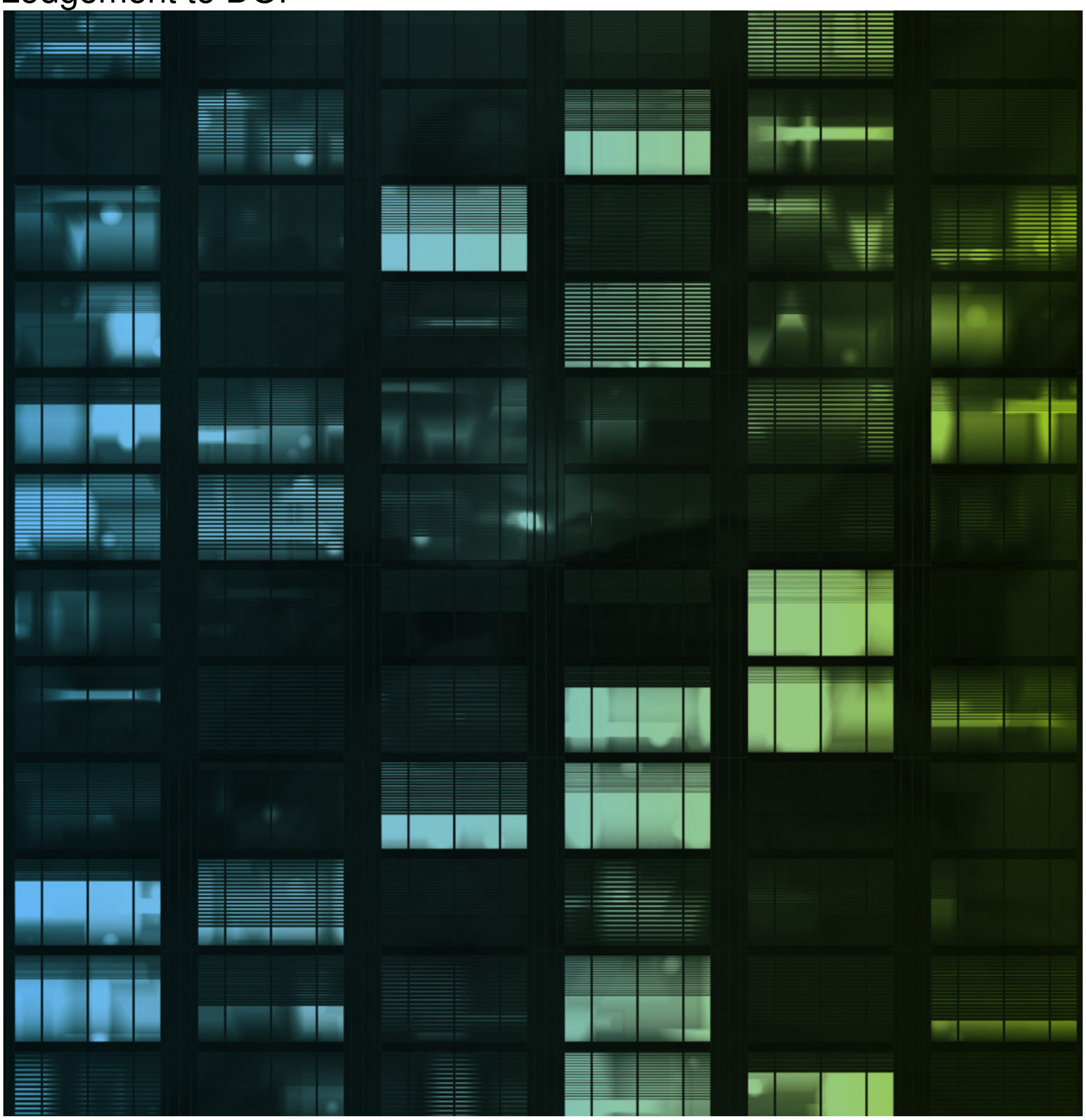
Barangaroo
Lend Lease (Millers Point)
27 July 2010

FOR LODGEMENT WITH CONCEPT PLAN APPLICATION

Air Quality Impact Assessment

Barangaroo Concept Plan Amendment (MP 06_0162 MOD 4) for Lodgement to DOP



Air Quality Impact Assessment

Barangaroo Concept Plan Amendment (MP 06_0162 MOD 4) for Lodgement to DOP

Prepared for

Lend Lease (Millers Point)

Prepared by

AECOM Australia Pty Ltd
17 Warabrook Boulevard Warabrook NSW 2304,
T +61 2 4911 4900 F +61 2 4911 4999   www.aecom.com
ABN 20 093 846 925

27 July 2010

60156271.1.1

This document was prepared by AECOM Australia Pty Ltd (AECOM) for the sole use of Lend Lease (Millers Point) Pty Limited, the only intended beneficiary of our work. Any advice, opinions or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and are considered current to the date of this document. Any other party should satisfy themselves that the scope of work conducted and reported herein meets their specific needs before relying on this document. AECOM cannot be held liable for any third party reliance on this document, as AECOM is not aware of the specific needs of the third party. No other party should rely on the document without the prior written consent of AECOM, and AECOM undertakes no duty to, nor accepts any responsibility to, any third party who may rely upon this document.

