	1.36×10^{-08} $g \cdot m^{-2} \cdot s^{-1}$	Calculated

Note: (a) Particulate matter emitted as 100 % in the $PM_{2.5}$ fraction

5.1.5 Short Term Pollutant Concentrations

With reference to criteria air pollutants with sub-hourly criteria (SO_2 and CO, refer **Section 3.1.1**), hourly dispersion model outputs are required to be adjusted to allow provision of data on those timescales. The following Power Law adjustment[5] has been applied:

$$C_{p,t} = C_{p,60}\left[\frac{60}{t}\right]^{0.2}$$

Where:

$C_{p,t}$ = concentration of pollutant (p) at averaging time (mins) (t)

$C_{p,60}$ = concentration of pollutant (p) at averaging time (60 mins)

t = time (mins)

The evaluation of odour impacts requires the estimation of short or peak concentrations on the time scale of less than one second. As noted above, dispersion model predictions are typically valid for averaging periods of one hour and longer and are therefore required to be supplemented to accurately simulate dispersion of odours, and the instantaneous perception of those odours by the human nose (NSW EPA, 2017). To allow this approximation, peak-to-mean (P/M60) ratios are provided in the Approved Methods (NSW EPA, 2017) for a variety of source types. Of relevance to this assessment, the P/M60 ratios are associated with area sources (relevant to the landfill surface), and wake-free point sources[6], (relevant to the flares). The P/M60 factors for far-field impacts have been applied as presented in **Table 12**.

Table 12 Factors for estimating peak H_2S emissions

Source type	Pasquill-Gifford stability class	Far-field P/M60
Area	A, B, C, D	2.3
	E, F	1.9
Surface wake-free point	A, B, C	4
	D, E, F	7

[5] http://www.epa.vic.gov.au/~/media/Publications/1551.pdf

[6] Wake-free point sources are more than 2.5 times the height of the largest nearby building, so that surrounding buildings do not influence the stack top airflow (NSW EPA, 2017)

5.1.6 NO_X to NO_2 Reactions

Emissions of NO_X have been calculated, with subsequent ground-level concentrations predicted using dispersion modelling techniques. Given that NO_X is a mixture of NO_2 and nitric oxide (NO), conversion of NO_X predictions to NO_2 concentrations may be performed. Within this assessment, the conservative assumption that all NO is converted to NO_2 has been adopted (i.e. 100 % of NO_X is emitted as NO_2). This is in accordance with a Method 1, Level 1 assessment as outlined within the NSW EPA 'Approved Methods' document (NSW EPA, 2017). In that method, the maximum dispersion model prediction is added to the maximum background concentration to provide a cumulative impact, which provides a highly conservative cumulative impact.

5.2 Greenhouse Gas Assessment

To assess the potential greenhouse gas benefits of the Proposed Development Modification, a greenhouse gas assessment has been performed.

The emissions reductions afforded through the combustion of captured methane have been calculated, using a range of data collected at the Premises. The National Greenhouse and Energy Reporting (NGER) Solid Waste Calculator 2019-2020[7] was reviewed for the purposes of assessing current and proposed future GHG emissions. However, even including site-specific waste acceptance and composition data for the Premises (see (JEP, 2021)) the calculated emissions totals could not be reconciled against likely emissions following methane capture and treatment through flaring, and an alternative method has been adopted.

Given that the aim of this GHGA is to present the potential emission reduction afforded by the implementation of the Proposed Development Modification, precise quantification of emissions, year-on-year, is not considered to be critical.

Emissions have been calculated for two scenarios demonstrating:

a. Base case, representing a 'landfill only' activity (i.e. no flares).

b. Proposed Development Modification which incorporates the installation of two permanent flares for the combustion of LFG.

The assumptions and inputs outlined in **Table 13** were referenced in the calculations of those two scenarios.

Table 13 Greenhouse gas calculation assumptions

Parameter	Assumption	Reference
Reference year	2023	Assumed
Volume of LFG at 15°C	4 286 $Sm^3 \cdot hr^{-1}$ 37 542 857 $Sm^3 \cdot yr^{-1}$	Calculated from (Run Energy, 2021a)

7 http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/NGER-Solid-Waste-Calculator-2019-20.aspx

Parameter	Assumption	Reference
Volume of LFG at 25°C	4 434 $Am^3 \cdot hr^{-1}$ 38 846 428 $Am^3 \cdot yr^{-1}$	Calculated from (Run Energy, 2021a)
Collection efficiency	70 %	(Run Energy, 2021a)
% CH_4 in LFG	53.7 %	DADEC
% CO_2 in LFG	45.3 %	DADEC
Energy content factor (methane in LFG)	37.7×10^{-3} $GJ \cdot m^{-3}$	(DISER, 2021)
Emission factor	6.43 kg $CO2_{-e} \cdot GJ^{-1}$	(DISER, 2021)
Global warming potential of CH_4	28	(DISER, 2021)

6. AIR QUALITY IMPACT ASSESSMENT

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

- Incremental impact – relates to the concentrations predicted as a result of the operation of the Proposed Development Modification in isolation.
- Cumulative impact – relates to the incremental concentrations predicted as a result of the operation of the Proposed Development Modification PLUS the background air quality concentrations discussed in **Section 4.2**.

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

Results are presented as the maximum predicted concentrations within each receptor zone (refer **Section 4.1**).

Emissions of each pollutant have been calculated based on measured landfill gas data as discussed in **Section 5**. In all cases, the emissions calculations represent potential worst-case emissions and are appropriate for comparison with short-term air quality criteria, and provide a more conservative approximation of emissions over the longer-term. DADEC continue to collect data associated with the operation of the currently operational temporary gas extraction and treatment trial, which will be used to confirm as appropriate, the data used in this air quality impact assessment.

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

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

6.1 Sulphur Dioxide

The predicted maximum 10 minute, 1-hour, 24-hour and annual average SO_2 concentrations resulting from the operation of the Proposed Modification Development are presented in **Table 25**.

Contour plots of the incremental and cumulative maximum 10-minute average SO_2 concentration, assuming H_2S concentration in LFG of 967 ppm are presented in:

Figure 5 incremental 10-minute SO_2; and
Figure 6 cumulative 10-minute SO_2.

Figures are presented for the maximum 10-minute average SO_2 concentrations only, as the concentrations are highest when compared to the relevant criterion (refer **Table 14**).

The results indicate that predicted cumulative concentrations of SO_2 at all receptor locations over all assessment averaging periods are low below the criteria.

Table 14 Predicted sulphur dioxide concentrations

Receptor zone	Maximum 10-minute SO_2 concentration (µg·m^{-3})			Maximum 1-hour SO_2 concentration (µg·m^{-3})			Maximum 24-hour SO_2 concentration (µg·m^{-3})			Annual average SO_2 concentration (µg·m^{-3})		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
Criterion	712			570			228			60		
Max. % of criterion	38%	12%	50%	33%	11%	44%	16%	11%	28%	2%	23%	23%
A	82.2	86.2	168.4	57.6	60.3	117.9	23.8	26.2	50.0	0.9	1.8	2.7
B	108.8	86.2	195.0	76.1	60.3	136.4	25.9	26.2	52.1	1.1	2.8	3.9
C	63.0	86.2	149.2	44.0	60.3	104.3	5.4	26.2	31.6	0.3	3.8	4.1
D	99.8	86.2	186.0	69.8	60.3	130.1	7.4	26.2	33.6	0.6	4.8	5.4
E	165.2	86.2	251.4	115.5	60.3	175.8	11.9	26.2	38.1	0.8	5.8	6.6
F	89.4	86.2	175.6	62.6	60.3	122.9	4.9	26.2	31.1	0.2	6.8	7.0
G	115.5	86.2	201.7	80.7	60.3	141.0	7.5	26.2	33.7	0.3	7.8	8.1
H	36.8	86.2	123.0	25.7	60.3	86.0	4.5	26.2	30.7	0.2	8.8	9.0
I	82.0	86.2	168.2	57.1	60.3	117.4	4.6	26.2	30.8	0.2	9.8	10.0
J	90.0	86.2	176.2	62.8	60.3	123.1	7.7	26.2	33.9	0.3	10.8	11.1
K	270.3	86.2	356.5	188.1	60.3	248.4	26.8	26.2	53.0	0.8	11.8	12.6
L	178.3	86.2	264.5	124.7	60.3	185.0	36.6	26.2	62.8	1.2	12.8	14.0
M	31.4	86.2	117.6	22.0	60.3	82.3	6.5	26.2	32.7	0.2	13.8	14.0

Figure 5 Incremental maximum 10-minute average SO_2 concentration

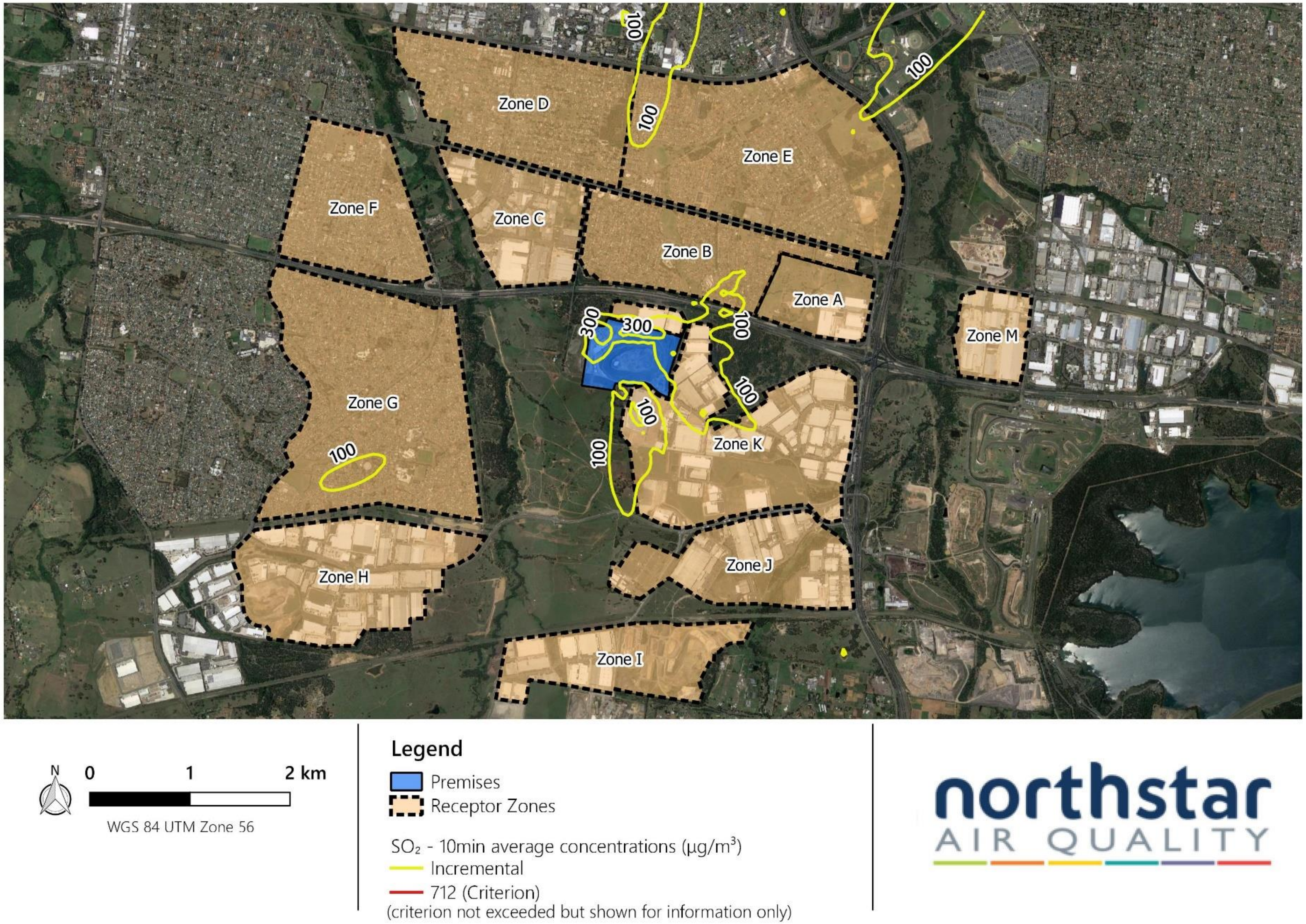
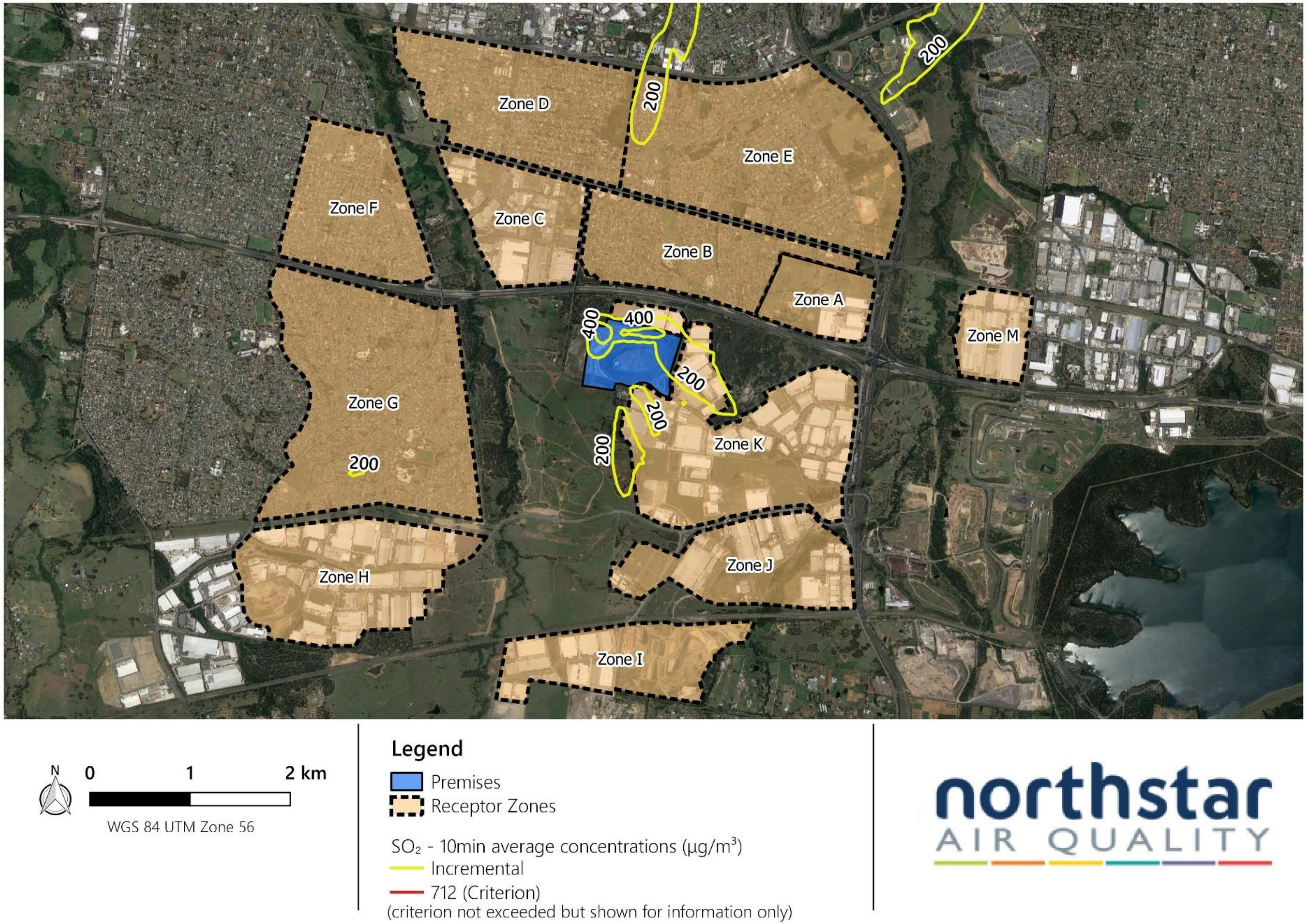


