Roads and Maritime Services/Sydney Airport Corporation Limited

Sydney Gateway Road Project

Environmental Impact Statement/ Preliminary Draft Major Development Plan

Technical Working Paper 17

Odour Assessment

November 2019

Roads and Maritime Services

Sydney Gateway Road Project

Technical Working Paper 17 – Odour Assessment

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G2S JV Gateway to Sydney Joint Venture

WSP Australia Pty Limited and GHD Pty Ltd

ABN: 55 836 411 311

Project Office

Level 27 Ernst & Young Centre
680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001
Australia
Tel: +61 2 9272 5100
Fax: +61 2 9272 5101

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Glossary

AMO	Aeronautical Meteorological Office
BoM	Bureau of Meteorology
CALMET	CALMET is a meteorological model which includes a diagnostic wind find generator containing objective analysis and parameterised treatments of slope flows, kinematic terrain effects, terrain blocking effects, a divergence minimisation procedure, and a micro-meteorological model for overland and overwater boundary layers.
CALPUFF	CALPUFF is a non-steady-state Lagrangian Gaussian puff model contain modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation.
EPA	NSW Environment Protection Authority
G2SJV	Gateway to Sydney Joint Venture
Leachate	Water which has contacted waste, other than VENM or other material approved by the EPA
Non-putrescible waste	As defined in the POEO Act and includes VENM and building and demolition waste
Odour assessment criteria	Odour assessment criteria for complex mixtures of odours specified in OU (odour units) as a nose-response-time average
Odour unit (OU)	The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is the numerical value equivalent to when 50% of a testing panel correctly detect an odour
OER	Odour Emission Rate. The odour concentration times the volume flow rate.
Pasquill-Gifford	Stability classification used in atmospheric dispersion models to define the turbulent state of the atmosphere
peak-to-mean ratio	A conversion factor that adjusts mean dispersion-model predictions to the peak concentrations perceived by the human nose
PMP	Project Management Plan
POEO Act	*Protection of the Environment Operations Act 1997*
Putrescible waste	As defined in the POEO Act; includes food waste
SEARs	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning, Industry and Environment
Sensitive receptor	A location where people are likely to work or reside; this may include a residential dwelling, school, hospital, office or public recreational area. An odour assessment should also consider the location of known or likely future receptors.
SOER	Specific Odour Emission Rate. The odour emission released per surface area per time
TAPM	TAPM is an air pollution model that predicts three-dimensional meteorology and air pollution concentrations.

Total cut area	The portion of the area of the former Tempe landfill where waste is currently located and would be disturbed and relocated by the project
UTM	Universal Transverse Mercator coordinate system
VENM	Virgin excavated natural material as defined in the POEO Act; includes rock, soil that is not contaminated
Working cut area	A portion of the total cut area where waste would be disturbed and relocated by the project.

1. Introduction

1.1 Overview

1.1.1 Sydney Gateway and the project

Sydney Kingsford Smith Airport (Sydney Airport) and Port Botany are two of Australia's most important infrastructure assets, providing essential domestic and international connectivity for people and goods. Together they form a strategic centre, which is set to grow significantly over the next 20 years. To support this growth, employees, residents, visitors and businesses need reliable access to the airport and port, and efficient connections to Sydney's other strategic centres.

The NSW and Australian governments are making major investments in the transport network to achieve this vision. New road and freight rail options are being investigated to cater for the forecast growth in passengers and freight through Sydney Airport and Port Botany. Part of this solution is Sydney Gateway, which comprises the following road and rail projects:

- Sydney Gateway road project (the subject of this assessment)
- Botany Rail Duplication.

Sydney Gateway will expand and improve the road and freight rail networks to Sydney Airport and Port Botany to keep Sydney moving and growing. The Sydney Gateway road project forms part of the NSW Government's long-term strategy to invest in an integrated transport network and make journeys easier, safer and faster.

Roads and Maritime Services (Roads and Maritime) and Sydney Airport Corporation propose the Sydney Gateway road project (the project). The project comprises new direct high capacity road connections linking the Sydney motorway network at St Peters interchange with Sydney Airport's terminals and beyond. It involves constructing and operating new and upgraded sections of road connecting to the airport terminals, four new bridges over Alexandra Canal, and other operational infrastructure and road connections.

The project and its location is shown on Figure 1-1.

1.1.2 Overview of approval requirements

The project is subject to approval under NSW and Commonwealth legislation. Parts of the project located on Commonwealth-owned land leased to Sydney Airport (Sydney Airport land) are subject to the Commonwealth *Airports Act 1996* (the Airports Act). In accordance with the Airports Act, these parts of the project are major airport development. A major development plan (MDP), approved by the Australian Minister for Infrastructure, Transport and Regional Development, is required before a major airport development can be undertaken at a leased airport.

Parts of the project located on other land are State significant infrastructure in accordance with the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State significant infrastructure, these parts of the project require approval from the NSW Minister for Planning and Public Spaces. An environmental impact statement (EIS) is required to support the application for approval for State significant infrastructure under the EP&A Act.

A combined EIS and preliminary draft MDP is being prepared to:

- Support the application for approval of the project in accordance with NSW and Commonwealth legislative requirements
- Address the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 15 February 2019
- Address the MDP requirements defined by Section 91 of the Airports Act.

This report was prepared on behalf of Roads and Maritime and Sydney Airport Corporation to support the EIS/preliminary draft MDP.

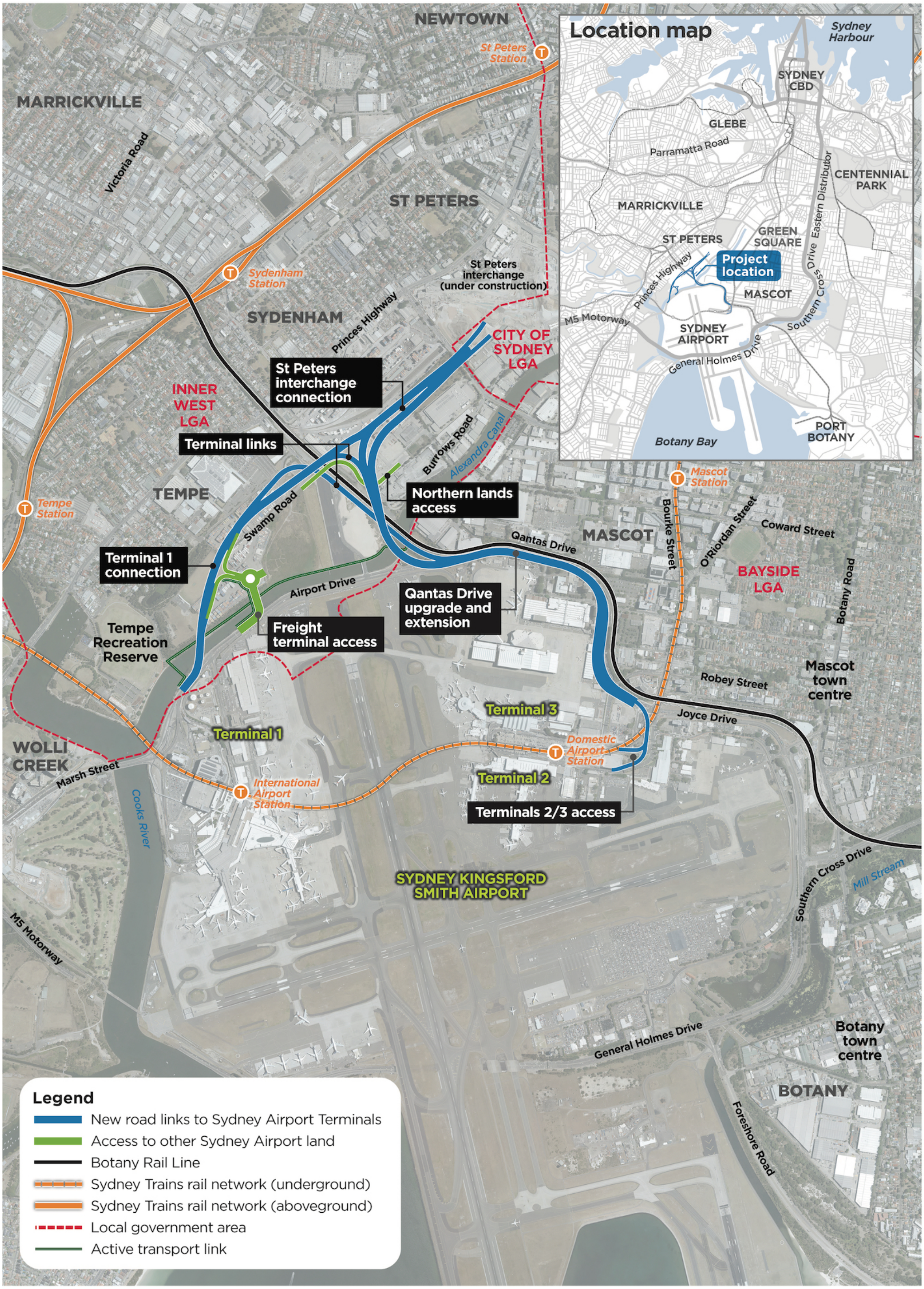


Figure 1-1 The project

1.2 Purpose and scope of this report

The purpose of this report is to assess the potential odour impacts from constructing and operating the project. This assessment addresses the relevant SEARs and the MDP requirements according to the Airports Act, as outlined in Table 1-1 and Table 1-2 respectively. The report:

- Describes the existing environment with respect to odour
- Assesses the odour impacts of constructing and operating the project
- Recommends measures to mitigate the impacts identified.

The methodology for the assessment is described in section 3.

Table 1-1 SEARs relevant to this assessment

Requirement	Where addressed in this report
14. Air Quality	
1. The Proponent must undertake an air quality impact assessment (AQIA) for construction and operation of the proposal in accordance with the current guidelines	This report specifically addresses the potential odour which might arise from the disturbance of waste at the former Tempe landfill. A separate Air Quality assessment is provided in Technical Working Paper 4.
2. The Proponent must ensure the AQIA also includes the following:	
a) Demonstrated ability to comply with the relevant regulatory framework, specifically the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Clean Air) Regulation (2010)*	As relevant to odour, sections 5 and 6.
b) The identification of all potential sources and types of air pollution (including PM10, PM2.5, CO, NOX, volatile organic compounds *and odour sources*) during construction and operation including mechanically generated combustion and transport related emissions and potential for landfill gas generation from the Tempe Tip site	Odour is addressed in section 3.2. The potential for odour impacts is only anticipated during the construction phase of the project. Combustion and transport-related emissions are addressed in Technical Working Paper 4 - Air Quality.
c) Any proposed air quality monitoring	section 6.
d) A cumulative local and regional air quality impact assessment including impacts generated by the operation of nearby key infrastructure proposals such as (but not limited to) the New M5, M4-M5 Link and Botany Rail Duplication	No cumulative odour impacts are anticipated from the listed projects. A cumulative air quality assessment is presented in Technical Working Paper 4 – Air Quality.
e) Proposed construction and operational management measures	section 6.

Table 1-2 MDP requirements relevant to this assessment

MDP Key Issues	Requirements	Where addressed in this report
Assessment of environmental impacts	(h) the airport-lessee company's assessment of the environmental impacts that might reasonably be expected to be associated with the development.	section 5
Plans for dealing with environmental impacts	(j) the airport-lessee company's plans for dealing with the environmental impacts (groundwater) mentioned in paragraph (h) (including plans for ameliorating or preventing environmental impacts).	section 6

1.3 The Project

1.3.1 Location

The project is located about eight kilometres south of Sydney's central business district and to the north of Sydney Airport on both sides of Alexandra Canal. The northern extent of the project is located at St Peters interchange, which is currently being constructed to the north of Canal Road in St Peters. The western extent of the project is located near the entrance to Sydney Airport Terminal 1 on Airport Drive, to the north of the Giovanni Brunetti Bridge and south-west of Link Road. The eastern extent of the project is located near the intersection of Joyce Drive, Qantas Drive, O'Riordan Street and Sir Reginald Ansett Drive.

The project is located mainly on government owned land in the suburbs of Tempe, St Peters and Mascot, in the Inner West, City of Sydney and Bayside local government areas.

1.3.2 Key design features

The project provides a number of linked road connections to facilitate the movement of traffic between the Sydney motorway network, Sydney Airport Terminal 1 (Terminal 1) and Sydney Airport Terminals 2 and 3 (Terminals 2/3). The project would connect Terminal 1 and Terminals 2/3 with each other and with the Sydney motorway network. The project would also facilitate the movement of traffic towards Port Botany via General Holmes Drive. It would provide three main routes for traffic:

- Between the Sydney motorway network and Terminal 1, and towards the M5 Motorway and Princes Highway
- Between the Sydney motorway network and Terminals 2/3, and towards General Holmes Drive, Port Botany and Southern Cross Drive
- Between Terminal 1 and Terminals 2/3.

The key features of the project include:

- Road links to provide access between the Sydney motorway network and Sydney Airport's terminals, consisting of the following components:
  - St Peters interchange connection – a new elevated section of road extending from St Peters interchange to the Botany Rail Line, including an overpass over Canal Road
  - Terminal 1 connection – a new section of road connecting Terminal 1 with the St Peters interchange connection, including a bridge over Alexandra Canal and an overpass over the Botany Rail Line
  - Qantas Drive upgrade and extension – widening and upgrading Qantas Drive to connect Terminals 2/3 with the St Peters interchange connection, including a high-level bridge over Alexandra Canal
  - Terminal links – two new sections of road connecting Terminal 1 and Terminals 2/3, including a bridge over Alexandra Canal
  - Terminals 2/3 access – a new elevated viaduct and overpass connecting Terminals 2/3 with the upgraded Qantas Drive

- Road links to provide access to Sydney Airport land:
  - A new section of road and an overpass connecting Sydney Airport's northern lands either side of the Botany Rail line (the northern lands access)
  - A new section of road, including a signalised intersection with the Terminal 1 connection and a bridge connecting Sydney Airport's existing and proposed freight facility either side of Alexandra Canal (the freight terminal access)
- An active transport link approximately 1.3 kilometres in length along the western side of Alexandra Canal to maintain connections between Sydney Airport, Mascot and the Sydney central business district
- Intersection upgrades or modifications
- Provision of operational ancillary infrastructure including maintenance bays, new and upgraded drainage infrastructure, signage and lighting, retaining walls, noise barriers, flood mitigation basin, utility works and landscaping.