This document was prepared for the specific purpose described in our proposal dated 9 June 2010 and as agreed to by Lend Lease (Millers Point). From a technical perspective, the subsurface environment at any site may present substantial uncertainty. It is a heterogeneous, complex environment, in which small subsurface features or changes in geologic conditions can have substantial impacts on water and chemical movement. Uncertainties may also affect source characterisation assessment of chemical fate and transport in the environment, assessment of exposure risks and health effects, and remedial action performance.

AECOM's professional opinions are based upon its professional judgement, experience, and training. These opinions are also based upon data derived from the testing and analysis described in this document. It is possible that additional testing and analysis might produce different results and/or different opinions. AECOM has limited its investigation to the scope agreed upon with its client. AECOM believes that its opinions are reasonably supported by the testing and analysis that have been done, and that those opinions have been developed according to the professional standard of care for the environmental consulting profession in this area at the date of this document. That standard of care may change and new methods and practices of exploration, testing, analysis and remediation may develop in the future, which might produce different results. AECOM's professional opinions contained in this document are subject to modification if additional information is obtained, through further investigation, observations, or validation testing and analysis during remedial activities.

Quality Information

Document	Air Quality Impact Assessment
Ref	60156271.1.1 Concept_Plan_Modification_AQIA_ Final_27Jul10
Date	27 July 2010
Prepared by	Holly Marlin Author Signature H. Marlin.
Reviewed by	David Rollings Technical Peer Reviewer Signature

Distribution

Copies	Recipient	Copies	Recipient
1	**Lend Lease (Millers Point) Pty Limited** 30 The Bond 30 Hickson Road Millers Point NSW 2000	1	**AECOM File Copy**

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	16/06/2010	Initial draft document issued to client	David Rollings	
2	29/06/2010	Updated to address client comments	David Rollings	
3	27/07/2010	Document finalisation	David Rollings	

Contents

List of Tables

List of Figures

Body Report

List of Appendices

1.0 Introduction

Barangaroo, located on the harbour in the Sydney Central Business District, will create a new mixed use precinct between Walsh Bay and Darling Harbour.

On 20 December 2009, Lend Lease (Millers Point) Pty Limited (Lend Lease) was appointed as the preferred proponent to develop Barangaroo South (also known as Barangaroo Stage 1) comprising Blocks 1 to 4 and associated public recreation areas.

AECOM was engaged by Lend Lease to undertake an Air Quality Impact Assessment to inform a Concept Plan Amendment (MP06_0162 MOD 4). The Air Quality Impact Assessment responds specifically to the Director-General's Requirements issued for the Concept Plan Amendment (MP 06_0162 MOD 4).

The Barangaroo Concept Plan was approved in February, 2007, by the Minister for Planning. The approved Concept Plan has been modified three times since originally being approved. The approved Concept Plan (as modified) provides for:

- a mixed use development with a maximum of 489,500 m^2 gross floor area (GFA) contained within 7 blocks on a total site area of 22 hectares, comprising:
  - a maximum of 97,075 m^2 and a minimum of 58,245 m^2 of residential GFA;
  - a maximum of 50,000 m^2 GFA for tourist uses;
  - a maximum of 39,000 m^2 GFA for retail uses; and
  - a minimum of 2,000 m^2 for community uses;
- approximately 11 hectares of new public open space/public domain, with a range of formal and informal open spaces serving separate recreational functions and including a 1.4 km public foreshore promenade;
- maximum building heights and maximum GFA for each development block within the mixed use zone;
- public domain landscape concept, including parks, streets and pedestrian connections; and
- alteration of the existing seawalls and creation of two enlarged coves (southern cove and northern cove) and a natural headland.

The proposed Concept Plan Amendment (MP 06_0162 MOD 4) seeks the Minister's consent for:

- additional GFA within Barangaroo South, predominantly related to an increase in residential GFA;
- redistribution of the land use mix;
- an increase in height of a number of the proposed towers within Barangaroo South;
- the establishment of the new pier and landmark building extending into the Harbour; and
- reconfiguration and activation of the public waterfront area through the introduction of uses including retail and residential to the west of Globe Street.

The principal amendment from an air quality impact perspective is that there is a new pier and Landmark Building extending into the Harbour. This amendment is not, however, expected to have any additional air quality impacts over that previously contemplated in the approved Concept Plan (as modified).

The construction works (as a whole) contemplated in the Concept Plan Amendment (MP 06_0162 MOD 4) are expected to generate air emissions typically associated with dust and fuel combustion, as well as possible emissions of contaminants contained within soils at the site. These worst-case air quality impacts are expected to be generated during the proposed preparatory and enabling site works associated with the bulk excavation and basement car parking works (as described in the Project Application MP 10_0023) and the remediation of the area declared by the Department of Environment, Climate Change and Water (DECCW) to be a remediation site under the Contaminated Land Management Act, 1997 (also known as the DECCW Declaration Area) (which are proposed to be the subject of a future Project Application MP 10_0026).