Figure 6 Cumulative maximum 10-minute average SO_2 concentration



6.2 Nitrogen Dioxide

The predicted maximum 1-hour and annual average NO_2 concentrations resulting from the operation of the Proposed Modification Development are presented in **Table 15**.

Contour plots of the incremental and cumulative maximum 1-minute average NO_2 concentration, assuming are presented in:

Figure 7 incremental maximum 1-hour average NO_2; and
Figure 8 cumulative maximum 1-hour average NO_2;

Figures are presented for the maximum 1-hour average NO_X as NO_2 concentrations only, as the concentrations are highest when compared to the relevant criterion (refer **Table 15**).

The results indicate that predicted cumulative concentrations of NO_2 at all receptor locations over both assessment averaging periods are low and below the criteria.

Table 15 Predicted nitrogen dioxide concentrations

Receptor zone	Maximum 1-hour NO_2 concentration ($\mu g \cdot m^{-3}$)			Annual average NO_2 concentration ($\mu g \cdot m^{-3}$)		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
Criterion	246			62		
Max. % of criterion	10%	46%	56%	0.3%	30%	30%
A	7.5	112.8	120.3	0.1	18.4	18.5
B	9.9	112.8	122.7	0.1	18.4	18.5
C	5.7	112.8	118.5	<0.1	18.4	18.5
D	9.0	112.8	121.8	0.1	18.4	18.5
E	15.0	112.8	127.8	0.1	18.4	18.5
F	8.1	112.8	120.9	<0.1	18.4	18.5
G	10.4	112.8	123.2	<0.1	18.4	18.5
H	3.3	112.8	116.1	<0.1	18.4	18.5
I	7.4	112.8	120.2	<0.1	18.4	18.5
J	8.1	112.8	120.9	<0.1	18.4	18.5
K	24.4	112.8	137.2	0.1	18.4	18.5
L	16.2	112.8	129.0	0.2	18.4	18.6
M	2.9	112.8	115.7	<0.1	18.4	18.5

Figure 7 Incremental maximum 1-hour average NO_X as NO_2 concentration

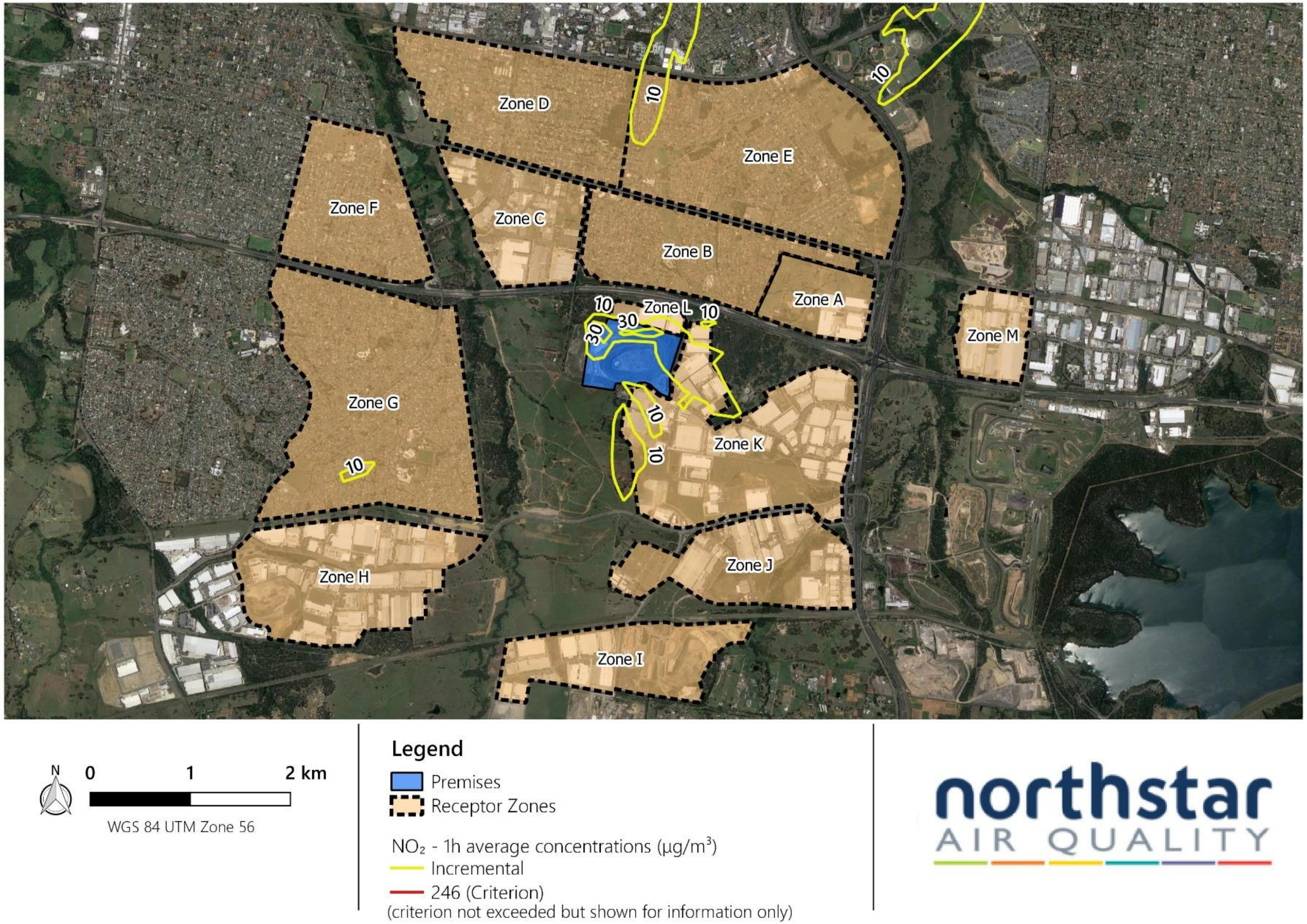
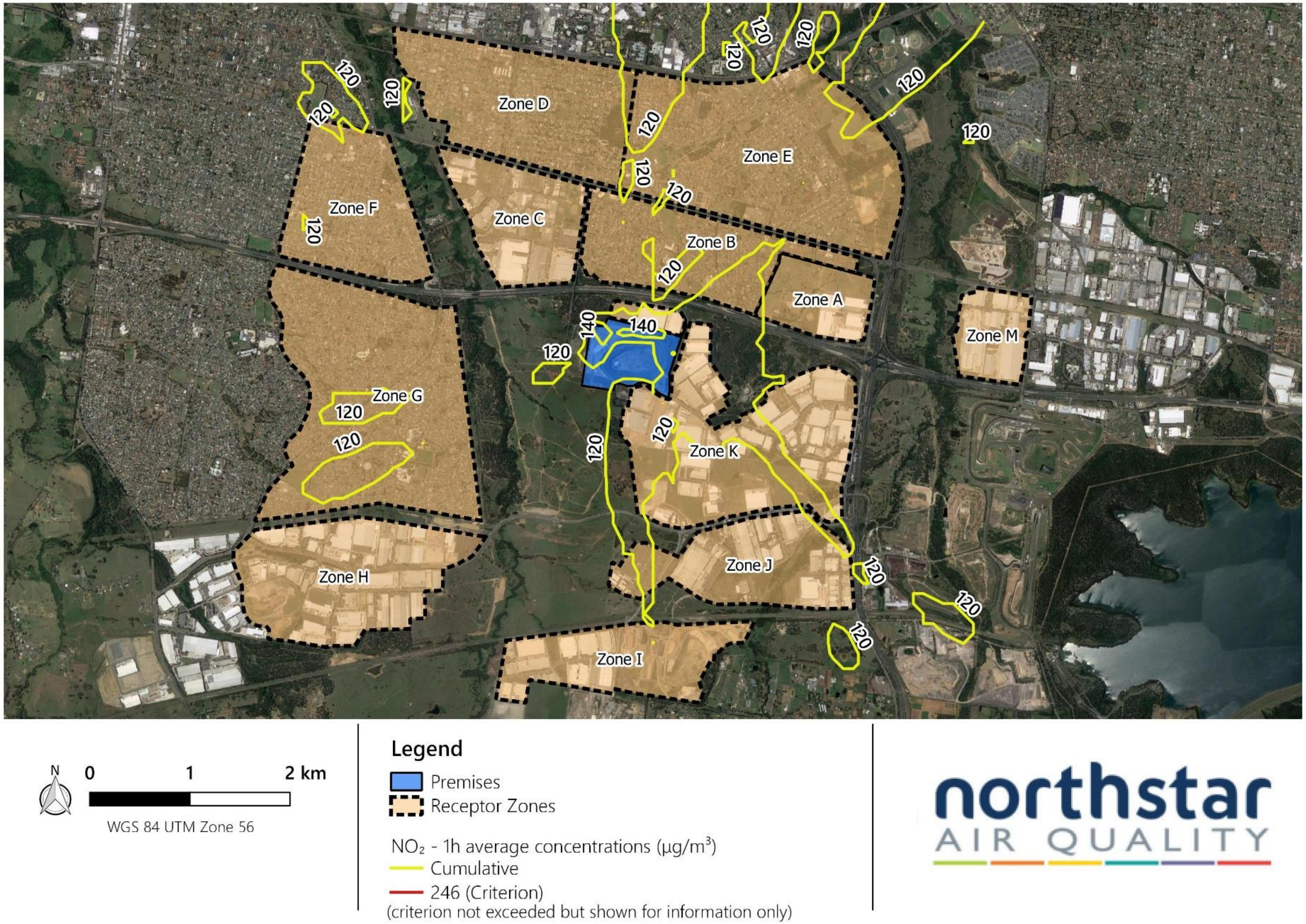


Figure 8 Cumulative maximum 1-hour average NO_X as NO_2 concentration



6.3 Particulate Matter – Annual Average PM_{10} and $PM_{2.5}$

The predicted annual average particulate matter concentrations (as TSP, PM_{10} and $PM_{2.5}$) resulting from the operation of the Proposed Development Modification are presented in **Table 16**.

The results indicate that predicted incremental annual average impacts of TSP, PM_{10} and $PM_{2.5}$ are negligible at all receptor locations. Addition of existing background particulate matter concentrations results in the achievement of the cumulative annual average concentrations of TSP, PM_{10} and $PM_{2.5}$ at all receptor locations, and across the entire modelling grid.

Table 16 Predicted annual average TSP, PM_{10} and $PM_{2.5}$ concentrations

Zone	Annual Average Concentration ($\mu g \cdot m^{-3}$)								
	TSP			PM_{10}			$PM_{2.5}$		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
Criterion	90			25			8		
Max. % of criterion	0.1%	43%	43%	0.2%	76%	76%	0.7%	96%	97%
A	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
B	0.1	38.9	39.0	0.1	18.9	19.0	0.1	7.7	7.8
C	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
D	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
E	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
F	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
G	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
H	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
I	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
J	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
K	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8
L	0.1	38.9	39.0	0.1	18.9	19.0	0.1	7.7	7.8
M	<0.1	38.9	40.0	<0.1	18.9	19.0	<0.1	7.7	7.8

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

6.4 Particulate Matter - Maximum 24-hour Average

Presented in **Table 17** are the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted to occur at the nearest sensitive receptors as a result of the operations of the Proposed Development Modification. All particulate has been assumed to be emitted as $PM_{2.5}$ which explains why concentrations for both PM_{10} and $PM_{2.5}$ are identical. No background concentrations are included within this table.

