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Brickworks Land And Development

Proposed Plant 2 Upgrade – SSD 9601

780 Wallgrove Road, Horsley Park, NSW

Air Quality Impact Assessment

Document Control

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KEY ACRONYMS

AHD	Australian Height Datum
Airlabs	Airlabs Environmental Pty Ltd
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CALMET	California Meteorological Model
CALPUFF	California Puff Dispersion Model
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cumulative Impacts	Incremental impacts from the upgraded Plant 2 facility + impacts from Plant 1 + impacts from Horsley Park WMF + background concentrations from the Prospect monitoring station)
DA	Development Application
DOEE	Department of the Environment and Energy
DOP&E	Department of Planning and Environment
EET	Emission Estimation Technique
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act, 1979
EPL	Environmental Protection Licence
ETBPP	Environmental Technology Best Practice Programme
HF	Hydrogen Fluoride
g/sec	Emission rate in grams per second
$g/m^2/month$	Units for deposited dust levels, grams per meter square per month
GHG	Greenhouse gas
Incremental	Impacts from the upgraded Plant 2 facility
Level 2	A refined dispersion modelling technique using site-specific input data
LGA	Local Government Area
m^2	square metres
m/sec	metres per second
m^3/hr	cubic metre per hour
Mt	Million tonnes
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure – Ambient Air Quality
NGAF	National Greenhouse Account Factors
NOx	Oxides of Nitrogen
NO_2	Nitrogen dioxide
NSW – EPA	New South Wales Environment Protection Authority
NSW – OEH	New South Wales Office of Environment and Heritage
Plant 1	Austral Bricks Plant 1, Horsley Park, NSW
Plant 2	Austral Bricks Plant 2, Horsley Park, NSW
Plant 3	Austral Bricks Plant 3, Horsley Park, NSW
PM	Particulate matter
PM_{10}	Particulate matter with an equivalent diameter of 10 microns or less
$PM_{2.5}$	Particulate matter with an equivalent diameter of 2.5 microns or less
POEO	Protection of the Environment Operations Act 1997

SEARs	Secretary Environmental Assessment Requirements
SEE	Statement of Environmental Effects
SOx	Sulfur oxides
SO_2	Sulfur dioxide
SO_3	Sulfuric acid mist and sulfur trioxide as SO_3
SRC	Sigma Research Corporation (now Exponent)
SRTM	Shuttle Radar Topography Mission
SSD	State Significant Development
TAPM	The Air Pollution Model
tpa	tonnes per annum
TSP	Total Suspended Particulates
tCO_2-e	Tonnes of CO_2 equivalent
$\mu g/m^3$	micrograms per cubic metre
US-EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VOCs	Volatile Organic Compounds
WMF	Horsley Park Waste Management Facility
WSP	Western Sydney Parklands

EXECUTIVE SUMMARY

Introduction

Brickworks Land and Development (Brickworks) are proposing planned upgrades to the existing brick manufacturing plant no 2 (Plant 2) at their Horsley Park premises located at 780 Wallgrove Road, Horsley Park, NSW. Current operations at the Plant 2 site produce up to 80 million bricks per annum and are licensed under the Environmental Protection Licence (EPL) No: 546.

The proposed upgrade is categorised as a State Significant Development (SSD), which is to be accompanied by an Environmental Impact Statement (EIS) suitable for submission to the Department of Planning and Environment (NSW- DOP&E) for seeking approval.

This air quality impact assessment report forms a part of the EIS, informing the potential impacts expected from the proposed upgrades.

Specifics of the Proposed Upgrade

A key objective of upgrading the existing Plant 2 site is to implement best practice measures and to increase efficiencies associated with the operations. The upgrade is also being planned to improve fuel consumption and the environmental performance, specifically air pollutant emissions discharged to the atmosphere from the brick kiln. The upgrade will not change any of the key brick manufacturing operations and nor the production rates, which will remain unchanged at 80 million bricks per annum, post upgrade.

With respect to air quality, the proposed upgrade will comprise the following works, which are aimed at lowering / improving the emissions profile:

- *New Kiln*: The two (2) existing kilns for Plant 2 will be replaced by a new kiln, which would improve fuel consumption and the emissions profile.
- *Scrubber to minimise acid gas emissions:* The upgraded Plant 2 kiln would comprise a scrubber to reduce acid gas emissions, mainly Hydrogen fluoride emissions. A fluorine cascade absorber would form a part of the upgraded Plant 2 kiln, which is intended to reduce high fluorine concentrations.
- *Increase in stack height:* The proposed upgrade also includes increasing the stack height of the existing Plant 2 kiln from 16m to 35m. Increasing the stack height would facilitate better dispersion of pollutants and minimise building wake effects that can potentially disrupt / impact the plume dispersion.

Assessment Methodology

To determine potential air quality impacts from the planned upgrades, air dispersion modelling was conducted using the US-EPA non-steady state CALPUFF dispersion model. Meteorological model governing the pollutant dispersion was developed using the combination of TAPM and CALMET models with observations assimilated from the BoM Automatic Weather Station (AWS) at Horsley Park.

The overall air quality impact assessment was conducted in accordance with the Level 2 impact assessment requirements specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) published by the NSW-EPA, January 2017.

Emissions from the Upgraded Plant 2 Operations

Emissions from the upgraded Plant 2 operations have been estimated for the following sources:

- Proposed upgraded Plant 2 kiln exhaust stack; and
- Fugitive dust emissions generated from various operational activities at the upgraded Plant 2 site.

With respect to emissions from the upgraded Plant 2 kiln, pollutant emission rates have been estimated based on the kiln supplier provided design concentrations (i.e. maximum in-stack concentrations expected from the upgraded kiln post commissioning) and the corresponding volumetric flow rates. It is expected that the actual discharge concentrations from the exhaust kiln stack will not exceed the design concentrations at any given time. Furthermore, the design concentrations provided to Airlabs also comply with the relevant emission limits / concentration standards referenced from the POEO Clean Air Regulation. Stack parameters critical to pollutant dispersion, such as exit velocity, discharge temperature, stack dimensions (height and diameter) have been provided to Airlabs.

Fugitive dust emission rates have been quantified through the application of emission factors listed in the Emission Estimation Technique (EET) manuals. Dust control measures currently implemented by the Plant 2 operations have been taken into account for developing the fugitive dust emissions inventory.

Air Quality Goals

Air quality goals / limits to assess potential impacts from the proposal were referenced from the Approved Methods. As there is no considerable change in the brick manufacturing operations, the pollutants identified in the EPL 546 for Plant 2 operations have been considered to be the pollutants of interest.

As per the Approved Methods, modelled maximum cumulative concentrations have been predicted at the nearest sensitive receptor for all of the assessed pollutants (TSP, PM_{10}, $PM_{2.5}$, HF, SO_2, NO_2 and deposited dust levels), with the exception of SO_3, for which the maximum incremental impacts (i.e. Plant 2 only) have been predicted at or beyond the Plant 2 site boundary.

Characterisation of Existing Air Quality

Characterisation of the existing air quality levels / background air quality concentrations is essential in determination of cumulative air pollution concentrations. To characterise the existing air quality levels for the cumulative assessment, reference was drawn to the following sources:

- Ambient air quality levels recorded at the Prospect monitoring station operated and managed by NSW-OEH
- Point and fugitive dust emissions generated from the existing Plant 1 operations, which is adjacent to the Plant 2 site.
- Fugitive dust emissions from the existing Horsley Park Waste Management Facility (WMF).

Stack emissions from the existing Plant 1 operations were obtained from historical stack emission test reports and fugitive dust emissions were estimated using emission factors from EET manuals, an approach similar to estimating fugitive dust emissions from the upgraded Plant 2 operations.

To account for emissions from the Horsley Park WMF, information was obtained from site-specific air quality assessment available on the public domain.

Model Predictions

Modelling shows that all the assessed pollutants comply with the relevant assessment criteria at all the identified sensitive receptors at all times. Furthermore, the incremental contribution of the upgraded Plant 2 operations to the overall cumulative predicted air quality levels is minimal, which is attributed to the improvements proposed by Brickworks.

Greenhouse Gas

Scope 1 and Scope 2 greenhouse gas (GHG) emissions were quantified for fuel (diesel, natural gas) combustion and on-site electricity consumption using emission factors published in the National Greenhouse Account Factors workbook for the 2017-18 period. The Plant 2 facility annual emissions are minimal, where in the contribution to state and national GHG emissions are approximately 0.02% and 0.004% respectively.

Conclusion

Dispersion modelling shows that the impacts from the upgraded Plant 2 operations would comply with the ambient air quality limits. Furthermore, modelling shows that the improvements proposed by

Brickworks ensure contribution from the Plant 2 operations to the overall cumulative air quality will be minimal and not affect sustainability of the local airshed.

1. INTRODUCTION

Airlabs Environmental Pty. Ltd. (Airlabs) was commissioned by Willowtree Planning on behalf of Brickworks Land and Development (Brickworks) to undertake an air quality impact assessment for the proposed upgrade to the existing brickmaking plant (known as Plant 2) located at 780 Wallgrove Road, Horsley Park, NSW.

Plant 2 currently operates as a face brick plant with an annual output of 80 million bricks per annum. The existing brick kiln and associated equipment were commissioned in the late 1960's but are in a good working condition and could operate for over 20 years, as there hasn't been significant changes in the brick manufacturing technology. However, it is understood that the current kiln loses heat and requires large amounts of gas to run and moreover, to further improve the environmental performance with specific regards to air pollutant emissions discharged from the kiln, this upgrade is being planned.

Another key objective of the upgrade is to implement best practices and increase efficiencies associated with the operation. The proposal seeks consent for the upgrade works which will ensure the production of bricks can continue to meet the operational needs of Brickworks.

Proposed upgrade works to the existing Plant 2 facility comprises the following features:

- A new kiln to replace the existing Plant 2 kiln.
- Commissioning of a new scrubber for the Plant 2 kiln to reduce acid gas emissions generated from the brick manufacturing operations.
- Developing a new 3,500 m^2 building for additional kiln car storage (fired product) and relocating the existing de-hacker into this area to create easy access for forklifts.
- A 1,600 m^2 building for consolidated additives area and regularisation of building.
- New footings for relocated clay bins and conveyor system.
- Extending existing clay storage building by 1,000 m^2 for additional undercover stockpile area; and
- New footings for existing scrubber.

The Environmental Planning and Assessment Act 1979 (EP&A Act) stipulates the framework for all developments in NSW. The subject proposal is categorised as a State Significant Development (SSD) pursuant to *Schedule 2 Part 5 of the State Environmental Planning Policy* (State and Regional Development) 2011, as the proposal has a capital investment value of more than $10 million and forms part of the *Western Sydney Parklands*.

As per Section 78A (8A) of the EP&A Act, a development application for a State Significant Development is to be accompanied by an Environmental Impact Statement (EIS).

This air quality impact assessment report forms a part of the EIS, which would be submitted to the NSW Department of Planning and Environment (DOP&E) seeking approval for the proposal.

The air quality assessment has been prepared in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, Environment Protection Authority (EPA), 2016 (hereafter 'the Approved Methods'). As per Section 9 of the Approved Methods, the NSW – Environment Protection Authority (EPA) has listed out minimum requirements regarding information contained within an impact assessment report which are specified below. The relevant sections of this report which address the minimum requirements are mentioned alongside.

- Site plan – Section **1**, Section **2** and Section **3**
- Description of the activities carried out on the site – Section **2** and Section **3**
- Emissions inventory – Section **9**
- Meteorological data – Section **10**

- Background air quality data – Section **8**
- Dispersion modelling – Section **11**, Section **12**
- Bibliography – Section **15**

As the proposal is an SSD, Secretary Environmental Assessment Requirements (SEARs) have been issued by the NSW Department of Planning & Environment (DOP&E) (SSD 9601, 16 November 2018) for the EIS and the air quality and greenhouse gas assessment. The SEARs issued with respect to air quality and greenhouse gas and the sections of this report addressing those relevant SEARs are summarised in **Table 1**.

Table 1: Secretary Environmental Assessment Requirements issued for Air Quality and Greenhouse Gas

SEARs issued for Air Quality and Greenhouse Gas (SSD: 9601)	Sections of the Assessment Report Addressing the Relevant SEARs
Air Quality	
- a comprehensive air quality impact assessment (AQIA) of all potential point source and fugitive air emissions (including odour) and dust impacts from the development, including details of air quality impacts on private properties in accordance with relevant Environment Protection Authority guidelines;	All sections
- details of mitigation, management and monitoring measures for preventing and / or minimising both point and fugitive emissions; and	Section **3**, Section **9**
- an assessment of the effectiveness of the proposed air quality mitigation measures.	Section **12**
Greenhouse Gas	
- a quantitative assessment of the potential Scope 1 and 2 greenhouse gas emissions of the development, and a qualitative assessment of the potential impacts of these emissions on the environment; and	Section **13**
- a detailed description of the measures that would be implemented on site to ensure that the development is energy efficient.	

2. FACILITY OVERVIEW

2.1 Facility Location

The subject site is identified as 780 Wallgrove Road, Horsley Park, NSW (Lot 7 in Deposited Plan 1059698). The entire site is 82 hectares (ha) in area and is considered to be the main brick manufacturing for the Austral Brick Company.

The subject site comprises two significant existing brick manufacturing facilities (Plant 1 and Plant 2), including existing stockpiles of clay used in the brick manufacturing operations. The subject site is largely cleared of vegetation as the land has been historically used for quarrying and brick manufacturing operations.

The Horsley Park Waste Management Facility (the Horsley Park WMF), is located immediately to the south of Plant 1 and to the west of Plant 2. As per information sourced from the public domain, the Horsley Park WMF is licensed to receive up to 430,000 tonnes per annum (tpa) of non-putrescible waste. The facility accepts waste directly from commercial entities and from council customers and comprises a large open area with void space for landfilling and resource recovery. The overall facility covers 43 ha, which includes the weighbridge, a designated area of 2 ha for storage of recovered material such as concrete, soils, timber and steel and land that is still to be excavated to create landfill space.

Adjoining to the west of the Plant 1 site is the M7 Motorway, which links the M2, M4 and M5 motorways. Surrounding development predominantly to the north and north-east of the Plant 2 site comprises industrial facilities used for warehousing and distribution purposes and other extractive industries.

An aerial overview of the subject site showing Plant 2 along with Plant 1 and the Horsley Park WMF are illustrated in **Figure 1**.

2.2 Licensing Details

Existing brick manufacturing operations at Plant 1 and Plant 2 are managed under the Environmental Protection Licence (EPL) No: 546, which also includes Plant 3 operations, located on Old Wallgrove Road, Horsley Park. The three (3) brick manufacturing operations, are collectively referred to as 'Austral Brick, Plants 1, 2 & 3' in the EPL. A spatial overview of Plant 1, 2 and 3 operations is shown in **Figure 2**.

According to EPL No: 546, the licence for Plants 1, 2 & 3 permits for:

- Annual ceramic production of >200,000 tonnes.
- > 5- 100 tonnes of annual volume of waste generated or stored
- Crushing, grinding or separating of >500,000 – 2, 000, 000 tonnes on an annual basis.
- Land-based extractive activity (extract, process or store) >500,000 – 2, 000, 000 tonnes on an annual basis.
- Mining for minerals - >500,000 – 2, 000, 000 tonnes on an annual basis.

The EPL provides information on the monitoring points across Plant 1, 2 and 3 to measure air emissions generated from the brick manufacturing process, including the pollutants that are to be monitored and their monitoring frequencies, details of which are summarised in **Table 2**.

Table 2: Air Monitoring Details – EPL 546 (Plant 1, 2 and 3)

Parameter	Plant 1	Plant 2	Plant 3
Number of monitoring points	1	1	2
EPA identification	4	5	6 (swindle), 7 (ceric)
Pollutants to be monitored	Cadmium, Fluorine, Hydrogen chloride, Hydrogen fluoride, Hydrogen sulfide, Mercury, Nitrogen oxides, Oxygen, Solid particles, Sulfuric acid mist and sulfur trioxide, Sulfur dioxide, Type 1 and 2 substances, Volatile organic compounds	Hydrogen fluoride, Nitrogen oxides, Total solid particulates	Cadmium, Dioxins and furans, Fluorine, Hydrogen chloride, Hydrogen fluoride, Hydrogen sulfide, Mercury, Nitrogen oxides, Oxygen, Sulfuric acid mist and sulfur trioxide, Sulfur dioxide, Total solid particulates, Type 1 and 2 substances, Volatile organic compounds
Monitoring frequency	Quarterly – all pollutants except Hydrogen fluoride,	Yearly	Quarterly – all pollutants except Hydrogen fluoride,

Parameter	Plant 1	Plant 2	Plant 3
	Nitrogen oxides, Total solid particulates which are to be monitored yearly		Nitrogen oxides, Total solid particulates which are to be monitored yearly

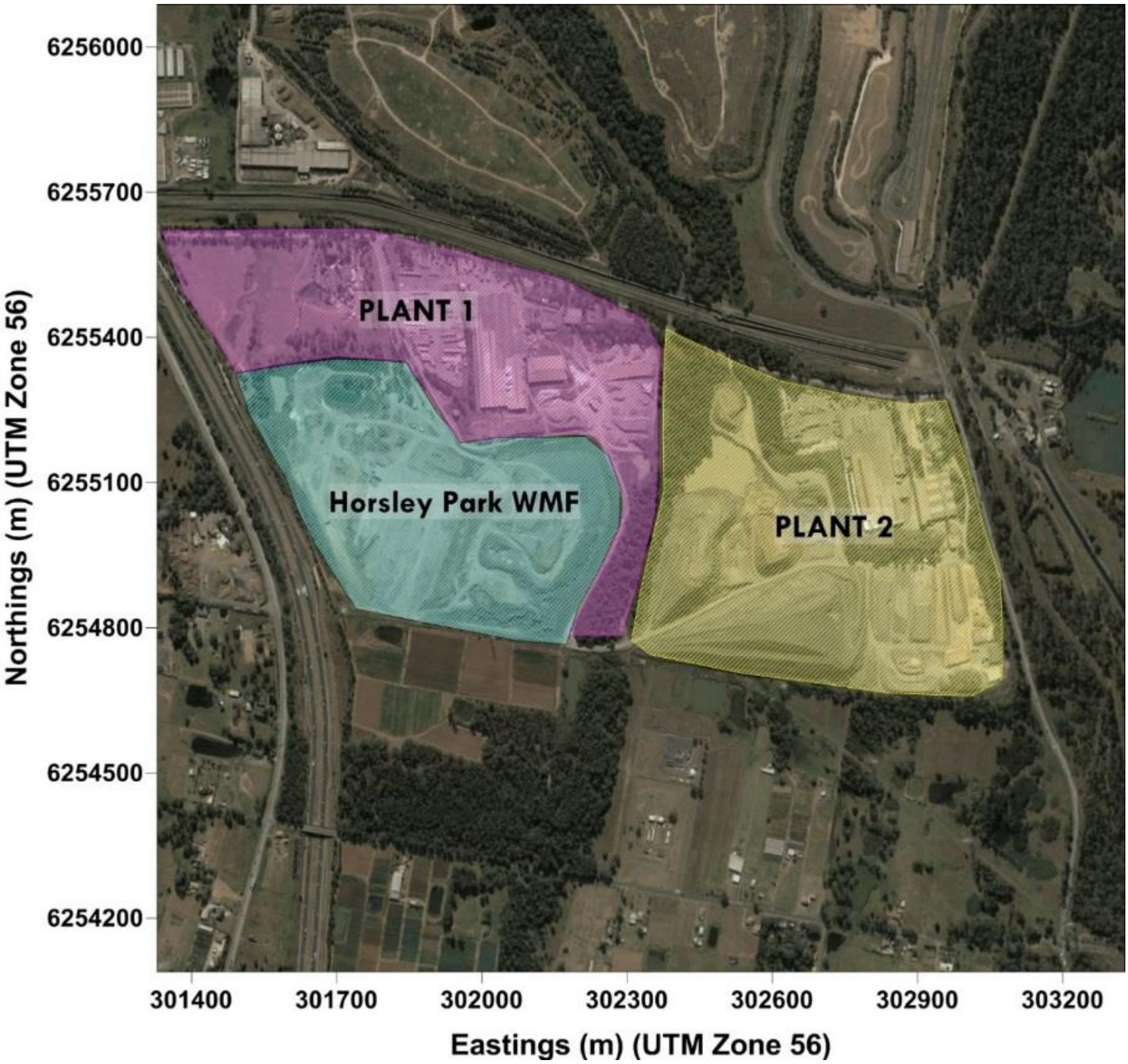
Section L3 of the EPL 546 provides the in-stack concentration limit for pollutants released from the Point 5 Stack for Kiln Number 5 at Plant 2. The concentration limits are specified in **Table 3**.

It is noted that concentration limits have been provided for sulfuric acid mist and sulfur trioxide; and sulfur dioxide, though these pollutants are not required to be monitored as shown in **Table 2**.

Table 3: In-Stack Concentration Limits for Point 5 in EPL 546 (Plant 2)

Pollutant	Units of Measure	100th percentile Concentration Limit	Reference Conditions	Averaging Period
Hydrogen fluoride	mg/m^3	50	Dry, 273 K, 101.3 kPa	1-hour or minimum duration in the test method
Total solid particles	mg/m^3	100	Dry, 273 K, 101.3 kPa	1-hour or minimum duration in the test method
Nitrogen oxides	mg/m^3	2,000	Dry, 273 K, 101.3 kPa	1-hour or minimum duration in the test method
Sulfuric acid mist and sulfur trioxide (as SO_3)	mg/m^3	100	Dry, 273 K, 101.3 kPa	1-hour or minimum duration in the test method
Sulfur dioxide (SO_2)	mg/m^3	400	Dry, 273 K, 101.3 kPa	1-hour or minimum duration in the test method

Figure 1: Aerial Overview of Plant 2 and Surrounds



3. PROPOSAL DETAILS

Brickworks are proposing to carry out upgrade works to the existing brick manufacturing operations at the Plant 2 site to implement best practice measures and to increase efficiencies associated with the operations. The upgrade is also being planned to improve fuel consumption and the environmental performance, specifically air pollutant emissions discharged to the atmosphere from the brick kiln.