As such, this Air Quality Impact Assessment addresses the expected worst-case impacts that are expected during the site preparatory and enabling phases of works associated with bulk excavation, remediation and construction works. Specific remediation activities associated with the DECCW Declaration Area will be addressed under a future Project Application (MP 10_0026).

1.1 Director-General's Requirements

The Director-General's Requirements (DGRs) were issued for the Concept Plan Amendment (MP06_0162 MOD 4) on 3 May, 2010 and revised on July 2, 2010. Item 11 of the DGRs requires that the Environmental Assessment must identify potential air quality and odour impacts, in particular during the construction and operation of the development , and appropriate mitigation measures.

1.2 Scope of Works

This Air Quality Impact Assessment addresses typical potential effects on air quality associated with the proposed site preparatory and enabling phases of works associated with bulk excavation, remediation and construction works under the proposed Barangaroo Concept Plan Amendment (MP 06_0162 MOD 4). These site preparatory and enabling works are typically associated with basement car parking works discussed in detail within the Bulk Excavation and Basement Car Parking Project Application MP 10_0023. Impacts associated with the Remediation of the DECCW Declaration Area will be assessed under a specific Air Quality Impact Assessment under Project Application MP 10_0026. The creation of the Southern Cove is not expected to give rise to air quality impacts beyond those of the proposed preparatory and enabling site works associated with the bulk excavation and basement car parking works. Specific and detailed activities associated with the creation of Southern Cove will also be addressed under a future Project Application (MP 10_0026).

This report assessed the following:

- Emissions of dust (total suspended particulates, fine particulates and deposited dust) from the earthworks, soil handling, remediation, emplacement and construction activities;
- Emissions of other soil contaminants associated with the above dust-generating activities;
- Diesel emissions from vehicles, plant and equipment used in the above activities; and
- Odour emissions associated with excavation, handling, stockpiling and treatment of contaminated soil.

This report:

- Describes the proposed works and their associated pollutant emissions and emission sources;
- Provides a description of existing air quality and meteorology at the site;
- Outlines the methodology used in the assessment, including choice of model, modelling parameters, and quantification of results;
- Assesses the predicted pollutant concentrations against the DECCW's impact assessment criteria; and
- Outlines management and monitoring procedures for the project.

2.0 Site Description

2.1 Location and Context

Barangaroo is located on the north-western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Central and Barangaroo South (also known as Barangaroo Stage 1). Lend Lease has been successfully appointed as the preferred proponent to develop Barangaroo South.

The area of land that is subject to the Concept Plan Modification is indicatively shown in **Figure 1**, and is herein referred to as "the Barangaroo South Site". It comprises an open apron that is largely reclaimed over water and identified in the existing approved Concept Plan as Blocks 1 – 4, and the immediately adjacent public recreation area. The Barangaroo South Site also extends beyond the western edge of the existing apron and includes a north-west oriented intrusion into the existing waters of Darling Harbour.

2.2 Existing Development

The Barangaroo South Site comprises an open apron which is largely reclaimed over water. A number of existing Passenger Terminal buildings and ancillary structures are being demolished. The Passenger Terminal has been relocated to an area to the north of the Barangaroo South Site.

2.3 Proposed Development

A Project Application for Bulk Earthworks and Basement Car Parking Works (MP10_0023) within the Barangaroo South Site has been submitted to the Department of Planning for assessment. The Project Application conforms to the existing Concept Plan Approval. It seeks approval for the bulk excavation and construction of a basement car park to accommodate up to 880 car parking spaces and associated services and infrastructure to support the future development of Barangaroo South. This Project Application also seeks approval for the transportation of excavated material to the temporary locations to the site of the Headland Park for future placement and land forming by the Barangaroo Delivery Authority under its Headland Park Early Works Project Application. AECOM understands the Headland Park Early Works Project Application (MP10_0047) will shortly be submitted to the Department of Planning for assessment.

2.4 Surrounding Land Use and Receptors

The Barangaroo South Site is bordered by Sydney Harbour on the western side and by Hickson/Sussex Streets to the east. The closest receptors are located approximately 30 m to the east of the site, in a multilevel residential building located on Hickson Road (38 Hickson Road). A child care centre is located 70 m to the north of 38 Hickson Road at the ground level of a multilevel office building (the Bond Building), which is open to the street. Commercial development is located approximately 40 m south of the site. A number of finger wharves containing a mixture of residential and commercial developments are located directly opposite the Barangaroo South Site, the closest being approximately 250 m west of the site, while the residential suburb of Balmain East is located approximately 400 m to the west of the proposed Headland Park emplacement area. Details and the location of sensitive receptors incorporated into the dispersion modelling are provided in **Section 6.3**.