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

Receptor	Maximum incremental 24-hour average concentration ($\mu g \cdot m^{-3}$)	
	PM_{10}	$PM_{2.5}$
Criterion	50	25
Max. % of criterion	4%	7%
A	1.2	1.2
B	1.3	1.3
C	0.3	0.3
D	0.4	0.4
E	0.6	0.6
F	0.2	0.2
G	0.4	0.4
H	0.2	0.2
I	0.2	0.2
J	0.4	0.4
K	1.3	1.3
L	1.8	1.8
M	0.3	0.3

As indicated in **Section 4.3**, the maximum 24-hour average PM_{10} concentration measured at the Prospect AQMS in 2017 was 61.1 $\mu g \cdot m^{-3}$, which exceeded the 50 $\mu g \cdot m^{-3}$ criterion. The highest non-exceeding background measured at the Prospect AQMS in 2017 was 40.2 $\mu g \cdot m^{-3}$ and therefore, the addition of the predicted PM_{10} concentrations as presented in **Table 17** would not result in any additional exceedances of that criterion. Note that this assumes that the highest increment and highest background concentration occur on the same day, which is a conservative assumption.

With respect to $PM_{2.5}$, the maximum 24-hour average concentration was measured at the Prospect AQMS in 2017 to be 30.1 $\mu g \cdot m^{-3}$ (exceeding the criterion of 25 $\mu g \cdot m^{-3}$), and the maximum non-exceeding background concentration was 24.3 $\mu g \cdot m^{-3}$. Assuming a worst-case addition of that maximum non-exceeding background, and the maximum predicted increments, does result in a nominal additional exceedance of the relevant criterion in Receptor Zones A, B, L and K (where the increment is predicted to be > 0.7 $\mu g \cdot m^{-3}$). A more refined approach has therefore been adopted to assess the likelihood of that additional exceedance occurring.

Table 18, **Table 19**, **Table 20**, and **Table 21** present the predicted maximum 24-hour average $PM_{2.5}$ concentrations resulting from the operation of the Proposed Development Modification, with background included, at receptor zones A, B, K, and L, respectively. These results present the sum of the predicted increment, and the assumed background, which change day-by-day.

The left side of the tables show the predicted concentration on days with the highest cumulative predictions (typically driven by elevated background concentrations), and the right side shows the total predicted concentration on days with the highest predicted incremental concentrations.

None of these tables indicate that any additional exceedances of the 24-hour $PM_{2.5}$ criterion are predicted to result from the operation of the Proposed Development Modification. The predicted exceedances shown in the tables are driven by the background air quality (i.e. existing sources) and is not contributed to by the Proposed Development Modification.

As previously indicated, in the presentation of results, the tables included shaded cells which represent the following:

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

Table 18 Summary of contemporaneous impact and background – $PM_{2.5}$, receptor zone A

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone A			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone A		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
2/09/2017	0.1	30.1	30.2	15/09/2017	1.2	5.2	6.4
3/09/2017	<0.1	29.3	29.4	18/08/2017	1.0	4.3	5.3
14/08/2017	0.2	26.6	26.8	8/09/2017	0.9	3.3	4.2
2/07/2017	<0.1	24.3	24.4	14/09/2017	0.8	2.8	3.6
12/09/2017	<0.1	22.5	22.6	7/09/2017	0.7	4.1	4.8
11/05/2017	<0.1	22.0	22.1	26/07/2017	0.5	4.1	4.6
26/08/2017	<0.1	20.9	21.0	20/02/2017	0.4	7.6	8.0
3/07/2017	<0.1	20.2	20.3	20/07/2017	0.4	6.9	7.3
22/07/2017	<0.1	19.6	19.7	14/01/2017	0.4	11.8	12.2
27/08/2017	0.3	19.3	19.6	19/09/2017	0.4	6.6	7.0
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposed Development Modification.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposed Development Modification.			

Table 19 Summary of contemporaneous impact and background – $PM_{2.5}$, receptor zone B

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone B			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone B		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
2/09/2017	0.1	30.1	30.2	15/09/2017	1.3	5.2	6.5
3/09/2017	<0.1	29.3	29.4	8/09/2017	1.1	3.3	4.4
14/08/2017	0.2	26.6	26.8	18/08/2017	1.1	4.3	5.4
2/07/2017	<0.1	24.3	24.4	14/09/2017	0.9	2.8	3.7
12/09/2017	<0.1	22.5	22.6	7/09/2017	0.7	4.1	4.8
11/05/2017	<0.1	22.0	22.1	20/07/2017	0.5	6.9	7.4
26/08/2017	<0.1	20.9	21.0	26/07/2017	0.5	4.1	4.6
3/07/2017	<0.1	20.2	20.3	20/02/2017	0.4	7.6	8.0
27/08/2017	0.4	19.3	19.7	27/08/2017	0.4	19.3	19.7
22/07/2017	0.1	19.6	19.7	14/01/2017	0.4	11.8	12.2
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposed Development Modification.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposed Development Modification.			

Table 20 Summary of contemporaneous impact and background – $PM_{2.5}$, receptor zone K

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone K			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone K		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
2/09/2017	0.1	30.1	30.2	18/08/2017	1.3	4.3	5.6
3/09/2017	<0.1	29.3	29.4	15/09/2017	0.8	5.2	6.0
14/08/2017	0.1	26.6	26.7	8/09/2017	0.6	3.3	3.9
2/07/2017	<0.1	24.3	24.4	14/09/2017	0.6	2.8	3.4
12/09/2017	<0.1	22.5	22.6	7/09/2017	0.6	4.1	4.7
11/05/2017	<0.1	22.0	22.1	26/07/2017	0.4	4.1	4.5
26/08/2017	<0.1	20.9	21.0	20/02/2017	0.4	7.6	8.0
3/07/2017	<0.1	20.2	20.3	14/01/2017	0.4	11.8	12.2
22/07/2017	0.1	19.6	19.7	6/09/2017	0.4	4.2	4.6
27/08/2017	0.2	19.3	19.5	19/09/2017	0.3	6.6	6.9
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposed Development Modification.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposed Development Modification.			

Table 21 Summary of contemporaneous impact and background – $PM_{2.5}$, receptor zone L

Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone L			Date	24-hour average $PM_{2.5}$ concentration ($\mu g \cdot m^{-3}$) – Receptor zone L		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
2/09/2017	<0.1	30.1	30.2	18/08/2017	1.8	4.3	6.1
3/09/2017	<0.1	29.3	29.4	6/09/2017	0.7	4.2	4.9
14/08/2017	0.1	26.6	26.7	25/09/2017	0.6	8.2	8.8
2/07/2017	<0.1	24.3	24.4	7/09/2017	0.5	4.1	4.6
12/09/2017	<0.1	22.5	22.6	26/07/2017	0.5	4.1	4.6
11/05/2017	<0.1	22.0	22.1	15/09/2017	0.4	5.2	5.6
26/08/2017	<0.1	20.9	21.0	3/12/2017	0.4	2.5	2.9
3/07/2017	<0.1	20.2	20.3	30/12/2017	0.4	9.1	9.5
22/07/2017	0.1	19.6	19.7	14/09/2017	0.4	2.8	3.2
27/08/2017	<0.1	19.3	19.4	9/10/2017	0.3	8.9	9.2
These data represent the highest Cumulative Impact 24-hour $PM_{2.5}$ predictions (outlined in red) as a result of the operation of the Proposed Development Modification.				These data represent the highest Incremental Impact 24-hour $PM_{2.5}$ predictions (outlined in blue) as a result of the operation of the Proposed Development Modification.			

No contour plots of 24-hour average PM_{10} or $PM_{2.5}$ are presented, given the minor predicted incremental contribution at the nearest sensitive receptors.

6.5 Carbon Monoxide

The predicted maximum 15 minute, 1-hour and 8-hour CO concentrations resulting from the operation of the Proposed Modification Development are presented in **Table 22**.

The results indicate that predicted cumulative concentrations of CO at all receptor locations over all assessment averaging periods are low and easily achieve the criteria at all sensitive receptor locations, and across the entire modelling grid.

Table 22 Predicted carbon monoxide concentrations

Receptor zone	Maximum 15-minute CO concentration (mg·m^{-3})			Maximum 1-hour CO concentration (mg·m^{-3})			Maximum 8-hour CO concentration (mg·m^{-3})		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
Criterion	100			30			10		
Max. % of criterion	<0.1%	2.4%	2.4%	<0.1%	6.0%	6.1%	<0.1%	13.0%	13.1%
A	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
B	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
C	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
D	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
E	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
F	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
G	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
H	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
I	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
J	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
K	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
L	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4
M	<0.1	2.4	2.5	<0.1	1.8	1.9	<0.1	1.3	1.4

No contour plots of CO for any averaging period are presented, given the minor predicted incremental contribution at the nearest sensitive receptors.

6.6 Hydrogen Sulphide

The predicted 99th percentile nose response time H_2S concentrations resulting from the operation of the Proposed Development Modification are presented in **Table 23** (assuming H_2S in LFG flared at 967 ppm) . Also included within those tables are the predicted impacts resulting from fugitive emissions resulting from the landfill surface as discussed in **Section 5.1.2**. No additional background concentrations of H_2S have been assessed, as discussed in **Section 4.3** and **Section 4.5**.

Contour plots are presented showing the incremental impacts of the flare operation (**Figure 9**), the potential impacts resulting from fugitive emissions from the landfill surface (**Figure 10**), and potential cumulative impacts (**Figure 11**).

Exceedances of the H_2S criterion are not predicted within any receptor zone associated with residential or industrial development.

Table 23 Predicted hydrogen sulphide concentrations

Receptor zone	Dominant land use	99th percentile nose response time H_2S concentration (µg·m^{-3})		
		Incremental Impact		
Scenario		Flares at 967 ppm H_2S in LFG	Landfill surface	Flares + Landfill
Criterion	-	1.38		
Max. % of criterion	-	26%	51%	70%
A	Crematorium, Industrial	0.3	0.2	0.4
B	Residential	0.4	0.3	0.6
C	Industrial	0.1	0.2	0.3
D	Residential	0.2	0.1	0.2
E	Residential	0.2	0.1	0.3
F	Residential	0.1	0.0	0.1
G	Residential	0.1	0.1	0.2
H	Industrial	0.1	0.0	0.1
I	Industrial	0.1	0.0	0.1
J	Industrial	0.1	0.1	0.2
K	Industrial	0.3	0.7	1.0
L	Industrial	0.3	0.6	0.9
M	Industrial	0.1	0.0	0.1

Figure 9 Incremental 99th percentile nose response time H_2S concentration – flare

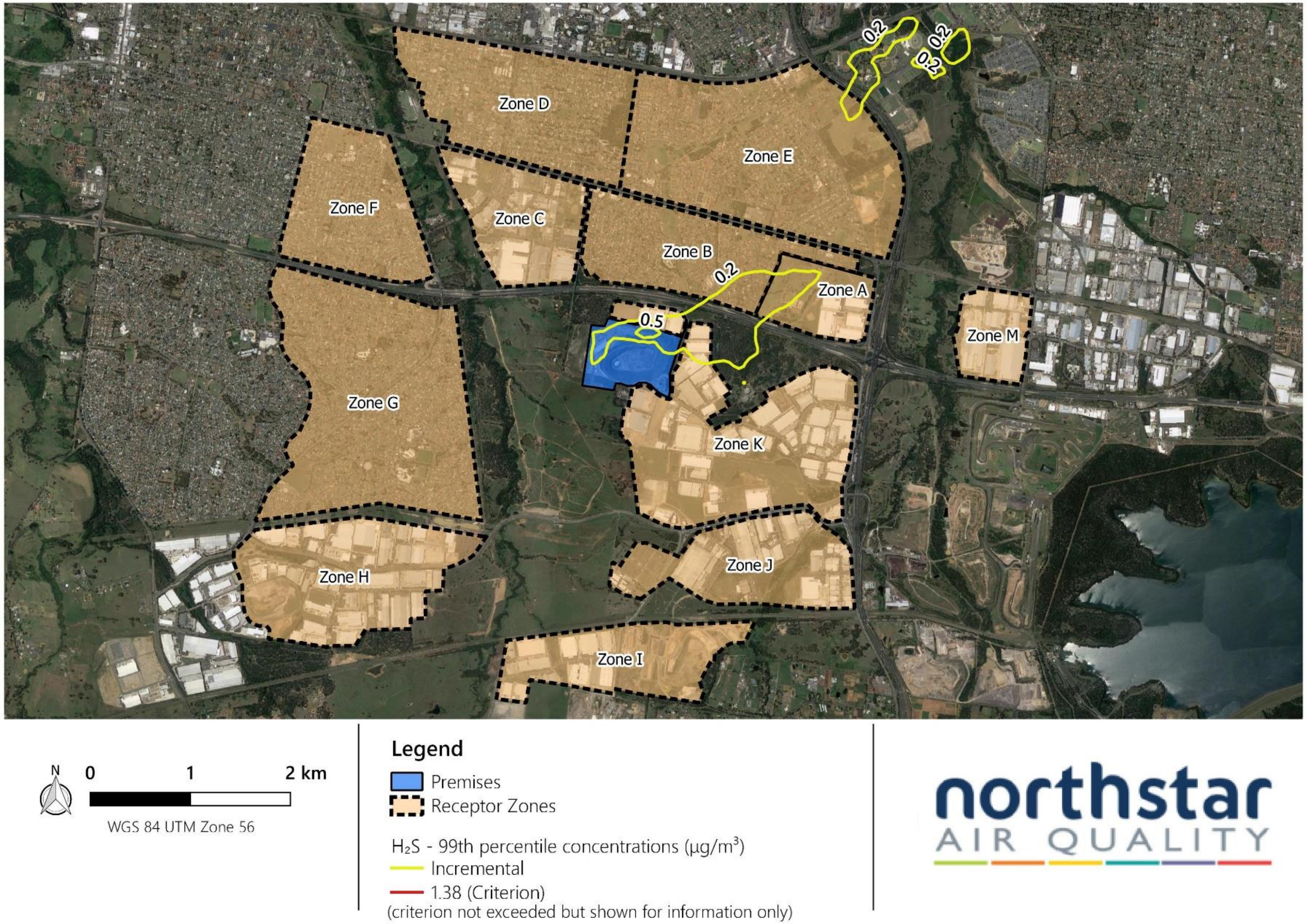


Figure 10 Incremental 99th percentile nose response time H_2S concentration – landfill surface