1.3.3 Construction overview

A conceptual construction methodology has been developed, based on the preliminary project design, to be used as a basis for the environmental assessment process. Detailed construction planning, including programming, work methodologies, staging and work sequencing, would be undertaken once construction contractor(s) have been engaged.

1.3.3.1 Timing and work phases

Construction of the project would involve four main phases of work. The indicative construction activities within each phase are outlined below.

Table 1-3 Construction work phases

Phase	Indicative construction activities
Enabling works	■ Construction of the temporary active transport link ■ Modification of various road intersections to facilitate main construction works.
Site establishment	■ Installing site fencing, hoarding and signage ■ Establishing construction compounds, work areas and site access routes.
Main construction works	■ Clearing/ trimming of vegetation ■ Removal (or partial removal) of a number of buildings and other existing infrastructure e.g. concrete hardstand areas, drainage infrastructure, sheds, advertising structures, containers ■ Roadworks, including bridge and viaduct construction and drainage works ■ Utility works.
Finishing works	■ Erecting lighting, signage and street furniture, landscaping works and site demobilisation and rehabilitation in all areas.

Specific construction issues that would require careful planning and management and close coordination with relevant stakeholders include:

- Works within the prescribed airspace of Sydney Airport
- Works interfacing with the Botany Rail Line
- Piling in the vicinity of the T8 Airport and South Line underground rail tunnels
- Works within the former Tempe landfill and Alexandra Canal, which are subject to remediation orders and specific management plans
- Excavation, storage and handling of contaminated soils generally within the project site and contaminated groundwater from the Botany Sands aquifer.

Construction is planned to start in mid-2020, subject to approval of the project, and is expected to take about three and a half years to complete. Further information on construction is provided in Chapter 8 (Construction) of the EIS.

The project would include work undertaken during recommended standard hours as defined by the *Interim Construction Noise Guideline* (DECC, 2009):

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sundays and public holidays: no work.

It would also include work outside these hours (out-of-hours work) to minimise the potential for aviation and rail safety hazards.

The proposed works at the former Tempe landfill where waste would be disturbed and relocated generally would be undertaken during standard hours. However, some proposed works may also need to occur outside the standard hours, for example during early morning and at night.

1.3.3.2 Construction footprint

The land required to construct the project (the construction footprint) is shown on Figure 1-2. The construction footprint includes the land needed to construct the proposed roadways, bridges and ancillary infrastructure and land required for the proposed construction compounds. Utility works to support the project would generally occur within the construction footprint; however, some works (such as connections to existing infrastructure) may be required outside the footprint.

1.3.3.3 Compounds, access and resources

Construction would be supported by five construction compounds located to support the main construction works (shown on Figure 1-2). Construction compounds would include site offices, staff amenities, storage and laydown areas, workshops and workforce parking areas.

Materials would be transported to and from work areas via construction haul routes, which have been selected to convey vehicles directly to the nearest arterial road.

The construction workforce requirements would vary over the construction period, based on the activities underway and the number of active work areas. The workforce is expected to peak at about 1,000 workers for a period of about 13 months, indicatively from the fourth quarter of 2021. Either side of this peak, workforce numbers are expected to reduce to about two thirds.

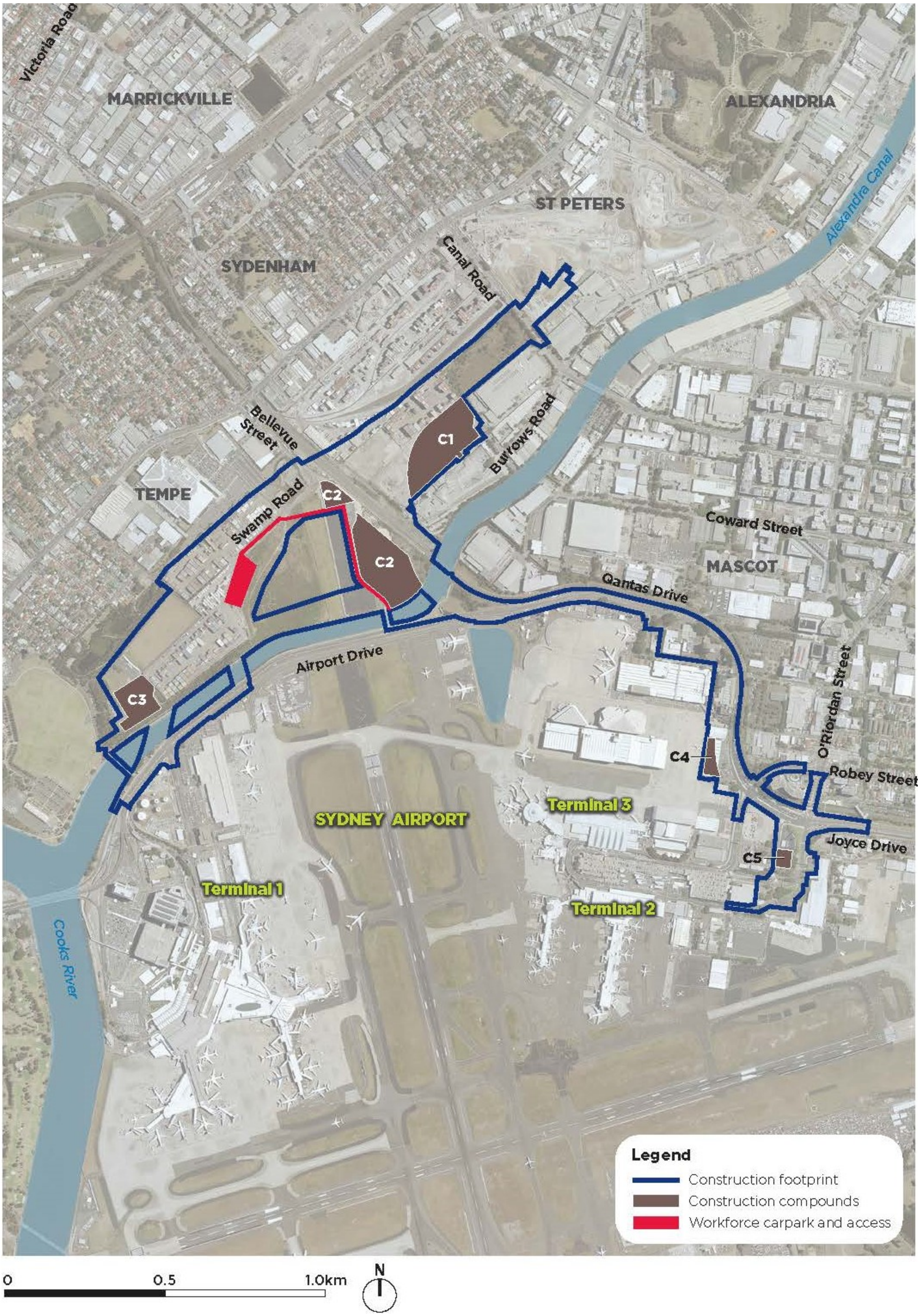


Figure 1-2 Construction footprint and facilities

1.4 Structure of this report

The remainder of this report is structured as follows:

- **Section 1 – Introduction** – Provides an introduction to the report
- **Section 2 – Relevant legislation and guidelines** – Describes the legislative and policy context for the assessment and other relevant guidelines
- **Section 3 – Methodology** – Describes the methodology for the assessment
- **Section 4 – Existing environment** – Describes the existing environment as relevant to this assessment
- **Section 5 – Impact assessment** – Presents a summary of the odour impact assessment results
- **Section 6 – Recommended mitigation measures** – Provides an overview of the proposed mitigation measures
- **Section 7 – Conclusion** – Presents a summary of the odour findings and sets out the principal conclusions of the assessment
- **Section 8 – References** – Provides a list of references.

The appendix also contain information relevant to the assessment and findings of this report.

2. Relevant legislation and guidelines

2.1 General

The assessment was undertaken with reference to the following legislation and guidelines:

- Commonwealth Airports (Environment Protection) Regulations 1997
- NSW *Protection of the Environment Operations Act 1997* (POEO Act)
- NSW Protection of the Environment Operations (Clean Air) Regulation 2010
- *Technical framework – Assessment and management of odour from stationary sources in NSW* (the Technical Framework), NSW Department of Environment and Conservation (DECC 2006)
- *NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (2016) (the Approved Methods).

It is recognised that the project site contains Commonwealth land subject to the (Commonwealth) Airports Act, and also land subject to NSW legislation. As such, both the applicable Commonwealth and State obligations with respect to odour have been considered.

2.1.1 Commonwealth Airports (Environment Protection) Regulations 1997

Under the Commonwealth Airports (Environment Protection) Regulations 1997, air pollution occurs when a pollutant (including odour) is present and is likely to cause harm to the environment or to cause an unreasonable inconvenience to a person at a place other than the source of the pollutant, or where the source is in a place to which members of the public have access. These Regulations apply to the Sydney Airport site shown in Figure 4-1.

2.1.2 NSW Protection of the Environment Operations Act 1997

Under the POEO Act, there is a requirement for no 'offensive odour' to be emitted from a premises. An offensive odour is defined as an odour:

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

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

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

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

2.1.3 NSW Technical Framework – Assessment and management of odour from stationary sources in NSW

The Technical Framework provides a legislative context for the control of odour and presents odour assessment criteria guidelines. It provides a framework for different levels of odour assessment, strategies to mitigate odour, and guidance for performance monitoring, regulation and enforcement.

2.1.4 NSW Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales

The Approved Methods lists the statutory methods for modelling and assessing emissions of all air pollutants from stationary sources in NSW. The modelling results are then able to be compared to quantified odour assessment criteria to assess whether a project may achieve compliance with the offensive odour provisions in the POEO Act. The odour assessment criteria are further discussed in section 2.2.

2.2 Odour assessment criteria

The assessment criteria for odour are applied at the nearest existing or likely future off-site sensitive receptor. The Approved Methods defines odour assessment criteria (measured in odour units (OU[1])) and specifies how they should be applied in dispersion modelling to assess the likelihood of nuisance impact arising from the emission of odour.

Odour impact is a subjective experience and has been found to depend on many factors, the most important of which are:

- Frequency of the exposure
- Intensity of the odour
- Duration of the odour episodes
- Offensiveness of the odour
- Location of the source.

These factors are often referred to as the 'FIDOL' factors.

The odour assessment criteria are defined to take account of two of these factors (F is set at 99th percentile; I is set at between 2 to 7 OU). The choice of assessment criteria is also dependent on the population of the affected area, as shown in Table 2-1.

Table 2-1 Odour assessment criteria in the Approved Methods

Population of the affected community	Odour performance criteria (nose response odour certainty units at 99th percentile[1])
Single residence (≤ ~2)	7
~ 10	6
~ 30	5
~ 125	4
~ 500	3
Urban (≥~2,000)	2

(1) This is a prediction of the odour level that may occur 99 per cent of the time, or that is below these criteria for 99 hours in every 100. Odour performance criteria are designed to be precautionary, so that impacts on sensitive receivers can be minimised.

The criteria assume that 7 OU at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases, there is a chance that more sensitive individuals would be encountered. The criterion of 2 OU at the 99th percentile is considered to be acceptable for large populations (more than 2,000 people).

[1] *The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is the numerical value equivalent to when 50 per cent of a testing panel correctly detect an odour*

The criteria have also been specified at an averaging time of nominally one second. The choice of the short averaging time recognises that the human nose has a response time of less than one second, so that modelling of odour impact should allow for the short-term concentration fluctuations in an odour plume due to turbulence.

As the dispersion model cannot predict concentrations for a one second average, a ratio between the one second peak concentration and 60 minute average concentration has been applied in accordance with Section 6.6 of the Approved Methods. This is known as the peak to mean ratio (PM60). PM60 is a function of source type, stability category and range (that is, near or far-field), and values are tabulated in the Approved Methods.

The odour assessment criteria applicable in NSW and detailed in Table 2-1 have been adopted for the project.

The odour assessment criteria are designed to provide a quantifiable and practical means of assessing a project to minimise the potential odour impacts on people. These criteria do recognise that for up to one per cent of the time, odour may be identifiable at areas surrounding a project site. During construction activities for the project that may lead to odour impacts, it is important that management and mitigation practices are employed from the outset to limit the potential for odour problems. This approach has been taken in this assessment.

The potential population affected by the project was estimated based on the number of people who would experience 1 OU. It was estimated that the project has the potential to impact more than 2,000 people. Subsequently, the most stringent odour assessment criterion of greater than 2 OU was adopted for this project.

3. Methodology

3.1 General

The odour assessment only focuses on impacts during the construction stage because potential odour impacts are likely only when sections of the former Tempe landfill are uncovered during the construction of the project. Areas uncovered during the construction stage would be re-capped, either with appropriate fill material or with the proposed project infrastructure, and therefore odour from operation of the project is unlikely.

The approach to the construction odour assessment generally included the following activities:

- Conduct of a site inspection in May 2019 to verify features of the existing environment and identify any nearby odour sources
- Review of proposed construction scenarios to identify the potential odour sources
- Collation of relevant geotechnical, bore log and potential waste composition information and analysis of the potential interaction of the project
- Development of an odour emissions inventory
- Meteorological and dispersion modelling to predict potential construction odour impacts at nearby receptors
- Sensitivity analysis to understand the potential impact of a range of odour emission rates to assist in relation to identification of relevant mitigation and management approaches
- Development of this report.

3.2 Modelled construction scenarios

Two indicative construction scenarios were developed by Roads and Maritime to enable consideration from an odour perspective of different approaches to performing the work. These scenarios are identified as 'Scenario 1' and 'Scenario 2'. These are depicted in Figure 3-1 and Figure 3-2, respectively.

Scenario 1 assumes exposed waste across all of the total cut area and is considered the worst case. Scenario 2 assumes the majority of waste would remain covered and allows for a smaller proportion of exposed waste (termed the working cut area) than Scenario 1. Scenario 2 is considered a potentially realistic approach to the proposed works. Also, Scenario 2 assumes the total of the working cut areas accounts for no more than about 30 per cent of the total cut area, and that the works are completed progressively in this manner. Scenario 2 also assumes that all other portions of the total cut areas are effectively covered to limit the emission of odour.