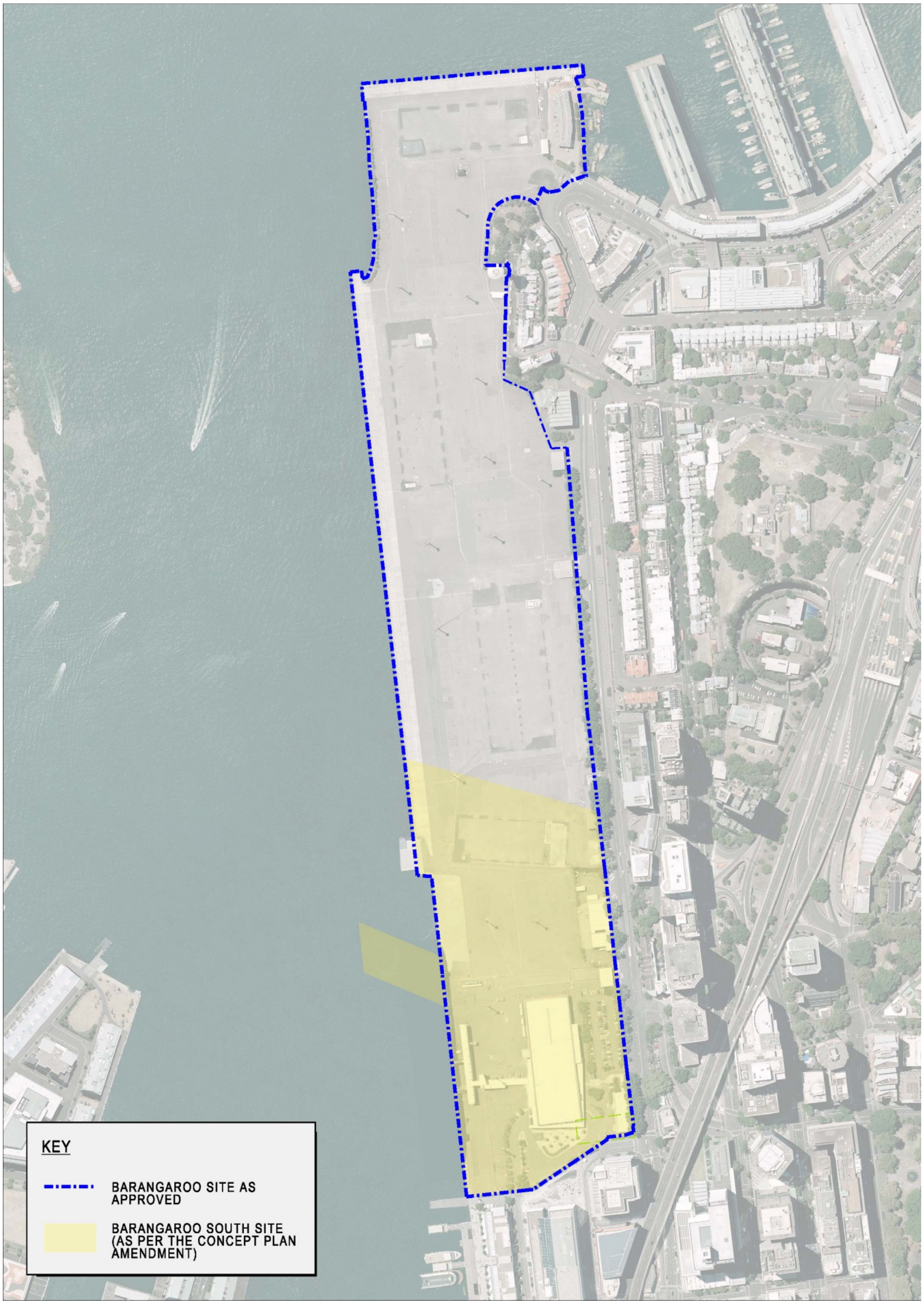


Figure 1: Barangaroo Site Plan

2.5 Existing Site Contamination

A number of investigations have been undertaken to investigate and characterise the contamination present in the soils of Barangaroo (the whole Site), which are reported in the Overall Remedial Action Plan prepared for the whole of the Barangaroo Site [1]and the detailed Remedial Action Plan – Other Remediation Works (South) Area prepared in support of the Bulk Excavation and Basement Car Parking Project Application (MP10_0023). A summary of the typical results of contaminants detected on the Barangaroo site (outside of the DECCW Declaration Area) for which the DECCW specifies air pollution impact assessment criteria is shown in **Table 1**. The way in which these results were included in the assessment is detailed in **Section 6.0**

Table 1: Soil Sampling Results Summary

Contaminant*	Concentrations – All Depths (mg/kg)	
	Maximum	Average
Arsenic and compounds	50	6
Barium (soluble compound)	410	53
Benzene	19.4	0.5
Beryllium and beryllium compounds	4	1
Cadmium and cadmium compounds	2	1
Chromium	81	12
Copper	425	39
Cyanide (as CN)	2.2	1.1
Ethylbenzene	10.5	0.6
Iron	22,600	9,589
Lead	2,050	121
Manganese	768	123
Mercury	9.1	0.4
Nickel	40	6
Polycyclic aromatic hydrocarbons (as benzo[α]pyrene)	1,536	39.4
Zinc	1,890	106
*as defined in DEC (2005)		

[1] ERM. (2010). Overall Remedial Action Plan.