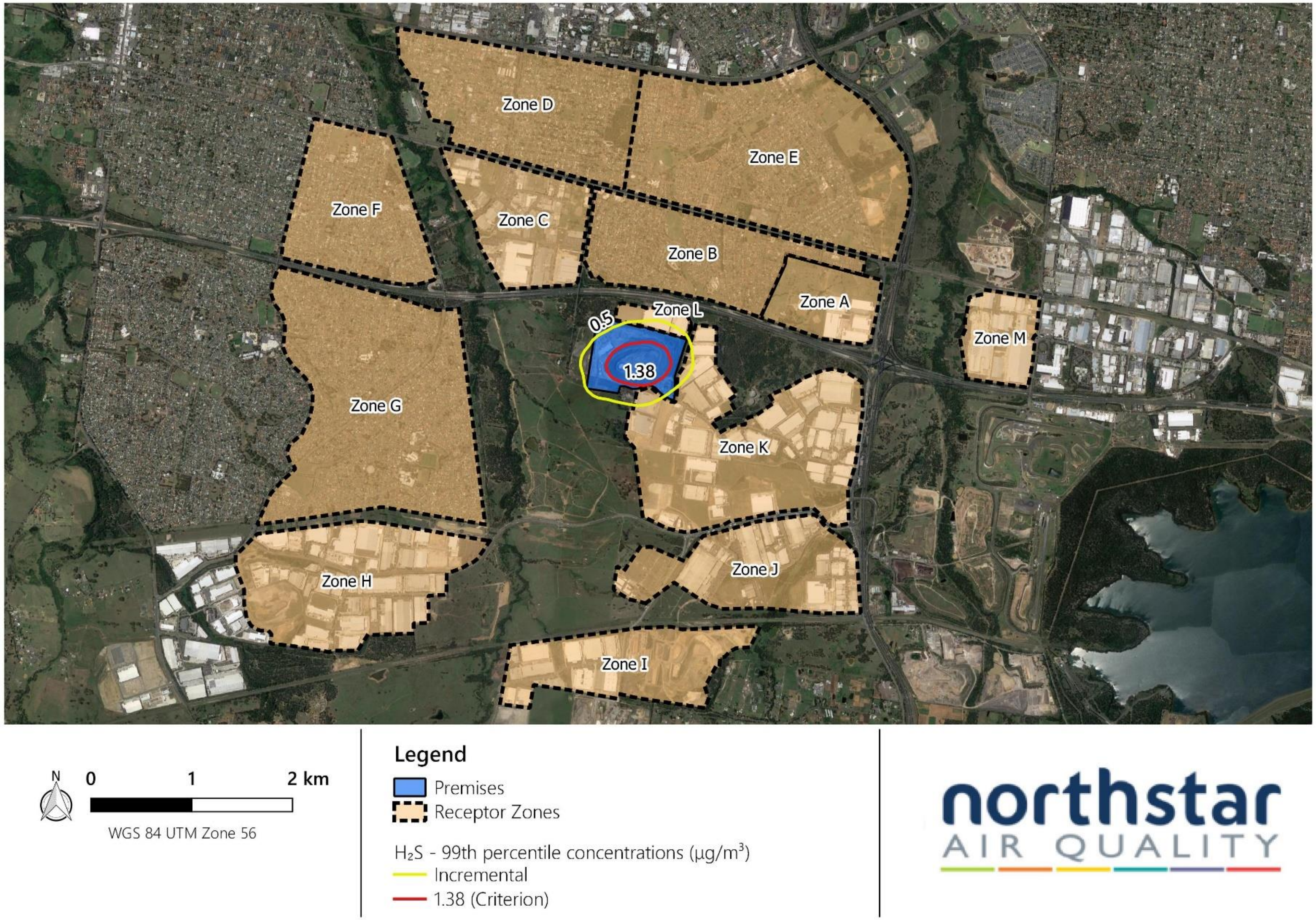
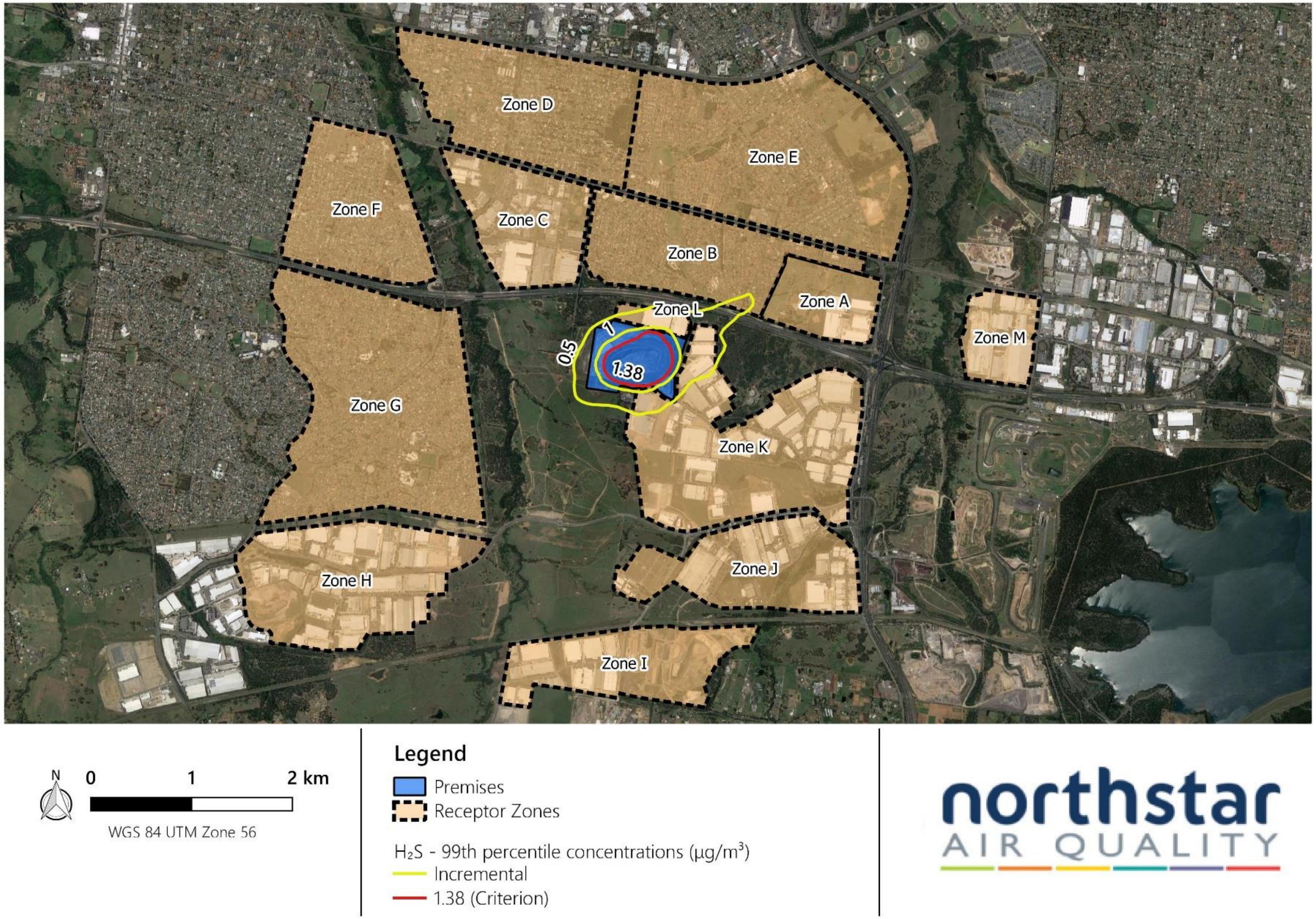


Figure 11 Incremental 99th percentile nose response time H_2S concentration – flare + landfill surface



7. GREENHOUSE GAS ASSESSMENT

A greenhouse gas assessment was performed to assess the potential GHG impacts associated with the Proposed Development Modification in comparison to a base case scenario.

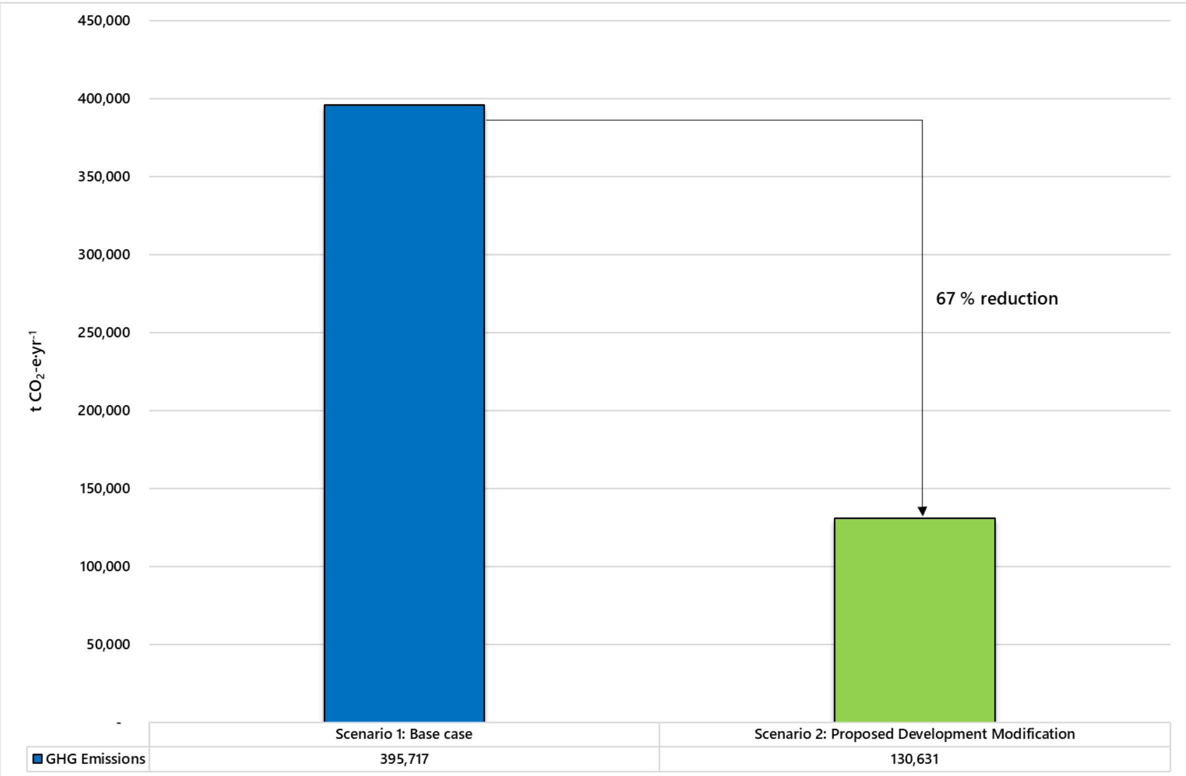
Scenario 1 (Base case) was assessed assuming no capture or treatment of LFG by flaring. Scenario 2 (The Proposed Development Modification) assumes combustion of methane gas resulting from the capture of 70 % of generated LFG (although up to 85 % may be captured), with the remainder (30 %) being emitted as per the base case scenario. Should a greater LFG capture rate be achieved, GHG emissions would be correspondingly reduced.

The results of the GHGA are presented in **Table 24** and **Figure 12**. These indicate annual GHG reduction of 265 085 t CO_2-e·yr^{-1} which equates to a total emission reduction of 67 %.

Table 24 Estimated greenhouse gas emissions under different operating scenarios

Operating scenario	Greenhouse gas emissions t CO_2-e·yr^{-1}
Scenario 1: Base case	395 717
Scenario 2: Proposed Development Modification	130 631
Total emissions reduction t CO_2-e·yr^{-1}	**265 085**

Figure 12 Calculated GHG reductions – Proposed Development Modification



8. DISCUSSION

8.1 Summary

JEP has engaged Northstar on behalf of Dial-A-Dump (EC) Pty Ltd (DADEC) to perform an AQIA and GHGA for a proposed landfill gas collection network including flares, at the Eastern Creek Recycling Ecology Park, located at Kangaroo Avenue, Eastern Creek, NSW.