The areas and volumes of material and waste to be excavated, handled and moved on-site have been calculated based on information developed for these two scenarios.

The scenarios identify the bulk earthworks required for construction works; specifically, the areas of cut (i.e. excavation) across the former Tempe landfill which may expose previously landfilled waste and/or require the relocation of waste material and potentially give rise to odour. Where waste material is encountered, it is proposed to be incorporated within newly constructed emplacement areas adjacent to the roadway.

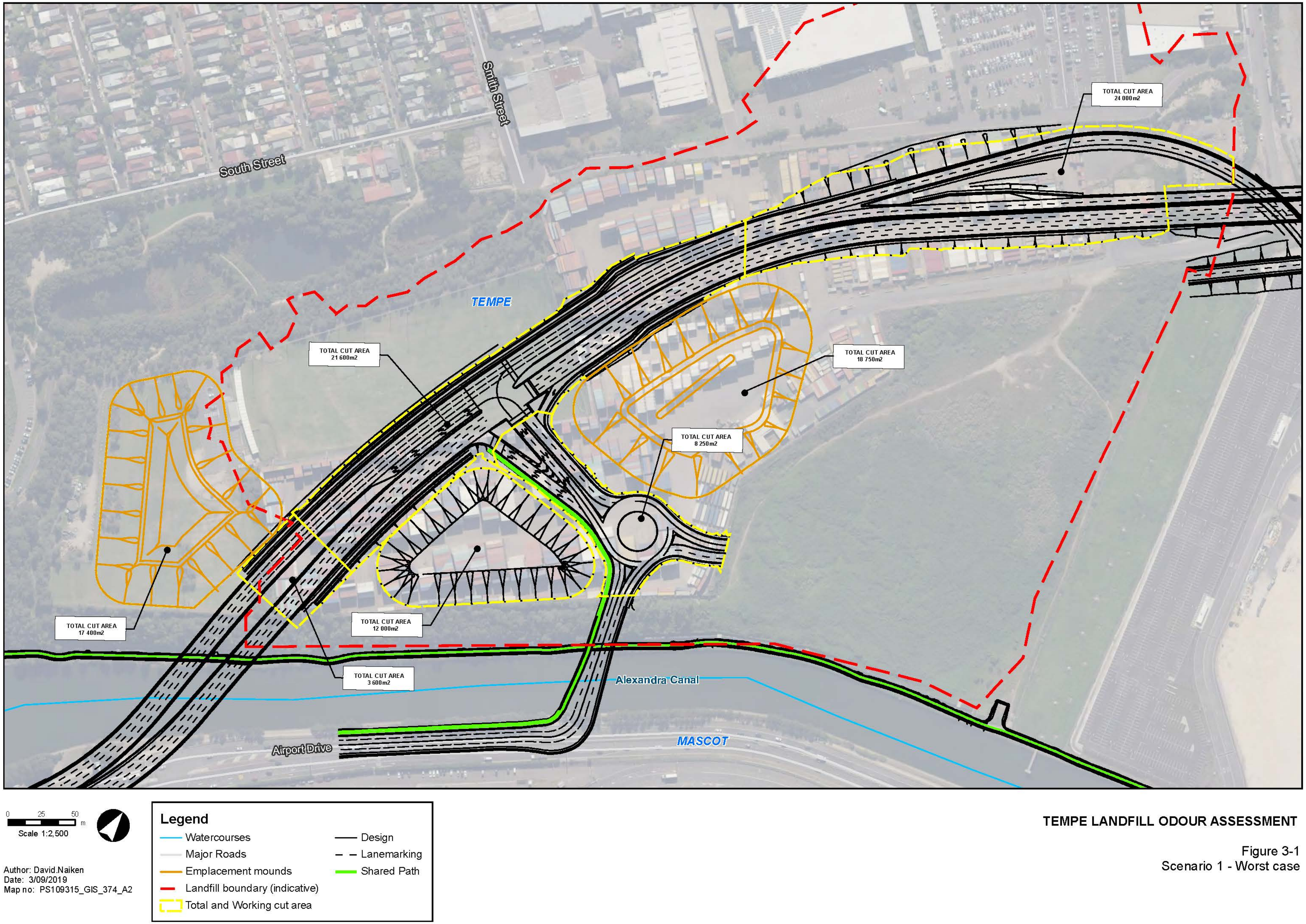
The working and total cut areas for both scenarios are provided in Table 3-1.

For both scenarios, the waste relocation works would generally be restricted to the standard hours proposed for the road project. Outside of these times, all waste is assumed either:

- To be covered with virgin excavated natural material (VENM) in the form of soil with a minimum cover depth of about 150 millimetres to supress the potential for odour emissions, or
- That the relevant mitigation measures detailed in section 6 are adopted.

Table 3-1 Scenario working and total cut areas

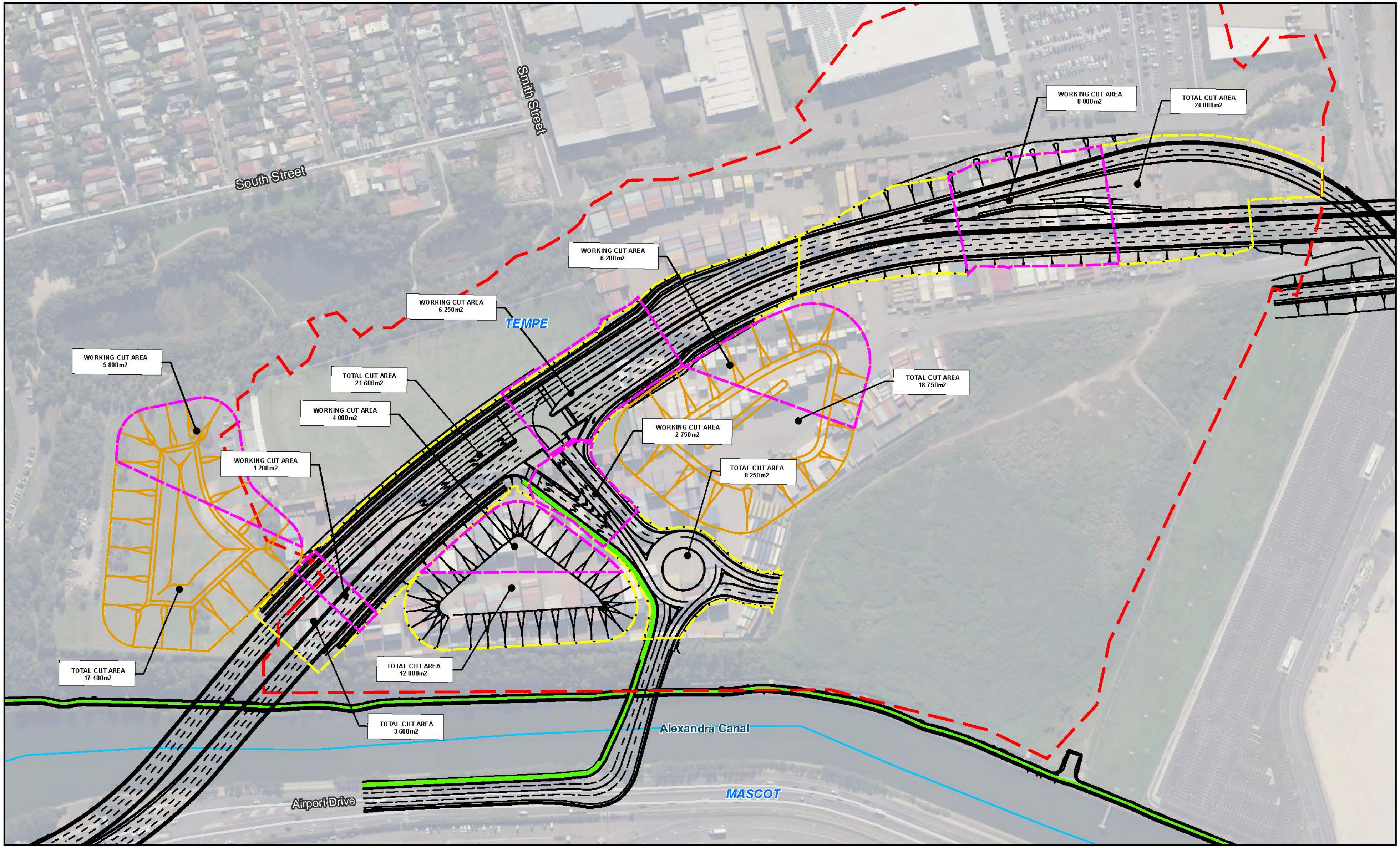
Scenario	Working cut area (m^2)	Total cut area (m^2)
1	Not applicable	105,600
2	34,200	105,600



Author: David.Naiken
Date: 3/09/2019
Map no: PS109315_GIS_374_A2

TEMPE LANDFILL ODOUR ASSESSMENT

Figure 3-1
Scenario 1 - Worst case



0 25 50 m
Scale 1:2,500

Author: David.Naiken
Date: 3/09/2019
Map no: PS109315_GIS_375_A2

Legend

- Major Roads
- Watercourses
- Emplacement mounds
- Landfill boundary (indicative)
- Working cut area
- Total cut area
- Design
- Lanemarking
- Shared Path

TEMPE LANDFILL ODOUR ASSESSMENT

Figure 3-2
Scenario 2 - Realistic

3.3 Preliminary waste composition analysis

A review was undertaken of the logs of 18 monitoring bores located within the proposed cut areas of the project, taking into account the design excavation levels. The purpose of this review was to gain an understanding of the waste types that would potentially be excavated and thereby guide the selection of the odour emission rates to be utilised for the assessment.

Bore logs taken from within the cut areas across the proposed road alignment are provided in Table 3-2. The material encountered has been divided into two categories:

- Material type 1: Soil fill with minor non-putrescible waste
- Material type 2: Non-putrescible and/or putrescible waste (as identified in Table 3-2).

Borehole locations have been bolded where the design excavation levels are expected to intercept material type 2 (waste). This is based on the 'design excavation level' intersecting the interval over which material type 2 (waste) was encountered or where the bores were not deep enough, and it was conservatively assumed that material type 2 (waste) could be encountered.

Based on the review, only one of the 18 bore log locations are likely to result in material type 2 (waste) being excavated and three of the 18 bore log locations could result in material type 2 (waste) being excavated:

- SG-BH-106: Approximately 1.7 m excavation depth into waste material (non-putrescible and putrescible waste), noting the lower 0.3 m depth extends beyond the bore depth (conservatively assumed to be putrescible waste)
- SG-BHTT-03sv: Approximately 1.4 m excavation depth into waste material (non-putrescible and putrescible waste)
- SG-BHTT-04sv: Approximately 1.4 m excavation depth into waste material (non-putrescible and putrescible waste), noting the lower 0.4 m depth extends beyond the bore depth (conservatively assumed to be putrescible waste)
- SG-BHTT-06sv: The bore depth does not extend beyond the cut depth, so it is conservatively assumed to be approximately 0.2 m excavation depth into waste material (conservatively assumed to be putrescible waste).

It is noted that three of the above locations (SG-BH-106, SG-BHTT-03sv and SG-BHTT-04sv) are in the northern part of the works and SG-BHTT-06sv in the south-western corner, where the most significant cut depths would occur.

Based on the data, it is expected that the majority of the earthworks would result in excavation of soil fill with minor non-putrescible waste (material type 1), with only a few locations of waste materials (material type 2) encountered.

Table 3-2 Selected bore log data within proposed cut areas

Bore ID	Approximate surface level (mAHD)	Design excavation level (mAHD)	Approximate base of bore (mAHD)	Interval of material type 1 (mAHD)	Interval of material type 2 (mAHD)
GW7	15.0	14.5	0.0	15.0 to 11.0	11.0 to base of bore (non-putrescible waste)
GW8	14.9	14.5	-0.9	14.9 to 13.4	13.4 to base of bore (non-putrescible waste)
GW8sv	14.9	14.5	9.3	14.9 to 12.1	12.1 to base of bore (non-putrescible waste)
GW9	12.3	9.2	1.6	12.3 to 8.3	8.3 to base of bore (non-putrescible and putrescible waste)
GW9sv	12.3	9.2	8.3	12.3 to 8.5	8.5 to base of bore (putrescible waste)
GW28A	15.0	14.5	0.0	15.0 to 13.5	13.5 to base of bore (non-putrescible and putrescible waste)
GW28Asv	15.0	14.5	11.0	15.0 to 13.5	13.5 to base of bore (non-putrescible waste)
SG-BH-102	14.9	14.5	10.5	14.9 to base of bore	Not encountered
SG-BH-103sv	12.9	10.9	7.9	12.9 to base of bore	Not encountered
SG-BH-106	**11.0**	**5.1**	**5.4**	**11.0 to 6.8**	**6.8 to base of bore (non-putrescible and putrescible waste)**
SG-BHTT-01sv	15.7	14.1	9.7	15.7 to base of bore	Not encountered
SG-BHTT-02sv	14.3	12.9	8.8	14.3 to base of bore	Not encountered
SG-BHTT-03sv	**10.7**	**3.3**	**-2.3**	**10.7 to 4.7**	**4.7 to base of bore (non-putrescible waste)**
SG-BHTT-04sv	**11.0**	**5.1**	**5.6**	**11.0 to 7.5**	**7.5 to base of bore (non-putrescible and putrescible waste)**
SG-BHTT-06sv	**13.8**	**9.5**	**9.7**	**13.8 to base of bore**	**Not encountered**
SG-BHTT-104sv	12.3	9.2	6.3	12.3 to base of bore	Not encountered
SG-EH-110	14.4	13.1	10.1	14.4 to base of bore	Not encountered
SG-EHTT-111	12.3	10.1	8.3	12.3 to base of bore	Not encountered

(1) Note: AHD – Australian Height Datum

3.4 Odour modelling

3.4.1 Dispersion modelling

Predicted odour impacts were modelled in accordance with the Approved Methods using an approved computer software model CALPUFF. CALPUFF is a non-steady-state, Gaussian puff dispersion model. It is accepted for use by the NSW EPA for application in environments where wind patterns and plume dispersion is strongly influenced by complex terrain, the land–sea interface or where there is a high frequency of stable, calm night-time conditions.

All CALPUFF model settings were selected based on the recommendations provided in 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* (J Barclay and J Scire, Atmospheric Studies Group TRC Environmental Corporation, 2011).