The purpose of the upgrade is not to change the operations or the brick production outputs but to address the key issues identified above. As-such, it is noted that post upgrade, the annual output for Plant 2 will remain unchanged at 80 million bricks per annum, and so are the operational hours, with the upgraded kiln operating 24 hours, 365 days of the year.

As per the scoping report prepared by Willowtree Planning (Willowtree Planning, 2018), the following objectives have been identified as forming the basis of the proposed Plant 2 upgrade works:

- Design the site to achieve a viable economic return.
- Ensure minimal environmental and amenity impact.

- Ensure ongoing compliance with all operational legislative requirements.
- Provide for an employment-generating land use; and
- Ensure development is compatible with surrounding development and the local and regional context.

Specific aspects of the upgrade planned for Plant 2 comprise the following:

- A new kiln to replace the existing Plant 2 kiln. Annual output remains unchanged at 80 million bricks per annum.
- Commissioning of a new scrubber for the Plant 2 kiln to reduce acid gas emissions generated from the brick manufacturing operations.
- Developing a new 3,500 m^2 building for additional kiln car storage (fired product) and relocating the existing de-hacker into this area to create easy access for forklifts.
- A 1,600 m^2 building for consolidated additives area and regularisation of building.
- New footings for relocated clay bins and conveyor system.
- Extending existing clay storage building by 1,000 m^2 for additional undercover stockpile area; and
- New footings for existing scrubber

A site plan of the proposed upgrade as provided to Airlabs is shown in **Figure 2**.

3.1 Proposed Improvements Specific to Air Quality

One of the main purposes of upgrading the Plant 2 kiln is to improve the emissions discharged to the atmosphere from the kiln. Airlabs have undertaken air quality assessments and stack emissions monitoring historically for Brickworks and are cognisant of the concerns raised by the EPA regarding emissions generated from the Plant 2 kiln, especially Hydrogen fluoride (HF), which is a key pollutant released from brick manufacturing facilities.

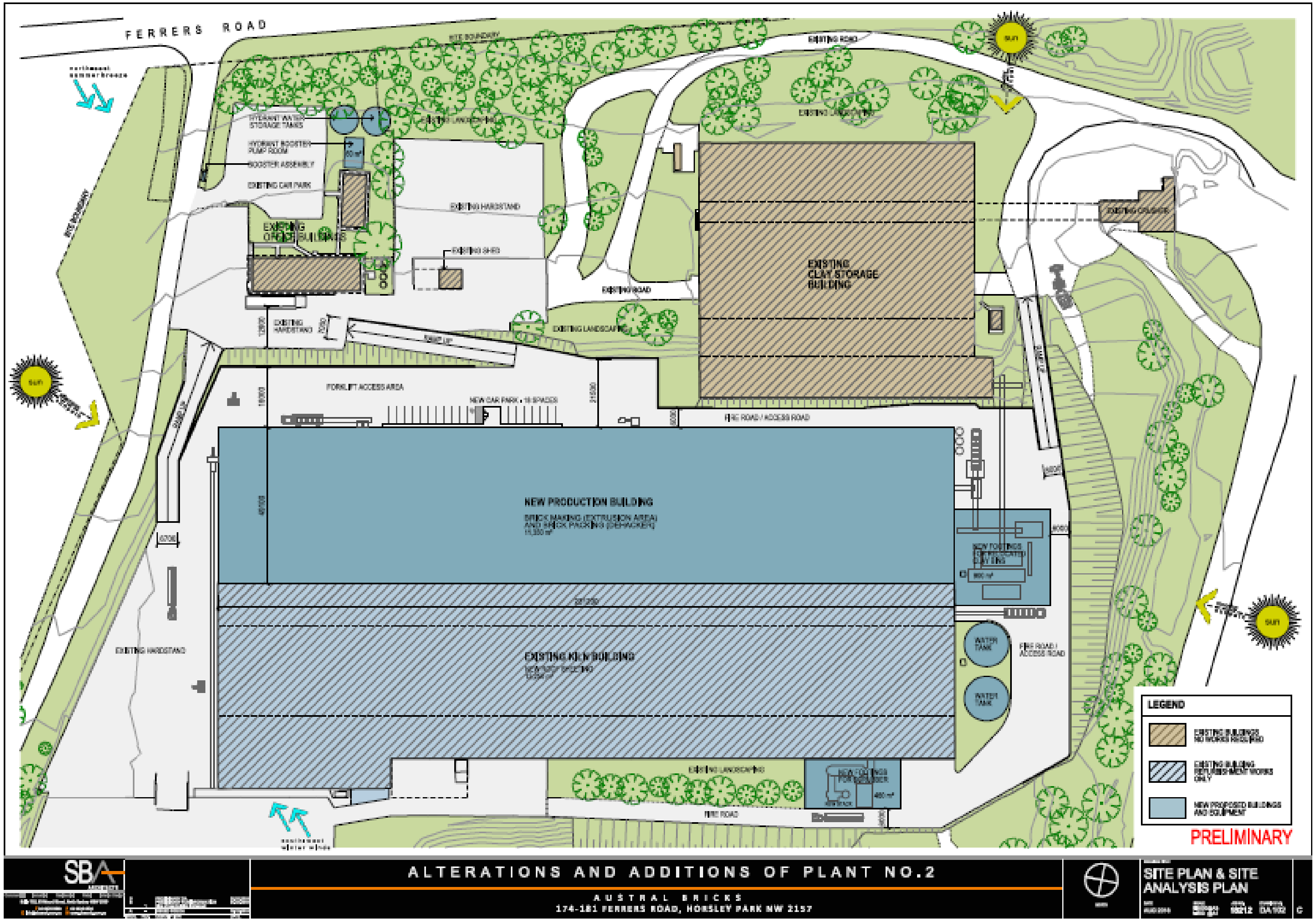
Therefore, this upgrade aims to improve the level of emissions released to the atmosphere, especially Hydrogen fluoride, and in order to achieve this, a range of improvements / mitigation measures have been proposed by Brickworks, which are discussed below:

- *New Kiln*: The two (2) existing kilns for Plant 2 will be replaced by a new kiln, which would improve fuel consumption and the emissions profile.
- *Scrubber to minimise acid gas emissions:* The upgraded Plant 2 kiln would comprise a scrubber to reduce acid gas emissions, mainly HF. A fluorine cascade absorber would form a part of the upgraded Plant 2 kiln, which is intended to reduce high fluorine concentrations. A brief working of the proposed cascade scrubber system is presented below:
    - The sorption material in the cascade scrubber would typically constitute limestone chippings, which would be located in a silo on top of the absorber.
    - The absorption material then trickles vertically out of the storage silo past the horizontally aligned cascades in the reaction chamber.
    - In doing so, the pollutants flow through the absorption materials and react with the limestone chippings. The saturated limestone chippings are collected in the unit hopper and removed continuously or intermittently with a screw conveyor.
    - The reacted surface of the limestone chippings is abraded in the rotating screen drum / peeling drum. The limestone chippings which now can be reused again, are then transported back to the storage silo via a pneumatic transport system.

- Based on the performance specifications provided by the scrubber supplier, it is expected that the proposed cascade scrubber system would offer a 45-65% control efficiency in reducing raw HF emissions released from the kiln.
- A simplified schematic of a typical cascade scrubber is shown in **Figure 3**.

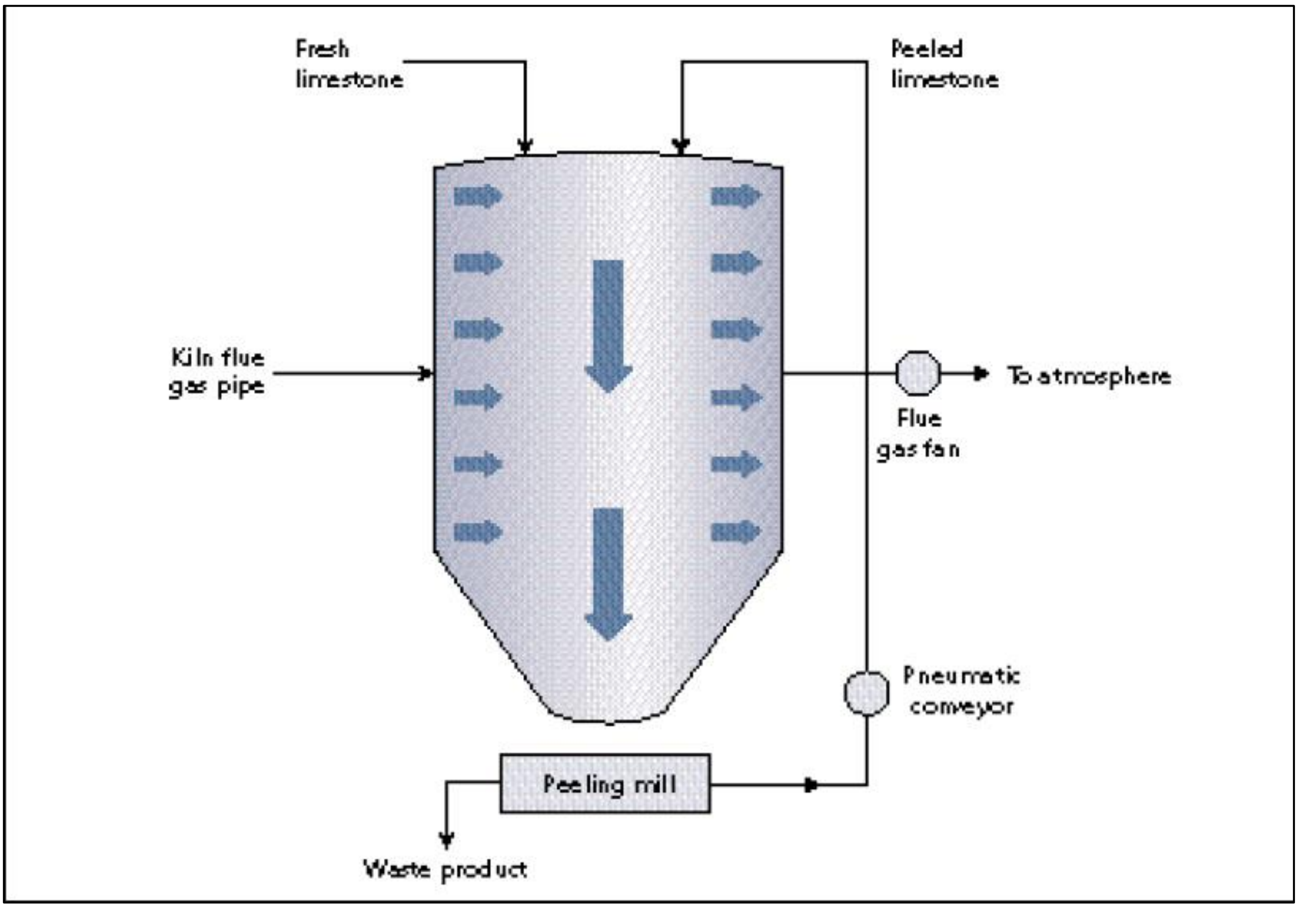
- *Increase in stack height:* In addition to commissioning a cascade scrubber, Brickworks are also proposing to increase the stack height of the existing Plant 2 kiln (i.e. Point No: 5) from 16m to 35m. Increasing the stack height would facilitate better dispersion of pollutants and minimise building wake effects that can potentially disrupt / impact the plume dispersion.

Figure 2: Overall Site Plan of the Proposed Plant 2 Upgrade



Source: Willowtree Planning, March 2019

Figure 3: Typical Schematic of a Fluorine Cascade Scrubber



Source: ETBPP (1999)

4. ASSESSMENT OBJECTIVE

This air quality impact assessment aims to achieve the following objectives:

- Quantifying air quality impacts from the upgraded Plant 2 kiln and associated operations.
- Comprehensively address the SEARs issued for air quality and greenhouse gas.
- Determination of cumulative air quality impacts on the receiving environment (i.e. impacts from the proposed upgrade and impacts from existing sources)

The assessment has been informed by the following regulatory guideline documents:

- Secretary Environmental Assessment Requirements (SEARs) issued by the NSW Department of Planning & Environment (DOP&E) (SEAR No: 9601, issued 16 November 2018)
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Environment Protection Authority, January 2017 (NSW-EPA, 2017) (hereafter 'the Approved Methods)
- Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia' (NSW-OEH, 2011)
- National Greenhouse Accounts Factors – Australian National Greenhouse Accounts – 2018, Department of the Environment and Energy, July 2018

5. ASSESSMENT STRUCTURE

A Level 2 impact assessment has been conducted to quantify operational impacts from the proposed Plant 2 upgrade works. As per the Approved Methods, a Level 2 assessment is a refined dispersion modelling technique using site-specific input data.

For cumulative impact determination, the assessment has also quantified the impacts from the nearby sources – which include the existing Plant 1 operations and the Horsley Park WMF, whose proximity to the Plant 2 can be observed in **Figure 1**.

In addition to the identified existing sources, background air quality concentrations recorded at the nearest / representative ambient air quality monitoring stations have been included in the cumulative impact assessment.

An overview of the air quality assessment undertaken is presented below:

- A detailed review of the planned upgrades for Plant 2 was undertaken through consultation with Brickworks.
- Key pollutants of concern were identified based on the EPL and the planned upgrades.
- Determination of relevant ambient air quality assessment criteria referenced from the Approved Methods for the identified pollutants of concern.
- Development of site-specific meteorology. Meteorological data was prepared in accordance with the Level 2 assessment requirements as outlined in the Approved Methods.
- Characterisation of the geographical setting of the facility and the surrounding land uses and identification of sensitive receptors. Sensitive receptors representative of residential dwellings and non-residential/industrial developments have been identified.
- Estimating pollutant emission rates from the upgraded kiln and associated operations.
- Modelling the estimated pollutant emission rates from the proposal and predicting incremental impacts at the identified sensitive receptors / outside the facility site boundary depending on the requirements prescribed in the Approved Methods.

- To predict cumulative pollutant concentrations where required, the following sources were taken into consideration:
    - Ambient air quality levels recorded at the nearest / representative National Environment Protection (Ambient Air Quality) Measure (Ambient Air Quality NEPM) monitoring station managed by the Office of Environment & Heritage (OEH) air monitoring network.
    - Point source and fugitive dust emissions from the existing Austral Bricks Plant 1 operations.
    - Fugitive dust emissions from the existing Horsley Park WMF.
- Predicted incremental (upgraded Plant 2) and cumulative (sum total of impacts from the Plant 2 upgrade + background levels from OEH monitoring station + impacts from Plant 1 + impacts from Horsley Park WMF) pollutant concentrations were compared against the relevant assessment criteria to determine compliance.
- For estimating cumulative particulate (PM_{10} and $PM_{2.5}$) concentrations, a Level 2 contemporaneous assessment was undertaken in accordance with the Approved Methods. Daily measured background levels recorded at the ambient air quality monitoring station were paired with the corresponding model predicted impacts for the proposal along with impacts predicted from the existing Plant 1 operations and the Horsley Park WMF at each of the identified sensitive receptors.
- Presentation of modelled pollutant concentrations in the form of tables and concentration isopleths.
- Preparation of assessment report.

6. STUDY AREA AND SURROUNDS

6.1 Existing Land Use and Topography

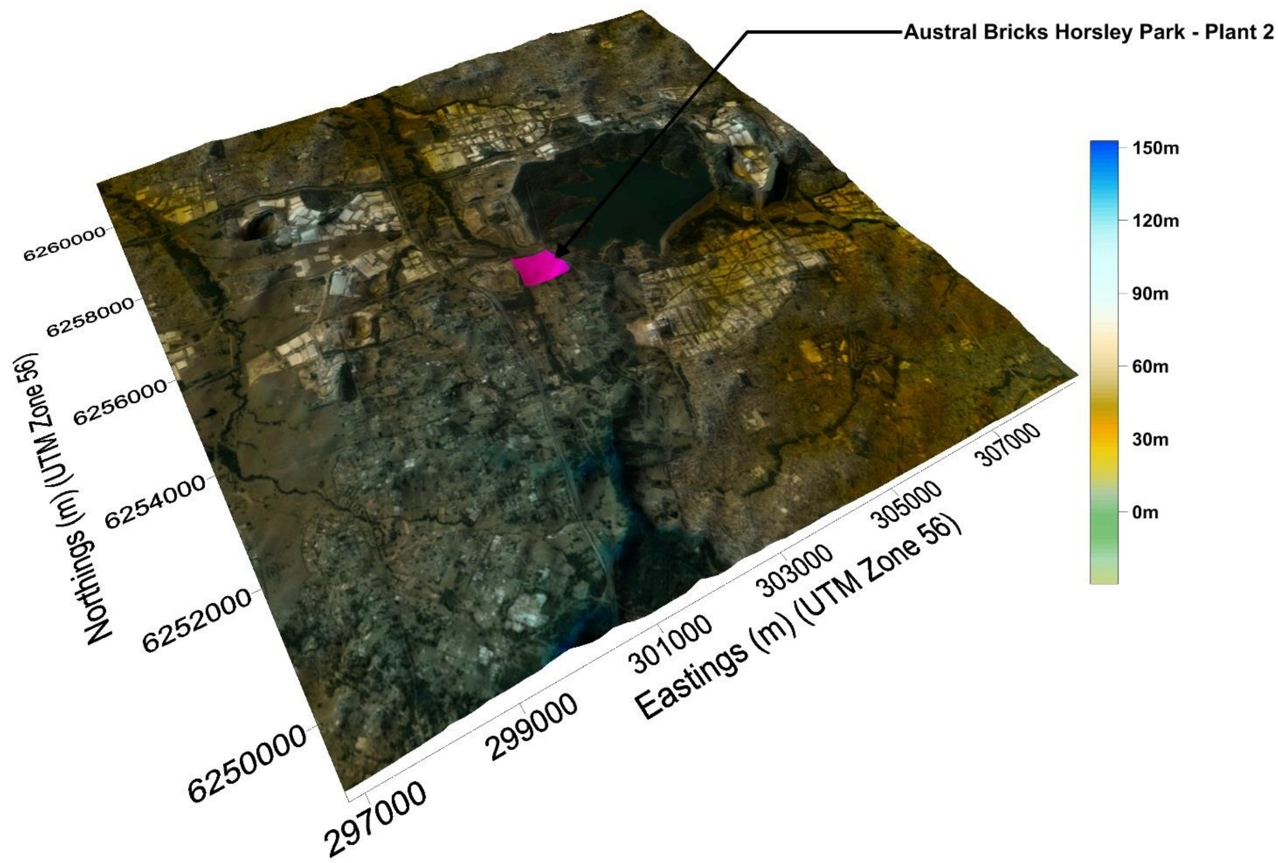
The subject site is located within the Fairfield City Council Local Government Area (LGA) and forms part of the Western Sydney Parklands (WSP), which is a 27km urban park corridor running north from Quakers Hill, south to Leppington accounting for approximately 5,280 hectares of land and as per the WSP *Plan of Management 2030*, the site is clearly delineated as 'Austral Bricks'.

Land-use surrounding the facility is predominantly rural-residential along with grazing / pastoral lands. Existing residential development surrounding the facility is quite spread out and scattered, which is typically indicative of low-medium density rural residential developments.

The Prospect Reservoir and its associated infrastructure is to the immediate east of the facility, whereas the existing Plant 1 operations and the Horsley Park WMF (refer **Figure 1**) are to the immediate west. Plant 3 is to the further east (approximately 2 km) and is separated by the M7 Motorway.

The local topography surrounding the facility is largely undulating with elevations typically ranging from 60m – 90m at the facility and the immediate surrounding areas. Elevations gradually increase towards the south, south-west of the facility, as observed from the 3-dimenstional representation of the topographical features presented over a 12km x 12km domain, as shown in **Figure 4**.

Figure 4: Topographical Features Surrounding the Plant 2 Facility



6.2 Sensitive Receptors

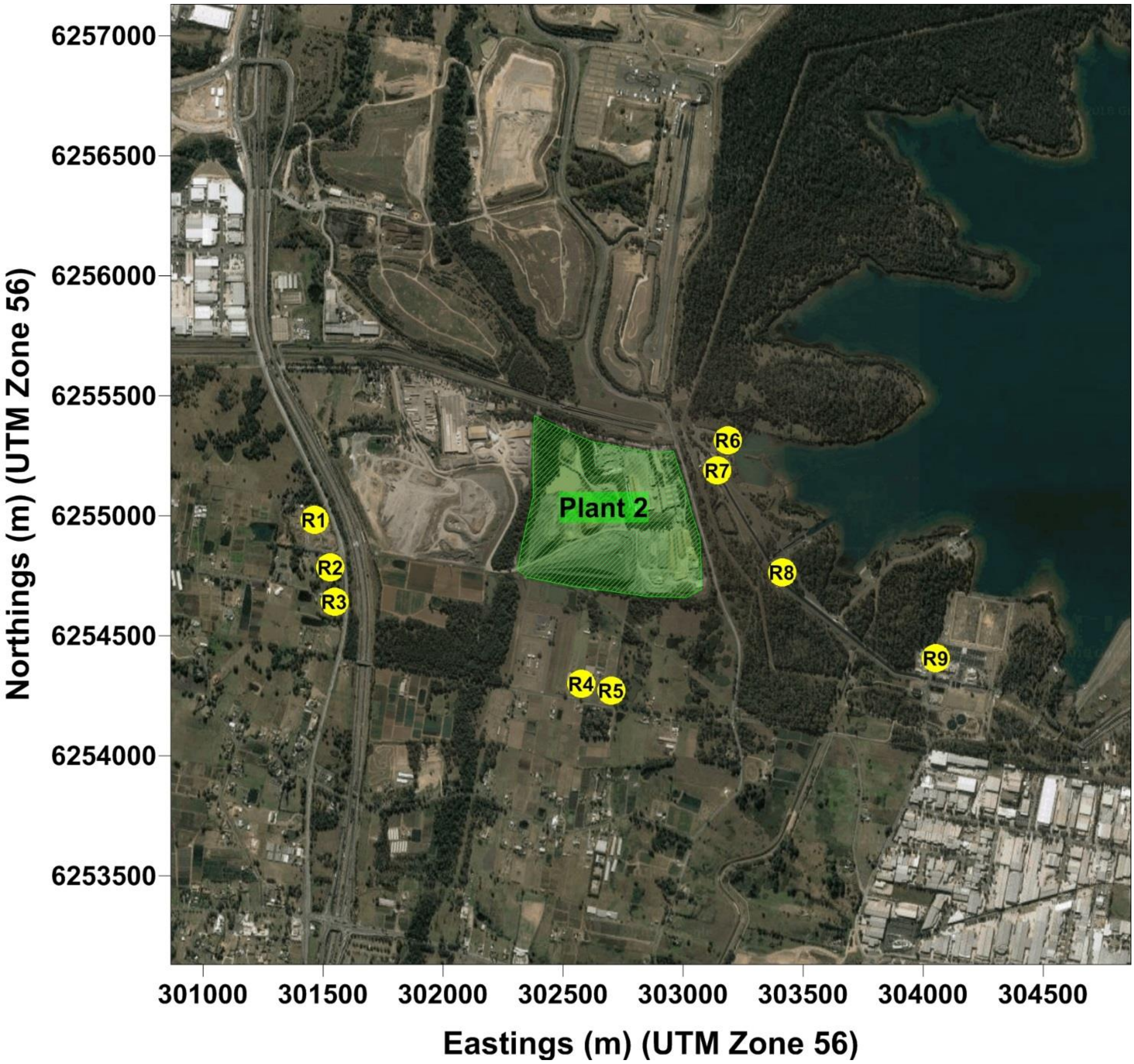
To predict air quality impacts from the upgraded Plant 2 facility, a set of sensitive receptors closest to the facility have been identified. Model predicted incremental (impacts from Plant 2 alone) and cumulative impacts (incremental + background + Plant 1 + Horsley Park WMF) have been determined at each of the identified sensitive receptors and compared against the assessment criteria to assess compliance.