This AQIA and GHGA form part of the EIS prepared to accompany the modification application for the Proposed Development Modification under Part 4 of the *Environmental Planning and Assessment Act* 1979.

8.1.1 Air Quality

The AQIA has been performed in accordance with the NSW EPA Approved Methods document and includes a detailed description of the operations to be performed as part of the Proposed Development Modification. The locations of surrounding sensitive receptor locations, a description of existing air quality and meteorology, and a description of the method used to assess potential impacts are also provided.

The AQIA has been performed to quantify the potential risk of off-site impacts of CO, NO_X, SO_2, particulate matter, and H_2S from the operation of the flare, and has additionally accounted for minor residual H_2S emissions from the surface of the landfill not captured by the LFG collection systems that feed the flares.

The AQIA does not predict any additional exceedances of the relevant air quality impact assessment criteria (i.e. additional to those measured in the air quality data adopted as background, due to sources other than the Proposed Development Modification) for any pollutants assessed, at any of the sensitive receptors subject to assessment.

The assessment shows no exceedance of the H_2S impact assessment criterion predicted at any residential or industrial locations in the surrounding communities. It has been established that H_2S emissions are the dominant driver for odour emissions from the Premises, and correspondingly the installation and operation of the two permanent LFG flares would be anticipated to have a significant positive impact on the odour conditions in the surrounding communities.

8.1.2 Summary of Compliance

A summary of the anticipated compliance status of the Proposed Development Modification when compared to the requirements, criteria, and guidelines referenced within this assessment, is provided in **Table 25**.

Table 25 Compliance status of Proposed Development Modification

Legislation/guidance	Requirement	Compliance
POEO Act 1997 Clause 129	The occupier of any premises at which scheduled activities are carried on under the authority conferred by a licence must not cause or permit the emission of any offensive odour from the premises to which the licence applies.	Dispersion modelling results indicate that the Proposed Development Modification aims to minimise any potential emissions of offensive odour. Modelling results indicate that the H_2S / odour criterion is predicted to be achieved in all surrounding residential and industrial areas.
POEO (Clean Air) Regulation 2021 Clause 50	Any flare operated for the treatment of air impurities is operated in such a way that a flame is present at all times while air impurities are required to be treated	A flame will be present at all times
POEO (Clean Air) Regulation 2021 Clause 51	An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the time between landfill gas entering and exiting the flare is more than 0.6 seconds.	The residence time has been calculated as 1.55 seconds (refer **Section 5.1.2**)
POEO (Clean Air) Regulation 2021 Clause 52	An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the temperature for the combustion of landfill gas by the flare is more than 760°C.	The operational temperature of the flare is set to 900°C
POEO (Clean Air) Regulation 2021 Clause 53	An enclosed ground-level flare for the treatment of landfill gas must be operated in such a way that the destruction efficiency of the flare, in relation to landfill gas entering the flare, is more than 98%.	The AQIA has been performed on the basis of a 98 % destruction efficiency. Monitoring would be performed following approval, in accordance with the requirements of the POEO (Clean Air) Regulation 2021
NSW EPA Environmental Guidelines, 2nd Edition, Solid Waste Landfills (2016)	Flares for treating landfill gas must be enclosed and at ground level. They must meet the operating requirements in the Protection of the Environment Operations (Clean Air) Regulation 2010, namely gas residence time >0.6 seconds, combustion temperature >760°C, destruction efficiency >98%, and flame present at all times while air impurities are required to be treated. Regular monitoring is required of temperature (in °C) and volumetric flow rate (in cubic metres/second).	Compliant, see above

Legislation/guidance	Requirement	Compliance
	The discharge point(s) from any landfill gas combustion source should be designed to promote good dispersion (i.e. by means of such factors as stack height, diameter and discharge velocity) and ensure that the ground level concentration criteria are not exceeded. Further information about the design of discharge points can be obtained from Local Government Air Quality Toolkit, Module 3: Guidelines for Managing Air Pollution, Part 1: Air pollution control techniques (chapter 3): www.epa.nsw.gov.au/air/lgaqt.htm (NSW DECC, 2007). Any liquid condensed from the landfill gas should be handled in the same manner as leachate. Because of the low pH and the potential odour it should not be spray-irrigated.	
Project Approval conditions MP 06_0139	The Proponent shall not cause or permit the emission of offensive odours from the site, as defined under Section 129 of the POEO Act. The Proponent shall implement all reasonable and feasible measures to minimise the scope 1, 2 and 3 greenhouse gas emissions produced on site, to the satisfaction of the Secretary. The Proponent shall prepare and implement an Air Quality, Odour and Greenhouse Gas Management Plan for the project to the satisfaction of the Secretary….of which requires a protocol for remediating uncontrolled landfill gas emissions.	The Proposed Development Modification aims to significantly reduce the potential for emissions of offensive odour from the Premises. Dispersion modelling indicates that H2S / odour impacts are below the criterion at all residential and industrial locations surrounding the Premises. Odour complaints are currently significantly reduced from those experienced in March and April 2021. The operation of a permanent gas collection network and flares, capable of treating additional LFG, is anticipated to improve the situation even further.

8.1.3 Greenhouse Gas

The GHGA has evaluated the potential change in GHG emissions of the Proposed Development Modification against a base case scenario, to establish the potential change in net GHG emissions.

The GHGA indicates that the installation and operation of the two permanent methane gas combustion flares will result in a reduction of greenhouse gas emissions of approximately 265 085 t CO_2-e each year, which corresponds to a reduction of approximately 67 % when compared to base case emission estimates.

8.2 Mitigation and Monitoring

8.2.1 Air Quality

The predictions presented in this AQIA indicate that there would be a low risk of any exceedances of the adopted air quality criteria as a result of the Proposed Development Modification.

Therefore, it is anticipated that no ambient air quality monitoring would be required to be performed for assurance purposes.

Landfill gas monitoring would be performed in line with the Landfill Gas Management Plan (Bingo Industries, 2021a), specifically:

- Landfill gas management action LPG-09 (from table 5 of (Bingo Industries, 2021a)):

  Undertake odour monitoring in accordance with requirements set out in the EC REP Air Quality, Odour and Greenhouse Gas Management Plan (Bingo Industries, 2021b).

  Undertake odour monitoring (olfactometry) to provide feedback to the operation of the gas extraction system and other odour controls:

  - ambient air beyond site boundary at fixed monitoring locations.

  - on site at the boundary – fixed locations upwind and downwind of prevailing conditions on the day of monitoring.

  - on site within the landfill to evaluate odour reduction from gas extraction system operation.

- Landfill gas management action LPG-10 (from table 5 of (Bingo Industries, 2021a)):

  Undertake LFG surface emissions monitoring;

  - within landfill area around the LFG wells and pipework to check for leaks.

  - within the landfill along transects to identify areas of high emissions of LFG (methane to aid additional well placement for odour reduction and need for placement of additional cover material.

  - at the waste/quarry wall interface to identify areas of high emissions of methane to aid additional future LFG well placement for odour reduction and need for placement of additional cover material.

  – landfill surface in system area & to target expansion of system (it is recommended that for targeted and operational investigation, transect spacings are reduced).

- LPG-16 (from table 5 of (Bingo Industries, 2021a)):

Update Air Quality, Odour & Greenhouse Gas Management Plan to refer to this LFGMP in relation to management of LFG emissions.

8.2.2 Greenhouse Gas

As discussed above, a program of LFG flux monitoring would help quantify and map passive CO_2 and CH_4 emissions from the landfill surface, providing assurance of effective LFG capture.

The Air Quality, Odour and Greenhouse Gas Management Plan (Bingo Industries, 2021b) should be updated to include the range of management measures above.

8.3 Conclusion

The AQIA indicates that the Proposed Modification Development can be operated to result in compliance with all relevant air quality criteria. Emissions of odorous gases (characterised by H_2S emissions) are predicted to be well below the NSW EPA air quality criterion.

In comparison to uncontrolled emissions of LFG through the surface of the landfill, the Proposed Development Modification is shown to provide effective capture, treatment and dispersion of any by-products into the atmosphere.

In relation to greenhouse gas emissions, the capture and treatment of methane results in emissions of CO_2-e being 67 % lower when compared to the uncontrolled and untreated release into the atmosphere.

It is respectfully considered that the Proposed Development Modification provides a preferential environmental outcome, when compared with a pre-LFG capture and treatment scenario.

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APPENDIX A

Report Units and Common Abbreviations

Units Used in the Report

All units presented in the report follow the International System of Units (SI) conventions, unless derived from references using non-SI units. In this report, units formed by the division of SI and non-SI units are expressed as a negative exponent, and do not use the solidus (/) symbol. For example:

- 50 micrograms per cubic metre would be presented as 50 $\mu g \cdot m^{-3}$ and not 50 $\mu g/m^3$; and,
- 0.2 kilograms per hectare per hour would be presented as 0.2 $kg \cdot ha^{-1} \cdot hr^{-1}$ and not 0.2 kg/ha/hr.

Table A1 Common Abbreviations

Abbreviation	Term
ABS	Australian Bureau of Statistics
AGL	above ground level
AHD	Australian height datum
Am^3	cubic metre of air, reported at actual (stated) temperature
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AWS	automatic weather station
BoM	Bureau of Meteorology
°C	degrees Celsius
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIE	NSW Department of Planning, Industry and Environment
dscm	dry standard cubic metre of air (see also Sm^3)
EETM	emission estimation technique manual
EPA	Environmental Protection Authority
FEL	front end loader
GDA	Geocentric Datum of Australia
GIS	geographical information system
$g \cdot m^{-2} \cdot s^{-1}$	gram per square metre per second
$g \cdot mol^{-1}$	gram per mole
$g \cdot s^{-1}$	gram per second
hr	hour

Abbreviation	Term
H_2S	hydrogen sulphide
LFG	landfill gas
K	kelvin (-273°C = 0 K, ±1°C = ±1 K)
kW	kilowatt
MGA	Map Grid of Australia
$mg \cdot m^{-3}$	milligram per cubic metre of air (see also Am^3, Nm^3 and Sm^3)
$\mu g \cdot m^{-3}$	microgram per cubic metre of air
NCAA	National Clean Air Agreement
NEPM	National Environment Protection Measure
Nm^3	cubic meter of air, normalised to 0 °C (273 K)
OEH	NSW Office of Environment and Heritage (now defunct)
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
s	second
SEARs	Secretary’s Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SEE	Statement of Environmental Effects
Sm^3	cubic metre of air, standardised to 15 °C (at 288 K)
SO_2	sulphur dioxide
TAPM	The Air Pollution Model
TPM	total particulate matter
TSP	total suspended particulates
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VKT	vehicle kilometres travelled

APPENDIX B

Meteorology

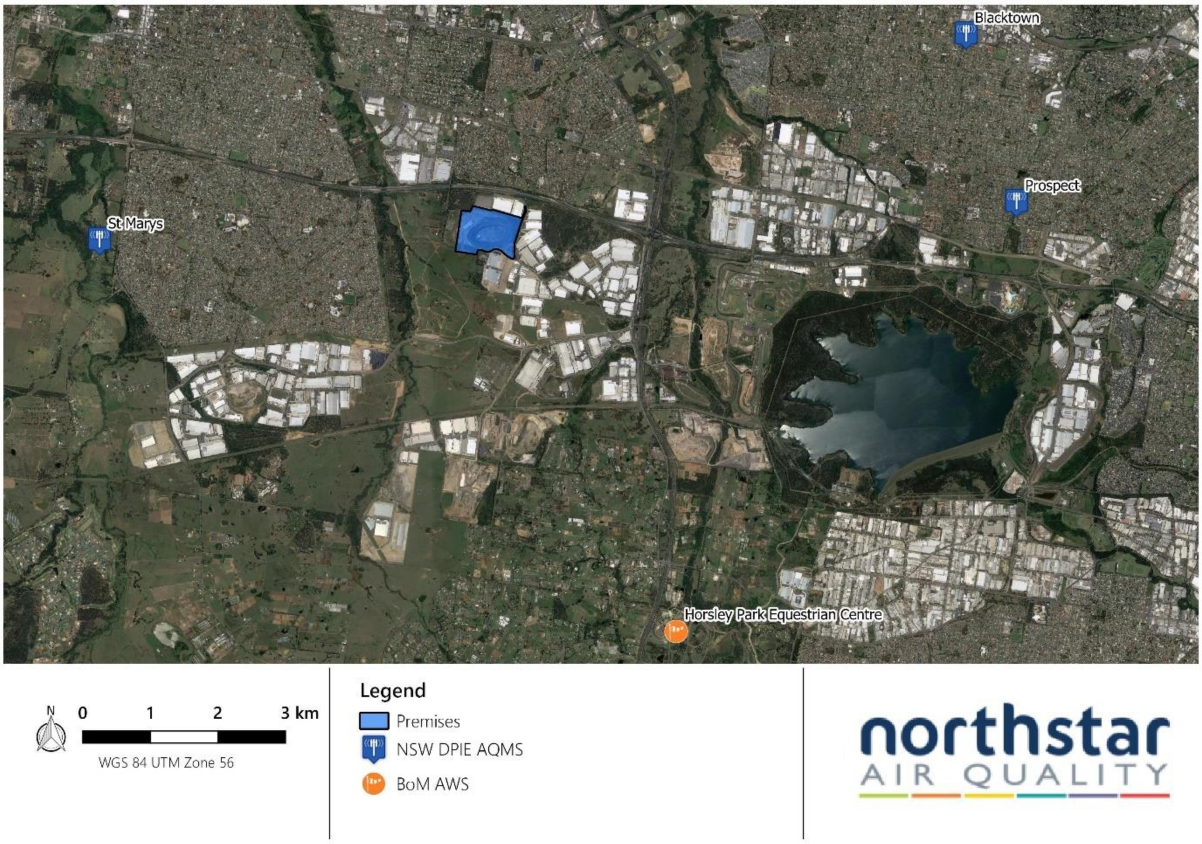
As discussed in **Section 4.2** a meteorological modelling exercise has been performed to characterise the meteorology surrounding the Premises in the absence of site-specific measurements. The meteorological modelling has been based on measurements taken at a nearby automatic weather station (AWS) operated by the Australian Government Bureau of Meteorology (BoM).