For this assessment, the CALPUFF dispersion model was used to predict ground-level 99th percentile one second averaged odour concentrations from the project, in accordance with odour modelling guidance supplied in the Approved Methods, noting PM60 application as described in section 2.2.

The grid size used in the CALPUFF model was equivalent to the CALMET domain (use of CALMET further discussed in section 3.4.2). The same grid resolution of 200 metres used for the CALMET model was used in CALPUFF.

The CALPUFF model utilised a construction time period greater than what is proposed for the project. This was done due to model limitations and results in conservative model predictions. The CALPUFF model considers construction activities occurring from 7am to 6pm seven days a week. Outside of these hours, it was assumed that there would be no construction activities and all excavated waste would be covered as discussed in section 3.2.

Odour emission rates utilised in the odour disposal modelling are detailed in section 3.5.

A sensitivity analysis of the potential odour emission rates utilised in the CALPUFF model was also undertaken. Tabulated results and contour plots present the results of this odour impact assessment. The results have been used to inform the odour mitigation strategy detailed in section 6.

3.4.2 Meteorology

Local meteorology including long term wind speed and direction, as well as atmospheric stability, influence how odourous substances are dispersed into the local environment.

Meteorology taken from the Sydney Airport AMO monitoring station (Bureau of Meteorology monitoring station ID: 66037) is considered to be conservative in relation to the localised wind climate at the site. The station is located close to the project site (approximately 2.2 kilometres south) and is expected to experience similar conditions to the project area. The site and Sydney Airport AMO are both exposed to winds from all directions and are likely to experience a large proportion of high wind speeds, which is consistent with monitoring undertaken at Sydney Airport AMO.

Site specific meteorology for the project was produced using a model called CALMET to produce a three-dimensional wind field which also takes into account local variations in the terrain. The CALMET simulation produced a 3D wind field for the modelled year. Prognostic data from the Air Pollution Model (TAPM) was used alongside observations taken at the Sydney Airport AMO (accessed 17 June 2019) as inputs into the CALMET model. A meteorological dataset of the 2016 calendar year was created. 2016 was chosen for the modelling year based on a review of the Technical Working Paper 4 - Air Quality Assessment (ERM, 2019). ERM reviewed numerous meteorological stations as part of the assessment and concluded that there was a high level of year-on-year consistency in the annual average wind speed and annual percentage of calms at each meteorological station. In order to be consistent with other technical studies undertaken for the road project, 2016 was adopted for this assessment also.

Details of the procedure undertaken to produce the site specific meteorology are provided in Appendix A.

3.5 Emission sources and estimates

3.5.1 General

Based on a review of the proposed construction works and historical site information, three sources of odour during the construction of the project were identified:

- Odour from exposed waste on working cut and emplacement areas (modelled as an area source)
- Odour from covered waste areas (modelled as an area source)
- Odour from disturbance and handling of waste, i.e. from plant and equipment performing cut and fill operations (modelled as a volume source).

A sensitivity analysis of potential higher odour emission rates was also undertaken (refer section 3.5.4).

The following were not included in the odour modelling:

- Odour from the landfill gas collection and venting system
- Odour from any water coming into contact with the exposed waste or encountered from excavating waste (leachate).

Mitigation measures are included in section 6 to reduce the risk of leachate resulting in odour impact.

Once construction works were completed, the working areas would be adequately capped to prevent future odour being released through the surface. No ongoing operational odour impacts are anticipated (as per the existing landfill) and therefore operational impacts are not discussed further in this report, other than a mitigation measure proposed in the event that the landfill gas venting system results in odour impacts. This is also considered unlikely based on site observations with the existing venting system.

3.5.2 Exposed and covered waste

The selection of odour emission rates for this assessment takes into account that the waste at the former Tempe landfill includes a mixture of different waste types and age.

The preliminary waste composition analysis in section 3.3 identified that of the 19 boreholes reviewed, 15 indicated that non-putrescible waste only would be at the depths to be excavated, and there were potentially only four boreholes in which putrescible waste would be disturbed. Three of these four boreholes are located in the north-eastern section of the site and one borehole is located to the south of the site, near Alexandra Canal. A majority of the excavations would be within non-putrescible waste (material type 1), with only a few locations where putrescible waste would likely encountered at depth. Non-putrescible waste is less odorous than putrescible waste.

Reference was made to an in-house database of odour emission rates from various landfills in NSW (putrescible and non-putrescible). Utilising this database, potential odour emissions were reviewed and are summarised in Table 3-3.

Table 3-3 Review of database odour emission rates

Odour source	Non-putrescible NSW landfill	Putrescible NSW landfill
Waste received from source and placed on the day of receipt (tipping face) and measured off the placed surface	0.25 $OU/m^2/s$	3 $OU/m^2/s$
Tipping face with VENM cover up to 150 mm thick	0.03 $OU/m^2/s$	0.03 $OU/m^2/s$
Tipping face measured while waste is being placed (up wind, downwind)	N/A	26 $OU/m^2/s$
Previously landfilled waste (exposed waste via cover material removal)	0.38 $OU/m^2/s$	1 $OU/m^2/s$

Based on the above, an exposed waste odour emission rate of 1 $OU/m^2/s$ was adopted for this assessment for exposed waste. This odour emission rate is based on exposed previously landfilled putrescible waste and is considered conservative, as the bore logs indicate that mostly soils and some non-putrescible waste would be excavated and exposed which are expected to be less odorous than this adopted emission rate.

During the proposed works, previously landfilled waste that is exposed and / or relocated would subsequently be covered with VENM at the end of each day's construction activities (unless otherwise managed in accordance with the mitigation measures in section 6). As no direct measurements at other sites were available which reflect this situation, an emission rate was estimated.

A review of the odour database identified recently placed non-putrescible and putrescible waste covered with at least 150 mm of VENM had the same odour emission rate (0.03 $OU/m^2/s$). However the ratio between odour emission rates at the tipping face and tipping face covered with VENM were different for non-putrescible and putrescible landfills. For non-putrescible landfills this ratio was 0.12 (0.03/0.25). For putrescible landfills this ratio was 0.01 (0.03/3). To estimate odour emissions from previously landfilled waste subsequently exposed and covered with VENM, GHD conservatively assumed the odour emission rate would be characterised by the greater of the two ratios. This results in an estimated odour emission rate from covered waste of 0.12 $OU/m^2/s$ (0.12*1 $OU/m^2/s$) being adopted.

This is also considered conservative, as it is based on odour samples at a putrescible landfill tipping face where the putrescible waste was recently placed and covered with at least 150 mm of VENM were measured as 0.03 $OU/m^2/s$.

3.5.3 Disturbed waste

The other significant potential source of odour emissions is from equipment disturbing, moving and relocating waste between cut and fill areas of the site. Waste which is being moved may have high odour emission rates, but be contained within a small area. In order to model these, an emissions rate from a putrescible landfill tipping face (where waste is being placed) has been assumed to be appropriate. This includes trucks releasing waste, and compactors and bulldozers moving waste around.

An assumed odour emission rate of 26 $OU/m^2/s$ has been used to model waste disturbance and handling. This emission rate was based on odour sampling at a tipping face of a putrescible waste facility in NSW.

The following assumptions were used to calculate odour emission rates:

- Odour emissions from waste disturbance and handling are provided in Table 3-4
- Once waste has been has been loaded into haul trucks, it has been assumed the trucks would be covered prior to waste transportation. Odour emissions from uncovered haul trucks have not been allowed for in the dispersion modelling.

To model the odour source as a volume source, the total cut required was averaged across an estimated project duration of six months (considering the proposed working hours). Should the works extend beyond this time, this assumption is conservative.

Table 3-4 Waste disturbance and handling odour emissions

Item	Value	Units	Assumptions
Total waste moved	100,000	m^3	Approximate
Working hours	40	hours/week	Conservative estimate for waste movements
Weeks	4	weeks/month	
Project duration	6	months	
Waste moved per hour	104	m^3/hour	
Disturbed waste sources	5	Sources per scenario	Assumed maximum five disturbed waste locations at any one time (for waste movement)
Volume of each source	21	m^3/h/source	
Source footprint area	21	m^2	Based on a one metre cut/fill depth per hour
Volume source footprint dimensions	4.6	m	Square footprint – 4.6 each side

The derived odour emissions inventory including Specific Odour Emission Rates (SOER) and Odour Emission Rates (OER) for Scenario 1 and Scenario 2 is provided in Table 3-5 and Table 3-6. These odour emission rates were adopted in the CALPUFF dispersion model. They are termed the 'base case' in this report.

Table 3-5 Scenario 1 odour emissions inventory

Item	Source type	Active hours	Area (m^2)	SOER ($OU/m^2/s$)	OER (OU/s)	Data source
Waste disturbance and handling	Volume	7am to 6pm	104[1]	26	2,708	Putrescible NSW landfill odour sampling – up wind/downwind concentration analysis for tip face
Exposed waste	Area	7am to 6pm	105,600	1	105,600	Putrescible NSW landfill odour sampling – exposed waste via cover material removal
Covered waste	Area	6pm to 7am	105,600	0.12	12,672	Non-putrescible NSW landfill odour sampling – scaled off ratio of tip face to waste under cover material

Note 1: Waste disturbance and handling shown in waste moved per hour (m^3/hour)

Table 3-6 Scenario 2 odour emissions inventory

Item	Source type	Active hours	Area (m^2)	SOER ($OU/m^2/s$)	OER (OU/s)	Data source
Waste disturbance and handling	Volume	7am to 6pm	1041	26	2,708	Putrescible NSW landfill odour sampling – up wind/downwind concentration analysis for tip face
Exposed waste	Area	7am to 6pm	34,200	1	34,200	Putrescible NSW landfill odour sampling – exposed waste via cover material removal
Covered waste	Area	7am to 6pm	71,400	0.12	5,976	Non-putrescible NSW landfill odour sampling – scaled off ratio of tip face to tip face with daily cover material
Covered waste	Area	6pm to 7am	105,600	0.12	12,672	Non-putrescible NSW landfill odour sampling – scaled off ratio of tip face to waste under cover material

(1) Waste disturbance and handling shown in waste moved per hour (m^3/hour)

3.5.4 Sensitivity analysis

In lieu of site-specific odour sampling to verify the adopted odour emission rates, a sensitivity analysis was undertaken. The sensitivity analysis multiplied the SOER adopted for exposed waste (shown in Table 3-5 and Table 3-6) by 0.5, 2 and 3. These multipliers are referred to as sensitivity factors. Three additional model runs were undertaken as part of the sensitivity analysis. The sensitivity analysis considered the following adjustments to the adopted odour emission rates:

- 0.5 OU/m^2/s as an assumed odour emission rate for construction and demolition waste exposed in the proposed works (assumed lowest level for modelling and still conservatively higher than sampling at a non-putrescible landfill) (sensitivity factor of 0.5)
- 2 OU/m^2/s as an assumed odour emission rate for areas scraped back to putrescible waste (assumed level for sensitivity analysis) (sensitivity factor of 2)
- 3 OU/m^2/s as an assumed odour emission rate for areas which may have odour as high as recently placed putrescible waste (considered highest value for sensitivity analysis) (sensitivity factor of 3).

The above range of source odour emission rates enables the consideration of a range of indicative odour impacts, which was used to inform the recommended mitigation strategies.

The odour emission rate for areas of exposed waste that is covered has not been changed in the sensitivity analysis as there is low potential for considerable odour from covered waste.

Similarly, the volumetric odour emission rate is considered to be a higher rate based on measurements from putrescible waste and conservatively was not changed as part of the sensitivity analysis.

Odour mitigation strategies would be dependent on the source odour concentrations, the scale of the construction activities and the weather conditions.

4. Existing environment

4.1 Air quality

The Department of the Environment and Energy's National Pollution Inventory (NPI) provides public information about emissions in specific regions of Australia. The NPI is implemented and enforced by the NSW EPA. The National Environment Protection (National Pollutant Inventory) Measure 1998 requires industrial facilities in NSW to report the types and amount of certain substances being emitted. This information is collated and uploaded in the NPI database.

A review of the NPI database (accessed on 20 June 2019) was undertaken to identify nearby sources of air quality pollutants. Five pollutant emitting facilities were identified within a three kilometre radius of the project site:

- Viva Energy Sydney Airport
- Sydney (Kingsford Smith) Airport
- Qantas Sydney
- Sydney Trains Sydenham Maintenance Centre
- Alexandria Asphalt Plant.

A review of the emissions reports of each facility was undertaken and no significant odour emissions with a similar odour character were identified in the surrounding area. During the site visit in May 2019, odours from the airport (aviation fuel) were observed, with a different odour character to landfill waste or landfill gas.