Spatial distribution of the identified sensitive receptors selected for the air quality impact assessment is illustrated in **Figure 5** and details summarised in **Table 4**.

Table 4: Details of Identified Sensitive Receptors

Receptor I.D.	Eastings (m) (UTM Zone 56)	Northings (m) (UTM Zone 56)
R1	301464	6254982
R2	301531	6254784
R3	301547	6254641
R4	302576	6254299
R5	302700	6254271
R6	303187	6255314
R7	303143	6255188
R8	303412	6254764
R9	304053	6254406

Figure 5: Location of the Identified Sensitive Receptors



7. REGULATORY GUIDELINES

7.1 Key Pollutants of Concern

As per EPL No. 546, the stack for the Plant 2 operations is formally identified by EPA Identification No: 5 (Point 5).

According to section *L3 – Concentration Limits* of the EPL, air concentration limits have been issued for Point 5 for the following pollutants:

- Hydrogen fluoride (HF)
- Total solid particles (TSP)
- Nitrogen oxides (NOx)
- Sulfuric acid mist and sulfur trioxide (as SO_3); and
- Sulfur dioxide (SO_2)

The purpose of the upgrade is to improve fuel consumption and the environmental performance; however, the upgrade is not aimed at changing / modifying the operational process nor the production outputs.

As there is no change in the operational parameters of the upgraded Plant 2 kiln, it is reasonable to assume that the aforementioned pollutants listed out in the EPL for the existing Plant 2 operations, would still be considered as the key pollutants of concern.

Therefore, with respect to air quality, the performance of the upgraded Plant 2 kiln would be determined based on assessing the impacts for these identified pollutants.

Based on Airlabs' understanding of the brick manufacturing operations at Plant 2, the main sources that would release the identified pollutants of concern include:

- Exhaust emissions generated from the Plant 2 kiln discharged to the atmosphere through the upgraded Point 5 stack.
- Fugitive dust / particulate matter (PM) emissions generated from various operational activities at Plant 2 including material handling (loading / unloading / conveying) activities, crushing and milling operations, wind erosion of exposed areas and material stockpiles, and wheel generated dust from heavy vehicle haulage on unsealed surfaces with a gravel finish.

Airborne particulate matter typically consists of dust particles of varying size fractions. From a health and nuisance perspective, particles are categorised primarily by size as total suspended particulates (TSP), PM_{10} and $PM_{2.5}$ and deposited dust levels.

Although, TSP is defined as the total mass of all particles suspended in air, an effective upper limit of 30 microns aerodynamic diameter is assigned. Within the TSP matter, lie two sub-categories; particulate matter with an equivalent diameter of 10 microns or less (PM_{10}) and particulate matter with an equivalent diameter of 2.5 microns or less ($PM_{2.5}$)

Dust deposition rate is the mass of particulate matter that collects over an area for a certain time period (usually monthly). Dust deposition is used as a measure of the potential for dust to affect amenity.

For the air quality assessment, impacts from all the particulate size fractions i.e. TSP, PM_{10} and $PM_{2.5}$ along with deposited dust levels have been assessed.

7.2 National Legislation

In June 1998 (revised in 2003), the National Environment Protection Council (NEPC) developed the Ambient Air Quality National Environmental Protection Measure (NEPM) which sets out uniform standards for air quality at the national levels and has included ambient air quality standards for carbon monoxide (CO), nitrogen dioxide (NO_2), photochemical oxidants (as ozone – O_3), sulfur dioxide (SO_2), lead and particulate matter with a nominal aerodynamic diameter of less than or equal to 10 microns (PM_{10}). The NEPM was revised in 2003 to include an advisory reporting goal for particulate matter with a nominal aerodynamic diameter of less than or equal to 2.5 microns ($PM_{2.5}$)

7.3 Legislation in New South Wales

In NSW, air pollution is regulated by *Part 5.4 – Air Pollution* of the Protection of the Environment Operations Act 1997 (POEO 1997). The impact assessment criteria for the identified pollutants of concern, namely HF, NO_X, SO_3, SO_2 and particulates (incl. TSP, PM_{10}, $PM_{2.5}$ and deposited dust) are outlined in the Approved Methods.

The Approved Methods specifies air quality assessment criteria to determine whether emissions from a particular premise will comply with the appropriate environmental outcomes adopted by the EPA.

As per the Approved Methods, cumulative impact of emissions from nearby sources and existing environment need to be considered along with the emissions from the facility in concern for the following pollutants – sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particles (PM_{10}, $PM_{2.5}$), total suspended particulates (TSP), deposited dust, carbon monoxide (CO) and hydrogen fluoride (HF).

As per the cumulative impact assessment guidelines provided in the Approved Methods, point and fugitive source emissions from the upgraded Kiln 2 and non-project related sources (which include background levels referenced from the nearest NEPM monitoring station + impacts from Plant 1 + impacts from Horsley Park WMF) are to be cumulatively assessed to determine compliance. For these pollutants, model predicted cumulative concentrations are to be presented as the 100^{th} percentile value (i.e. maximum) at the nearest sensitive receptor.

The Approved Methods also specifies assessment criteria for metals and individual VOCs which are categorised as individual air toxics. For the principal and individual air toxic pollutants, the model predicted concentrations are to be reported as 99.9^{th} percentile (Level 2 assessment) incremental (i.e. proposed facility only) impacts at or beyond the proposed facility site boundary. The only individual air toxic pollutant included in this assessment, is sulfuric acid, representing sulfuric acid mist and sulfur trioxide (SO_3) emissions.

7.4 Impact Assessment Criteria

The impact assessment criteria referenced from the Approved Methods for the identified pollutants are summarised in **Table 5**.

Table 5: Adopted Air Quality Impact Assessment Criteria for the Identified Pollutants

Pollutant	Assessment Criteria	Averaging Period	Assessment	Reporting Percentiles
TSP	90 µg/m^3	Annual	Cumulative	n.a.
PM_{10}	50 µg/m^3	24-hours	Cumulative	100th percentile
	25 µg/m^3	Annual	Cumulative	n.a.
$PM_{2.5}$	25 µg/m^3	24-hours	Cumulative	100th percentile
	8 µg/m^3	Annual	Cumulative	n.a.
Hydrogen fluoride (HF) (a)	0.5 µg/m^3	90-days	Cumulative	100th percentile
	0.84 µg/m^3	30-days	Cumulative	100th percentile
	1.7 µg/m^3	7-days	Cumulative	100th percentile
	2.9 µg/m^3	24-hours	Cumulative	100th percentile
Sulfur dioxide (SO_2)	712 µg/m^3	10-minutes	Cumulative	100th percentile
	570 µg/m^3	1-hour	Cumulative	100th percentile
	228 µg/m^3	24-hours	Cumulative	100th percentile
	60 µg/m^3	Annual	Cumulative	n.a.
Nitrogen dioxide (NO_2)	246 µg/m^3	1-hour	Cumulative	100th percentile
	62 µg/m^3	Annual	Cumulative	n.a.
Sulfuric acid *(representing sulfuric acid mist and sulfur trioxide emissions)*	18 µg/m^3	1-hour	Incremental	99.9th percentile, at or beyond Plant 2 facility boundary
Deposited dust levels	2 g/m^2/month – maximum increase in deposited dust level	Annual	Incremental	n.a.
	4 g/m^2/month – maximum total deposited dust level	Annual	Cumulative	n.a.

(a) In the Approved Methods, impact assessment criteria for HF is presented for General Land Use – i.e. land which includes all areas other than specialised land uses and Specialised Land Use – i.e. which includes all areas with vegetation sensitive to fluoride, such as grape vines and stone fruits. As per discussions with Brickworks, it is understood that the land-use surrounding the subject site is largely grazing / pastoral land and is not considered sensitive to fluoride impacts and therefore, the general land-use have been used in this assessment.

n.a.: not available

8. EXISTING AIR QUALITY

Characterisation of the existing air quality levels / background air quality concentrations is essential in determination of cumulative air pollution concentrations and subsequently determining compliance with ambient air quality assessment criteria (refer **Table 5**).

8.1 Existing Sources of Air Emissions

The Plant 2 site is located within an 82-ha area at 780 Wallgrove Road, Horsley Park, NSW. This land parcel is also the site for the existing Plant 1 operations along with associated stockpile areas and hardstand areas, as shown in **Figure 1**.

Brick manufacturing operations at Plant 1 are largely similar in nature to the operations at Plant 2, and as observed from the facility licensing details (refer **Table 2**), pollutants released from the Plant 2 kiln stack are also emitted by the existing Plant 1 operations. Therefore, point and fugitive dust emissions from the existing Plant 1 operations have been included for the cumulative impact assessment.

In addition to Plant 1 operations, the Horsley Park WMF, which is a waste management facility is located immediately to the south of Plant 1 and to the west of Plant 2. The waste management facility is licensed to receive up to 430,000 tpa of non-putrescible waste. It is expected that the operations at the WMF would generate particulate matter emissions and therefore have been included in the assessment for the cumulative impact assessment of particulates.

In addition to contributions from the Plant 1 operations and the Horsley Park WMF, ambient air quality levels have also been included in cumulative assessment (referenced from the NEPM monitoring station at Prospect, which is operated and managed by the NSW-OEH).

The following sections provide additional details on the background concentrations recorded at the Prospect monitoring station along with pollutant emission rates and the source parameters estimated from the Plant 1 and Horsley Park WMF operations for the cumulative impact assessment.

8.2 Monitoring Data from the OEH Prospect Station

The Prospect air quality monitoring station (Lat: 33^0 47^1 41^{11} South, Long: 150^0 54^1 45^{11} East) has been operational since February 2007 and measures ambient concentrations of the following pollutants – ozone (O_3), oxides of nitrogen (NO, NO_2 and NOx), sulfur dioxide (SO_2), carbon monoxide (CO), visibility, $PM_{2.5}$, PM_{10} along with providing data on wind speed, direction and sigma-theta and ambient temperature, relative humidity and solar radiation.

The station is approximately 5.3km north-east of the Plant 2 facility on the other side of the Prospect Reservoir. Background concentrations measured in 2017 at the Prospect air quality monitoring station for particulates, NO_2 and SO_2 are discussed below. For contemporaneous assessment it is imperative that the selected year for estimating background concentration matches with the modelled meteorological year. The justification for selecting 2017 as the modelled meteorological year is presented in the meteorological modelling section of this report (refer **Section 10**).

Particulate Concentrations

Daily observations of the particulate concentrations (PM_{10} and $PM_{2.5}$) for the calendar year 2017 have been downloaded from the OEH website and analysed.

Timeseries representation of the daily observed PM_{10} and $PM_{2.5}$ concentrations are presented in **Figure 6** and **Figure 7** respectively. Statistics for the top five (5) days of 24-hour average PM_{10} and $PM_{2.5}$ levels recorded at the Prospect monitoring station are summarised in **Table 6** and **Table 7** respectively.

As observed from **Figure 6** and **Table 6** , the daily varying 24-hour average PM_{10} concentrations recorded during 2017 showed one (1) exceedance of the assessment criteria of 50 $\mu g/m^3$, recorded on 24 September. A further investigation was conducted on the exceedance and as per information presented in the NSW Air Quality Statement for 2017 (*Clearing the Air – NSW Air Quality Statement, 2017*), the exceedance was categorised as "*Exceptional Events*" i.e. those related to bushfires, hazard reduction burns and dust storms. These are not counted towards the NEPM goal of '*no days above the particle standards in a year*' and therefore, this exceedance was excluded from the cumulative assessment.

Annual average PM_{10} concentrations were below the relevant criterion of 25 $\mu g/m^3$ for the reviewed period.

With respect to 24-hour average $PM_{2.5}$ concentrations, as observed from **Figure 7** and **Table 7**, there were three (3) individual exceedances of the assessment criteria of 25 $\mu g/m^3$ recorded in 2017. The exceedances were observed on 14 August, 02 September and 03 September, all of which were attributed to *Exceptional Events* as per the NSW Air Quality Statement for 2017. Consequently, these three (3) exceedances were excluded from the contemporaneous assessment.

For those 24-hour periods where data has been excluded from the PM_{10} and $PM_{2.5}$ time-series, the excluded data has been substituted / replaced with the corresponding 70th percentile value for the 2017 calendar year.

Table 6: Statistics for Top Five (5) Days of Daily Varying 24-Hour PM_{10} Concentrations Recorded at Prospect Monitoring Station in 2017

Date	24-Hour Average PM_{10} Concentration ($\mu g/m^3$), Prospect 2017	Rank	Comments
24/09/2017	61.1	1	Excluded from the contemporaneous assessment, as categorised as *Exceptional event*. Replaced with 70th percentile value for the 24-hour average concentrations measured in 2017 at Prospect.
02/09/2017	40.2	2	Included in contemporaneous assessment.
25/01/2017	38.8	3	Included in contemporaneous assessment
22/12/2017	37.9	4	Included in contemporaneous assessment
12/09/2017	37.6	5	Included in contemporaneous assessment

Table 7: Statistics for Top Five (5) Days of Daily Varying 24-Hour $PM_{2.5}$ Concentrations Recorded at Prospect Monitoring Station in 2017

Date	24-Hour Average $PM_{2.5}$ Concentration ($\mu g/m^3$), Prospect 2017	Rank	Comments
02/09/2017	30.1	1	Excluded from the contemporaneous assessment, as categorised as *Exceptional event*. Replaced with 70th percentile value for the 24-hour average concentrations measured in 2017 at Prospect.
03/09/2017	29.3	2	Excluded from the contemporaneous assessment, as categorised as *Exceptional event*. Replaced with 70th percentile value for the 24-hour average concentrations measured in 2017 at Prospect.
14/08/2017	26.6	3	Excluded from the contemporaneous assessment, as categorised as *Exceptional event*. Replaced with 70th percentile value for the 24-hour average concentrations measured in 2017 at Prospect.
02/07/2017	24.3	4	Included in contemporaneous assessment
12/09/2017	22.5	5	Included in contemporaneous assessment

Figure 6: 24-Hour Average PM10 Concentrations – OEH Monitoring Station at Prospect – 2017

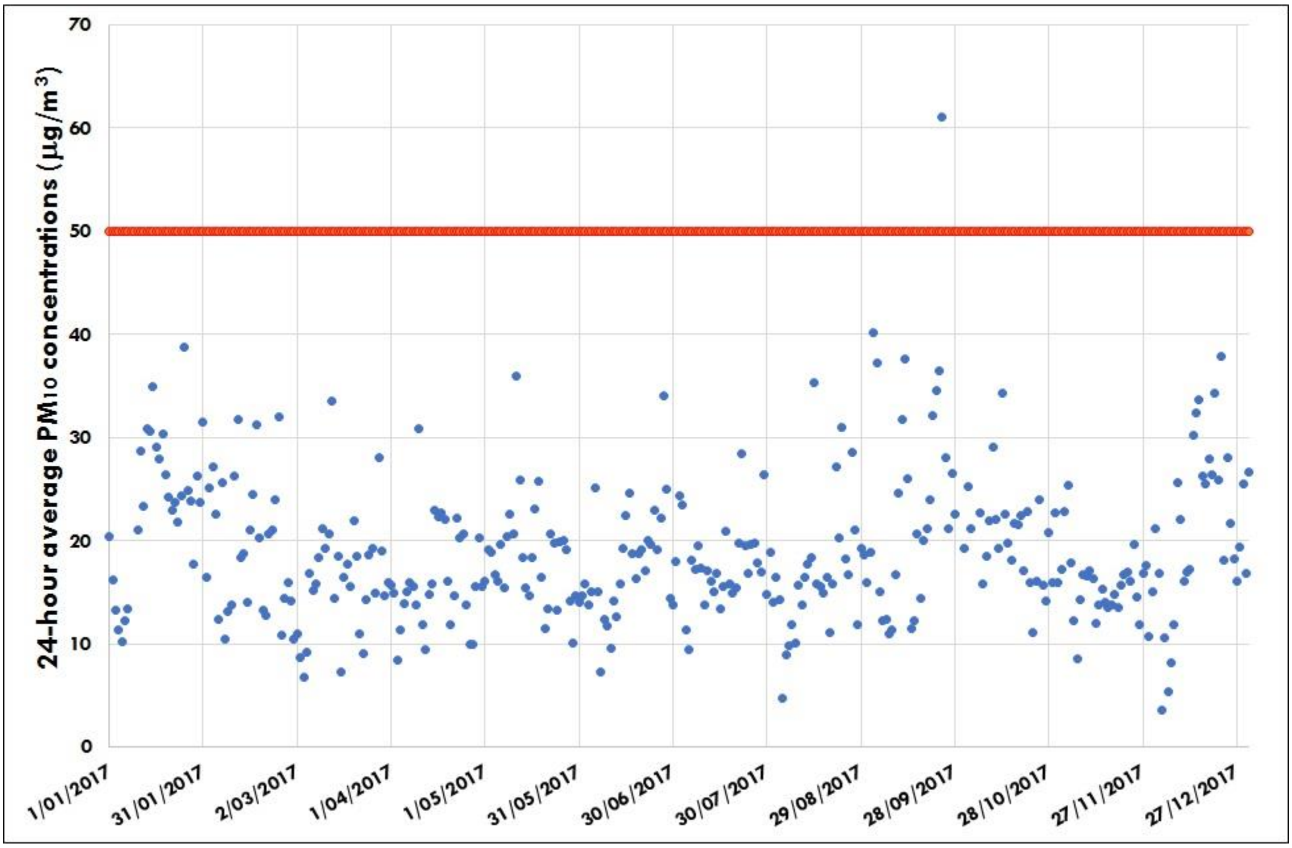
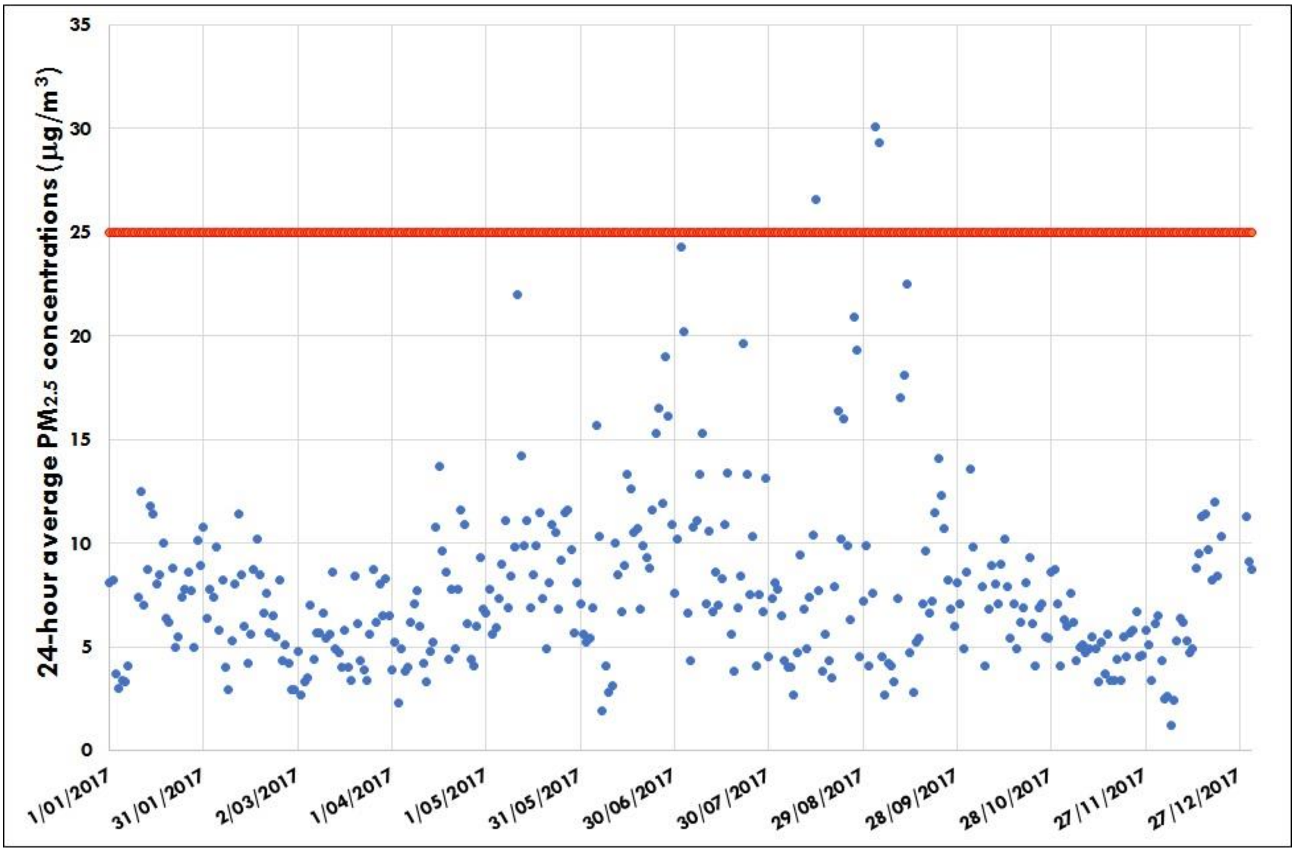


Figure 7: 24-Hour Average PM2.5 Concentrations – OEH Monitoring Station at Prospect – 2017



Nitrogen dioxide (NO_2) and Sulfur dioxide (SO_2) Concentrations

Statistics for the NO_2 and SO_2 ambient concentrations recorded at the Prospect station in 2017 are summarised in **Table 8.**

Measured NO_2 and SO_2 concentrations comply with the relevant assessment criteria (refer **Table 5**) and no exceedances have been reported for the 2017 calendar year.