A summary of the relevant AWS is provided in **Table B1** and also displayed in **Figure B1**.

Table B1 Details of the meteorological monitoring surrounding the Premises

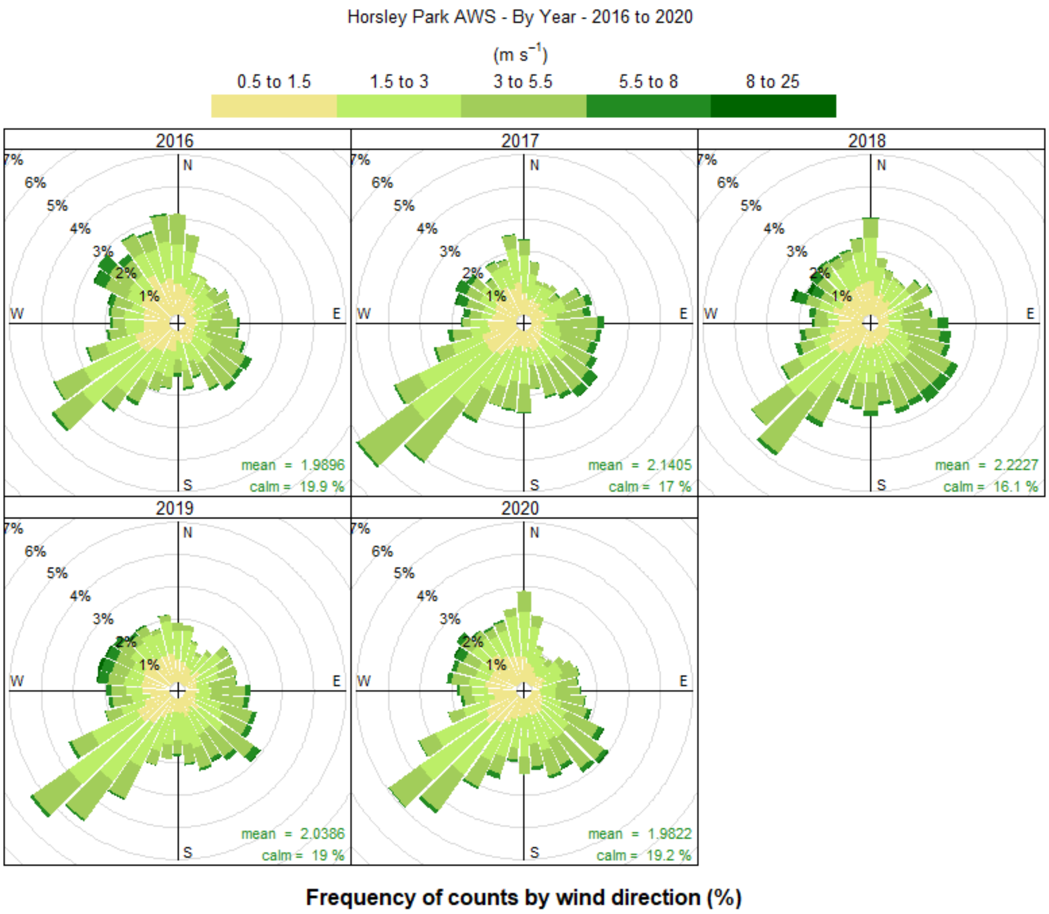
Site Name	Source	Approximate Location (UTM)		Approximate Distance
		mE	mS	km
Horsley Park Equestrian Centre - #067119	BoM	301 708	6 252 298	6.0

Figure B1 Meteorological and air quality monitoring surrounding the Premises



Meteorological conditions at Horsley Park Equestrian Centre AWS have been examined to determine a 'typical' or representative dataset for use in dispersion modelling. Annual wind roses for the most recent years of data (2016 to 2020) are presented in **Figure B2**.

Figure B2 Annual wind roses 2016 to 2020, Horsley Park Equestrian Centre AWS



The wind roses indicate that from 2016 to 2020, winds at Horsley Park Equestrian Centre AWS show a predominant east south-easterly wind direction.

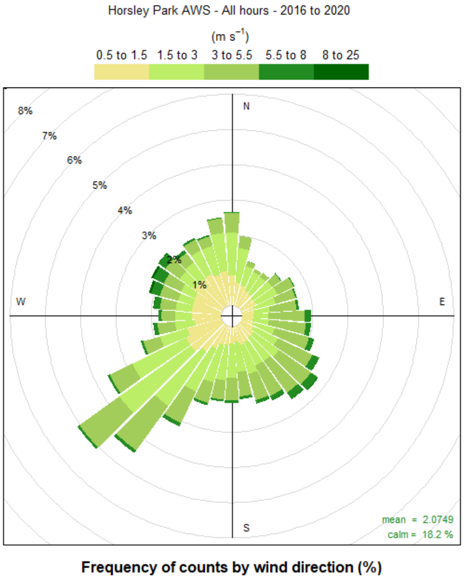
The majority of wind speeds experienced at Horsley Park Equestrian Centre AWS over the 5-year period, 2016 to 2020 are generally in the range 0.5 metres per second ($m \cdot s^{-1}$) to 5.5 $m \cdot s^{-1}$ with the highest wind speeds (greater than 8 $m \cdot s^{-1}$) occurring from a north-westerly direction. Winds of this speed are not frequent, occurring during approximately 0.3 % of the observed hours over the 5-year period at Horsley Park Equestrian Centre AWS. Calm winds (<0.5 $m \cdot s^{-1}$) occur during 17.5 % of hours on average across the 5-year period.

Given the wind distributions across the years examined, data for the year 2017 has been selected as being appropriate for further assessment, as it best represents the general trend across the 5-year period studied.

Presented in **Figure B3** are the annual wind rose for the 2016 to 2020 period and the year 2017 and in **Figure B4** the annual wind speed distribution for Horsley Park Equestrian Centre AWS. These figures indicate that the distribution of wind speed and direction in 2017 is very similar to that experienced across the longer-term period.

It is concluded that conditions in 2017 may be considered to provide a suitably representative dataset for use in dispersion modelling.

Figure B3 Annual wind roses 2016 to 2020, and 2017 Horsley Park Equestrian Centre AWS



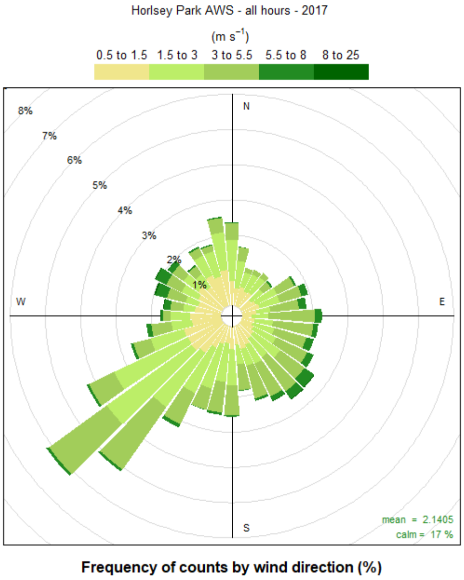
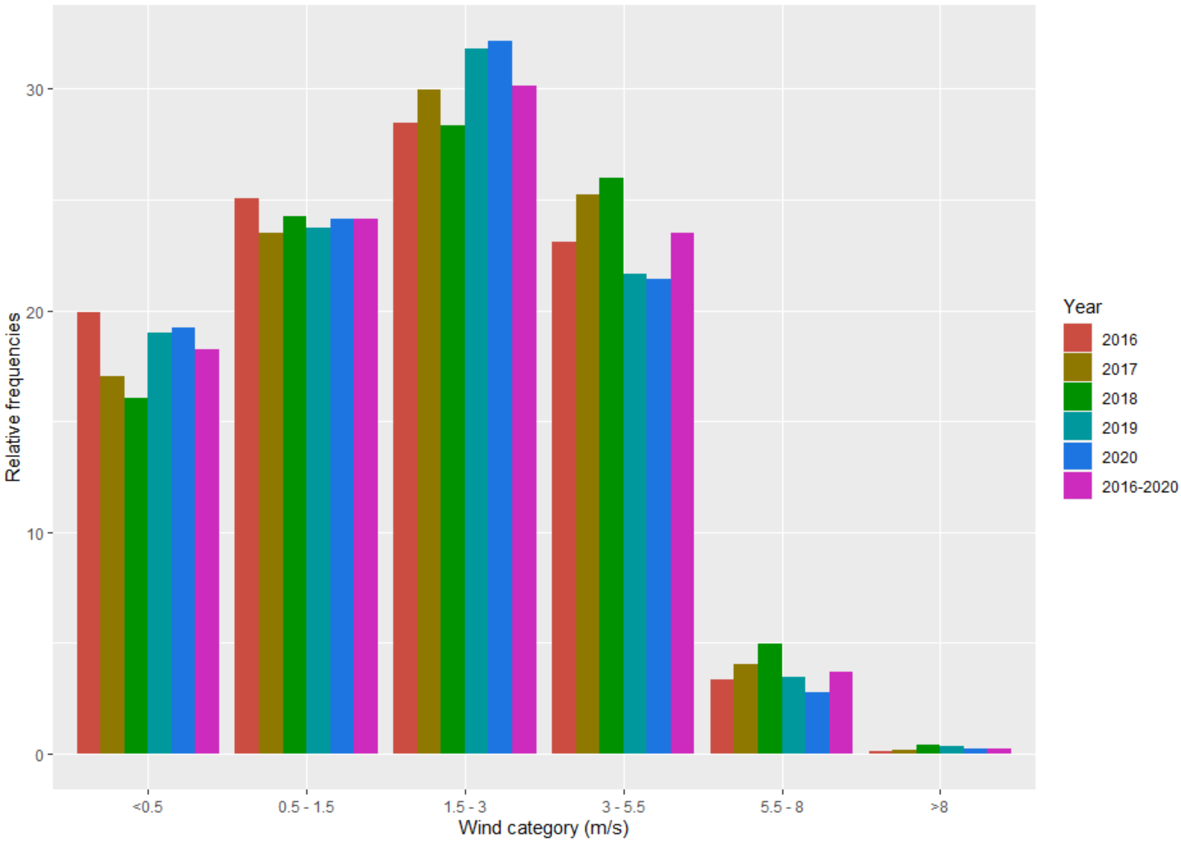


Figure B4 Annual wind speed distribution – Horsley Park Equestrian Centre AWS



Meteorological Processing

The BoM data adequately covers the issues of data quality assurance, however it is limited by its location compared to the Premises. To address these uncertainties, a multi-phased assessment of the meteorological data has been performed.

In absence of any measured onsite meteorological data, site representative meteorological data for this assessment was generated using the CALMET meteorological model which is a component of the CALPUFF modelling system (refer **Section 5.1.1**).

CALMET develops wind and temperature fields on a three-dimensional gridded modelling domain. 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, 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 and thus the final wind field reflects the influences of local topography and current land uses.

In this study, CALMET has been run in no-observations ("no-obs") mode using gridded prognostic data generated by The Air Pollution Model (TAPM, v 4.0.5), developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

TAPM is a prognostic model which predicts wind speed and direction, temperature, pressure, water vapour, cloud, precipitation and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

The parameters used in TAPM and CALMET are presented in **Table A2**.

Table A2 Meteorological parameters used for this study (TAPM v 4.0.5)

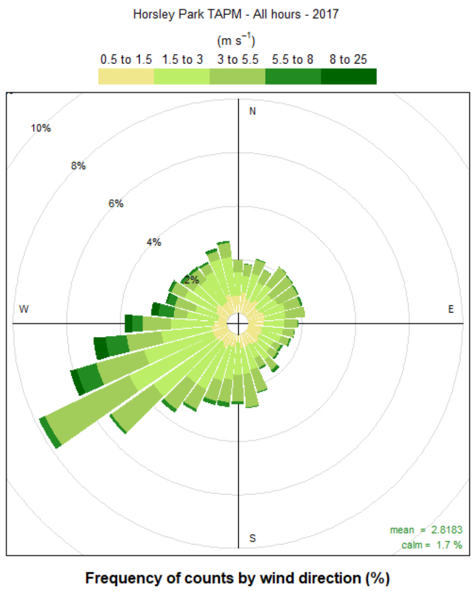
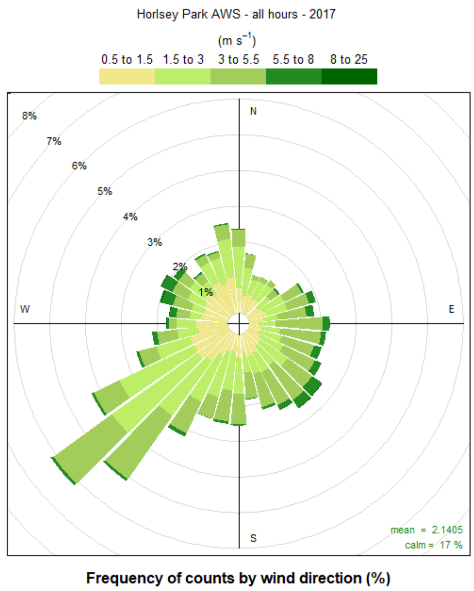
TAPM v 4.0.5	
Modelling period	1 January 2017 to 31 December 2017
Centre of analysis	295 708 mE, 6 251 357 mS (UTM Coordinates)
Number of grid points	25 × 25 × 25
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	-
CALMET	
Modelling period	1 January 2017 to 31 December 2017
South-West corner of analysis	295 500 mS, 6 255 000 mS (UTM Coordinates)
Meteorological grid domain (resolution)	7 km x 7 km (0.1 km)

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	No-obs approach using TAPM – 3D.DAT file

A comparison of the TAPM generated meteorological data, and that observed at the Horsley Park Equestrian Centre AWS is presented in **Figure A1**.