4.2 Sensitive receptors

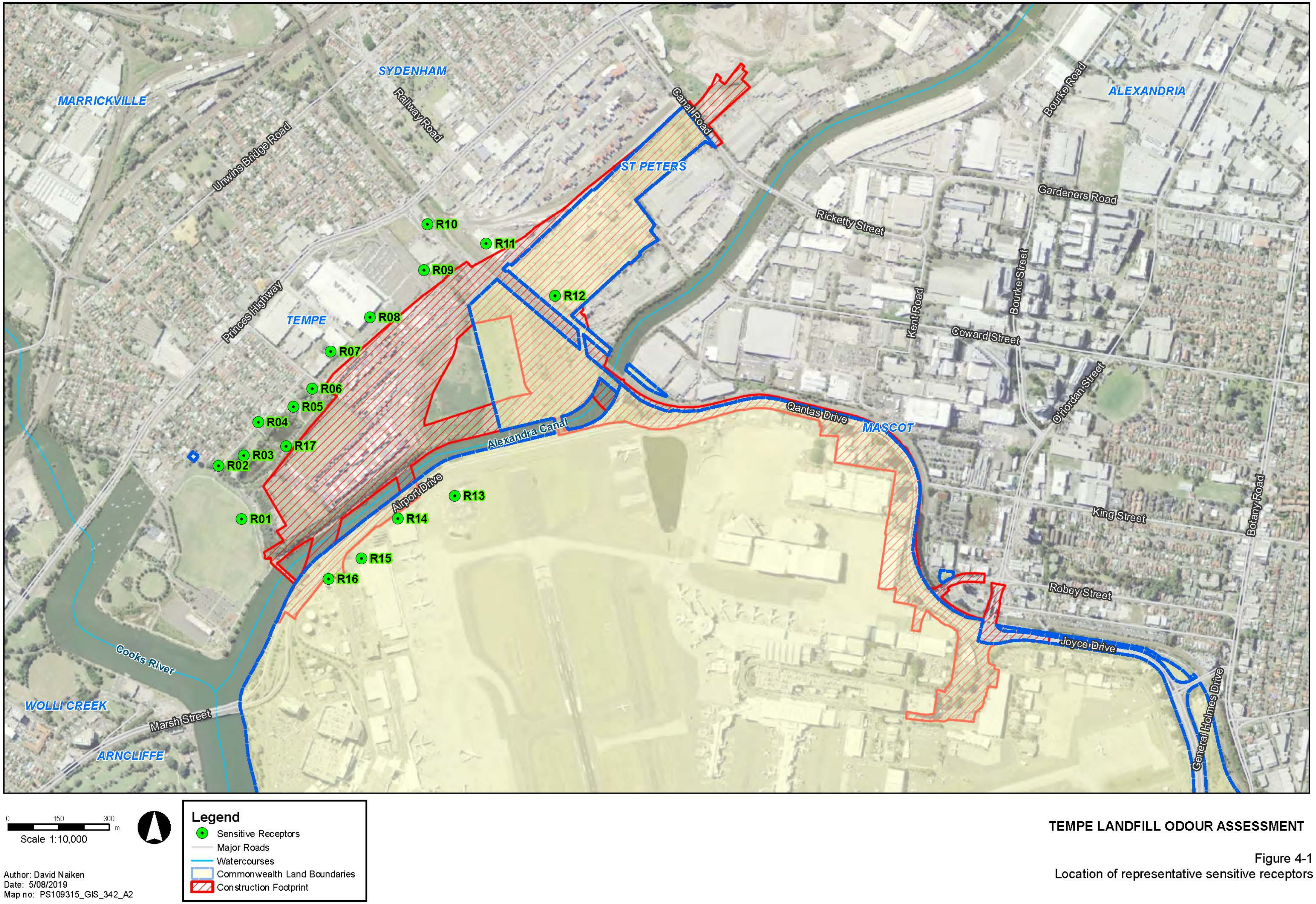
The Approved Methods defines sensitive receptors as locations where people are likely to work or reside and may include a dwelling, school, hospital, office or recreation areas.

Due to the extent of the project, there are many nearby sensitive receptors. Rather than identifying all sensitive receptors, representative receptors closest to the former Tempe landfill in various directions have been selected. It is expected that the closest receptors would experience the worst-case odour impacts. If potential odour impacts from the project comply with the adopted assessment criteria at the nearest receptors, then those situated at a greater distance would also comply. Contour maps of predicted odour emissions indicate the results for all selected receptors within the project area.

The locations of the representative sensitive receptors relative to the site are presented in Table 4-1 with universal transverse mercator coordinates, receptor type and address. The locations of representative sensitive receptors in the study area are shown in Figure 4-1.

Table 4-1 Representative sensitive receptor locations

Receptor ID	Easting	Northing	Receptor type	Address
R01	330134	6244224	Recreational	Tempe Recreation Reserve, Tempe
R02	330065	6244382	Residential	2 Station Street, Tempe
R03	330140	6244413	Residential	South Street, Tempe
R04	330183	6244511	Residential	5 Wentworth Street, Tempe
R05	330287	6244557	Residential	5 South Street, Tempe
R06	330343	6244610	Vacant lot	2 South Street, Tempe
R07	330398	6244720	Commercial – Brissett Rollers	6 Wood Street, Tempe
R08	330515	6244822	Commercial – IKEA	634–726 Princes Highway, Tempe
R09	330674	6244962	Commercial – Salvos Stores	7 Bellevue Street, Tempe
R10	330685	6245098	Residential	3 Bellevue Street, Tempe
R11	330859	6245040	Industrial – Maritime Container Services	20 Canal Road, St Peters
R12	331064	6244886	Industrial – Boral Recycling	25 Burrows Road, St Peters
R13	330766	6244293	Commercial – Sydney Airport	Airport Drive, Mascot
R14	330597	6244226	Commercial – Atlas Air Inc building	Airport Drive, Mascot
R15	330489	6244107	Commercial – Qantas Freight Terminal	Airport Drive, Mascot
R16	330391	6244047	Commercial – C & L Sales & Services	258 Link Road, Mascot
R17	330266	6244441	Recreational	Tempe Wetlands, Tempe



Author: David Naiken
Date: 5/08/2019
Map no: PS109315_GIS_342_A2

TEMPE LANDFILL ODOUR ASSESSMENT

Figure 4-1
Location of representative sensitive receptors

5. Impact assessment

5.1 Predicted odour concentrations (all hours)

Predicted odour concentrations at each receptor for Scenario 1 and 2 are provided in Table 5-1. This table includes the results of the sensitivity analysis. An odour assessment criterion of 2 OU was adopted (as outlined in section 2.2). Predicted exceedances of the assessment criteria are shaded in Table 5-1.

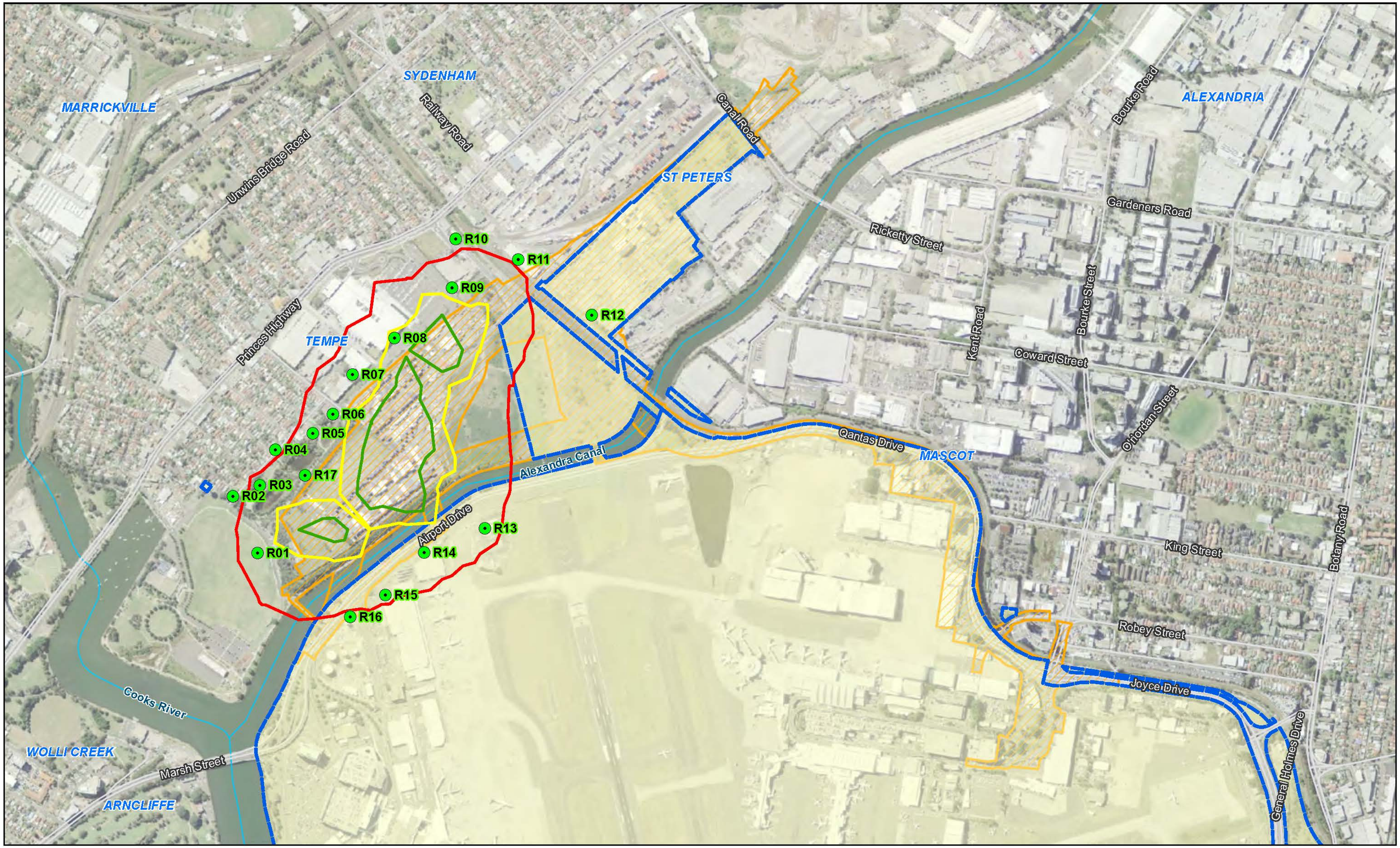
The analysis predicted exceedances of 2 OU at two or more receptors for Scenario 1 for all assessed odour emission rates. Only one potential exceedance at the Tempe Wetlands (R17) was predicted for Scenario 2 for the base case. No odour assessment criterion exceedances were predicted during Scenario 2 for sensitivity factors of 0.5. The highest potentially impacted receptor was identified to be R08 (IKEA) for Scenario 1 sensitivity factors and a sensitivity factor of 0.5 for Scenario 2.

Odour modelling has also identified times of worst case odour dispersion during the daytime period as the morning period (7am to 9am) and the afternoon (4pm to 6pm). These are times when higher odour impacts are predicted to most often occur due to weather conditions, although this does not mean they cannot occur at any time of the day.

The predicted odour dispersion plots are shown in Figure 5-1 and Figure 5-2 for the base case for Scenarios 1 and 2, respectively.

Table 5-1 Predicted odour concentrations and sensitivity analysis (99th percentile)

Base case and odour source sensitivity factor	Base case (1.0)		0.5		2.0		3.0	
Scenario	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Criteria (OU)	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
R01	2.8	1.5	1.6	1.2	5.2	2.4	7.8	3.4
R02	1.5	0.8	0.9	0.7	2.8	1.4	4.2	1.9
R03	2.3	1.4	1.3	1.0	4.4	2.2	6.5	3.0
R04	1.7	0.9	1.0	0.7	3.2	1.5	4.7	2.1
R05	2.6	1.4	1.5	1.1	5.0	2.3	7.5	3.3
R06	3.3	1.9	1.8	1.3	6.4	3.3	9.5	4.7
R07	3.1	1.5	1.7	1.2	5.9	2.4	8.8	3.4
R08	4.1	2.0	2.3	1.5	8.0	3.3	11.8	4.8
R09	3.7	1.9	2.2	1.4	7.0	3.0	10.5	4.2
R10	1.4	0.8	0.9	0.6	2.8	1.3	4.1	1.8
R11	1.8	1.0	1.2	0.9	3.1	1.3	4.6	1.5
R12	0.8	0.5	0.5	0.5	1.5	0.6	2.2	0.8
R13	2.4	1.1	1.3	0.9	4.6	1.6	7.0	2.1
R14	3.2	1.6	1.8	1.4	6.3	2.4	9.4	3.2
R15	2.2	1.1	1.3	1.0	4.2	1.4	6.2	1.9
R16	1.8	1.0	1.2	0.9	3.4	1.2	5.0	1.5
R17	3.5	2.1	2.0	1.4	6.8	3.5	10.2	4.9



0 150 300 m

Scale 1:10,000

Author: David Naiken
Date: 5/08/2019
Map no: PS109315_GIS_343_A2

Legend

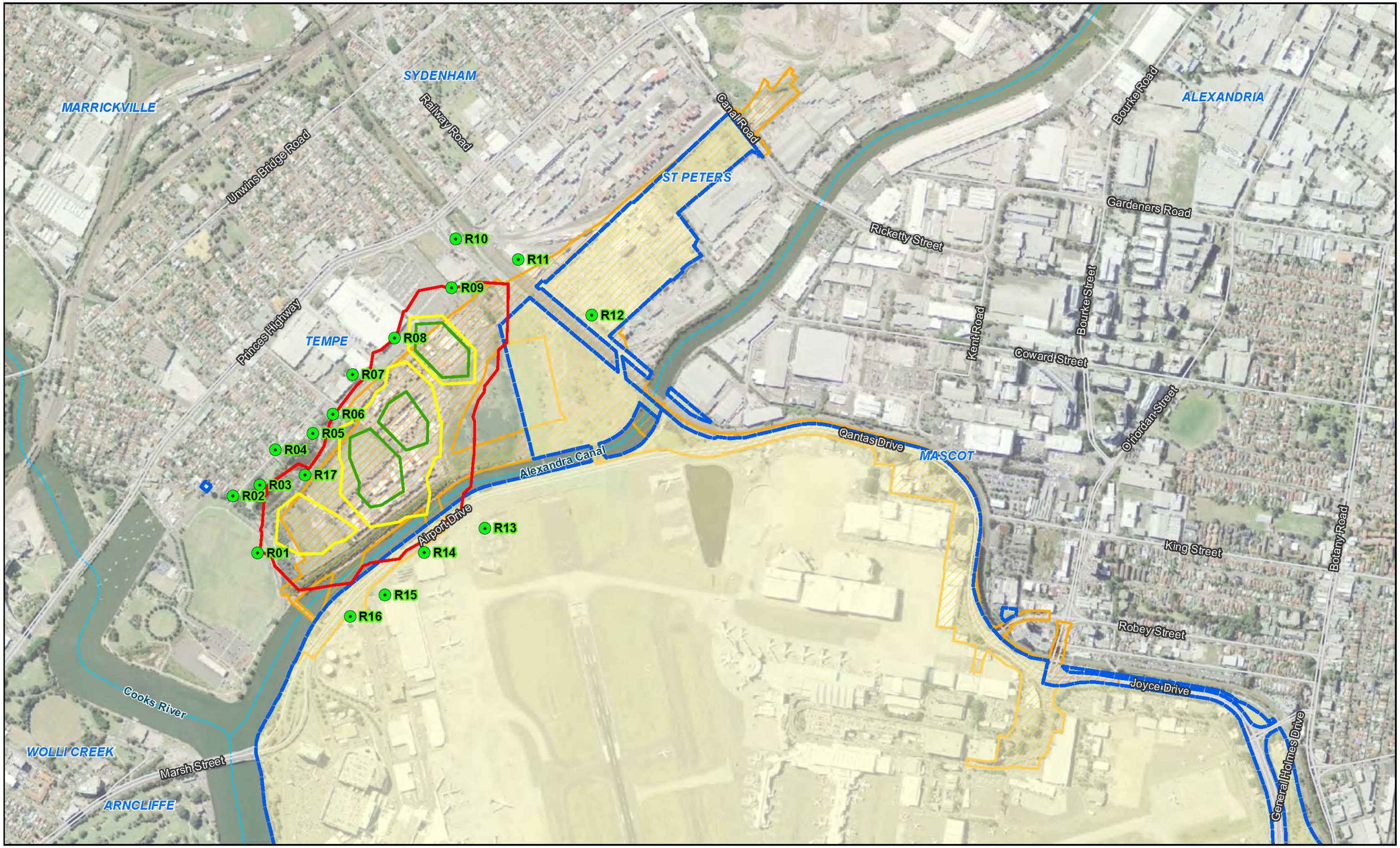
- Sensitive Receptors
- Major Roads
- Watercourse
- Commonwealth Land Boundaries
- Construction Footprint

Contour Level

- 2
- 10
- 20

TEMPE LANDFILL ODOUR ASSESSMENT

Figure 5-1
Predicted Odour Concentration during Scenario 1 (OU, 99th Percentile)



0 150 300 m
Scale 1:10,000

Author: David Naiken
Date: 5/08/2019
Map no: PS109315_GIS_344_A2

Legend

- Sensitive Receptors
- Major Roads
- Watercourse
- Commonwealth Land Boundaries
- Construction Footprint

Contour Level

- 2
- 5
- 10

TEMPE LANDFILL ODOUR ASSESSMENT

Figure 5-2
Predicted Odour Concentration during Scenario 2 (OU, 99th Percentile)

5.2 Predicted odour concentrations during the night time

The predicted odour impacts between 6pm and 7am for Scenario 2 were investigated to assess the odour impacts from areas assumed to be covered at the end of each work shift.