Table 8: Summary of NO_2 and SO_2 Ambient Concentrations Recorded at Prospect Monitoring Station in 2017

Pollutant	Averaging Period	Measured Concentration at OEH Station - Prospect, 2017	Notes
Nitrogen dioxide (NO_2)	1-hour	123 µg/m³	Maximum 1-hour measured at Prospect – 2017
	24-hour	59.45 µg/m³	Maximum 24-hour measured at Prospect – 2017
	Annual	20.07 µg/m³	Annual average, Prospect – 2017
Sulfur dioxide (SO_2)	1-hour	65.8 µg/m³	Maximum 1-hour measured at Prospect – 2017
	24-hour	11.4 µg/m³	Maximum 24-hour measured at Prospect – 2017
	Annual	2.0 µg/m³	Annual average, Prospect – 2017

8.2.1 Background Concentrations from the Prospect Station Adopted for the Cumulative Assessment

A summary of the background concentrations measured in 2017 at the Prospect station for the cumulative assessment is summarised in **Table 9.**

Table 9: Background Air Quality Concentrations Adopted for the Cumulative Assessment

Pollutant	Averaging Period	Adopted Background Concentration	Description
PM_{10}	24-hours	Daily Varying	Assessed contemporaneously with daily varying PM_{10} background levels measured at the Prospect monitoring station in 2017
	Annual	18.9 µg/m³	Annual average PM_{10} value measured at Prospect monitoring station in 2017
$PM_{2.5}$	24-hours	Daily Varying	Assessed contemporaneously with daily varying $PM_{2.5}$ background levels measured at the Prospect monitoring station in 2017

Pollutant	Averaging Period	Adopted Background Concentration	Description
	Annual	7.6 µg/m^3	Annual average $PM_{2.5}$ value measured at Prospect monitoring station in 2017
TSP	Annual	47.4 µg/m^3	No monitoring data available, therefore TSP background concentration from the below assumption *TSP = Annual average PM_{10} / 0.4* Based on assumption that the PM_{10} particle size mass fraction is typically of the order of 40% of TSP mass.
Deposited Dust	Annual	2 g/m^2/month	Conservative assumption based on similar projects undertaken by Airlabs

8.3 Emissions from the Adjacent Plant 1 Facility

As shown in **Figure 1**, the Austral Bricks Plant 1 facility is located immediately to the west of the Plant 2 site.

At the time of undertaking this assessment, Airlabs were informed that the production capacity at Plant 1 is approximately 62 million bricks per annum.

Brick manufacturing operations at Plant 1 are managed under EPL 546, which also regulates the operations for Plant 2 and Plant 3 facilities. As noted in **Table 2**, Plant 1 has one (1) point source / kiln exhaust stack (Point 4), which emits pollutants into the atmosphere.

Measured pollutant concentrations at the Point 4 monitoring plant along with corresponding volumetric air flow details were analysed over a six (6) month period between December 2017 – June 2018. An average of this dataset (i.e. concentrations and corresponding volumetric flow rates) was used to determine pollutant mass emission rates from Plant 1, to be used in the cumulative assessment.

Pollutant concentrations and volumetric flow rates measured between December 2017 – June 2018 were obtained from the following stack emission test reports.

- *Air Emissions Monitoring of the No.1 Kiln Exhaust Duct (DP 4) at the Austral Bricks Horsley Park Plant 1*, Airlabs Environmental Pty. Ltd., Testing undertaken in December 2017, Report No: DEC17239B.1, issued 16 January 2018
- *Air Emissions Monitoring of the No.1 Kiln Exhaust Duct (DP 4) at the Austral Bricks Horsley Park Plant 1*, Airlabs Environmental Pty. Ltd., Testing undertaken in March 2018, Report No: MAR18038B.1, issued 19 April 2018
- *Air Emissions Monitoring of the No.1 Kiln Exhaust Duct (DP 4) at the Austral Bricks Horsley Park Plant 1*, Airlabs Environmental Pty. Ltd., Testing undertaken in June 2018, Report No: JUN18091B.1, issued 28 August 2018

An average of the pollutant concentrations measured over the six (6) month period along with corresponding volumetric flow details obtained from the aforementioned test reports along with the calculated pollutant mass emission rates used in the cumulative assessment are summarised in **Table 10**. Point 4 source parameters as referenced from the above test reports are presented in **Table 11**.

Table 10: Measured Pollutant Concentrations and Emission Rates – Plant 1

Pollutant	Average Concentration Measured between Dec 2017 – June 2018	Units	Average Volumetric Flow (Nm^3/sec) Measured between Dec 2017 – June 2018 expressed at Reference Conditions	Calculated Pollutant Mass Emission Rate (g/sec) for Cumulative Assessment
TSP	17	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	0.25
PM_{10}	14	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	0.21
$PM_{2.5}$ (a)	8.5	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	0.13
HF	45	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	0.66
SO_2	233.3	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	3.44
NOx as NO_2	76.0	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	1.12
Sulfuric acid mist	24	mg/Nm^3, corrected to 273K, dry and 101.325 kPa	14.7	0.35

(a) $PM_{2.5}$ concentrations are not measured in the monitoring program. As-such, $PM_{2.5}$ concentrations have been estimated assuming that they are approximately 50% of the measured TSP concentrations.

Table 11: Plant 1 Stack (Point 4) Parameters

Parameter	Value
Stack I.D.	Point 4
Type of release	Point Source
Location – Easting (m)	302023
Location – Northing (m)	6255241

Parameter	Value
Stack height (m) from ground level	30
Stack diameter (m)	1.6
Stack exit temperature (K)	458 (average of measured exit temperature between Dec 17 – Jun 18)
Stack exit velocity (m/sec)	13.5 (average of measured exit temperature between Dec 17 – Jun 18)

In addition to emissions released from the Plant 1 kiln stack, fugitive particulate emissions were also quantified for the existing brick manufacturing associated operations at the Plant 1 site. Fugitive particulate emissions were quantified for the following activities:

- Material handling (incl. loading / unloading and conveying)
- Crushing, milling and grinding operations
- Wind erosion – exposed areas and material stockpiles
- Heavy vehicle haulage on gravel surfaces.

Particulate emission rates for TSP, PM_{10} and $PM_{2.5}$ size fractions for the overmentioned activities were quantified based on production rates / throughputs provided to Airlabs and with the aid of Emissions Estimation Technique (EET) manuals. Details of the EET manuals used in estimating dust emissions are provided in **Section 9.2**.

Inventory of the estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions rates from the existing Plant 1 operations are summarised in **Table 12**.

Table 12: Estimated Annual Fugitive Particulate Matter Emission Rates – Plant 1

Activity	Quantity	Units	Modelled Annual Emission Rates (kg/year)		
			TSP	PM_{10}	$PM_{2.5}$
Front end loader on raw material stockpiles	215,000 [(a)]	tpa	811	384	58
Haul truck unloading raw materials	215,000 [(a)]	km	13,435	3,649	365
Crushing operations	215,000 [(a)]	tpa	626	296	45
Conveying to mill building	215,000 [(a)]	tpa	28	9	3
Milling operations	215,000 [(a)]	tpa	446	150	10
Conveying to brick kiln	215,000 [(a)]	tpa	243	109	20
Wind erosion – exposed areas and stockpiles	2.8	ha	608	243	14
Heavy vehicle haulage on gravel finish surface	215,000 [(a)]	tpa	28	9	3
Total			**3,649**	**1,016**	**151**

(a) Production capacity at the existing Plant 1 site is 62 million standard brick equivalents (SBE) per annum. As per information provided to Airlabs, 115 million SBE roughly translates to 400,000 tpa. Based on this information, the Plant 1 material quantities were calculated.

8.4 Emissions from the Adjacent Horsley Park WMF Facility

In addition to accounting emissions from the existing Plant 1 facility, the operations at the nearby Horsley Park Waste Management Facility have also been taken into account for the cumulative impact assessment. As shown in **Figure 1**, the Horsley Park WMF facility is located to the south of Plant 1 and to the west of the Plant 2 site.

Based on information provided on the public domain, the Horsley Park WMF is a licensed waste management facility which receives up to 430,000 tpa of non-putrescible waste and comprises a large open area with void space for landfilling and resource recovery.

Operations at the Horsley Park WMF have the potential to generate particulate matter / dust emissions from various operations such as stockpiling and handling of waste and wind erosion of exposed areas and stockpiles, and therefore, this facility has been considered for the cumulative impact assessment.

To estimate emissions from the Horsley Park WMF, Airlabs undertook a search on the public domain and identified a Statement of Environmental Effects undertaken in 2015 for the Horsley Park Waste Management Facility (AECOM (a), 2015). The SEE was a part of a proposal to immobilise contaminated soil. The SEE comprises assessment of air quality impacts from the proposal and this information was used to inform fugitive dust emissions. It is noted that no other documentation pertaining to air quality / dust emissions from the Horsley Park WMF were available to Airlabs at the time of preparing this assessment.

Potential sources of dust emissions from the Horsley Park WMF and their corresponding emission rates were referenced from the following publicly available assessment report:

- *Air Quality Impact Assessment for the Horsley Park Waste Management Facility Contaminated Soil Stabilisation*, AECOM Australia, June 2015 (AECOM (b), 2015) (hereafter 'the AECOM 2015 air quality assessment')

According to the AECOM 2015 air quality assessment, the main sources of particulate / dust emissions included:

- Environmental enclosure stack
- External material handling and stockpiles.

The assessment mentions that the particulate emissions from the enclosure stack would be reduced by 98% through the use of HEPA filters. As the HEPA filters offer considerable reduction in particulate emissions, this source has been excluded from the cumulative assessment and the sources considered include – external material handling and stockpiles.

Particulate emission rates expressed in g/sec, as referenced from the AECOM 2015 air quality assessment, are summarised in **Table 13**. Location of the below sources were referenced from the AECOM 2015 air quality assessment.

Table 13: Estimated Fugitive Particulate Matter Emission Rates – Horsley Park WMF (AECOM, 2015)

Activity	Modelled Emission Rates (g/sec) – AECOM 2015		
	TSP	PM_{10}	$PM_{2.5}$
Material handling [a]	0.19	0.15	0.01
Stockpile wind erosion [b]	0.07	0.04	0.005

(a) Material handling emissions based on unmitigated and mitigated emission rate expressed per stockpile (g/sec /stockpile) in the AECOM 2015 air quality assessment, and the number of unmitigated and mitigated hours and the total number of external stockpiles.

(b) Stockpile wind erosion emission rates determined based on unmitigated and mitigated emission rate expressed per stockpile (g/m²/sec), the number of unmitigated and mitigated hours and the total number of external stockpiles.

9. UPGRADED PLANT 2 SITE EMISSIONS

This section quantifies the emissions generated from the upgraded Plant 2 operations. Emissions have been estimated for the following sources:

- Proposed upgraded Plant 2 kiln exhaust stack; and
- Fugitive particulate emissions generated from various operational activities at the upgraded Plant 2 site.

9.1 Emissions from the Upgraded Plant 2 Kiln

As mentioned in the *Proposal Details* section (**Section 3**), one of the main objectives of this upgrade is to improve the environmental performance – specifically the air pollutant emissions discharged to the atmosphere from the brick kiln. To achieve this, Brickworks have proposed to implement mitigation measures which include a fluorine cascade scrubber for reducing HF concentrations and to increase the stack height from the existing 16m to 35m to facilitate better dispersion. These measures are in addition to commissioning of a new kiln for Plant 2.

In order to reflect the improvements in the modelled emissions from the Plant 2 kiln, Airlabs through Brickworks have requested the kiln manufacturer / supplier to provide expected discharge concentrations and corresponding volumetric flow details to estimate the pollutant mass emission rate.

Expected pollutant discharge concentrations (hereafter 'design concentrations') from the upgraded Plant 2 kiln stack as provided to Airlabs are summarised in **Table 14**.

Airlabs have been advised by Brickworks that once the upgraded Plant 2 kiln is operational, actual discharge concentrations from the exhaust kiln stack are not expected to exceed the design concentrations presented in **Table 14**.

The design concentrations have also been compared against the concentration standards specified in the NSW-EPA Protection of the Environment Operations (POEO) Clean Air Regulation 2010 (the Clean Air Regulation). Reference has been made to *Group 6* standards as these standards are applicable for those facilities whose operations and the corresponding licence conditions have been issued after 01 September 2005. As there are no concentration standards specific to brick manufacturing activities, Group 6 concentration limits for the assessed pollutants have been referenced from *Schedule 4 – Standards of concentration for scheduled premises: general activities and plant*. The concentration standards referenced from the Clean Air Regulation align with the limits specified in EPL 546 for the existing Plant 2 operations.

The upgraded Plant 2 kiln stack parameters critical to pollutant dispersion have been provided to Airlabs and are summarised in **Table 15**.

Pollutant emission rates determined from the design concentrations summarised in **Table 14** along with the stack parameters presented in **Table 15** have been used to determine the potential air quality impacts from the upgraded Plant 2 kiln.

Table 14: Pollutant Discharge Concentrations and corresponding Stack Emissions from the Upgraded Plant 2 Kiln

Pollutant	Design Concentration (as provided to Airlabs)	Units	Corresponding Group 6 Standard of Concentration – POEO Clean Air Regulation 2010, Schedule 4	Compliance with Clean Air Regulation Standard of Concentration	Estimated Mass Emission Rate (g/sec) [(b)]
TSP	34	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	50 mg/m^3	Yes	0.86
PM_{10}	28	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	n.d.	n.d.	0.71
$PM_{2.5}$	17 [(a)]	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	n.d.	n.d.	0.43
HF	45	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	50 mg/m^3	Yes	1.14
SO_2	150	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	1,000 mg/m^3	Yes	3.82
NOx as NO_2	100	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	350 mg/m^3	Yes	2.54
Sulfuric acid mist	50	mg/Nm^3 corrected to 273K, dry and 101.325 kPa	100 mg/m^3	Yes	1.27

(a) Design concentrations for $PM_{2.5}$ were not provided. As-such, $PM_{2.5}$ concentrations have been estimated assuming that they are approximately 50% of the design TSP concentrations.

(b) Mass emission rate calculated based on provided design concentration and corresponding volumetric flow rate of 25.4 Nm^3/sec

n.d. – no data

Table 15: Upgraded Plant 2 Kiln Stack Parameters

Parameter	Value	Units
Location – Easting (X)	302801	m
Location – Northing (Y)	6255028	m
Height above ground level	35	m
Stack diameter at exit	2.0	m
Design exit velocity (a)	15	m/sec
Stack temperature at exit (a)	130	degree C
	403	degree K
Operational hours	Continuous (24 hours, 365 days)	

(a) It is noted that the upgraded Plant 2 kiln stack would achieve a minimum exit velocity of 15m/sec and exit temperature of 130 °C at all times

9.2 Fugitive Dust Emissions from the Operational Activities at the Upgraded Plant 2 Site

Sources associated with the brick manufacturing operations at the upgraded Plant 2 site that have the potential to generate fugitive dust emissions have been quantified through the application of emission factors listed in Emission Estimation Technique (EET) manuals. Fugitive dust emissions have been quantified for the following sources:

- Loader activities on raw materials stockpile
- Truck unloading raw materials
- Loading raw material to the crusher unit
- Crushing operations
- Transfer / conveying crushed materials to the mill building
- Milling operations (incl. grinding)
- Material transfer / conveying to the new brick kiln
- Wind erosion emissions from the stockpiles on-site
- Heavy vehicle haulage on gravel surfaces

Fugitive particulate matter emissions for the various size fractions – TSP, PM_{10} and $PM_{2.5}$ for each of the aforementioned sources were quantified by drawing reference to the following EET manuals:

- National Pollutant Inventory (NPI), *Emission Estimation Technique Manual for Mining*, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012 (NPI, 2012).
- AP-42 Emission Factors, *Chapter 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing*, United States Environmental Protection Agency (US-EPA 2004).
- AP-42 Emission Factors, *Chapter 13.2.4 Aggregate Handling and Storage Piles*, United States Environmental Protection Agency (US-EPA 2006); and
- AP-42 Emission Factors, *Chapter 13.2.1 Paved Roads*, United States Environmental Protection Agency (US-EPA 2011).

Particulate matter (TSP, PM_{10} and $PM_{2.5}$) emission rates presented in **Table 16** have been quantified based on the emission factors corresponding to specific operational activities referenced from the above EET manuals, the current brick annual production rate of 80 million bricks per annum (it is noted that the production capacity would remain unchanged post upgrade works) and estimation of vehicle kilometres travelled.

Dust control measures specific to Plant 2 operations have been accounted for while developing the emissions inventory. Additional information on the quantifiable emission reduction factors applied in estimating the fugitive particulate emission rates are summarised in **Appendix A**.

Table 16: Estimated Annual Fugitive Particulate Matter Emission Rates from the Upgraded Plant 2 Site

Activity	Quantity	Units	Modelled Annual Emission Rates (kg/year)		
			TSP	PM_{10}	$PM_{2.5}$
Front end loader on raw material stockpiles	280,000 (a)	tpa	29.8	14.1	2.1
Haul truck unloading raw materials	280,000 (a)	km	29.8	14.1	2.1
Loading raw materials into the crusher unit	280,000 (a)	tpa	29.8	14.1	2.1
Crushing operations	280,000 (a)	tpa	25.2	11.3	2.1
Conveying to the mill building	280,000 (a)	tpa	8.9	4.2	0.6
Milling operations (incl. grinding)	280,000 (a)	tpa	308	103.6	51.8
Conveying to the new brick kiln	2.8	ha	8.9	4.2	0.6
Wind erosion – stockpiles	280,000 (a)	tpa	5,280.7	2,640.3	396.0
Heavy vehicle haulage on gravel surfaces			2,161.5	462.4	46.2
Total			**7,882.7**	**3,268.5**	**486.1**

(a) Production capacity for the upgraded Plant 2 would remain unchanged at 80 million standard brick equivalents (SBE) per annum. As per information provided to Airlabs, 115 million SBE roughly translates to 400,000 tpa. Based on this information, the material quantities forth upgraded Plant 2 site were calculated.

9.3 Fugitive Dust Emissions – Construction Phase

It is expected that there would be dust emissions generated during the construction phase of the upgrade works to the Plant 2 site. However, it is expected that these activities would occur only for a limited period of time, as opposed to operational activities.

As dust emissions generated during construction phase would be temporary and short-term in nature, a quantitative assessment has not been undertaken. However, a brief qualitative description of construction related dust generating sources is presented below.

Construction based activities, which have a potential to generate dust emissions include:

- Earthwork operations such as excavation and topsoil stripping.
- Handling of spoil and structural fill material.
- Wind erosion from temporary exposed areas and stockpiles.
- Wheel generated dust from haulage on work areas.

Given that construction activities are progressive and transient in nature, the potential for the aforementioned activities to adversely impact the local air quality is low. Moreover, construction activities would take place sporadically over a large area which would significantly limit the potential for any adverse off-site impacts. Nonetheless, the following mitigation measures have been recommended by Airlabs to minimise dust emissions during construction activities.

Table 17: Construction Dust Mitigation Measures

Source of Dust	Mitigation Measure	Timing
General	Identify dust-generating activities and inform site personnel about location	Throughout construction
	Identify adverse weather conditions (dry and high wind blowing from dust source to sensitive receptors) and halt dust emitting activities if visible dust impacts are identified at sensitive receptors.	Throughout construction
Handling of spoil and structural fill material	Minimise drop height for material handling equipment.	Throughout construction
Wind generated dust from temporary stockpiles and exposed areas	Apply watering through water trucks or sprinklers.	As required
	Progressive staging of dust generating activities throughout the day to avoid concurrent dust emissions.	Throughout construction
	Minimise exposed area if possible.	Throughout construction
	Minimise amount of temporary material stockpiled if possible.	Throughout construction
Wheel generated dust during hauling	Restrict vehicle movement to haul routes that are watered regularly.	Throughout construction
	Cleaning of haul roads.	As required
	Speed restrictions	Throughout construction

Combustion of diesel or petrol fuels (from vehicle movements and mobile machinery) could generate emissions of particulate matter, CO, SO_2, NO_X and VOCs. Based on the relatively small amount of fuel burning during the construction phase, emissions from vehicle exhaust and mobile machinery are not likely to cause adverse impacts on surrounding sensitive receptors and therefore have been excluded from the assessment.

9.4 Odour Emissions

As per the SEARs issued (SSD 9601) (refer **Table 1**), any potential odour emissions generated from the proposal need to be assessed.

However, upon reviewing the proposed upgrades and improvements for the Plant 2 facility, no significant odour generating sources have been identified and therefore odour emissions have not been quantified as a part of this assessment.

10. METEOROLOGICAL MODELLING

10.1 Assessment Methodology

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. The local meteorology at the site plays a significant role in understanding the pollutant transport and dispersion mechanisms, and in order to adequately characterise the local meteorological conditions, information is needed on key parameters such as prevailing wind regime, mixing depth, atmospheric stability, ambient temperatures, rainfall and relative humidity. The following sections outline the methodology for characterising the meteorological conditions at the proposed facility.

Meteorological modelling was conducted using a combination of 'The Air Pollution Model (TAPM) (Version 4) and CALMET meteorological models.

10.2 TAPM

For this modelling assessment, the meteorological model 'The Air Pollution Model (TAPM) (Version 4.0.5)' was used to generate the prognostic output. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which is used to predict three-dimensional meteorological data and air pollution concentrations. TAPM allows users to generate synthetic observations by referencing in-built databases (e.g. terrain information, synoptic scale meteorological observations, vegetation and soil type etc.) which are subsequently used in generating site-specific hourly meteorological data (Hurley P.J., 2008).