"This page has been left blank intentionally"

3.0 Proposed Concept Plan Amendment (MP 06_0162 MOD 4) Description

The proposed Concept Plan Amendment (MP 06_0162 MOD 4) seeks the Minister's consent for:

- additional GFA within Barangaroo South , predominantly related to an increase in residential GFA;
- redistribution of the land use mix;
- an increase in height of a number of the proposed towers within Barangaroo South ;
- the establishment of the new pier and landmark building extending into the Harbour; and
- reconfiguration and activation of the public waterfront area through the introduction of uses including retail and residential to the west of Globe Street.

The principal amendment to the approved Concept Plan from an air quality impact perspective is the proposed construction of a new pier and Landmark Building extending into the Harbour. This is discussed below in greater detail.

The construction works (as a whole) contemplated in the Concept Plan Amendment (MP 06_0162 MOD 4) are expected to generate air emissions typically associated with dust and fuel combustion, as well as possible emissions of contaminants contained within soils at the site. These works are not, however, expected to generate additional air quality impacts over and above that contemplated under the approved Concept Plan (as modified). The worst-case air quality impacts are expected to be generated during the proposed preparatory and enabling site works associated with the bulk excavation and basement car parking works (as described in the Project Application MP 10_0023) and the remediation of the DECCW Declaration Area) (proposed to be described in the Project Application MP 10_0026).

As such, the expected worst-case air quality impacts expected during the site preparatory and enabling phases of works, typically associated with bulk excavation, remediation and construction works, are detailed further below. Specific and detailed remediation activities associated with the DECCW Declaration Area will be addressed under a future Project Application (MP 10_0026). The creation of the Southern Cove is not expected to give rise to air quality impacts beyond those of the proposed preparatory and enabling site works associated with the bulk excavation and basement car parking works. Specific and detailed activities associated with the creation of Southern Cove will also be addressed under a future Project Application (MP 10_0026) .

3.1 Landmark Building and Public Pier

As previously discussed, the principal amendment to the approved Concept Plan from an air quality impact perspective is the addition of a new pier and Landmark Building extending into the Harbour.

A Landmark Building and Public Pier is proposed to be constructed within the Harbour to the west of the existing caisson seawall foreshore alignment. Both the Landmark Building and Public Pier will require foundations constructed within the Harbour. The Landmark Building is proposed to accommodate approximately 35,000 m^2 of GFA and will rise up to approximately RL 160 above the Public Pier. A submerged basement structure beneath the Public Pier is proposed to service the Landmark Building. The submerged basement will be supported by the Landmark Building tower and Public Pier foundations such that the basement structure does not at any point rest upon the existing harbour seabed. Above the level of the Public Pier, conventional tower construction techniques are proposed with materials handling principally via tower cranes serviced from the landside of Barangaroo

The exact details of the plant, equipment and methods to be utilised in the construction of the Public Pier and the proposed Landmark Building and submerged basement are not yet finalised. The initial stages will, however, include the use of large barge-mounted pin jib cranes servicing specialist piling rigs capable of the driving or screwing of steel casings/liners associated with augured, cast *in situ* piles through the seabed and into underlying rock strata. For the purpose of installing the piles, piling rigs could either be supported from the existing wharf using a long reach piling rig with an incrementally constructed deck placed progressively out over the water or from a barge or jack-up platform. The craneage and piling works would be supported by other smaller work boats and barges.

Where a basement is proposed that does not reach the existing seabed, piles could be constructed as described above and the casings cut down to the required level below water level. A basement structure could then be lifted in sections or floated over the foundations and sunk with an *in situ* connection formed to the piles. A further option would be to construct the basement structure *in situ* using conventional concrete construction over floating formwork in a manner similar to the recent development of Walsh Bay. The cast *in situ* basement structure would be progressively sunk into final position in conjunction with the extension of walls above the waterline using conventional *in situ* construction techniques. Upon completion of the basement and subsequent construction of sufficient tower structure above (to act against the buoyant force of the basement), the basement would be pumped clear of water and sealed. The basement below the Public Pier could then be connected landside through the existing caisson seawall and sealed off using conventional submerged tunnel techniques to those adopted on the Sydney Harbour Tunnel project.

Alternatively, the installation of a sheet pile cofferdam around the perimeter of the proposed structure that is dewatered with construction of foundations and subsequent basement structure taking place from a temporary platform constructed on the existing sea bed might also be considered. The cofferdam could either be designed as a double skin sheet piled self supporting structure or it could be strutted internally.

For the majority of the Public Pier construction period, the works zone required by water-based plant under the various construction options discussed above could be typically managed within a 50 m distance of the northern and southern sides of the Public Pier. Limited instances of works extending out further to the west than the west end of the Public Pier may also occur.