The predicted 99th percentile odour concentrations for hours between 6pm and 7am have been calculated for all receptors in Table 5-2. No exceedances of the 2 OU criterion are predicted during the night-time period when the only odour sources are assumed to be covered cut and fill areas.

Should works be proposed to be undertaken at night (between 6pm and 7am), mitigation measures are detailed in section 6.

Table 5-2 Predicted overnight odour concentrations for Scenario 2

Receptor	Odour concentration (99th percentile)
R01	1.3
R02	0.7
R03	0.9
R04	0.8
R05	1.1
R06	1.3
R07	1.3
R08	1.5
R09	1.6
R10	0.7
R11	1.3
R12	0.5
R13	1.1
R14	1.6
R15	1.2
R16	1.1
R17	1.3

5.3 Impacts on Sydney Airport (Commonwealth) land

Receptors R12 to R16 are located on Commonwealth land. Odour concentrations are predicted to comply with the odour assessment criterion at all of these receptors during Scenario 2 for the base case.

Exceedances of the odour assessment criterion within the construction footprint are predicted to occur over a small portion of Commonwealth Sydney Airport land south of Swamp Road, at the northern end of the High Intensity Approach Lights and along Airport Drive adjacent to the international freight terminal for Scenario 2. Significant impacts on these or other parts of Commonwealth Sydney Airport land are not predicted for Scenario 2 for the base case.

6. Recommended mitigation measures

6.1 Approach

An odour modelling study has been completed and indicates compliance can be achieved under certain working conditions, consistent with a number of assumptions made. Key to these are the area of waste exposed, the period of exposure and ambient meteorological conditions. As discussed in this report, the applied odour emission rates are based on desktop information and assumed working methods that are subject to confirmation once a construction contractor is appointed. Mitigation and management measures to reduce the potential for odour impact are provided in Table 6-3 and include the development of an odour management strategy. The aim of the odour management strategy is to guide the completion of pre-construction investigations and identify the work methods to be implemented to ensure compliance with the odour criteria is achieved and any exceedances of the odour criteria are minimised, rapidly identified and effectively resolved.

The odour management strategy would involve:

- Conduct of odour emission sampling of the waste that will be exposed to verify the odour emission rates likely to be encountered
- Detailed construction planning to determine the proposed methods and activities to minimise the potential for emissions of odour
- Update of the odour modelling based on the above information to confirm the odour impact predictions and refine the mitigation measures required to avoid exceedances of the criterion. This would also involve updating the landfill water balance to disposal measures for leachate so that it does not become an additional odour source
- Confirmation of the necessary approach to the construction work and mitigation measures that would be employed as well as other complementary procedures to confirm compliance of the works and actions to be taken in response to any offsite offensive odour events or complaints.

Further details of the odour management strategy activities are outlined below.

6.2 Odour management strategy

The overarching intent of the odour management strategy would be to devise the means by which the project would be constructed so as to protect receivers from landfill odours during construction. This would include the mitigation measures necessary to ensure the odour assessment criterion of 2 OU is not exceeded at all off site sensitive receptors.

The strategy would also identify the steps to be taken in case odour impacts are observed at receptors, including any mitigation measures not mentioned in this report in order to comply with the 2 OU assessment criterion under all circumstances. Examples might include the use of odour eliminator sprays (or deodorisers) as a short term means of reducing odour.

Pre-construction odour sampling at the site should be used to further inform the potential for odour impacts during construction and the necessary mitigation measures. Sampled odour concentrations should be compared with the SOERs assumed in this assessment. Should the site-measured SOERs be greater than those used in this assessment (for the Scenario 2 base case), revised odour modelling should be undertaken to guide detailed construction planning and the identification of appropriate mitigation measures.

The odour sampling should be based on exposed waste and using a flux chamber (over static exposed waste) with upwind and downwind measurements (for immediately relocated waste) to measure the SOERs for representative waste samples. The sample numbers and locations should be guided by the available bore logs within the area where waste would be disturbed.

When developing the odour management strategy, the contractor should also address the potential for leachate to arise and to develop measures to ensure it does not become a significant source of odour. The working areas would need to be effectively dewatered before excavating into the waste to reduce the risk of leachate being encountered. The other potential source of leachate is from stormwater coming into contact with the exposed or relocated waste. In both of these situations, the leachate should not be allowed to be exposed to air for a duration which may result in an odour nuisance.

Before commencing the construction works, the contractor should update the leachate water balance to reflect their detailed construction methodology. One aim of the water balance would be to document the measures to prevent leachate being exposed to the air and that may create an odour nuisance off-site.

The odour modelling performed in the combined EIS/preliminary draft MDP would be updated to include the site-specific information gained from the above activities, including the proposed work methods and mitigation measures to ascertain the level of compliance likely to be achieved. The mitigation measures necessary to ensure compliance with the odour criteria would be implemented as part of the air quality management plan of the CEMP.

The following steps should be followed to guide the planning of construction works or identified exceedances during construction from the perspective of minimising potential odour occurrence.

6.2.1 Step 1 – Meteorology review and monitoring

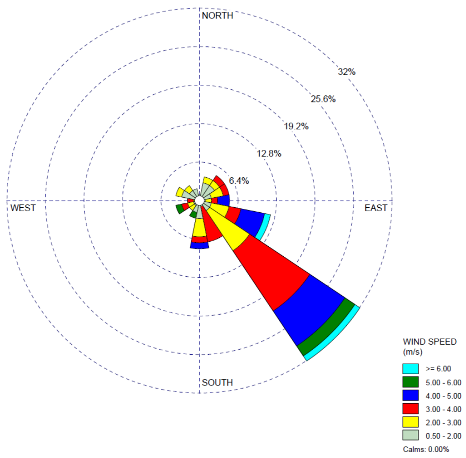
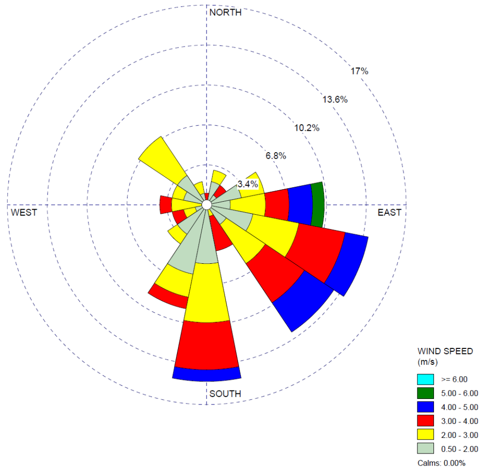
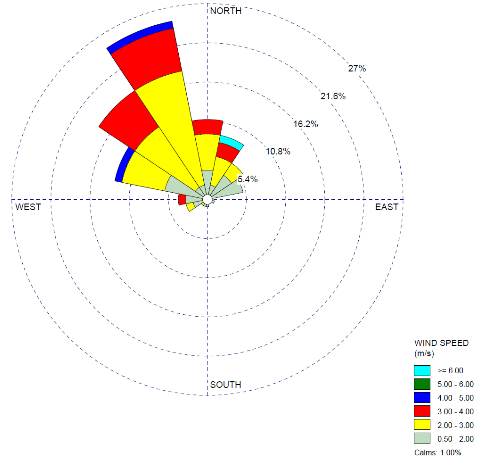
Limiting or altering the construction work methodology during worst case meteorological conditions can significantly reduce the potential for odour impacts on nearby receptors. An understanding of current weather conditions during construction would help identify which direction odours are likely to disperse in and identify which receptors are likely to be impacted by elevated odour. Analysing the modelling data would also identify which weather conditions are most likely to cause elevated odour impacts at each receptor.

An analysis of the meteorological conditions that produce worst case odour impacts was undertaken for three receptors, R06 (2 South Street), R08 (IKEA – higher commercial) and R14 (Sydney Airport) for Scenario 2. The analysis examined the meteorology of the 100 hours that resulted in the worst impacts for each receptor. An analysis of the meteorological conditions including wind roses is provided in Table 6-1.

The average wind speed that produces the worst case impacts (2.9, 2.4 and 2.3 m/s respectively) is significantly lower than the site average wind speed (4.7 m/s). Wind directions that result in worst case impacts are shown by the wind roses in Table 6-1. Therefore, meteorological conditions that result in potentially higher impacts are consistent: low wind speeds blowing in the direction of the receptor.

A daily review of Sydney Airport AMO meteorology should be undertaken before construction activities commence in the morning and mid-afternoon to anticipate the likely locations of worst case odour impacts. This meteorology review would inform the odour survey (discussed in section 6.2.2) to identify which receptors are likely to experience odour impacts.

Table 6-1 Worst case meteorological analysis (Scenario 2, worst case 100 hours)

Item	R06 (residential)	R08 (IKEA-commercial)	R14 (Sydney Airport)
Weather conditions leading to maximum odour impact			
Worst case wind speed and direction	Wind speed: 0.5–4 m/s Wind direction: 110–160º	Wind speed: 0.5–4 m/s Wind direction: 80º–210º	Wind speed: 0.5–4 m/s Wind direction: 280º–350º
Time of day that higher impacts may occur	Afternoon (4–5pm) accounts for 47% of worst case meteorology (17% at 4pm, 30% at 5pm)	Afternoon (4–5pm) accounts for 37% of worst case meteorology (8% at 4pm, 29% at 5pm)	Morning (midnight – 8am) accounts for 57% of worst case meteorology (23% at 7am)
Average wind speed (m/s)	2.9	2.4	2.3
Monitoring requirements	Odour investigation to be undertaken along South Street	Odour investigation to be undertaken outside IKEA and eastern end of South Street	Odour investigation to be undertaken along Airport Drive and Link Road near Terminal 1 freight terminal

6.2.2 Step 2 – Odour surveys at downwind receivers

Scheduled odour surveys should be undertaken as part of the construction works to identify and reduce potential odour impacts. The odour surveys should involve a site boundary and sensitive receptor 'walk through' to assess if mitigation measures are required to reduce odour impacts. The location of the odour survey should be at potentially impacted receptors as determined by the weather conditions at the time of the survey.

Field odour surveys should be undertaken daily as follows:

- When construction activities commence in the morning for at least one hour
- For at least one hour before construction activities cease in the afternoon
- If wind speeds at the former Tempe landfill drop below 3 m/s.

The field odour surveys should focus on downwind areas from all construction areas. Additional surveys should be undertaken if source odour levels are observed to be higher than usual, or when work commences in a new part of the site.

Field odour surveys should also be undertaken upon receipt of a validated odour complaint, as soon as practicable.

Odour surveys would be undertaken by at least two people, trained and certified as per the requirements of AS 4323.3. A field survey plan would be developed by an experienced professional, tailored for use by the contractor's environmental officers.

The approach used for field odour survey should be based on the German Standard *Determination of odorants in ambient air by field inspection* (VDI 3940, 1993). A useful scale for describing odour intensity during field observations is detailed in German Standard VDI 3882 (I) 1992: *Olfactometry Determination of Odour Intensity*. It is acknowledged that regular field surveys or observations may not need to be compliant with these methods due to the excessive rigour involved, but it is important that a trained and certified person prepares the site specific field odour survey plan.

6.2.3 Step 3 – Identify source of odour

It is anticipated that the majority of odour impacts at receptors would originate from the closest working cut and fill areas. Consequently, identification of the primary odour source causing the elevated odour emissions is a vital part of mitigating odour impacts at the receptor.

If the odour survey identifies elevated odour concentrations at the receptors, the location of the primary odour source causing the elevated odour concentrations should be identified. The primary source can be identified based on a review of live weather conditions taken from the Sydney Airport AMO weather station. For example, if odour is identified at R08 (IKEA, commercial receptor located north of the site) and westerly winds (blowing from east to the west) are observed at Sydney Airport AMO, the primary odour source would be working cut areas to the east of R08. Consequently, mitigation measures should be applied to the identified primary odour source to reduce the odour impacts at receptors.

Any areas which are identified to be the potential source of high odour should be investigated, in order to gain an appreciation of the site activities, areas and sources which may be the cause of elevated source odour. This should then be used to identify appropriate odour mitigation (discussed in section 6.2.4).