Hourly meteorological observations from the nearby Bureau of Meteorology (BoM) Horsley Park Automatic Weather Station (AWS No: 067119) were assimilated into TAPM. The Horsley Park AWS is approximately 2.4km from the southern boundary of the Plant 2 site.

Technical details of the model equations, parameterisations, numerical methods and assimilation of observations are described in Hurley (2008).

Details of the TAPM model configuration are outlined in **Table 18**.

Table 18: TAPM Model Configuration

Parameter	Value
Year of Analysis	2013 to 2017 (01/01/2013 to 31/12/2017)
Grid Centre Coordinates (latitude, Longitude) (degree)	-33 deg -49.500 min, 150 deg 52.002 min
Number of grids (spacing)	4 (30km, 10km, 3km, 1km)
Grid dimensions (nx, ny, nz)	25, 25, 25
Data Assimilation	Yes – BoM AWS at Horsley Park (AWS: 067119) recorded from 2013 to 2017

10.3 CALMET

CALMET (version 6.4.0) was used to derive meteorological fields at 250m resolution over a 12km x 12km modelling domain centred over the Plant 2 site. CALMET was run in no-observations (NOOBS = 2) mode with prognostic output from TAPM used as an input to the CALMET model.

The CALMET model settings were in general accordance with the NSW - Environment Protection Agency (NSW-EPA) (formerly Office of Environment and Heritage – OEH) '*Generic Guidance and Optimum*

Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia' (OEH, 2011).

Details of the CALMET model configuration are outlined in **Table 19**.

Table 19: CALMET Model Configuration

Parameter	Value
Year of Analysis	2013 to 2017
No. X Grid Cells (NX), No. Y Grid Cells (NY)	49,49
Grid spacing (DGRIDKM) (km)	0.25
XORIG (km), YORIG (km)	296.700, 6249.000
No. of Vertical Levels (NZ)	10
Meteorological Data Option	NOOBS=2
Upper Air and Surface Data	TAPM generated MM4/MM5/3D
Geophysical Datasets	USGS (Land-Use) & SRTM1 (Terrain)

The geophysical dataset for CALMET contains terrain and land use information for the modelling domain. For this assessment, terrain data for the CALMET grid was extracted from 1- arc second (30m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000 (downloaded from USGS website). The land use or land cover data for the 12km x 12km modelling domain was derived from the USGS land global land cover dataset. The geotechnical parameters for the land use classification were adopted from the default CALMET corresponding land use categories.

A 3-dimensional representation of the topographical features surrounding the proposed facility has been presented in **Figure 4**.

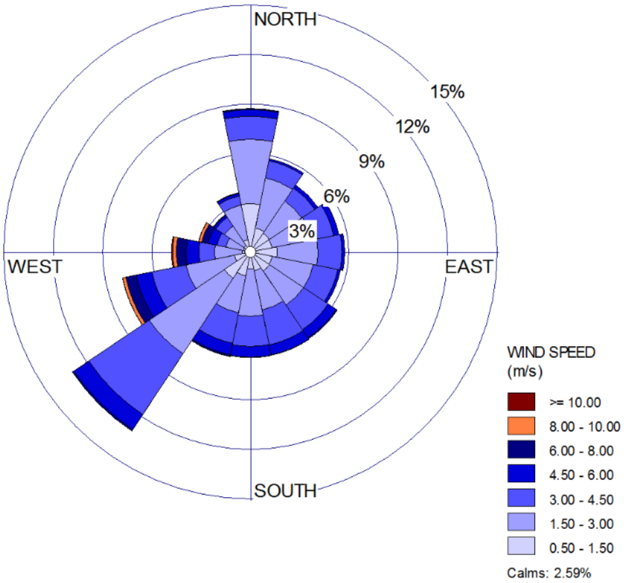
10.4 Modelled Meteorology and Inter Annual Comparison

Hourly wind speeds and direction for calendar year 2013 to 2017 were extracted from the CALMET output at the centre of the Plant 2 site and are visually presented in the form of wind roses in **Figure 8**.

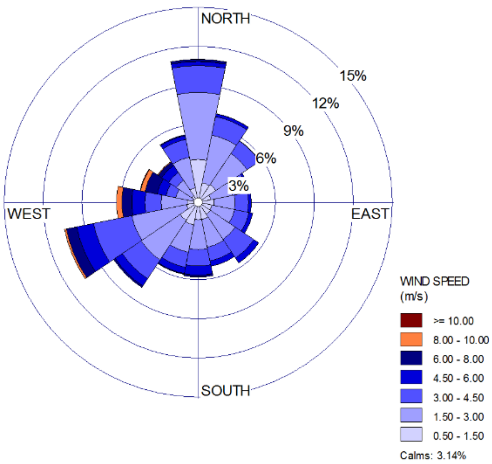
Annual wind roses for each of the modelled five years (2013 to 2017) show winds predominantly from the south-west, west-south west and the northern vectors. Inter-annual wind roses (2013-17) presented in **Figure 8** show good agreeability over the modelled five (5) years.

Calm wind conditions (wind speeds less than 0.5 m/sec) did not vary considerably over the modelled 5 years, with occurrence of calm conditions ranging from 2.6% to 3.7%, which further corroborates the similarity between the modelled years.

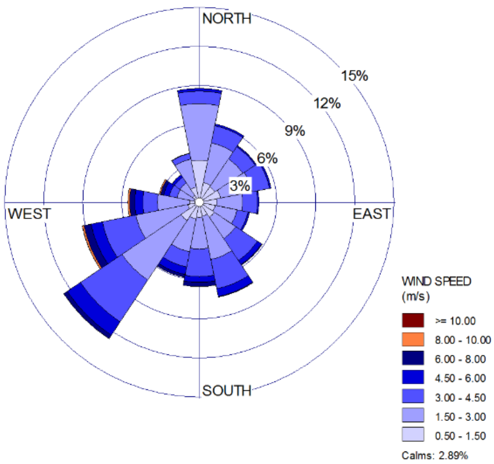
Figure 8: CALMET Predicted Wind Rose – Five Years (2013 to 2017)



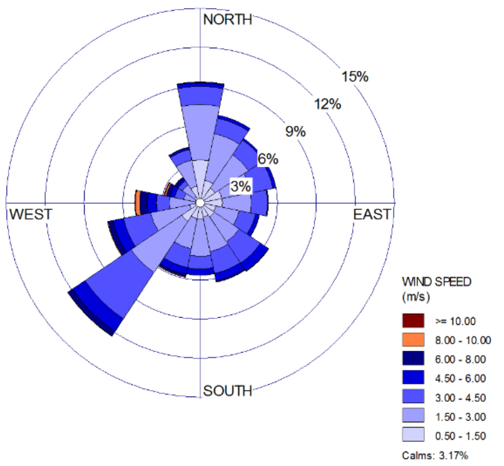
2017 - CALMET



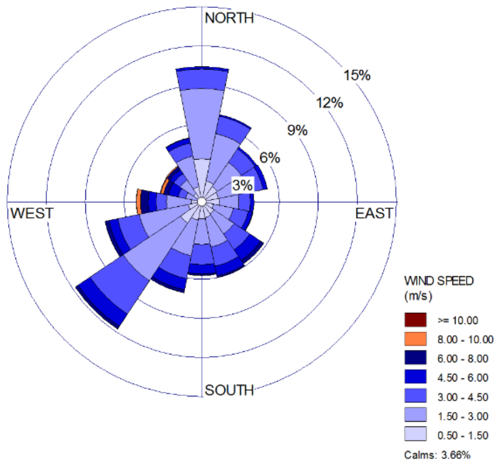
2016 - CALMET



2015 - CALMET



2014 - CALMET



2013 – CALMET

The comparison of the annual wind roses for the five modelled years (2013 to 2017) demonstrate similarity and good aggregability in the wind profile. Average wind speeds ranged between 2.5 - 2.62 m/sec across the five (5) modelled years.

Predicted wind speeds were slightly higher in 2016 (2.62 m/sec), when compared to rest of the four (4) years. However, selecting a year (such as 2017) with lower wind speeds (2.59 m/sec) for dispersion modelling may be conservative as it may lead to poor dispersion of modelled pollutants.

Additional analysis of the modelled meteorology is presented below:

Stability of the atmosphere is determined by a combination of horizontal turbulence caused by the wind and vertical turbulence caused by the solar heating of the ground surface. Stability cannot be measured directly; instead, it must be inferred from available data, either measured or numerically simulated.

The Pasquill-Gifford scale defines stability on a scale from A to G, with stability class A being the least stable, occurring during strong daytime sun and stability class G being the most stable condition, occurring during low wind speeds at night. For any given wind speed, the stability category may be characterised by two or three categories depending on the time of day and the amount of cloud present. In meteorological models such as CALMET, the stability classes F and G are combined.

A summary of the numerically simulated hourly stability class data using CALMET for the selected meteorological year (i.e. 2017) is presented in **Figure 9**. A higher frequency (39%) of stability class D was predicted by CALMET followed by class F (30%) indicating that conditions are largely neutral – stable.

Inter annual comparison of stability class (**Figure 10**) demonstrate similarities in the predicted stability class across the five (5) modelled years.

Figure 9: Frequency of Stability Class - 2017 CALMET

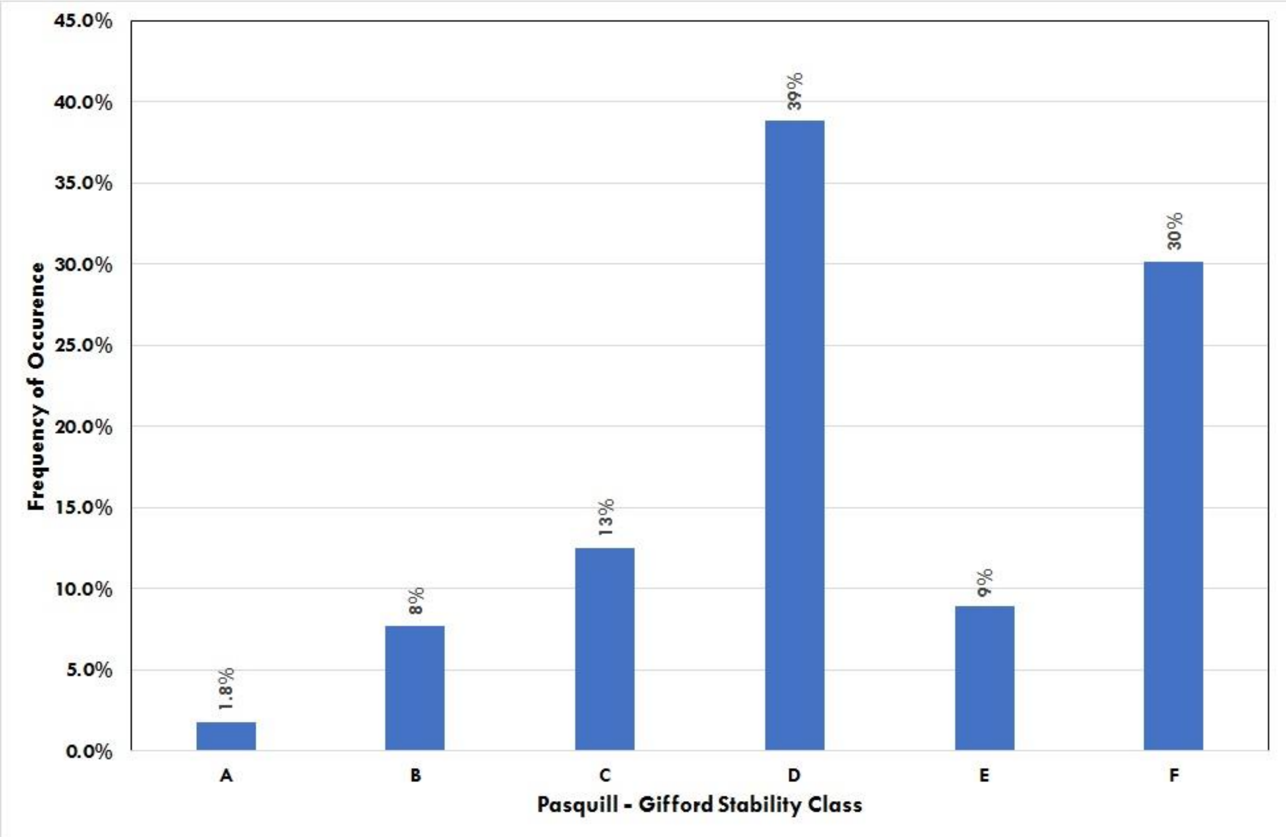
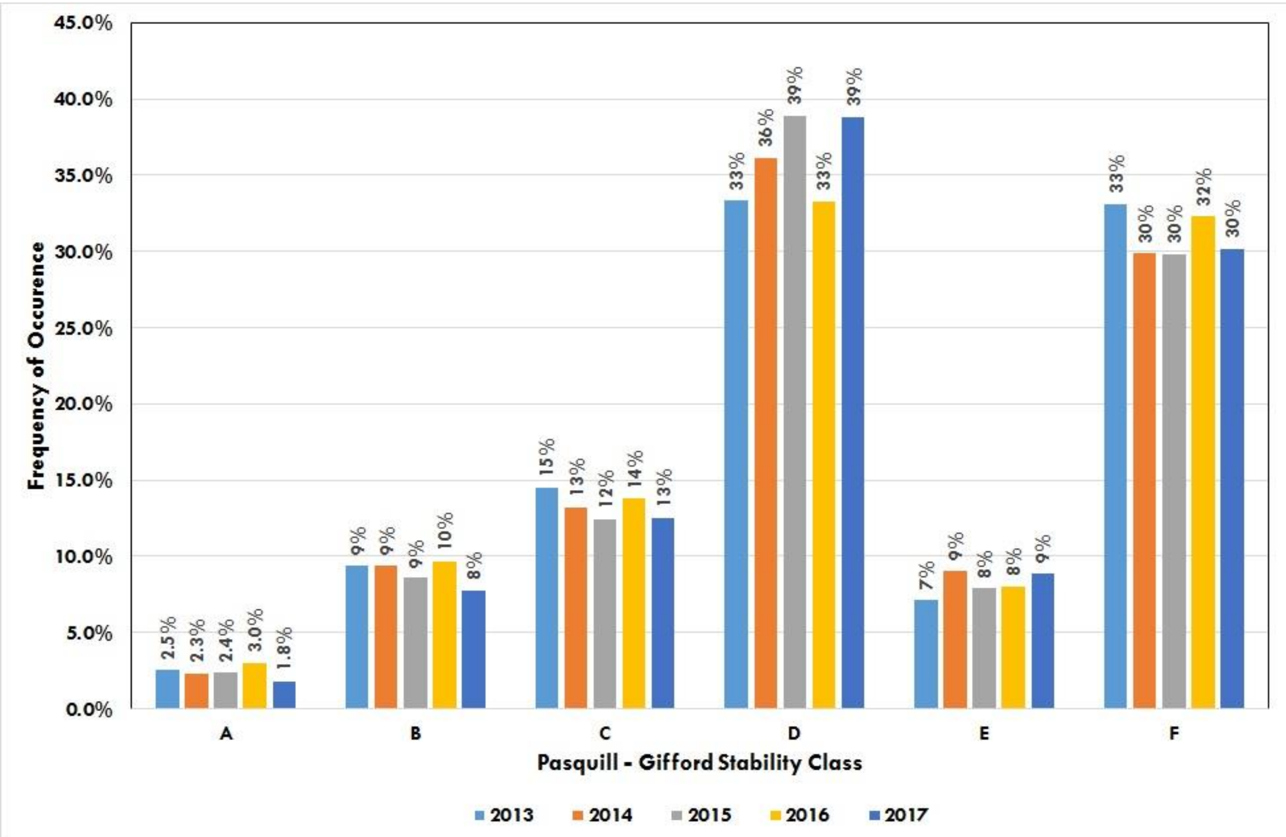


Figure 10: Comparison of Stability Class – 2013 to 2017 CALMET



The mixing height quantifies the vertical height of mixing in the atmosphere and is a modelled parameter that cannot be measured directly. The mixing height decreases in the late afternoon, particularly after sunset, due to the change from surface heating from the sun to a net heat loss overnight. Low mixing heights typically translate to stagnant air with little vertical motion, while high mixing heights allow vertical mixing and good dispersion of pollutants.

CALMET simulated hourly mixing height data is presented in **Figure 11** for the modelled year - 2017.

Figure 11 shows the mixing height as a function of the hour of the day at the Plant 2 site. The graph represents the typical growth of the boundary layer, whereby the mixing height is generally lowest during the night and into the early morning and highest during the late afternoon. Comparison of CALMET predicted interannual mixing heights (**Figure 12**) for 2013 – 2017 does not demonstrate any irregularities across the modelled years.

Figure 11: CALMET Predicted Diurnal Variations in Mixing Heights – 2017

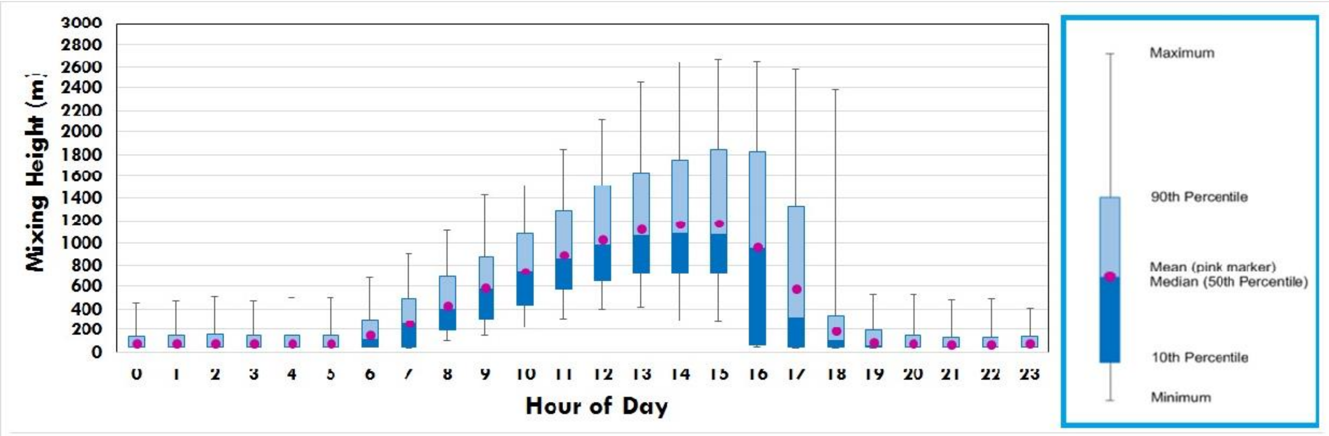
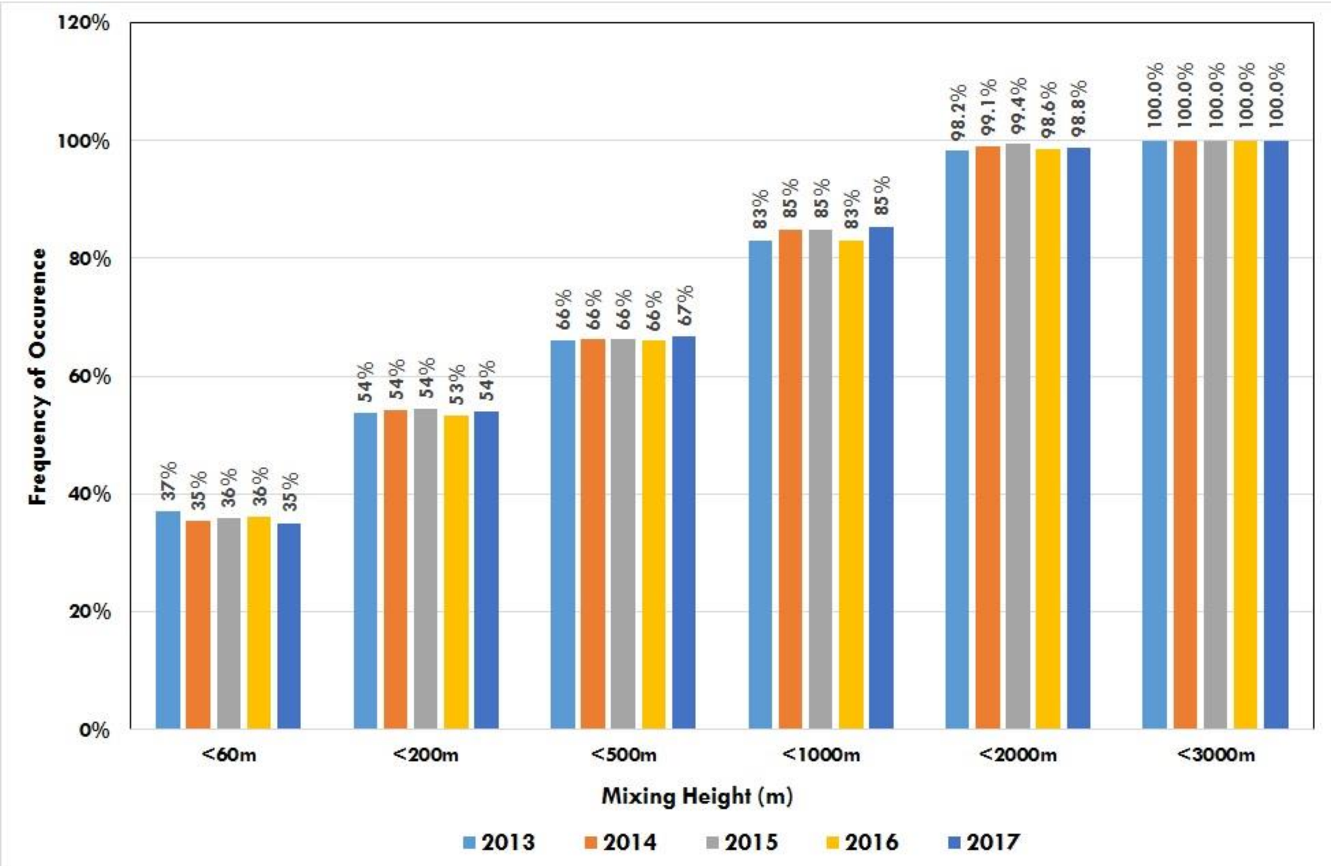


Figure 12: Comparison of Mixing heights – 2013 to 2017 CALMET

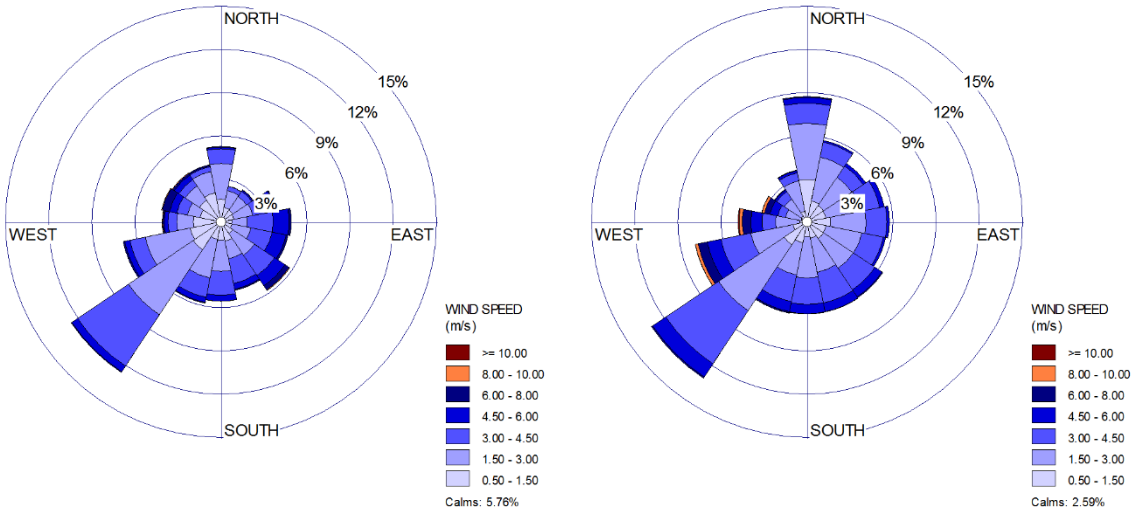


Inter annual comparison of wind profile, stability class and mixing height shows minimal inter-annual variability across the five-yearly dataset (2013-17), and therefore, the most recent calendar year, 2017 was considered to be a representative year for dispersion modelling and was selected. Additionally, in order to assess the cumulative impacts contemporaneously with the latest available observations from the ambient air quality monitoring stations (refer **Section 8.2**) – year 2017 was selected for the dispersion modelling.