Once the Public Pier is created and the Landmark Building basement structure sunk into position (but remaining suspended above the harbour bed), the Landmark Building itself could be largely constructed from the Public Pier utilising climbing tower cranes and other conventional materials handling techniques associated with typical high rise building construction, all serviced via access from Barangaroo South landside.

The works associated with the greatest disturbance to soils are those related to the site enabling and preparation works, which typically relate to bulk earthworks and remediation associated with building basements and the reshaping of the site. Those works are further described below.

3.2 Excavation and Installation of Basement Perimeter Retention Systems

The first phase of the preparatory and enabling works associated with the proposed Concept Plan Amendment (MP06_0162 MOD 4) would typically include:

- Establishment of site and perimeter hoardings and the like;
- Removal of existing services;
- Installation of temporary services
- Demolition of ground slabs;
- Concrete crushing and screening;
- Establishment of environmental structures; and
- Archaeological test pitting and archaeological excavation works.

The second phase of preparatory and enabling works associated with the proposed Concept Plan Amendment (MP06_0162 MOD 4) would typically involve the installation of a basement perimeter retention system around the perimeter of the proposed basement excavation area to control groundwater infiltration and to provide support , where applicable, to the subsequent structures to be constructed on the site. The perimeter retention system would typically vary in width up to 1m (subject to design development), and would be filled with materials such as bentonite, concrete and steel reinforcement bars, and socketed into the underlying bedrock (where required). Additionally, pilings would be installed throughout the bulk basement areas to support the future basement structures. Lend Lease proposes to transfer materials excavated for the basement retention system to a stockpile that would also contain materials excavated for the diversion of services and archaeological works. This stockpile was included as a source of dust emissions in the dispersion modelling.

3.3 Bulk Excavation Works, Soil Treatment and Emplacement Activities

3.3.1 Excavation

The preparatory and enabling works associated with the proposed Concept Plan Amendment (MP06_0162 MOD 4) are likely to involve the staged excavation of approximately 500,000 m^3 of material, principally for the purpose of basement car parking with associated loading bays, below-ground retail and ancillary plant and equipment over the entire Barangaroo South site.

Excavated materials are expected to generally comprise heterogeneous fill materials, soil, and bedrock. Materials would typically be excavated using bulldozers and hydraulic excavators and loaded to trucks by front end loaders and hydraulic excavators. Material would generally be classified *in situ* to determine whether it requires treatment or is suitable for beneficial reuse without treatment. Material not requiring treatment is proposed to be directly transported to the site of the proposed Headland Park area or Public Domain areas (as applicable) for placement by others under separate Project Applications. Material requiring treatment would be typically transferred to the soil treatment area on-site.

Drainage, sediment and erosion control measures would be installed within stockpiling areas at the commencement of the works, and maintained, repaired and replaced where necessary for the duration of the stockpiling activities. All long-term soil stockpiles on-site would be covered or stabilised with spray grass seeding or other suitable dust/erosion reduction measures as required.

3.3.2 Haul Roads

The Barangaroo site is currently covered in hardstand, which would be retained wherever possible. As such, haul roads between the excavation and emplacement areas would generally be paved, while roads within these areas could potentially be unpaved. Paved haul roads were assumed to have negligible wheel-generated dust emissions in this assessment. As a result of this assumption, regular cleaning/sweeping of haul roads is required as part of the excavation activities to ensure silt buildup does not occur.

3.3.3 Headland Park

The construction of the Headland Park would be the subject of separate design and a project application by the Barangaroo Delivery Authority. Final details and agreement between the proponent and the Barangaroo Delivery Authority on material supply are still to be confirmed. For the purposes of this assessment, some key activities related to potential material placement at the Headland Park are summarised below.

Sandstone may be excavated from the site of the proposed Headland Park area by the Barangaroo Delivery Authority for potential material re-use at Barangaroo or off-site. Quarried voids would potentially be filled with material excavated from Barangaroo South, involving activities such as unloading/dumping of material from trucks, emplacement of the material as backfill, and compacting and shaping of the emplaced material using bulldozers and excavators. These works may include the establishment of a temporary concrete crusher and screening plant for this phase of development.

Lend Lease proposes to cover haulage trucks prior to exiting the excavation area when prevailing conditions require, and trucks would be decontaminated (where required) at the end of each shift of haulage operations in accordance with the Environmental Construction and Site Management Plan (ECSMP).

3.4 Potential Emission Sources

The main modification to the approved Concept Plan relevant to air quality is the construction of the proposed Public Pier and Landmark Building Construction of the Landmark Building and Public Pier is discussed in **Section 3.1** and is not expected to require dredging works; rather, pilings would be embedded in the floor of the harbour, a process not expected to generate air quality or odour emissions significantly above or different to those already expected to arise from the works proposed under the current Approved Concept Plan. The creation of the Southern Cove is not expected to give rise to air quality impacts beyond those of the proposed preparatory and enabling site works associated with the bulk excavation and basement car parking works. Specific and detailed activities associated with the creation of Southern Cove will also be addressed under a future Project Application (MP 10_0026).