6.2.4 Step 4 – Reduce source odour

Reducing or managing the source odour emissions can reduce impacts at nearby sensitive receptors. Any odour management or specific mitigation should be undertaken once it has been established to be an issue and the source of odour has been identified. Odour mitigation may include the following:

- Minimising the size of the working cut or fill area of exposed waste to mitigate odour impacts from the identified primary odour source
- Stopping or moving odour generating activities to a different area during worst-case weather conditions if they are causing odour impacts at receptors
- Removing leachate should it pool at the site and become a significant odour source
- Planning to undertake works in known odorous areas outside poor weather conditions for odour dispersion
- Using odour eliminator (deodoriser) sprays or similar where necessary
- Covering all trucks transporting odorous excavated material to reduce odour emissions.

The primary odour source would likely be the nearest construction area onsite identified to be contributing substantial odour.

Compliance with the odour assessment criteria can be achieved by a combination of the above source odour reduction measures. The combination and magnitude of the source odour reduction measures implemented is subject to the contractor's discretion as long as compliance with the odour assessment criteria is achieved. During construction, verification of the effectiveness of the source odour reduction techniques implemented should be undertaken via odour surveys to ensure compliance with the odour assessment criteria.

The odour management actions that should be implemented during construction of the project are summarised in Table 6-2.

Table 6-2 Odour management actions

Step	Action	Comment
1	Daily review of weather conditions using live Sydney Airport AMO data from BoM	Refer to section 6.2.1 to understand which wind directions and speeds are likely to cause odour impacts for key receptors.
2	Undertake field odour surveys at downwind receptors	Refer to section 6.2.2 for details on suggested times and approach to field odour surveys to prevent and provide a rapid means of identifying any odour off site.
3	If odour is detected from a field survey, identify which work area onsite (primary odour source) is the main source of odour leading to odour at the receptor	Modelling shows that the highest source of odour at any receptor would generally originate from one distinct area on site. This would likely be directly upwind from the receptor experiencing elevated odour.
4	Reduce source odour by reducing scale of exposed waste (or other odour sources) in an identified construction work area	Refer to section 5.1 for results of sensitivity testing and guidance on potential odour reductions needed in various receptor locations. At any time, a deodoriser/neutralising system could also be implemented, if needed, in accordance with the manufacturer's specifications, to help mitigate the potential for odour impacts. Section 6.2 and Technical Working Paper 16 – Landfill Assessment provides further guidance on managing leachate odour.

6.3 Night time construction works

Should construction works be proposed between the hours of 6pm and 7am, there is a higher risk of not meeting the odour impact assessment criterion due to less favourable meteorological conditions. The mitigation measures for any proposed night-time work periods may involve containing the works area within a building, employing a negative pressure atmosphere and treating the air before it is discharged. However, alternative mitigation measures may also be able to be adopted so the project could meet the odour impact assessment criteria; these should be confirmed via revised odour modelling as indicated in the odour management strategy.

6.4 Communication and consultation

The contractor should discuss the potential for odour impacts with the local community and individuals who may experience odour at some time during construction works, including at least those indicated in this assessment. It is important to keep the local community informed about the construction methodology and mitigation measures that would be implemented to manage potential odour impacts, as required.

6.5 Complaints management

An odour complaints management procedure should be developed as part of the broader complaints management procedures in the CEMP to ensure that any complaints regarding odour are received by appropriate site personnel and that potential issues can be investigated and site practices adjusted accordingly.

6.6 Recommended mitigation measures

Table 6-3 provides an overview of the recommended mitigation measures to be implemented to minimise the potential for exceedances of the odour assessment criterion to occur during the project. These are in addition to the assumptions adopted for Scenario 2 (base case).

Table 6-3 List of mitigation measures – odour

Mitigation measure	Timing
Detailed design and construction planning would seek to minimise emissions of odour by: ▪ Minimising the need to expose waste, where practical, and the area exposed at any time ▪ Emissions sampling to identify and verify the potential emissions rates from all likely odour sources ▪ Ensuring means to achieve effective reduction in odour emissions during working and non-working periods ▪ Modelling of odour based on the proposed work methods, all likely odour sources and the proposed controls to demonstrate compliance will be achieved with the 2 OU criterion at the nearest sensitive receptor	Detailed design/ pre-construction
Develop and implement the findings from the odour management strategy as well as contingency measures e.g. use of deodorisers in case of observed odour exceedances.	Pre-construction/ construction
Ensure that appropriate resources and issues management protocols are identified in relation to consultation plans and complaints handling procedures	Pre-construction/ construction

7. Conclusion

The G2SJV has conducted an odour impact assessment of the proposed construction activities at the former Tempe landfill required as part of the Sydney Gateway road project.

A review of odour emissions from other landfills in NSW has been used to determine a range of potential odour emission rates from activities expected during construction. The odour assessment included a sensitivity analysis to account for the unknown emission rates from the site.

Two construction scenarios were provided and have been used to estimate and model odour emissions at nearby sensitive receptors. Scenario 1 is worst case in terms of potentially exposed waste (waste is exposed at all cut and fill areas at the same time), and Scenario 2 is a refined, more reasonable construction option (waste is exposed in a staged approach) given the physical and operational constraints in the landfill area.

The assessment found compliance with the 2 OU criterion is predicted to be achieved for Scenario 2 at all assessed sensitive receptors when using an elevated odour emission rate (0.5 $OU/m^2/s$) compared to a non-putrescible landfill for cut and fill areas associated with construction. For the base case, only one potential exceedance at the Tempe Wetlands was predicted for Scenario 2. This indicates that potential odour impacts associated with the project could be effectively reduced by managing the maximum amount of waste material exposed to the atmosphere at any one time.

Exceedances of the odour assessment criteria are predicted to occur over a small region of Sydney Airport land south of Swamp Road, at the northern end of the High Intensity Approach Lights and along Airport Drive adjacent to the international freight terminal for Scenario 2. Significant odour impacts on these or other parts of Sydney Airport land are not predicted for Scenario 2.

Further scenarios were undertaken as part of the sensitivity analysis, where impacts were assessed using higher odour rates consistent with a putrescible landfill (up to 3 $OU/m^2/s$). The 2 OU odour assessment criterion was predicted to be exceeded at a majority of sensitive receptors around the site using these higher rates.

Recommended odour mitigation measures include implementing a staged approach, consisting of reviewing weather conditions, undertaking field odour surveys, identifying primary odour sources onsite and then reducing the source of odour by the suggested methods.

A site odour management strategy should be developed for the construction stage, taking into account the odour mitigation measures detailed in this assessment. As part of developing this strategy, site specific odour sampling should be undertaken before construction works commence to verify the odour emission rates used in this assessment. Additional odour and landfill water balance modelling should also be undertaken and further mitigation identified:

- If the site specific odour emission rates are found to be greater than those applied in the base case in this assessment
- If the working cut areas are proposed to be greater than those used in this assessment
- To confirm the proposed leachate disposal arrangements would not become an additional odour source.

If night-time works are proposed to be undertaken, they should be contained within a building and the air treated before being discharged, or alternative odour mitigation measures demonstrated by revised odour modelling.

It is recommended to keep the local community informed about the construction methodology and mitigation measures that would be implemented to manage potential odour impacts, as required. The project complaints management procedure should include consideration of odour issues and relevant resources should be identified for these works.

During operation and following replacement of the landfill cap, including appropriate seals around new infrastructure penetrating the cap, odour emissions would be similar to the existing landfill.

8. References

Australian Standard 4323.3:2014 *Stationary source emissions: determination of odour concentration by dynamic olfactometry.*

DECC, 2006. *Technical framework – Assessment and management of odour from stationary sources in NSW.*

Environmental Services Group, 2019. *Closed Tempe Landfill Technical Paper*.

EPA, 2016. *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. NSW Government Gazette of 26 August 2005, minor revisions November 2016. Sydney, NSW: Department of Environment and Conservation NSW (DEC).

German Standard CDI 3940, *Determination of odorants in ambient air by field inspection* (1993).

German Standard VDI 3882 (I), *Olfactometry Determination of Odour Intensity* (1992).

J Barclay and J Scire, Atmospheric Studies Group TRC Environmental Corporation, 2011. *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.*

Australian Government Bureau of Meteorology, climate data for Sydney Airport AMO (accessed 17 June 2019).

Appendix A
Meteorology modelling methodology

A1. Overview

This appendix outlines the methodology used to synthesise meteorology for the project site. The meteorology is used in CALPUFF to drive the dispersion model.

Local meteorology, including long term wind speed and direction as well as atmospheric stability, can influence how pollutants are dispersed into the local environment.

Site specific meteorology for the project was produced using a model called CALMET. The CALMET simulation produced a 3D wind field for the modelled year. Prognostic TAPM data was used alongside observations taken at one NSW Bureau of Meteorology (BoM) site as inputs into the CALMET model. Details of the procedure undertaken to produce the site specific meteorology is outlined in the following sections.

A2. Methodology

The characterisation of local wind patterns generally requires accurate site-representative hourly recordings of wind direction and speed over a period of at least a year.

Existing observational data is available from the Sydney airport AMO (BoM ID: 66037).

In order to produce a representative site-specific meteorological data set encompassing the meteorological data from the observational site, the following methodology was carried out:

- Producing a 3D gridded dataset with the prognostic model TAPM
- Using the TAPM 3D gridded dataset as an initial guess field for the CALMET meteorological model
- Using data from the observation site (Sydney Airport AMO) for surface level observations.

A2.1 Representative year selection

The representative year was selected as 2016 to be consistent with Technical Working Paper 4 (Air Quality).

A2.2 Prognostic meteorology

The TAPM prognostic model was run to obtain a coarse meteorological 3D gridded dataset for the site for the selected year (2016). This dataset is based on synoptic observations, local terrain and land use information with a resolution of 1,000 metres. The TAPM model parameters are summarised in Table A.1 and were selected in accordance with the Approved Methods.

Table A.1 TAPM model parameters

Parameter	Value
Modelled period	1 December 2015 to 1 January 2017
Domain centre	UTM: 56H 332,847 mE, 6,244,687 mS Latitude = -33° 55.5' Longitude = 151° 11.5'
Number of vertical levels	25
Number of easting grid points	25
Number of northing grid points	25
Outer grid spacing	30,000 m x 30,000 m
Number of grid levels	4
Grid level horizontal resolution	Level 2 – 10,000 m Level 3 – 3,000 m Level 4 – 1,000 m

A3. CALMET modelling

The US EPA approved version of CALMET (Version 5) was used to resolve the wind field around the subject site to 200 metres spatial resolution. The application of CALMET for this purpose is an approved modelling approach in NSW as per the Approved Methods with model guidance documentation provided.

Upon completion of the broad scale TAPM modelling runs, a CALMET simulation was set up to run for the model period, combining the three dimensional gridded data output from the TAPM model with the site specific surface data from the Sydney Airport BoM station. This approach is consistent with guidance documentation.

All model settings were selected based on the recommendations provided in the model guidance documentation. CALMET was run using the 'Hybrid' mode with the TAPM data provided as an initial guess field.

The southwest corner of the CALMET domain, or the origin, was located at UTM Zone 56 coordinates 321.847 kilometres east and 6233.687 kilometres north. The CALMET domain extended 22 kilometres to the east and north.

The CALMET domain consisted of 110 grids in both the east and north directions, with a grid resolution of 0.2 kilometre.

CALMET settings were selected as per the model guidance document for 'Hybrid' mode.

The TERRAD, RMAX and R variables were set to the values presented in Table A.2 based on an inspection of the terrain elevations in the immediate vicinity of the subject site, based on model guidance. The CALMET model parameters are summarised in Table A.2.

Terrain and land use data used for the CALMET modelling are presented in Figure A.1 and Figure A.2.

Table A.2 Summary of CALMET model parameters

Parameter	**Value**
Modelled period	1 January 2016 to 31 December 2016
Mode	Hybrid (NOOBS = 1)
UTM zone	56
Domain origin (south-west corner)	Easting: 321.847 km Northing: 6233.687 km
Domain size	110 x 110 at 0.2 km resolution (22.0 km x 22.0 km)
Number of vertical levels	11
Vertical levels (m)	20, 40, 60, 90, 120, 180, 250, 500, 1000, 2000, 3000
CALMET settings for hybrid mode Settings selected in accordance with (OEH, 2011)	TERRAD = 10.0 km RMAX1 = 10.0 km RMAX2 = 10.0 km RMIN = 0.1 km R1 = 5.0 km R2 = 5.0 km
Initial guess field	TAPM .m3d file used as an initial guess field for CALMET
Surface data	Sydney Airport AMO E: 331.173 km, N: 6242.272 km
Upper air data	No site specific upper air data is used. Upper air data is included within the TAPM .m3d initial guess field.
Land use and terrain data	Land use data was manually developed through assessment of aerial imagery to accurately reflect the land use in the area. High-resolution terrain data was sourced from the STRM 1-second (~30 m) database.

The local meteorology largely determines the pattern of off-site air quality impact on receptors (houses, businesses and industry). The effect of wind on dispersion patterns can be examined using the wind and stability class distributions at the site from the dataset that is produced by CALMET. The winds at the site are most readily displayed by means of wind rose plots, giving the distribution of winds and the wind speeds from these directions.

The features of particular interest in this assessment are:

- The dominant wind directions
- The relative incidence of stable light wind conditions that yield minimal mixing (defines peak impacts from ground-based sources).