Comparison was also made between the CALMET predicted wind data and observed wind data at the BoM Horsley Park AWS for the year 2017 as shown in **Figure 13**. Similar wind profile was observed at the Horsley Park BoM AWS as compared to CALMET predictions for the modelled year – i.e. 2017.

Therefore, based on the above analysis, it can be inferred that the CALMET modelling and the selected year for the dispersion modelling (2017) largely reflects the expected wind distribution patterns determined based on data from the BoM AWS at Horsley Park and the effect of local terrain and land-use in the immediate surrounds of the Plant 2 site.

Figure 13: Comparison of Observed Horsley Park BoM AWS (Left) vs CALMET Predicted (Right) Wind Data – 2017



11. OVERVIEW OF DISPERSION MODELLING

To determine air quality impacts from the upgraded Plant 2 kiln along with associated fugitive dust emissions (refer **Section 9**) and the existing sources of air emissions in the immediate vicinity (refer **Section 8**), air dispersion modelling was conducted using the US-EPA CALPUFF dispersion model.

CALPUFF is the dispersion model that calculates the dispersion of plumes within the three-dimensional (3D) meteorological field calculated by CALMET. CALPUFF is a non-steady state US-EPA approved dispersion model, which "advects" puffs of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so, it typically uses the wind fields generated by CALMET.

Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period (SRC, 2011).

The CALPUFF model domain was similar to the CALMET model domain, with a computational grid spanning 12km x 12km and a grid resolution of 250m centred at the Plant 2 site location. The sampling grid had a resolution of 50m (using a nesting factor of 5). The impact of building wake effects on plume dispersion has been included in the modelling for buildings and structures located around the Plant 2 kiln stack. The heights and locations of these structures were entered into the Building Profile Input Program (BPIP) utility using the PRIME algorithm. The wind direction specific building dimensions calculated by BPIP for the Plant 2 kiln stack at their corresponding heights were then entered into the CALPUFF model.

Ground level concentrations were predicted at the identified sensitive receptors (refer **Table 4**) and for individual air toxics (i.e. sulfuric acid concentrations) the 99.9th percentile incremental concentrations were predicted at or beyond the Plant 2 site boundary, in accordance with the reporting requirements of the modelled concentrations outlined in the Approved Methods .

Fugitive sources of dust generation associated with the Plant 2 operations (**Table 16**) and the sources from the existing Plant 1 operations (**Table 12**) and the Horsley Park WMF (**Table 13**) were all represented in the CALPUFF model as a series of volume-sources.

Emissions from the upgraded Plant 2 kiln stack (**Table 14**) and the existing Plant 1 kiln stack (**Table 10**) were modelled as a continuous release (24 hours, 365 days) point source.

Point source parameters for the Plant 2 kiln stack have been presented in **Table 15**. For the particulate emissions from the Plant 2 kiln, dry deposition was set to zero in the dispersion model.

All other CALPUFF model settings were referenced from the '*Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia*' (NSW-OEH, 2011).

12. DISPERSION MODELLING RESULTS

12.1 Incremental Impacts – Plant 2 Upgrade Only

Predicted ground level concentrations of all modelled pollutants from the upgraded Plant 2 project (incremental concentrations) are discussed below. Incremental concentrations discussed in this section are a consequence of the following sources:

- Point source emissions from the upgraded Plant 2 kiln exhaust stack
- Fugitive dust emissions generated from the identified operational activities at the upgraded Plant 2 site.

Maximum predicted incremental concentrations at the identified sensitive receptors for all the modelled pollutants are presented in **Table 20**.

With respect to reporting sulfuric acid concentrations, the Approved Methods specifies that ground level concentrations are to be reported as the 99.9th percentile 1-hour average concentrations predicted at or beyond the Plant 2 site boundary, and subsequently, this value has been extracted from the predicted model outputs and is presented in **Table 20**.

It is noted that the impact assessment criteria (except deposited dust levels and sulfuric acid concentrations) presented in **Table 20** are relevant for cumulative concentrations. However, for the sake of comparison, they have been presented, nonetheless. Particulate concentrations (TSP, PM_{10} and $PM_{2.5}$) presented below are reflective of the point source emissions generated from the upgraded Plant 2 kiln exhaust stack and the fugitive dust emissions as a result of the operational activities at Plant 2 site.

From the model predicted incremental concentrations presented in **Table 20**, the following observations can be made:

- Incremental concentrations and dust deposition rates at all the identified sensitive receptors are well below the relevant impact assessment criteria.
- With respect to Hydrogen Fluoride, which is a key pollutant generated from the brick manufacturing operations, incremental concentrations have been observed to be well below the impact assessment criteria, with the 24-hour averaging period identified as the most critical assessable component for HF. The maximum incremental 24-hour average HF concentrations is predicted at Receptor R7 – 1.48 $\mu g/m^3$, which is approximately 51% of the assessment criteria. For the remaining averaging periods (i.e. 90 days, 30 days and 7 days), the maximum predicted concentration at the sensitive receptors is less than 35% of the assessment criteria. This observed improvement in the model predicted HF concentrations can be directly attributed to the improvements proposed by Brickworks – which includes:
    - Commissioning of a fluorine cascade absorber, which will ensure that the HF concentration in the upgraded Plant 2 stack will not exceed 45 mg/m^3; and
    - Increasing the Plant 2 kiln exhaust stack height from the current 16m to 35m, which would considerably improve the pollutant dispersion.
- The maximum incremental 1-hour average sulfuric acid (representing sulfuric acid mist and sulfur trioxide emissions) concentrations to be reported according to the Approved Methods as the 99.9th percentile 1-hour average incremental concentration at or beyond the Plant 2 site boundary is 9.3 $\mu g/m^3$, is approximately 52% of the assessment criteria, demonstrating compliance with the assessment criteria.
- For all other pollutants including particulates (TSP, PM_{10}, $PM_{2.5}$ and deposited dust levels), SO_2 and NO_2, incremental impacts are well below the assessment criteria.

Isopleths for the incremental Hydrogen fluoride (HF) concentrations, which is the critical pollutant amongst all the assessed pollutants are presented in **Appendix B.**

Table 20: Summary of Predicted Incremental (Plant 2 Upgrade Only) Impacts – All Pollutants

Pollutant	Averaging Period	Impact Assessment Criteria (µg/m³)	Model Predicted Maximum (100th Percentile) Incremental Concentrations (µg/m³) at Identified Sensitive Receptors									Maximum (100th Percentile) Incremental Across All Receptors	% of Impact Assessment Criteria – Maximum Predicted Incremental Across All Receptors
			R1	R2	R3	R4	R5	R6	R7	R8	R9		
TSP	Annual	90	0.19	0.21	0.22	0.56	0.52	0.65	1.02	0.42	0.08	1.02	1.1%
PM_{10}	24-hours	50	1.37	1.16	1.32	2.56	2.80	1.88	2.48	3.89	1.20	3.89	7.8%
	Annual	25	0.15	0.18	0.18	0.43	0.41	0.44	0.62	0.32	0.09	0.62	2.5%
$PM_{2.5}$	24-hours	25	0.48	0.41	0.51	0.66	0.80	0.49	0.78	0.73	0.30	0.80	3.2%
	Annual	8	0.04	0.04	0.05	0.10	0.09	0.10	0.14	0.07	0.02	0.14	1.8%
HF	90-days	0.5	0.11	0.10	0.10	0.16	0.14	0.12	0.17	0.10	0.05	0.17	34.9%
	30-days	0.84	0.15	0.13	0.15	0.20	0.22	0.15	0.25	0.12	0.06	0.25	29.7%
	7-days	1.7	0.29	0.31	0.41	0.33	0.38	0.23	0.42	0.35	0.17	0.42	25.0%
	24-hours	2.9	1.01	0.85	1.07	1.22	1.47	0.91	1.48	1.23	0.62	1.48	51.0%
SO_2	10-minutes	712	38.47	20.80	23.16	26.30	26.64	77.33	106.15	66.28	46.39	106.15	14.9%
	1-hour	570	20.46	11.07	12.32	13.99	14.17	41.13	56.46	35.26	24.68	56.46	9.9%
	24-hours	228	3.37	2.84	3.57	4.09	4.92	3.06	4.95	4.11	2.08	4.95	2.2%
	Annual	60	0.19	0.18	0.19	0.31	0.29	0.28	0.37	0.19	0.10	0.37	0.6%
NO_2 [a]	1-hour	246	13.61	7.36	8.19	9.30	9.42	27.35	37.54	23.44	16.41	37.54	15.3%

Pollutant	**Averaging Period**	**Impact Assessment Criteria (µg/m³)**	**Model Predicted Maximum (100th Percentile) Incremental Concentrations (µg/m³) at Identified Sensitive Receptors**									**Maximum (100th Percentile) Incremental Across All Receptors**	**% of Impact Assessment Criteria – Maximum Predicted Incremental Across All Receptors**
			R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**		
	Annual	62	0.13	0.12	0.13	0.21	0.19	0.19	0.24	0.13	0.07	0.24	0.4%
Sulfuric acid	1-hour	18	3.59	3.17	3.63	4.32	4.45	5.20	5.36	4.85	2.95	9.3 (b)	51.7%
Deposited Dust Levels (expressed in $g/m^2/month$)	Annual	2 $g/m^2/month$ (max increase in deposited dust levels)	0.03	0.04	0.04	0.06	0.05	0.13	0.19	0.08	0.02	0.19	9.7%

(a) To predict ground level NO_2 concentrations, it has been conservatively assumed that all the NOx released is converted to NO_2 (100% NOx to NO_2 conversion). This approach is listed in Section 8.1.1 of the Approved Methods

(b) The value presented is the maximum (reported as 99.9th percentile) 1-hour average sulfuric acid concentration predicted at or beyond the Plant 2 site boundary as per the Approved Methods

12.2 Assessment of Cumulative Impacts

Cumulative model predictions for all the assessed pollutants are presented in **Table 21**. The presented cumulative concentrations are a sum total of the following sources:

- Incremental impacts from Plant 2, discussed in **Section 12.1**
- Impacts from the existing Plant 1 operations
- Impacts from the existing Horsley Park WMF; and
- Background concentrations from the Prospect monitoring station (refer **Table 9**)

The following observations can be made from the cumulative concentrations presented in **Table 21**.

- Cumulative concentrations of all the modelled pollutants are below the relevant assessment criteria across all the identified sensitive receptors.
- Based on the comparison of maximum predicted concentration against the relevant impact assessment criteria, the 24-hour and annual average $PM_{2.5}$ concentrations are noted to be the key pollutant, as the cumulative concentrations are respectively 98.8% and 97.2% of the assessment criteria. However it is noted that, the maximum incremental contribution from the upgraded Plant 2 operations (which include emissions from the kiln stack and fugitive dust emissions) are 3.2% of the assessment criteria for the 24-hour averaging period and 1.8% for the annual averaging period as noted from **Table 20**.
- A similar observation is made from the 24-hour average and annual average PM_{10} concentrations, where the cumulative model predictions are 83.1% and 79.6% of the respective assessment criteria, however, the maximum predicated incremental concentration from the upgraded Plant 2 operations is less than 10% of the criteria for all the averaging periods.
- With respect to Hydrogen fluoride (HF) concentrations, the cumulative predictions are a result of emissions generated simultaneously from both the existing Plant 1 kiln stack and the upgraded Plant 2 kiln stack. No ambient HF concentrations are measured at the Prospect monitoring station and it is unlikely that there would be any HF generating sources at the Horsley Park WMF, and therefore the cumulative concentrations are attributed to Plant 1 and 2. The maximum predicted cumulative HF concentrations for all the averaging periods are well below the assessment criteria as seen in **Table 21**. The 24-hour averaging period has been identified to be the most critical assessable component for HF impacts, with the maximum 24-hour average HF concentrations across all the identified receptors, predicted to be in the order of 54.9% of the assessment criteria.
- The maximum 1-hour average and annual average NO_2 ground level cumulative concentrations predicted across all the sensitive receptors is 65.9% and 32.9% respectively of the assessment criteria. Though modelling shows cumulative concentrations well below the assessment criteria, it is to be noted that for the sake of modelling, a conservative approach was adopted whereby it was assumed that all of the NOx would be converted to NO_2 (i.e. 100% NOx to NO_2 conversion)
- For all the other modelled pollutants (i.e. TSP, SO_2 and deposited dust levels), the cumulative model predictions are considerably below the relevant assessment criteria and the corresponding contribution from the Plant 2 facility is minimal.
- As per the Approved Methods, sulfuric acid (representing sulfuric acid mist and sulfur trioxide emissions) impacts are to be reported as incremental and therefore, have been excluded from the cumulative impact assessment.

Model predicted cumulative concentration isopleths for Hydrogen fluoride (HF), PM_{10}, $PM_{2.5}$ and NO_2 are presented in **Appendix B**.

Table 21: Summary of Model Predicted Cumulative Concentrations – All Pollutants

Pollutant	Averaging Period	Impact Assessment Criteria (µg/m³)	Model Predicted Maximum (100th Percentile) Cumulative Concentrations (µg/m³) at Identified Sensitive Receptors									Maximum (100th Percentile) Cumulative Across All Receptors	% of Impact Assessment Criteria – Maximum Predicted Cumulative Across All Receptors
			R1	R2	R3	R4	R5	R6	R7	R8	R9		
TSP	Annual	90	48.21	48.09	47.91	48.02	47.97	48.12	48.49	47.84	47.47	48.49	53.9%
PM_{10}	24-hours	50	41.55	41.48	41.16	40.70	40.71	41.35	41.55	40.41	40.16	41.55	83.1%
	Annual	25	19.89	19.80	19.56	19.45	19.40	19.44	19.63	19.25	18.99	19.89	79.6%
$PM_{2.5}$	24-hours	25	24.29	24.60	24.54	24.36	24.31	24.56	24.70	24.40	24.21	24.70	98.8%
	Annual	8	7.78	7.76	7.72	7.71	7.70	7.71	7.75	7.66	7.61	7.78	97.2%
HF	90-days	0.5	0.25	0.21	0.21	0.18	0.16	0.19	0.26	0.15	0.08	0.26	51.6%
	30-days	0.84	0.37	0.25	0.24	0.23	0.24	0.24	0.33	0.17	0.09	0.37	44.3%
	7-days	1.7	0.88	0.54	0.54	0.38	0.42	0.30	0.50	0.45	0.22	0.88	51.7%
	24-hours	2.9	1.25	1.12	1.07	1.22	1.47	0.98	1.51	1.59	0.78	1.59	54.9%
SO_2	10-minutes	712	181.56	176.20	180.74	184.25	176.31	202.87	238.23	209.92	189.55	238.23	33.5%
	1-hour	570	96.57	93.72	96.14	98.00	93.78	107.91	126.72	111.66	100.83	126.72	22.2%
	24-hours	228	17.72	16.76	15.92	15.53	16.36	15.11	16.56	17.46	14.34	17.72	7.8%
	Annual	60	2.53	2.52	2.54	2.42	2.39	2.47	2.56	2.29	2.15	2.56	4.3%
NO_2 (a)	1-hour	246	137.33	135.77	135.50	133.49	132.42	150.67	162.00	149.90	142.78	162.00	65.9%
	Annual	62	20.31	20.31	20.32	20.32	20.30	20.32	20.38	20.24	20.16	20.38	32.9%

Pollutant	**Averaging Period**	**Impact Assessment Criteria ($\mu g/m^3$)**	**Model Predicted Maximum (100th Percentile) Cumulative Concentrations ($\mu g/m^3$) at Identified Sensitive Receptors**									**Maximum (100th Percentile) Cumulative Across All Receptors**	**% of Impact Assessment Criteria – Maximum Predicted Cumulative Across All Receptors**
			R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**		
Deposited Dust Levels (expressed in $g/m^2/month$)	Annual	4 $g/m^2/month$	2.16	2.10	2.06	2.07	2.07	2.14	2.21	2.09	2.02	2.21	55.1%

(a) To predict ground level NO_2 concentrations, it has been conservatively assumed that all the NOx released is converted to NO_2 (100% NOx to NO_2 conversion). This approach is listed in Section 8.1.1 of the Approved Methods

13. GREENHOUSE GAS ASSESSMENT

Determination of greenhouse gas (GHG) emissions has been undertaken in accordance with:

- The World Resources Institute / World Business Council for Sustainable Development (WRI/WBCSD) *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* (WRI/WBSCD, 2004) (hereafter 'the GHG protocol')
- *National Greenhouse Account Factors July 2018*, Department of the Environment and Energy, (hereafter 'NGAF 2018')
- *State and Territory Greenhouse Gas Inventories 2016*, Australia's National Greenhouse Accounts, Department of the Environment and Energy, February 2018 (2016 State and Territory Inventory)

13.1 Overview of GHG Emissions

NGAF 2018 defines three (3) scopes for different emission categories based on whether the emissions generated are 'direct' or 'indirect' emissions. As per NGAF 2018 direct emissions *are produced from sources within the boundary of an organisation as a result of the organisations' activities*, whereas indirect emissions *are emissions generated in the wider economy as a consequence of an organisation's activities, but which are physically produced by the activities of another organisation.*

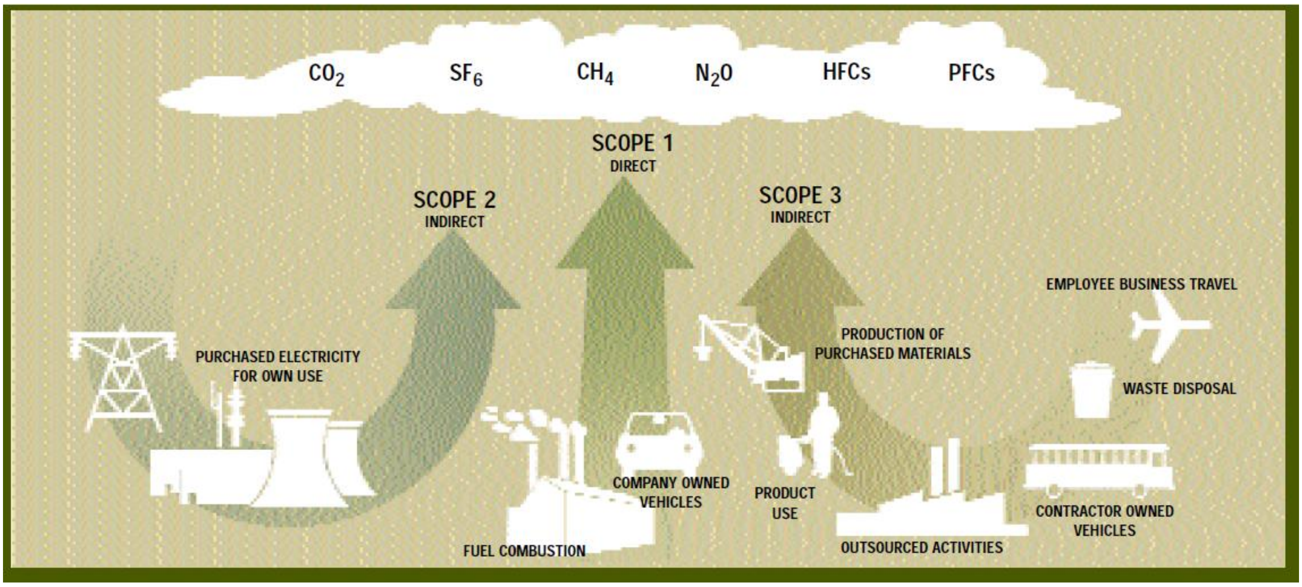
The 'scopes' of emissions (scope 1, 2 and 3) are defined for GHG reporting and are summarised below and presented in **Figure 14**.

The three (3) scopes are:

- **Scope 1**, which covers direct emissions from sources within the boundary of an organisation, such as fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal etc.
- **Scope 2**, which covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation; and
- **Scope 3**, which includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation

According to the GHG protocol, Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services. Moreover, the SEARs issued for the greenhouse gas assessment (refer **Table 1**) do not specify scope 3 emissions, and as-such quantification of the indirect scope 3 GHG emissions has been excluded from this assessment.