3.4.1 Construction

While specific construction vehicle and equipment details were not available for all of the works contemplated under the proposed Concept Plan Amendment, potential emission sources during the enabling and preparatory works phases (that is, the works for the Barangaroo project associated with the greatest likely pollutant emissions), were determined based on conceptual understanding of the excavation and soil movement phases of these works. Primary emissions considered by the assessment were:

- Dust emissions:
- Fuel combustion emissions from vehicles and equipment; and:

- Odour emissions from activities involving contaminated soils.

Specific potential emission sources are summarised in **Table 3** .

Table 2: Emission Sources - Summary Table

Emission Sources	Number	Emission Type		
		Dust*	Combustion Products	Odour
Retention system plant operation				
80 t piling rigs	4	x	x	
80 t cranes	4	x	x	
Compressor	4		x	
30 t excavators (one with hammer)	2	x	x	x
Bulk excavation				
Bulldozer D11	2	x	x	x
80 t mobile crane	1		x	
Ground anchor drilling rigs	3	x	x	
Water cart	1	x	x	
30 t excavators (with or without a hammer)	6	x	x	x
60 t excavators (with or without a hammer)	4	x	x	x
Trucks	30	x	x	x
Loading to trucks	2	x		x
Loader	2	x	x	x
Haul road	5	x		
^Concrete crushing and screening plant	1	x	x	
Wind erosion / pit stockpile emissions	1	x		x
Archaeological and retention system material stockpile (indicatively 25,000m^3)	1	x		x
Dewatering and treatment plant	Not modelled			
Diesel crane	1		x	
Soil treatment				
Pugmill/treatment temporary enclosure structure	1	x	x	x
Odour temporary enclosure structure	1	x		x
Front end loader with backhoe on back	2	x	x	x
Contaminated material stockpile loading	1	x		x
Contaminated material stockpile management	1	x		x
Contaminated material stockpile wind erosion	1	x		x
Treated material stockpile management	1	x		
Treated material stockpile wind erosion	1	x		

Emission Sources	**Number**	**Emission Type**		
		Dust*	**Combustion Products**	**Odour**
Trucks	2		x	
Headland Park emplacement activities				
Bulldozer	1	x	x	
Excavator	2	x	x	
Concrete crusher	1	x	x	
Concrete stockpile	1	x		
Wind erosion - active area	1	x		
Trucks	3	x	x	
Trucks dumping overburden	1	x		
* Dust includes TSP, PM_{10}				
^ Location of concrete crusher to be confirmed, but likely to be near the waterfront on the north-western corner of the excavation area				
The type and number of equipment is in accordance with currently proposed work method and program for the bulk excavation and construction of the basement which is considered indicative of the enabling and preparatory works associated with the proposed Concept Plan amendment.				

The following assumptions were made in the determination of potential emission sources:

- Paved roads were assumed to be maintained, swept and free of dust; watering is proposed such that no wheel-generated dust was assumed to occur.
- Concrete would be delivered in trucks to the top of the excavation area (i.e. no concrete batching plant would be required, and there would be no wheel-generated dust from concrete trucks. Refer to above).
- The bentonite batching plant (if utilised) was assumed to use granulated bentonite, so there would be no dust emissions associated with this plant. In the event that ungranulated bentonite is used, watering would be implemented for dust suppression. As such, this plant was not included in the modelling.
- As trucks would typically be covered or uncovered carrying wet (high moist content) loads, dust emissions from transport activities (apart from wheel-generated dust of vehicles on unpaved roads) were assumed to be negligible.
- Trucks delivering construction materials were assumed to drive on hard stand areas only. Where this is not the case, haul roads would be watered to a sufficient degree to mitigate dust emissions.
- The archaeological stockpile would be removed as a priority activity prior to the commencement of bulk excavation works.
- Odour emissions were assumed to occur from a front end loader operating on the contaminated soil stockpile; the treated soil stockpile was assumed to emit no odour as potentially odorous contaminants may no longer be active, and treated material meeting the site reuse criteria would be transported directly to Headland Park.
- The concrete stockpile would be typically be loaded to a capacity to run a concrete crusher for a six-day campaign (typical).

3.4.2 Operation

Emissions to air from the operation of the proposed development will depend on the nature of the building tenants. For example, restaurant and/or other food preparation facilities may emit odours, while businesses that require the installation and operation of generators, incinerators or other combustion plant may generate air pollutants such as particulates and NO_X. As the project is still in the relatively early phases of planning, quantification of such emissions could not be achieved at the time of preparation of this assessment report. It should be noted, however, that industry standard design and construction techniques will be utilised in all developments across all land uses to address and treat exhaust points such that emissions meet the requirements of relevant Australian Standards. Details regarding general emission requirements and mitigation measures are provided in **Section 8.0**.