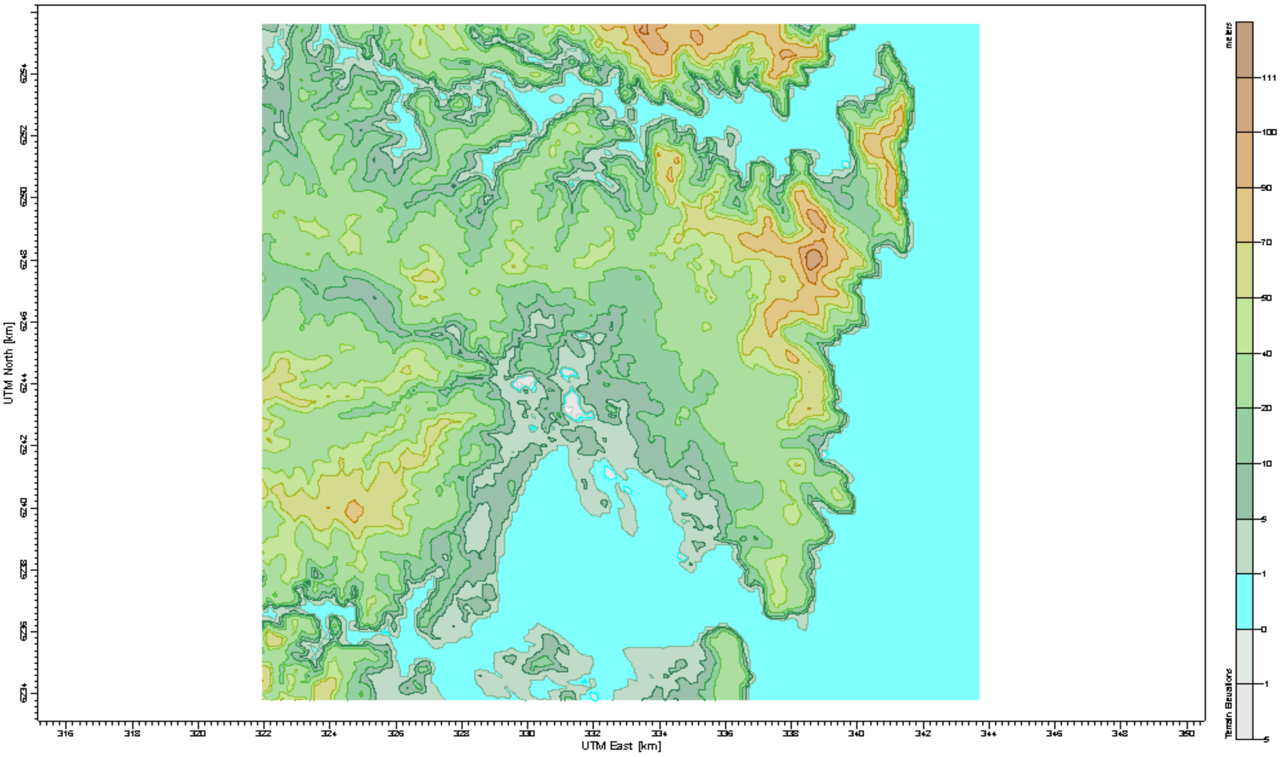


Figure A.1 Terrain data used for CALMET modelling

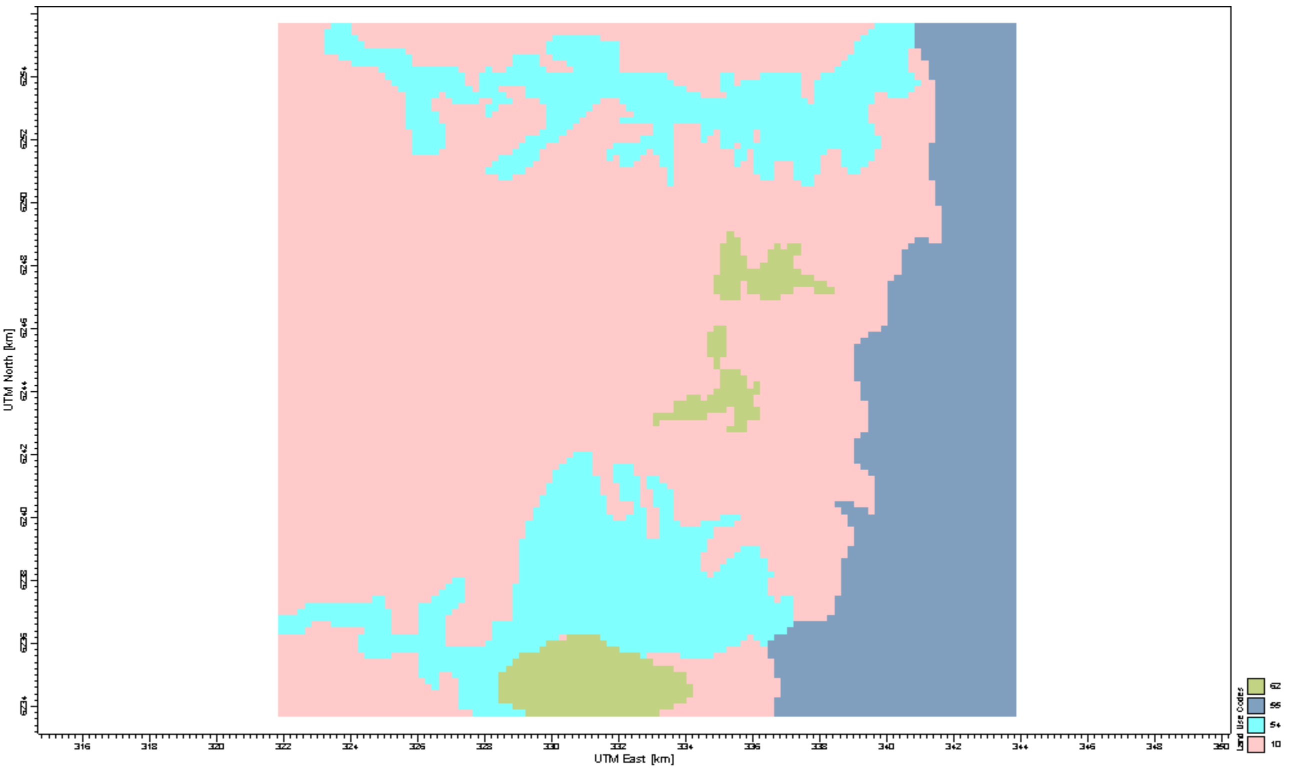


Figure A.2 Land use data used for CALMET modelling

A3.1 Annual wind patterns

The wind rose for the entire data period taken at the project site is shown in Figure A.3 and shows the following features:

- The predominant annual average wind directions are from the north-west, north-east and south
- The majority of lower wind speeds (2–4 m/s) are from the northwest
- The average wind speed measured was 4.73 metres per second
- Calm conditions (wind speeds less than 0.5 m/s) occurred 0.18 per cent of the time.

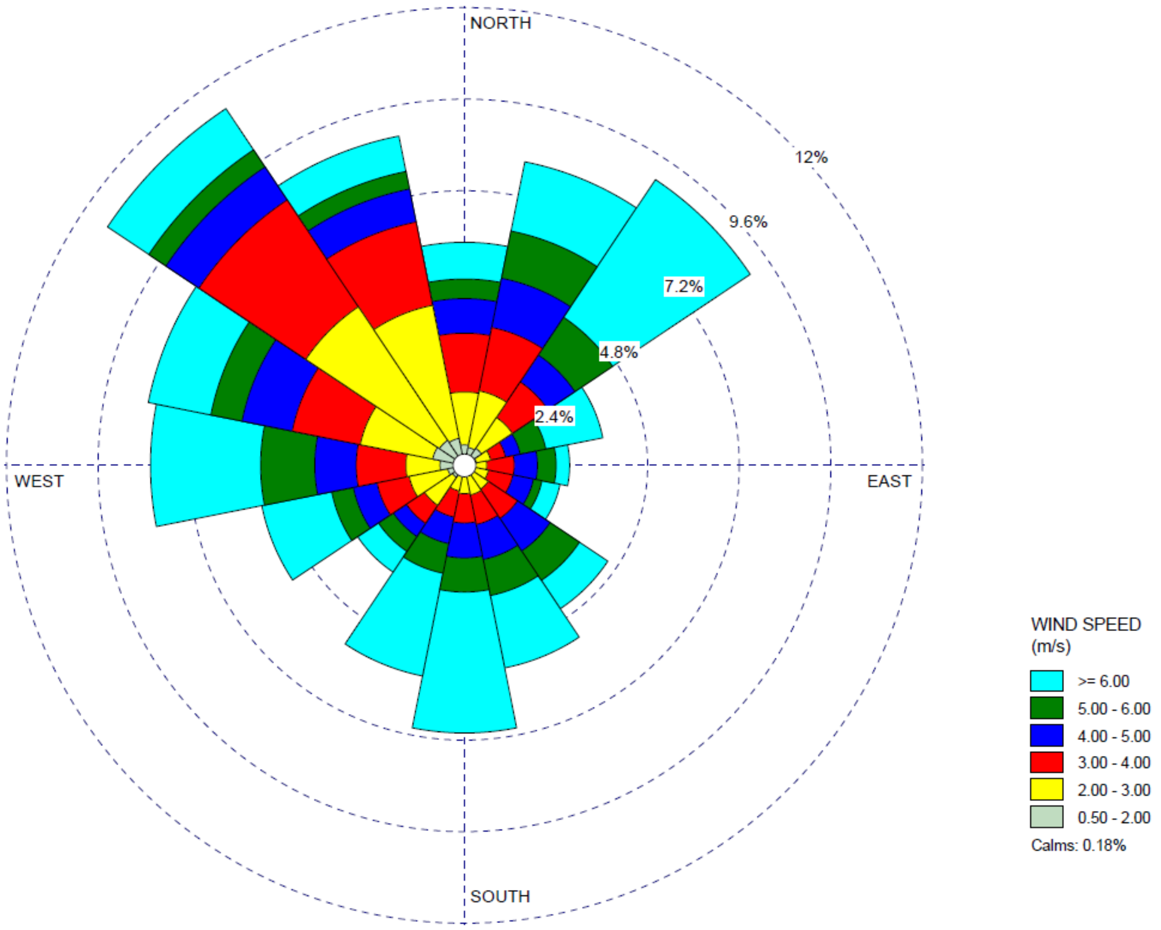


Figure A.3 Wind rose at site from CALMET (2016)

A3.2 Pattern of atmospheric stability

Atmospheric stability substantially affects the capacity of a pollutant such as gas, particulate matter or odour to disperse into the surrounding atmosphere upon discharge and is a measure of the amount of turbulent energy in the atmosphere.

There are six Pasquill-Gifford classes (A-F) used to describe atmospheric stability, and these classes are grouped into three stability categories; stable (classes E-F), neutral (class D), and unstable (classes A-C). The climate parameters of wind speed, cloud cover and insolation (solar radiation) are used to define the stability category as shown in Table A.3. As these parameters vary from day to night, there is a corresponding variation in the occurrence of each stability category.

Stability is most readily displayed by means of stability rose plots, giving the frequency of winds from different directions for various stability classes A to F.

Table A.3 Stability category relationship to wind speed and stability characteristics

Stability category	Wind speed range (m/s)a	Stability characteristics
A	0 – 2.8	Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud
B	2.9 – 4.8	Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud
C	4.9 – 5.9	Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud
D	≥6	Neutral atmospheric conditions. These occur during the day or night with stronger winds, during periods of total cloud cover or during the twilight period
E	3.4 – 5.4 b	Slightly stable atmospheric conditions occurring during the night-time with significant cloud and/or moderate winds
F	0 – 3.3 b	Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds

(1) Data sourced from the Turner's Key to the P-G Stability Categories, assuming a Net Radiation Index of +4 for daytime conditions (between 10:00am and 6:00pm) and –2 for night-time conditions (between 6:00pm and 10:00am)

(2) Assumed to only occur at night, during Net Radiation Index categories of –2.

Figure A.4 shows the frequency of stability class for all hours of the model generated dataset. The following observations were made:

- Neutral atmosphere conditions (class D) are the dominant stability state of the atmosphere occurring 41 per cent of the time
- Stable conditions (classes E and F) occur 35 per cent of the time
- Unstable atmospheres (classes A, B and C) occur about 24 per cent of the time.

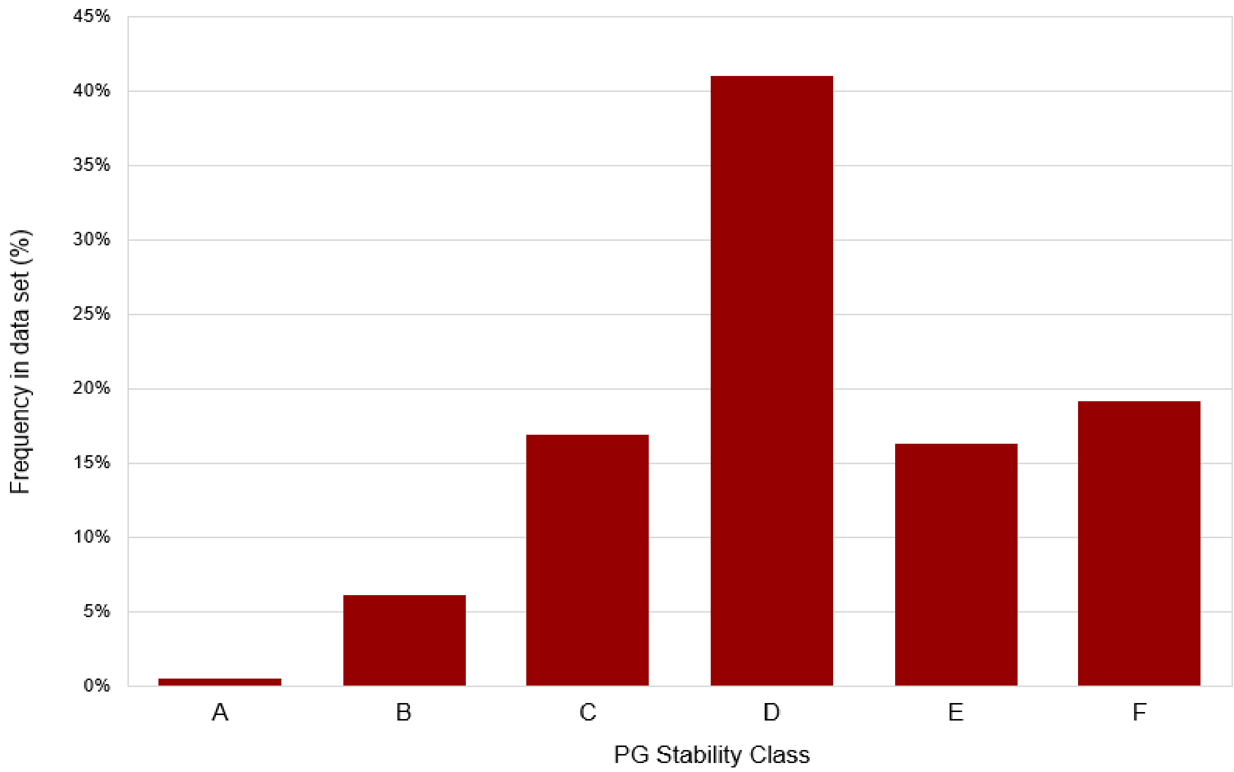


Figure A.4 Distribution of stability class for the model period

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