Figure 14: Overview of Scope 1, 2 and 3 GHG Emissions



Source: The Greenhouse Gas Protocol, WRI/WBSCD, 2004

13.2 GHG Emission Estimates

GHG emissions from a facility can be calculated using published emission factors. As per NGAF 2018, emission factors are used to calculate GHG emissions by multiplying a given quantity of GHG emitted per unit of energy or fuel or a similar measure with the activity data. Estimated GHG emissions are referred to in terms of carbon dioxide equivalent (CO_2-e).

Scope 1 and 2 GHG emissions from the Plant 2 upgrade have been quantified for:

- On-site combustion of diesel fuel and natural gas – Scope 1 emissions
- On-site consumption of electricity – Scope 2 emissions.

Amounts of diesel fuel and natural gas used at the Plant 2 site for the 2017-18 period along with the electricity consumption for the corresponding period as provided to Airlabs is summarised in **Table 22.** As noted earlier, the Plant 2 upgrade does not include change in operations or the production volumes, and, therefore, the estimated quantities for the 2017-18 period summarised in **Table 22** can be considered relevant for the assessment.

Table 22: Estimates of Fuel and Electricity Consumption at the Plant 2 site – 2017-18 Period

Parameter	Reporting Period	Value	Units
Diesel Fuel	2017-18	214.96	kL / annum
Natural Gas		335,692.24	GJ/annum
Electricity usage		6154.53	MWh/annum

Estimated annual Scope 1 and 2 GHG emissions, expressed in tonnes of CO_2-e (t CO_2-e/annum) for Plant 2 are summarised below in **Table 23.**

Table 23: Annual Scope 1 and 2 GHG Emissions from the Plant 2 Upgrade

Scope	Annual Emissions (t CO_2-e/annum)	Source of Emissions
Scope 1 GHG emissions	17,834.6	Diesel fuel and natural gas consumption
Scope 2 GHG emissions	5169.8	Electricity consumption
Total Scope 1 and 2 GHG emissions	23,004.4	All sources

The total estimated annual operational GHG emissions from the Plant 2 facility are expected to be approximately 23,004.4 tonnes of carbon dioxide equivalent (CO2-e).

In order to further understand the impacts on a larger scale, the total emissions have been compared against state (NSW) and national (Australia) GHG emissions.

The most recent annual GHG emissions for NSW and Australia have been reported for calendar year 2016. The information has been obtained from the *State and Territory Greenhouse Gas Inventories 2016 – Australia's National Greenhouse Accounts* compiled by the Department of the Environment and Energy, February 2018 (DOEE, 2018)

According to the estimates presented in the 2016 State and Territory inventory, the annual GHG emissions for NSW and Australia in 2016 were 131.6 Mt CO_2-e and 524 Mt CO_2-e. The Plant 2 facility annual emissions contribute to approximately 0.02% and 0.004% of the state and national GHG emissions respectively.

Though the contribution of Plant 2 emissions to the state and national GHG emissions is relatively minimal as observed from comparing the estimated emissions with the state and national inventories, the following recommendations are being made to further minimise the facility's GHG footprint:

- Ensuring proper maintenance and management of stationary and mobile equipment to improve fuel efficiency, which will result in lower fuel consumption.
- Periodic review and implementation of energy efficient measures to minimise electricity consumption.

14. CONCLUSION

Airlabs were commissioned by Willowtree Planning on behalf of Brickworks to conduct an air quality assessment to evaluate potential impacts from the proposed upgrades to the existing brick manufacturing Plant 2 at their Horsley Park site.

This air quality assessment forms a part of the EIS which would be submitted to the DOP&E seeking approval.

With respect to air quality, the main improvements proposed include a new kiln for Plant 2, a fluorine cascade absorber to minimise HF emissions discharged from the kiln stack and increasing the Plant 2 kiln stack height from the current 16m to 35m, which would facilitate better dispersion.

Pollutant emission rates from the upgraded Plant 2 kiln were based on the design concentrations (i.e. the maximum concentrations expected from the stack post commissioning) supplied by the manufacturer and the corresponding volumetric flow rates. Critical stack parameters which influence dispersion namely – exit velocity, stack temperature were provided to Airlabs.

In addition to evaluating impacts from the upgraded Plant 2 kiln stack, fugitive dust emissions generated from the operational activities were also estimated. For establishing background concentrations / existing air quality levels necessary for cumulative assessment, stack and fugitive dust emissions from the adjacent Plant 1 operations and fugitive dust emissions from the Horsley Park WMF were considered along with ambient concentrations measured at the Prospect monitoring station.

To predict off-site impacts from the Plant 2 upgrade, modelling was conducted using the US-EPA non-steady state CALPUFF dispersion model.

Modelling shows that all the assessed pollutants comply with the relevant assessment criteria at all the identified sensitive receptors at all times. Furthermore, the contribution of the upgraded Plant 2 operations to the overall predicted air quality levels is minimal, which is a direct consequence of the improvements proposed by Brickworks.

Scope 1 and 2 GHG emissions generated from the Plant 2 operations are low when compared to the state and national greenhouse gas inventories, with the operations contributing to approximately 0.02% and 0.004% of the state and national GHG emissions respectively.

Overall, the findings from the dispersion modelling show low-level impacts from the upgraded Plant 2 operations.

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APPENDIX A

Fugitive Dust Emission Reduction Factors

Table A.1: Fugitive Dust Control Measures and Quantifiable Emission Reduction Factors

Fugitive Dust Control Measure	Emission Reduction Efficiency	Source
Enclosed conveyors	70%	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Water sprays on stockpiles	50%	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Wind breaks from taller stockpiles and vegetation to reduce wind erosion emissions	30%	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Water sprays on crusher	50%	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Enclosed crushing operation	70%	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Presence of hard "crust" on existing non-active clay stockpiles at the Plant 1 and Plant 2 site, which considerably minimise the potential for wind erosion emissions	95%	Katestone Environmental (2011), NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining, Prepared for NSW Office of Environment and Heritage, KE1006953, June 2011
Application of Level 1 watering (<2L/m^2/hour) on unsealed surfaces	50% (a)	National Pollutant Inventory (NPI), Emission Estimation Technique Manual for Mining, Version 3.1, Australian Government – Department of Sustainability, Environment, Water, Population & Communities, January 2012
Imposing speed restrictions (max. of 40km/hr on major haul routes)	44% (a)	Teralba Quarry Extensions, Air Quality Assessment, Report Prepared by SLR Consulting Pty. Ltd. for Metromix Pty. Ltd., January 2012
Application of low silt aggregate (gravel finish) on unsealed haulage routes	30% (a)	Katestone Environmental (2011), NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining, Prepared for NSW Office of Environment and Heritage, KE1006953, June 2011

(a) For haulage emissions, combined control efficiency applied. The combined control efficiency is multiplicative. For example, if Level 1 watering is used in conjunction with application of low silt aggregate, the resultant emissions will be (1-0.5) x (1-0.3) = 0.35 of the uncontrolled emissions (i.e. 65% combined control efficiency)

APPENDIX B

– Incremental and Cumulative Concentration Isopleths

Figure B.1: Incremental (Plant 2 only) 90-days average maximum HF concentrations ($\mu g/m^3$) (Assessment criteria: 0.5 $\mu g/m^3$)

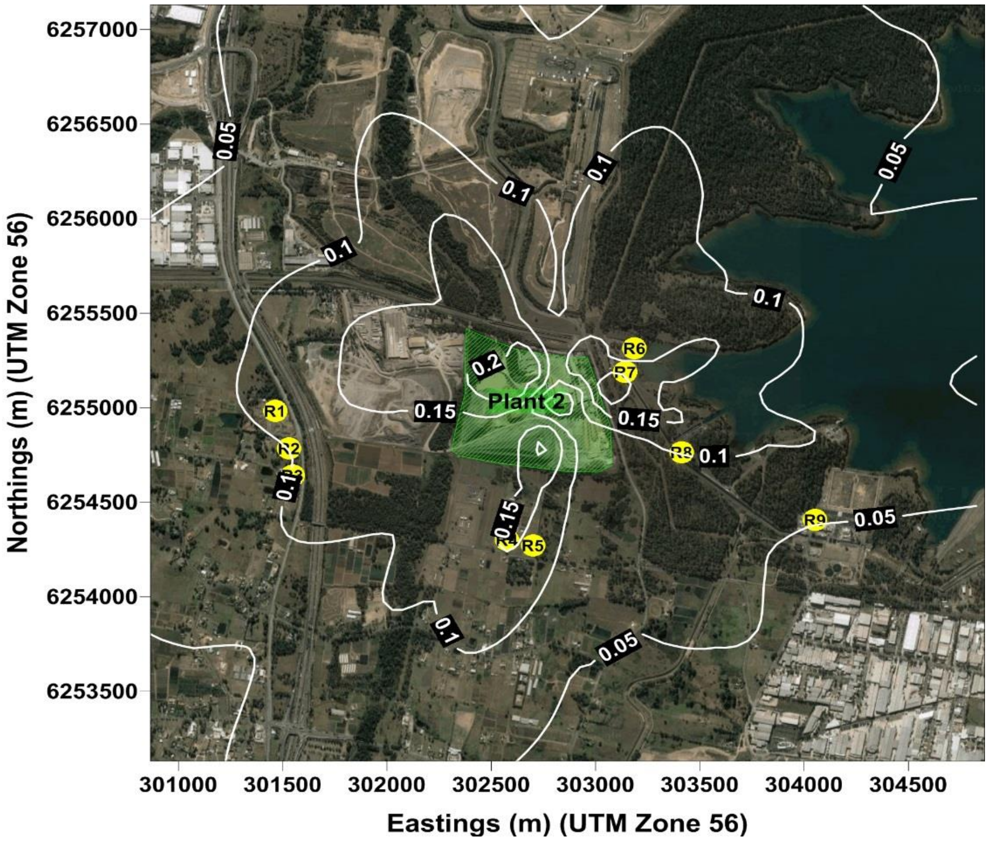

Figure B.2: Incremental (Plant 2 only) 30-days average maximum HF concentrations ($\mu g/m^3$) (Assessment criteria: 0.84 $\mu g/m^3$)

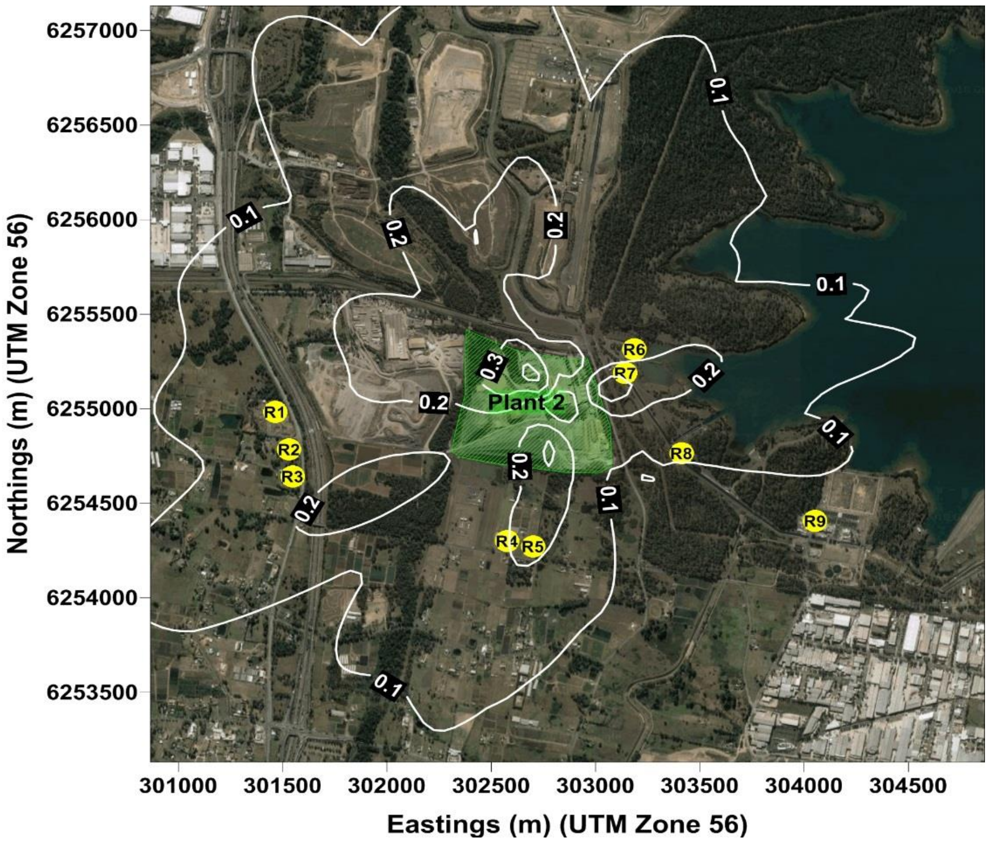

Figure B.3: Incremental (Plant 2 only) 7-days average maximum HF concentrations (μg/m^3) (Assessment criteria: 1.7 μg/m^3)

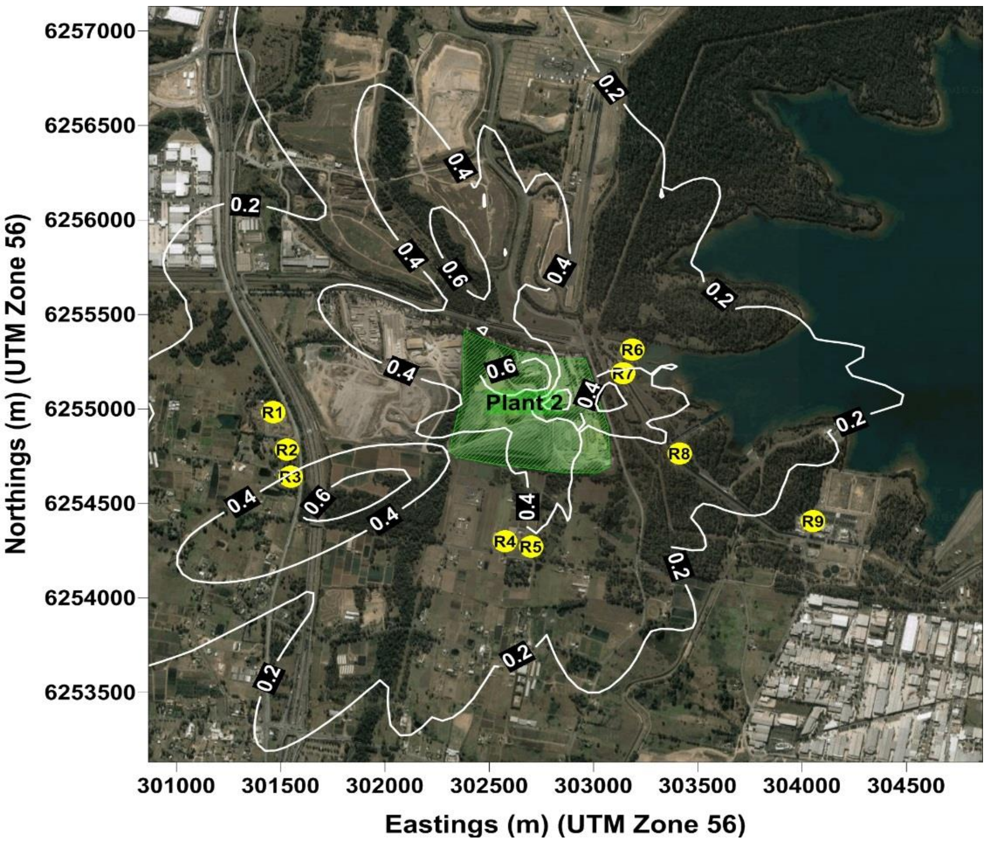

Figure B.4: Incremental (Plant 2 only) 24-hours average maximum HF concentrations (μg/m^3) (Assessment criteria: 2.9 μg/m^3) (Assessment criteria contour shown in red)

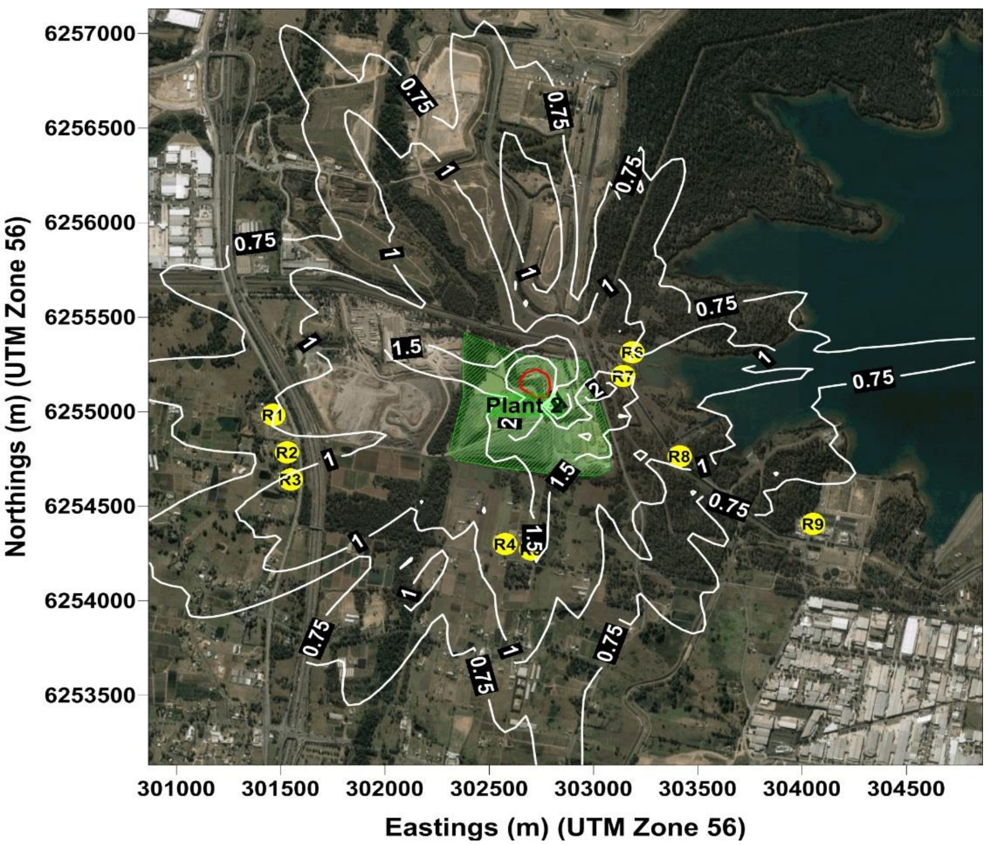

Figure B.5: Cumulative 90-days average maximum HF concentrations (μg/m³) (Assessment criteria: 0.5 μg/m³)

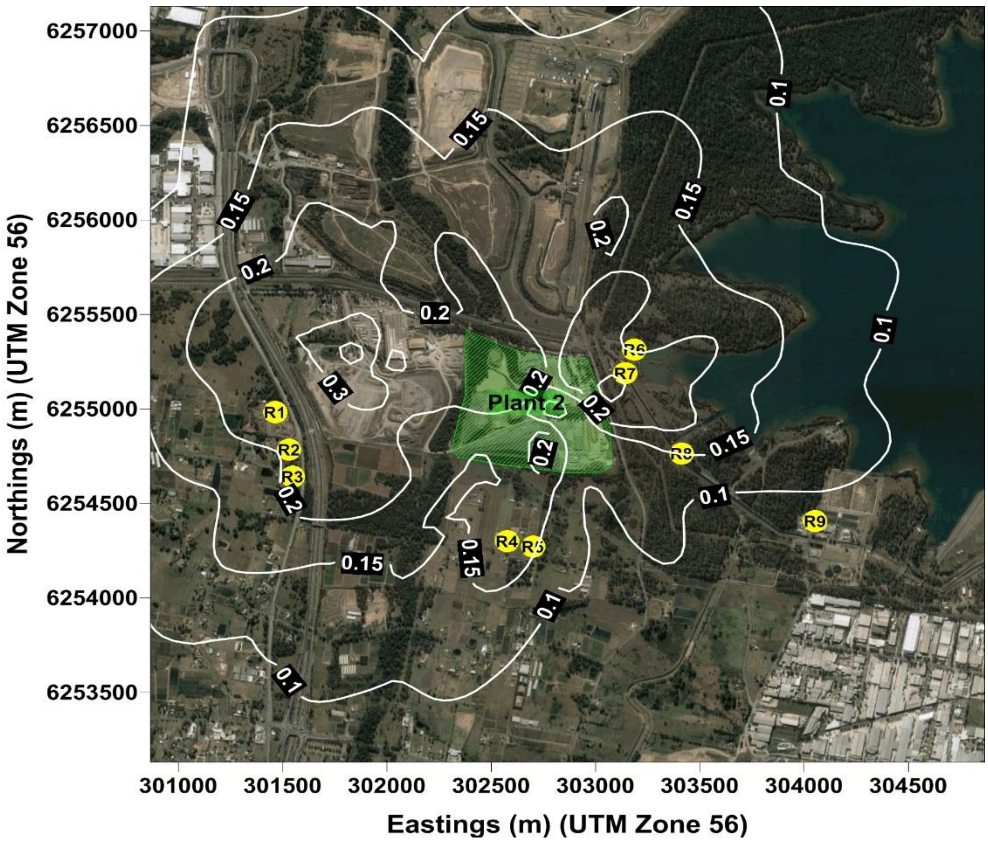

Figure B.6: Cumulative 30-days average maximum HF concentrations (μg/m³) (Assessment criteria: 0.84 μg/m³)