These data generally compare well which provides confidence that the meteorological conditions modelled as part of this assessment are appropriate.

Figure A1 Modelled and observed meteorological data – Horsley Park Equestrian Centre AWS, 2017

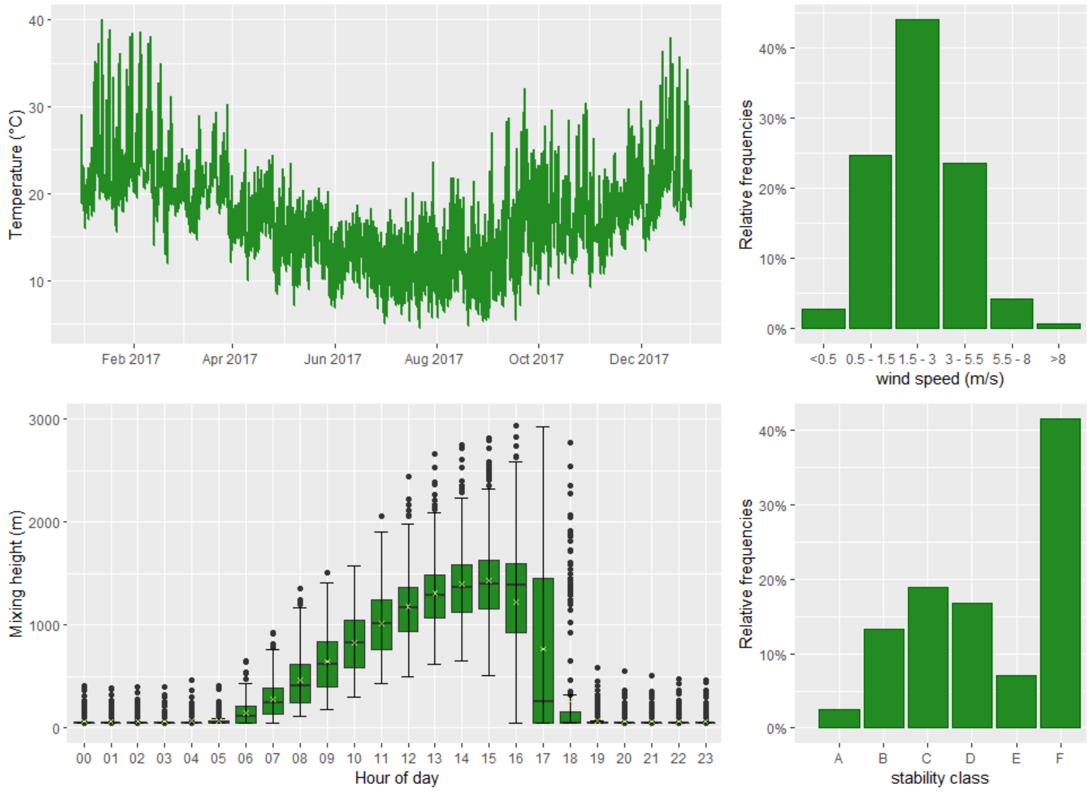
TAPM generated windrose	Observations at Horsley Park AWS
	

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

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Premises during 2017 period are illustrated in **Figure A2**. Also presented are predicted temperature, stability class and wind speed frequency.

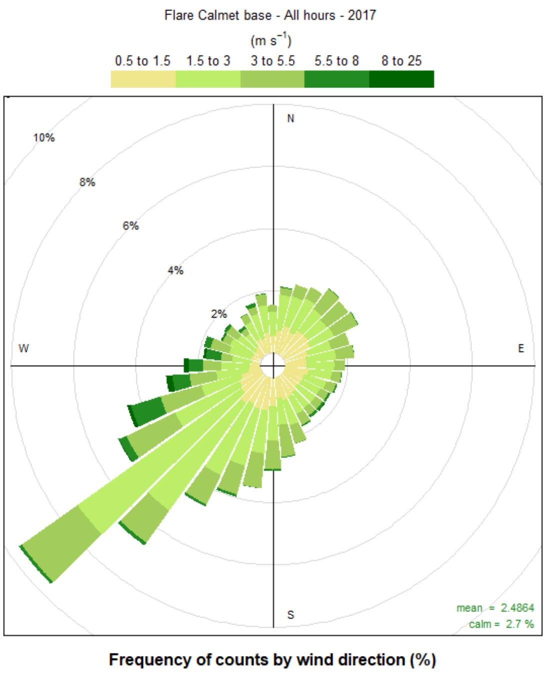
As expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure A2 Predicted meteorological parameters – Premises



The modelled wind speed and direction at the Premises during 2017 are presented in **Figure A3**.

Figure A3 Predicted wind speed and direction – Premises 2017



APPENDIX C

Background Air Quality Data

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

- the sources of air pollutant emissions around the Premises and representative air quality monitoring station(s); and
- the variability of particulate matter concentrations (often impacted by natural climate variability).

Air quality monitoring is performed by the NSW Department of Planning, Industry and Environment (DPIE) at two air quality monitoring station (AQMS) within a 10 km radius of the Premises. Details of the monitoring performed at these AQMS is presented in **Table C1** and **Figure B1**. As discussed in **Section 4.2** and **Section 4.3**, the year 2017 was selected for assessment based upon an analysis of meteorological and background air quality data.

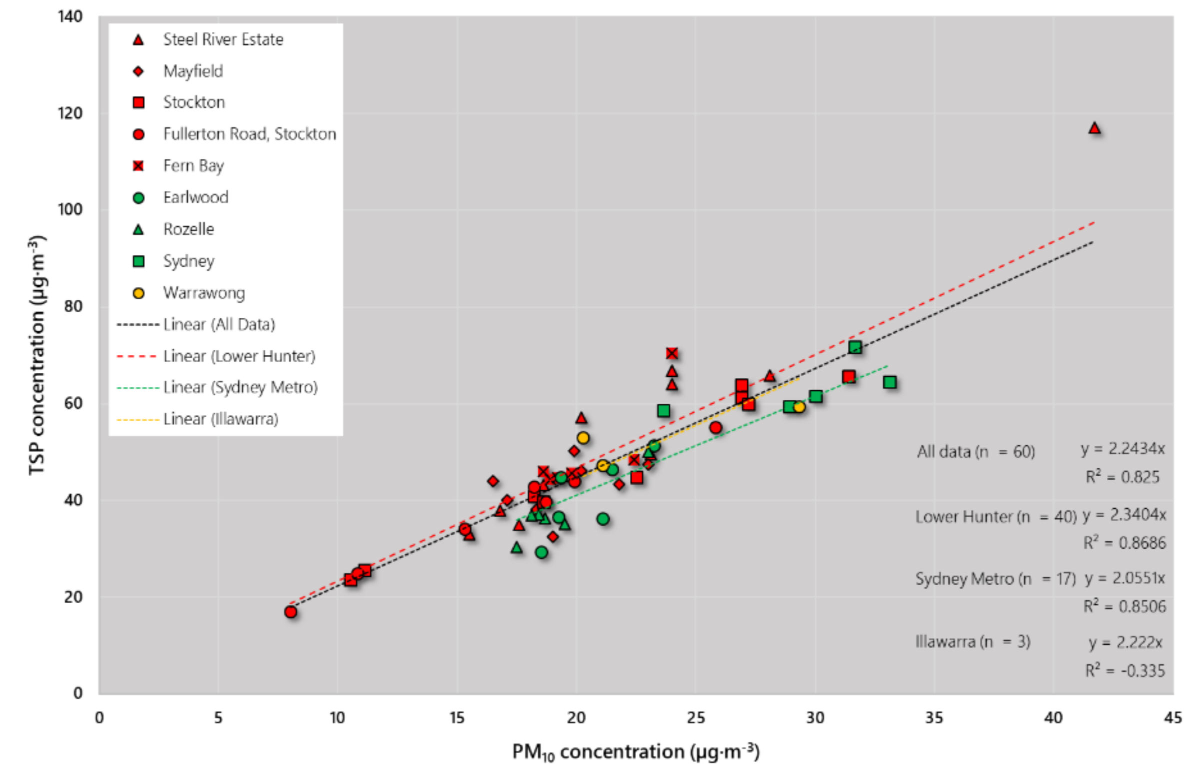
Table C1 Details of closest AQMS surrounding the Premises

AQMS Location	Approximate distance to Premises (km)	2017 Data	Measurement						
			PM_{10}	$PM_{2.5}$	TSP	NO_2	SO_2	CO	H_2S
St Marys	5.3	✓	✓	✓	×	✓	×	×	×
Blacktown	7.0	×	×	×	×	×	×	×	×
Prospect	7.3	✓	✓	✓	×	✓	✓	✓	×

Based on the sources of AQMS data available and their proximity to the Premises, Prospect AQMS was selected as the source of air quality data for use in this assessment.

Concentrations of TSP are not measured at any AQMS surrounding the Premises. An analysis of co-located measurements of TSP and PM_{10} in the Lower Hunter (1999 to 2011), Illawarra (2002 to 2004), and Sydney Metropolitan (1999 to 2004) regions is presented in **Figure C1**. The analysis concludes that, on the basis of the measurements collected in all regions between 1999 to 2011, the derivation of a broad TSP:PM_{10} ratio of 2.0551 : 1 (i.e. PM_{10} represents ~49 % of TSP) is most appropriate to be applied to the Eastern Creek area. In the absence of any more specific information, this ratio has been adopted within this AQIA. These estimates have not been adjusted for background exceedances.

Figure C1 Co-located TSP and PM_{10} Measurements, Lower Hunter, Sydney Metro and Illawarra



Similarly, no dust deposition data is available for the area surrounding the Premises. The incremental impact criterion of 2 g·m^{-2}·month^{-1} as outlined within the Approved Methods has been adopted which effectively provides a background deposition level of 2 g·m^{-2}·month^{-1} (the total allowable deposition being 4 g·m^{-2}·month^{-1}).

In the absence of measured data, the sub hourly concentrations of SO_2 (10 minutes) and CO (15 minutes) were calculated using the following Power Law adjustment[8]:

$$C_{p,t} = C_{p,60}\left[\frac{60}{t}\right]^{0.2}$$

Where:

$C_{p,t}$ = concentration of pollutant (p) at averaging time (mins) (t)

$C_{p,60}$ = concentration of pollutant (p) at averaging time (60 mins)

t = time (mins)

A summary of the data recorded at Prospect AQMS in 2017 is presented in **Table C2**.

Graphs presenting 1-hour concentrations of SO_2, NO_2, and CO, are presented in **Figures C2** to **C4** and daily varying PM_{10} and $PM_{2.5}$ data are presented in **Figure C5** and **Figure C6**, respectively.

8 http://www.epa.vic.gov.au/~/media/Publications/1551.pdf

Table C2 Summary of background air quality data (Prospect 2017)

Pollutant	SO_2 (µg·m^{-3})	SO_2 (µg·m^{-3})	NO (µg·m^{-3})	NO_2 (µg·m^{-3})	CO (mg·m^{-3})	CO (mg·m^{-3})	CO (mg·m^{-3})	TSP (µg·m^{-3})	PM_{10} (µg·m^{-3})	$PM_{2.5}$ (µg·m^{-3})
Averaging Period	**10 min**	**1 hour**	**1 hour**	**1 hour**	**15 min**	**1 hour**	**8 hour rolling**	**Annual**	**24 hour**	**24 hour**
Data Points (number)	8274	8274	8256	8256	8291	8291	8650	359	359	354
Mean	4.6	1.8	10.1	18.4	0.2	0.1	0.1	38.9	18.9	7.7
Standard Deviation	4.6	3.2	22.3	16.1	0.3	0.2	0.2	-	6.9	4.1
Skew[1]	41.0	4.6	3.6	1.1	2.5	2.5	2.2	-	1.2	2.1
Kurtosis[2]	-3.7	41.0	16.0	1.0	8.3	8.3	5.9	-	3.8	6.6
Minimum	-3.7	-2.6	-1.2	-5.6	-0.2	-0.1	-0.1	-	3.6	1.2
Percentiles (µg·m^{-3})										
1	0.0	0.0	-1.2	0.0	-0.2	-0.1	0.0	-	7.1	2.5
5	0.0	0.0	0.0	1.9	0.0	0.0	0.0	-	10.0	3.3
10	0.0	0.0	0.0	1.9	0.0	0.0	0.0	-	11.5	3.9
25	0.0	0.0	0.0	5.6	0.0	0.0	0.0	-	14.6	4.9
50	0.0	0.0	1.2	13.2	0.0	0.0	0.1	-	17.7	6.9
75	3.7	2.6	7.4	28.2	0.2	0.1	0.1	-	22.5	9.3
90	7.5	5.2	33.2	43.2	0.5	0.3	0.3	-	28.0	11.6
95	11.2	7.9	59.0	50.8	0.8	0.6	0.5	-	32.0	15.4
97	11.2	7.9	77.5	56.4	0.9	0.7	0.6	-	34.4	18.5
98	15.0	10.5	86.1	60.2	1.1	0.8	0.7	-	35.8	20.2
99	18.7	13.1	107.0	65.8	1.2	0.9	0.8	-	37.7	23.3
Maximum	86.2	60.3	239.9	112.8	2.4	1.8	1.3	125.6	61.1	30.1
Data Capture (%)	94.5	94.5	94.2	94.2	94.6	94.6	98.7	98.4	98.4	97.0