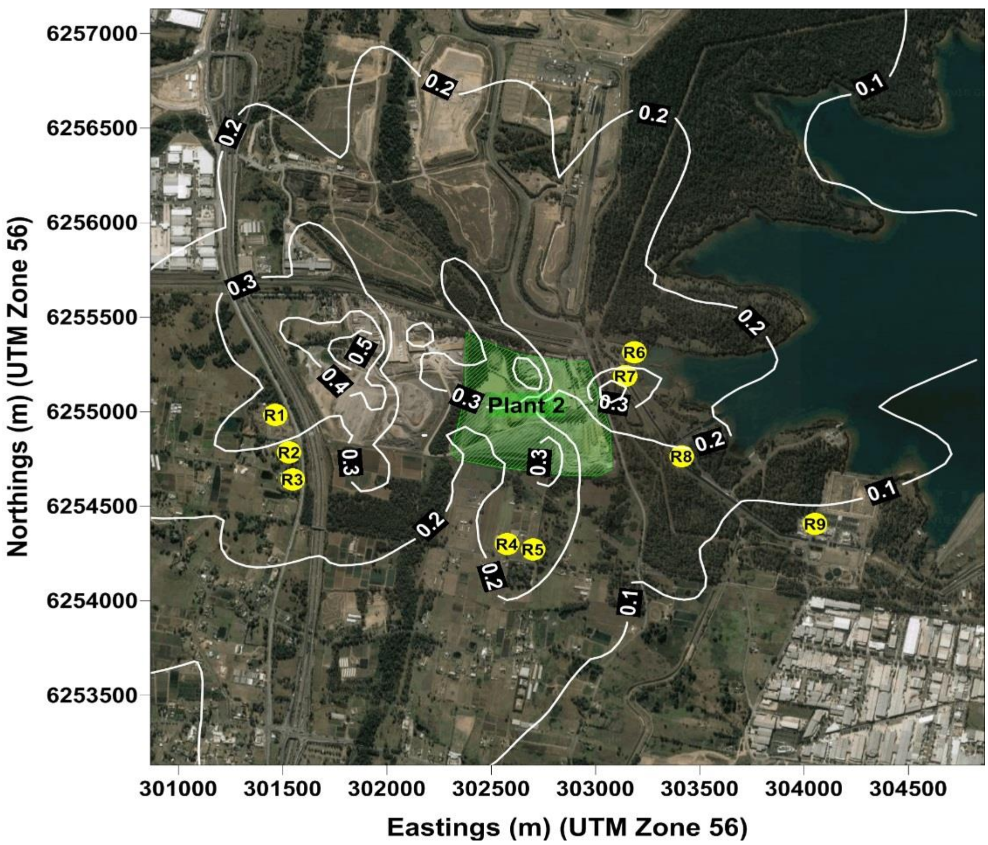

Figure B.7: Cumulative 7-days average maximum HF concentrations (μg/m^3) (Assessment criteria: 1.7 μg/m^3)

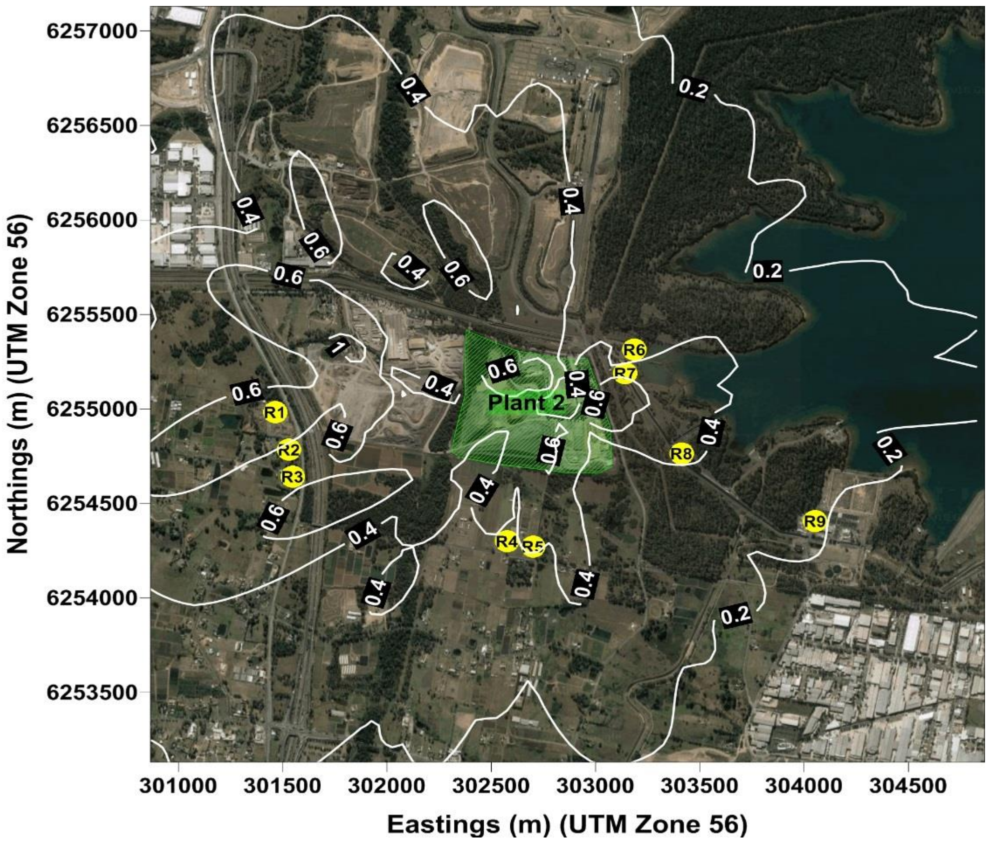

Figure B.8: Cumulative 24-hours average maximum HF concentrations (μg/m^3) (Assessment criteria: 2.9 μg/m^3) (Assessment criteria contour shown in red)

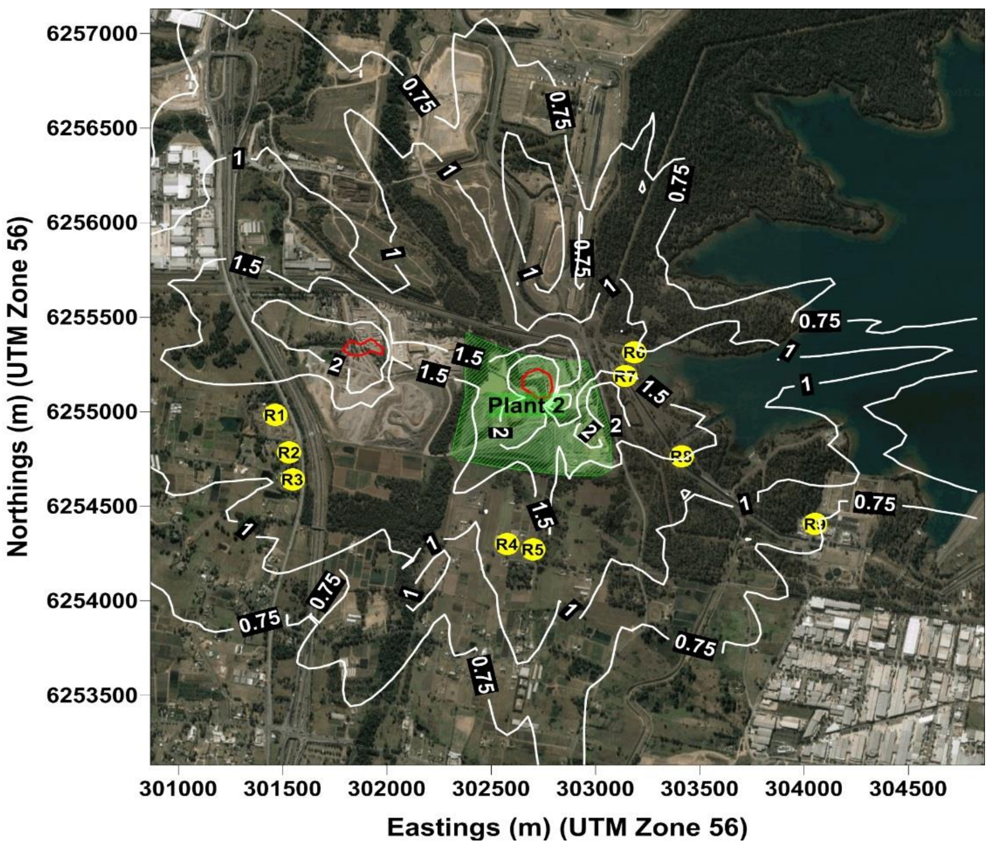

Figure B.9: Cumulative 24-hours average maximum PM_{10} concentrations ($\mu g/m^3$) (Assessment criteria: 50 $\mu g/m^3$) (Assessment criteria contour shown in red)

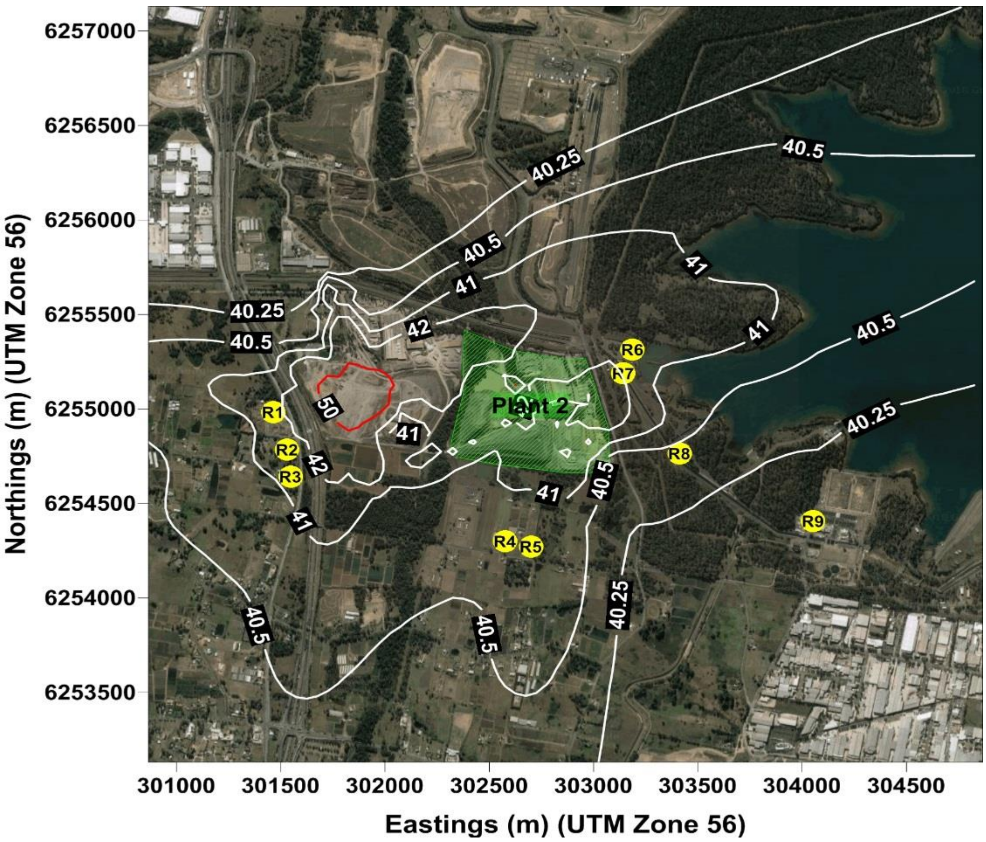

Figure B.10: Cumulative annual average PM_{10} concentrations ($\mu g/m^3$) (Assessment criteria: 25 $\mu g/m^3$) (Assessment criteria contour shown in red)

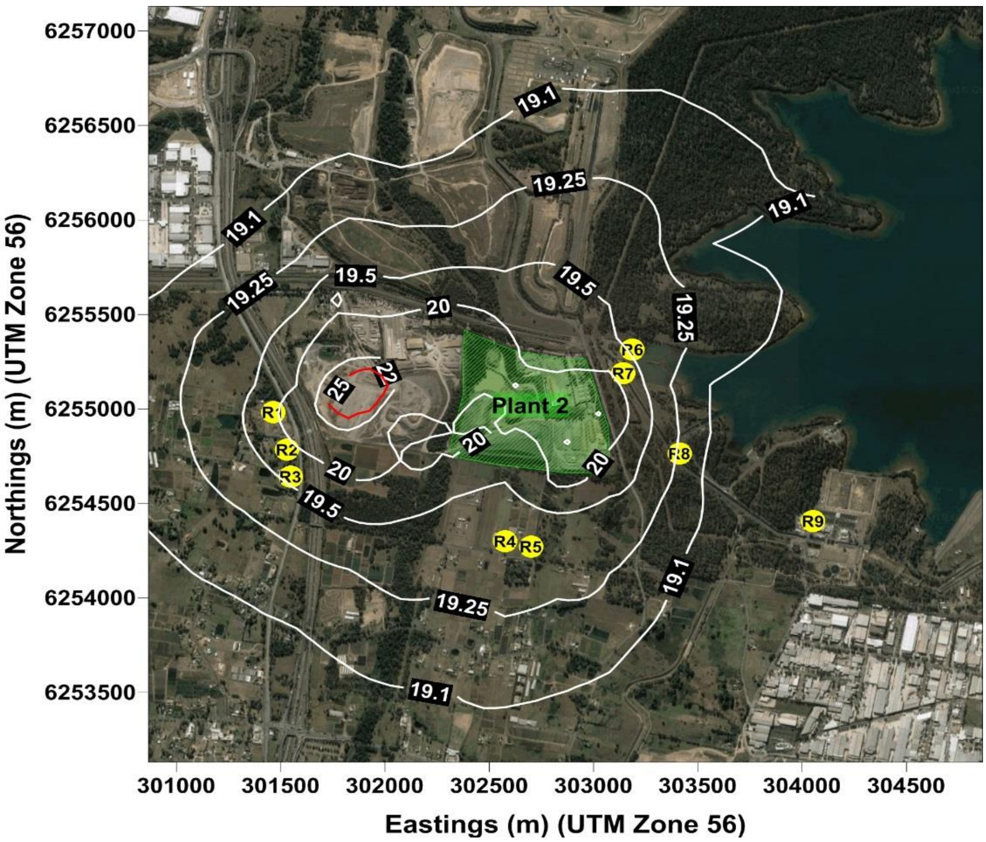

Figure B.11: Cumulative 24-hours average maximum $PM_{2.5}$ concentrations (µg/m³) (Assessment criteria: 25 µg/m³) (Assessment criteria contour shown in red)

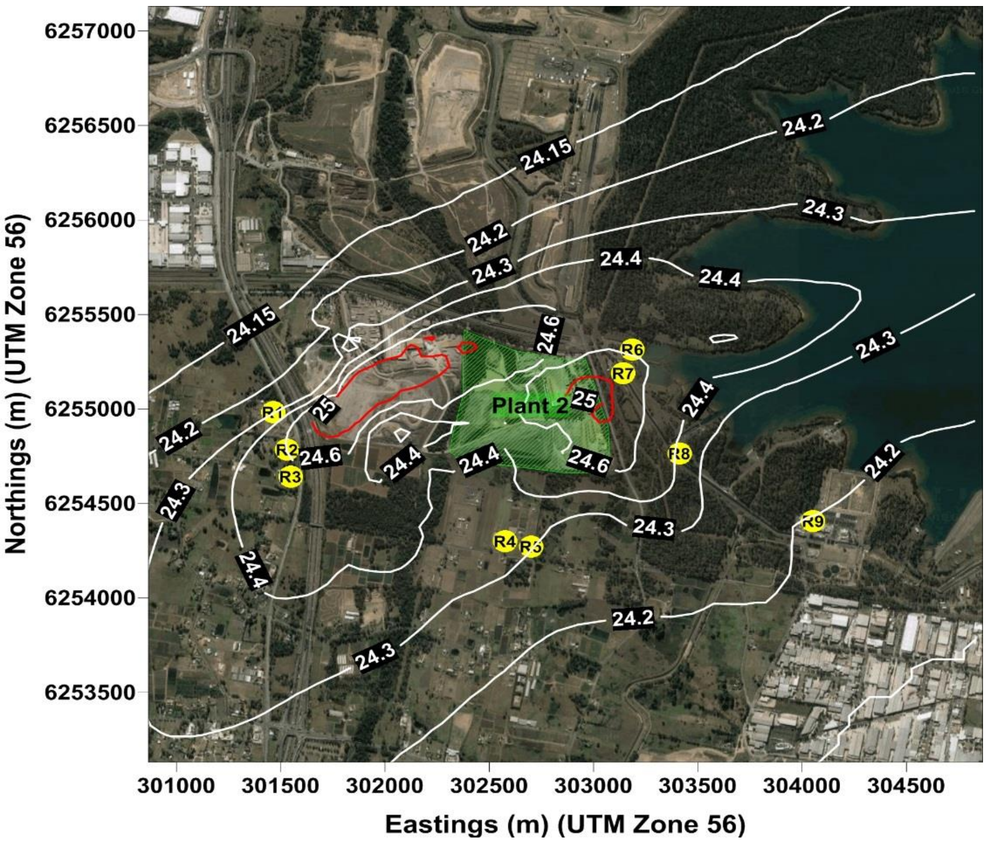

Figure B.12: Cumulative annual average $PM_{2.5}$ concentrations (µg/m³) (Assessment criteria: 8 µg/m³) (Assessment criteria contour shown in red)

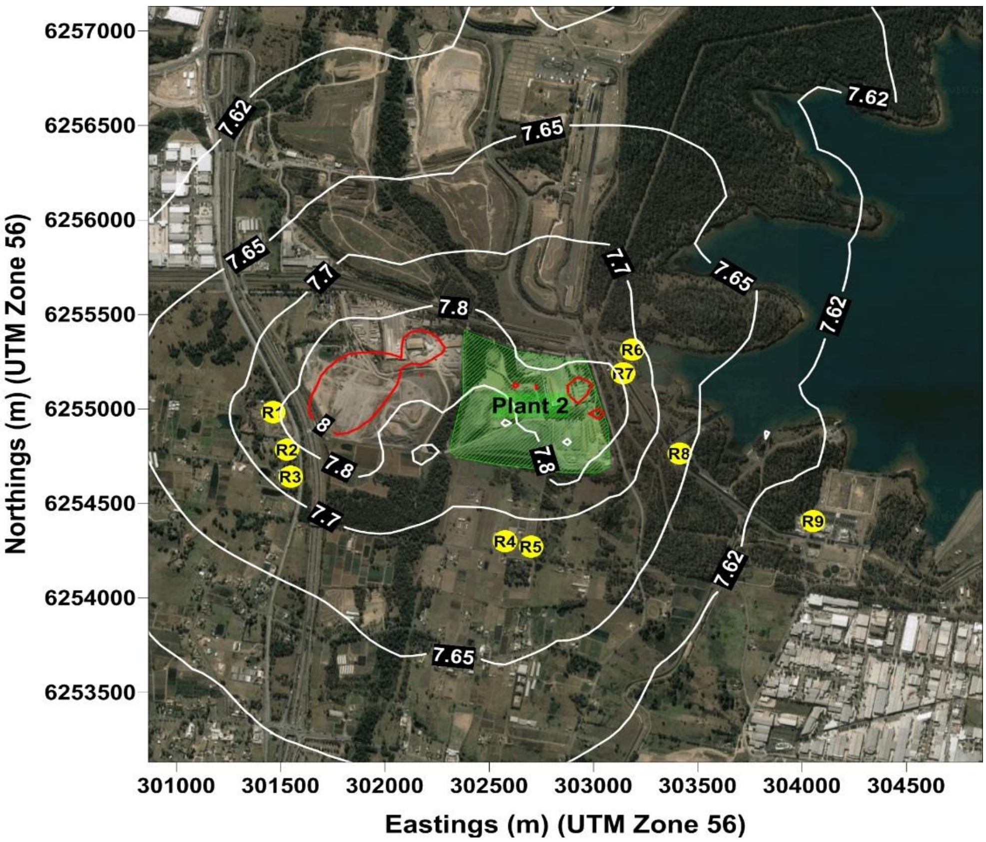

Figure B.13: Cumulative 1-hour average maximum NO_2 concentrations ($\mu g/m^3$) (Assessment criteria: 246 $\mu g/m^3$)

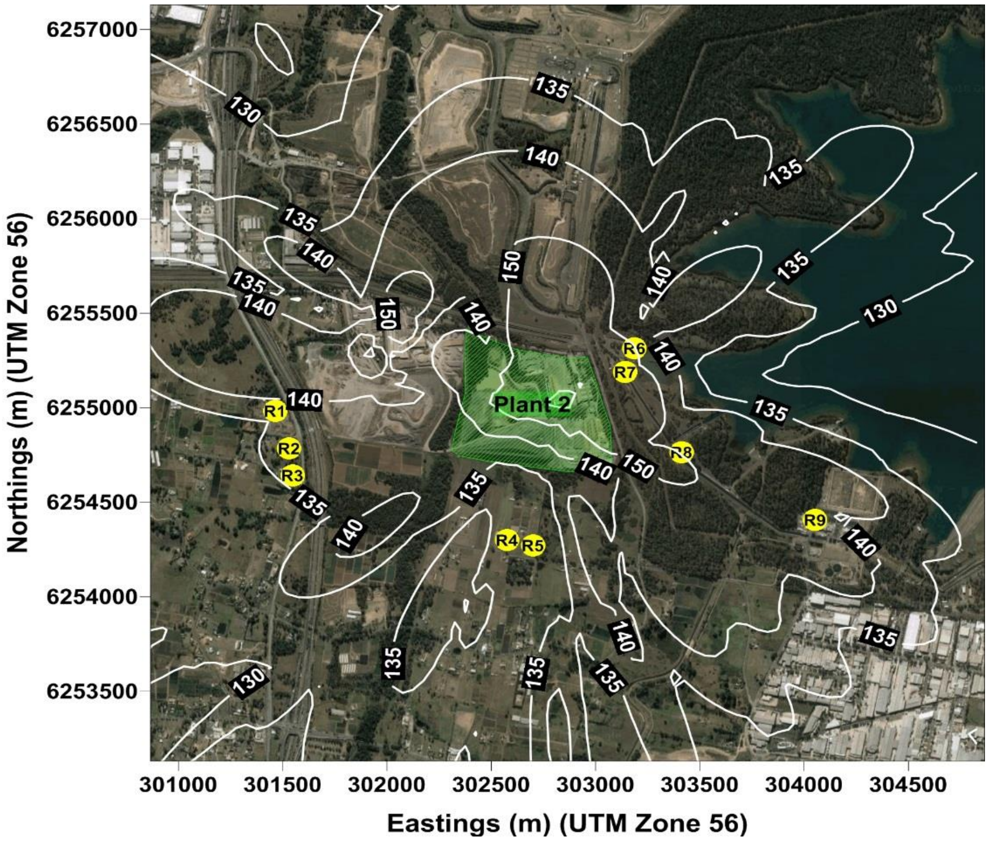

Figure B.14: Cumulative annual average maximum NO_2 concentrations ($\mu g/m^3$) (Assessment criteria: 62 $\mu g/m^3$)