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

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

Figure C2 SO$_2$ measurements, Prospect 2017

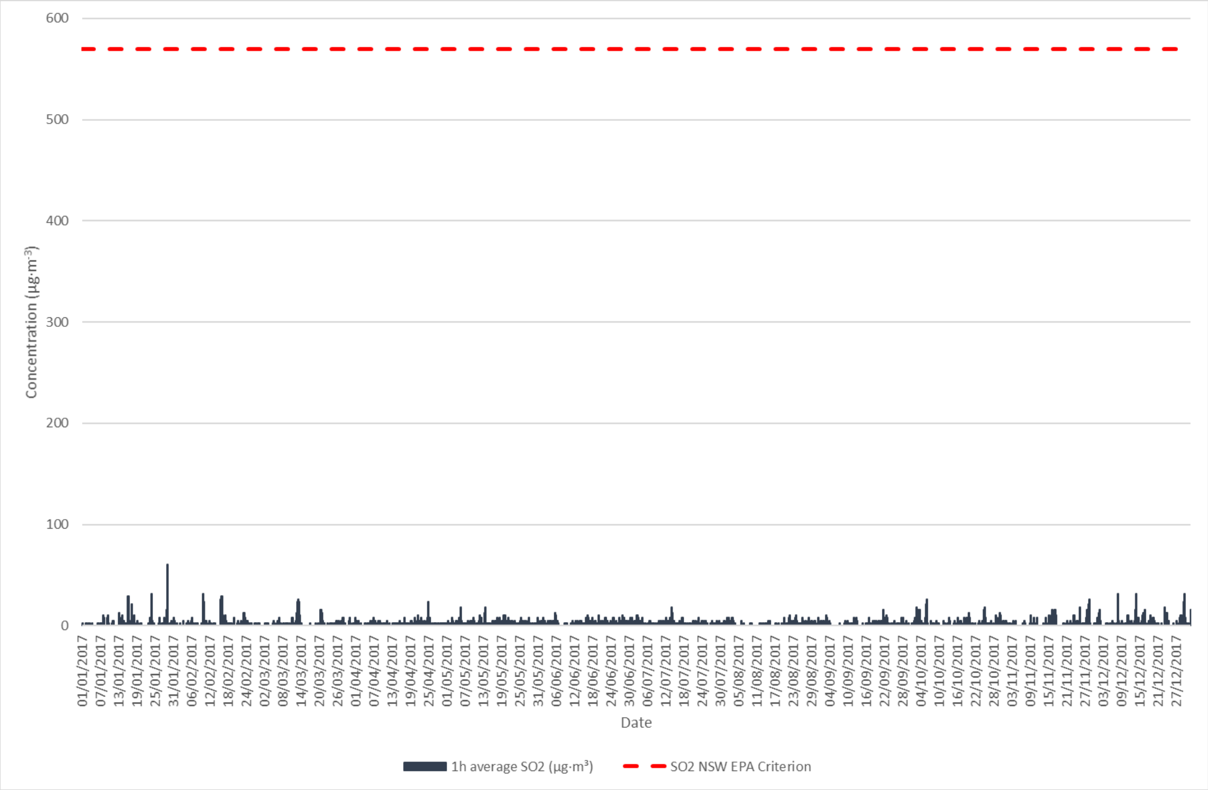


Figure C3 NO$_2$ measurements, Prospect 2017

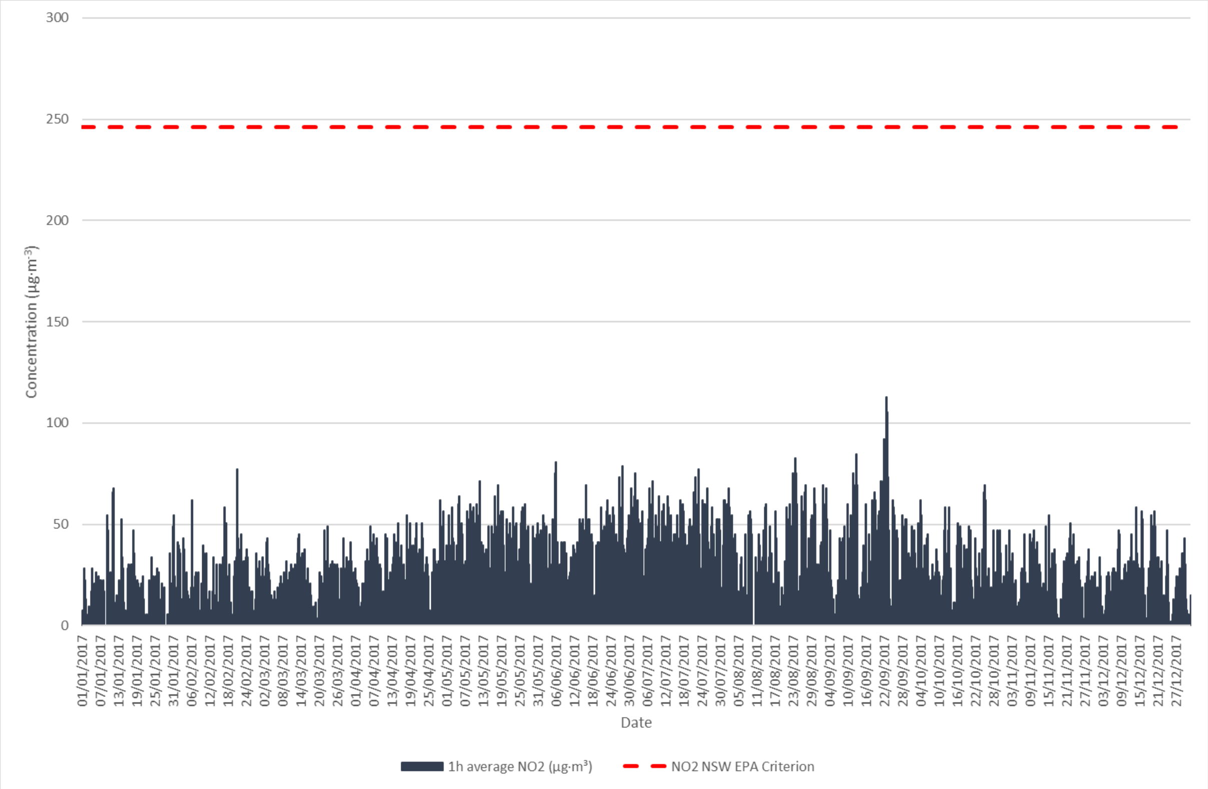


Figure C4 CO measurements, Prospect 2017

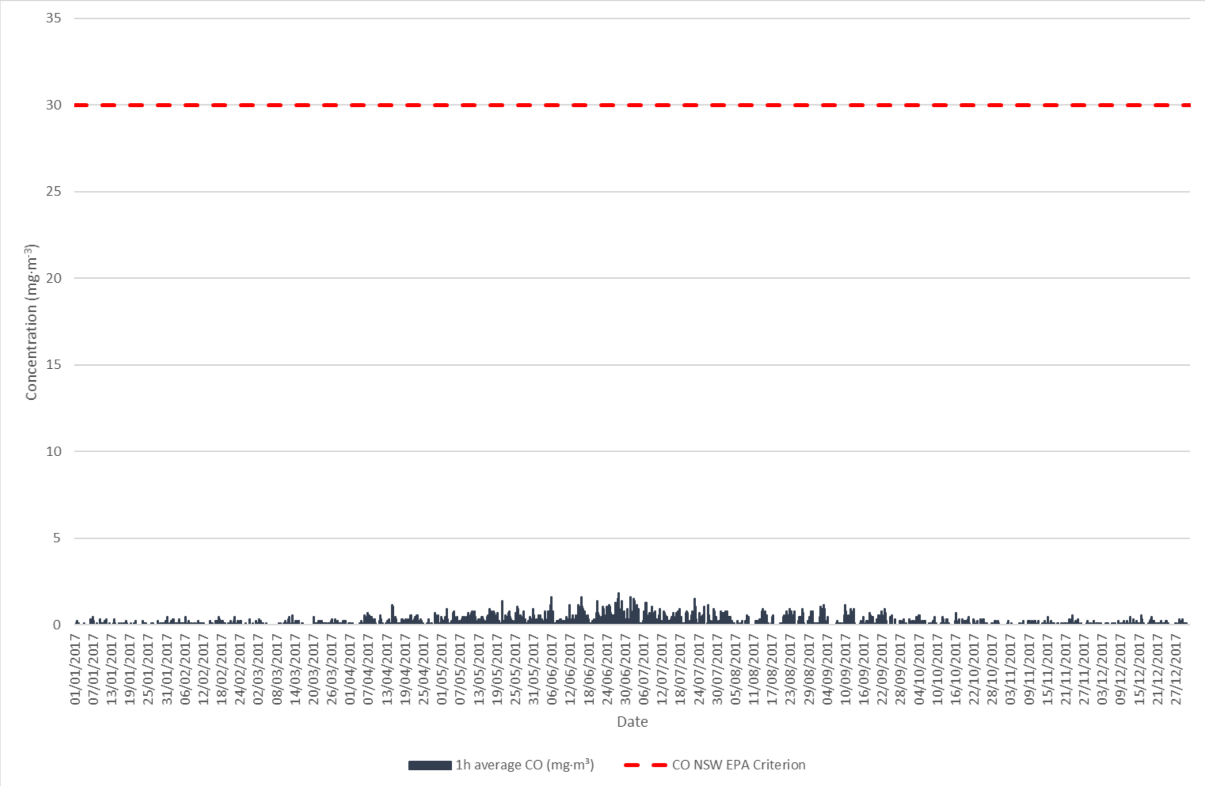


Figure C5 PM_{10} measurements, Prospect 2017

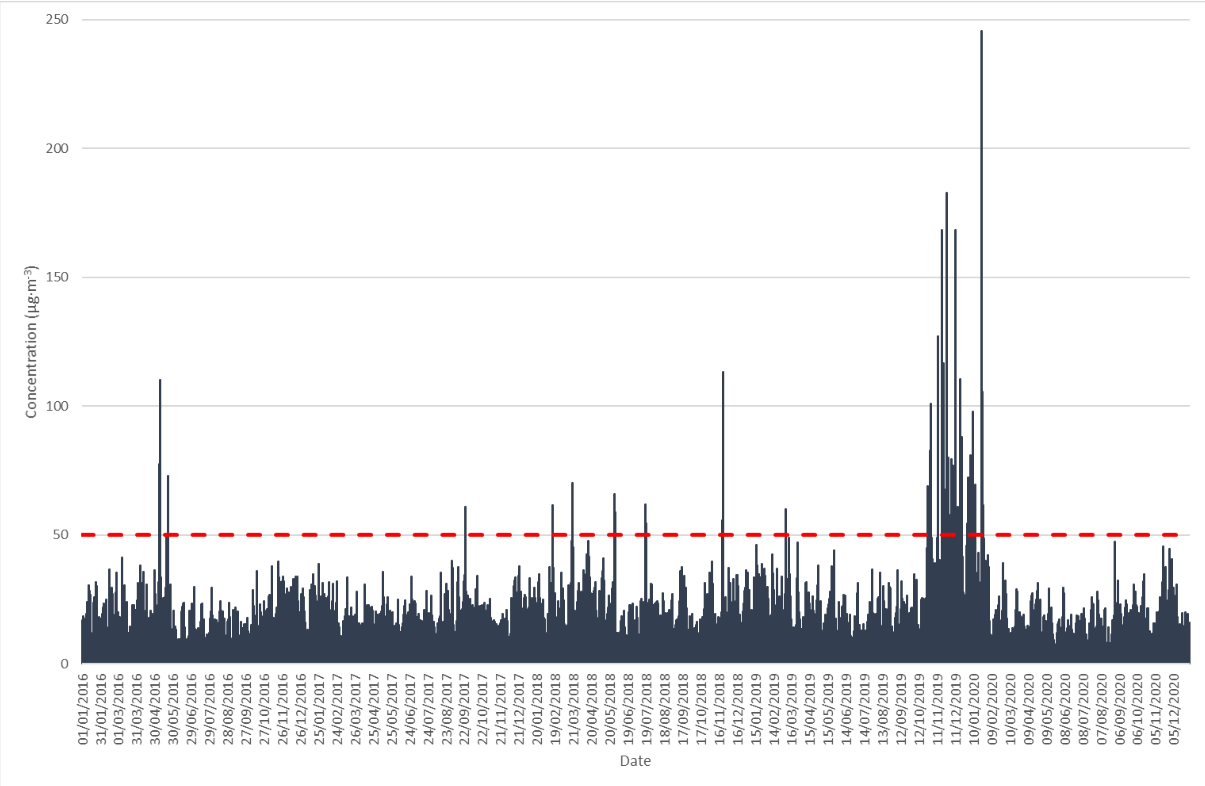


Figure C6 PM$_{10}$ measurements, Prospect 2017