3.5 Potential Impacts

Construction activities are typically associated with potential pollution in the form of dust and vehicle emissions. As the site contains contaminated material, some of which is potentially odorous, odour emissions were also assessed. Potential effects on air quality are discussed below. Pollutants of potential concern are described in **Section 4.0**, predicted impacts are discussed in **Section 7.2**, and mitigation measures are discussed in **Section 8.0**.

The construction works contemplated under the Concept Plan Amendment MP 06_0162 MOD 4 are expected to typically generate air emissions associated with dust and fuel combustion, as well as possible emissions of contaminants contained within soils at the site. The worst-case air quality impacts are expected to be generated during the Enabling and Preparation Works phases of the development. As the proposed modification is not expected to generate additional air quality impacts, this assessment addresses the expected worst-case impacts associated with the development as a whole.

3.5.1 Air Quality

The proposed construction activities involve the excavation of a significant amount of material to form basement car parking facilities. Dust can be generated from all types of activities involving soil, including excavation, handling, loading and unloading from stockpiles, and wind erosion of exposed areas.

As some of the soil to be excavated contains contaminants, additional pollutants may be emitted to air during the proposed works. Soil sampling was undertaken at the site and identified the presence of a number of pollutants, including heavy metals and volatile organic compounds (VOCs) (refer to **Section 4.0**). As these pollutants are contained within the soil, they may be liberated through handling processes, resulting in contaminant emissions to air. Pollutants identified at the site in the areas of enabling and preparatory works were assessed as part of this Air Quality Impact Assessment, using maximum pollutant concentrations sampled from the site. Assessment of the DECCW Declaration Area will be the subject of a future Project Application.

The enabling and preparatory works are likely to involve significant numbers of diesel-powered plant and equipment. The combustion of diesel fuel generates a range of pollutant emissions, such as oxides of nitrogen (NO_X), carbon monoxide (CO) and particulate matter. Emissions from the plant and equipment to be used on site were estimated using factors published by the Australian Government for use in the National Pollutant Inventory, measured vehicle emissions from the M5 Freeway Project [2] and emission factors published for a large construction project (The Cadiz Valley Groundwater Storage Project, 2001[3]). Dust and pollutant emissions are discussed in **Section 6.2.5**.

3.5.2 Odour

A number of the contaminants identified at the site have associated odours. These odours may be liberated to air during excavation, handling and stockpiling of the material during the enabling and preparatory works phases. An assessment of the potential odour emissions was conducted as part of this Air Quality Impact Assessment using odour emissions identified at a similar site (Egis Consulting, 2002[4]). These are discussed in **Section 6.2.5**.

---

[2] SKM. (2002). M5 East Freeway Sub-Regional Air Quality Management Plan.
[3] Pacific Institute (2001) The Cadiz Valley Groundwater Storage Project; http://www.pacinst.org/reports/cadiz/feir/volumes/vol1/appendix/v1a_c1.pdf
[4] Egis Consulting Australia Pty Ltd. (2002). Former Lednez Site and Homebush Bay Remediation Environment Impact Assessment – Air Quality Human Health Risk Assessment.

4.0 Pollutants of Potential Concern

The primary pollutants of potential concern (POPC) that may be generated during the preparatory, enabling and construction works associated with the works under the proposed Concept Plan Amendment (MP06_0162 MOD 4) are dust [total suspended particulates (TSP), and fine particulates (PM_{10})] and products of the combustion of fuel (carbon monoxide and nitrogen dioxide). Additionally, the site is known to contain some soil contamination due to previous activities at the site. Pollutants detected at limits above the DECCW pollutant criteria were chosen for inclusion in this assessment.

The pollutants considered in this assessment were:

- Particulate matter (TSP and PM_{10});
- Carbon monoxide (CO);
- Heavy metals and other contaminants (arsenic, barium, beryllium, cadmium, chromium, copper, cyanide, lead, manganese, mercury, nickel and zinc);
- Nitrogen dioxide (NO_2);
- Odour; and
- Volatile organic compounds.

A brief discussion regarding these pollutants and their potential effects on health and the environment is provided in the following sections. Sources of the pollutants are outlined in **Section 3.4**.

4.1 Particulate Matter

Particulate matter can be emitted from natural sources (bushfires, dust storms, pollens and sea spray) or as a result of human activities such as combustion activities (motor vehicle emissions, power generation and incineration), excavation works, bulk material handling, crushing operations, unpaved roads and wood heaters.

Airborne particles are commonly differentiated according to size based on their equivalent aerodynamic diameter. Particles with a diameter of less than or equal to 50 micrometres (µm) are collectively referred to as total suspended particulates (TSP). TSP primarily causes aesthetic impacts associated with coarse particles settling on surfaces, which also causes soiling and discolouration. These large particles, however, can cause some irritation of mucosal membranes and can increase health risks from ingestion if contaminated. Particles with diameters less than or equal to 10 µm (known as PM_{10} or fine particles) tend to remain suspended in the air for longer periods than larger particles, and can penetrate into human lungs.

Exposure to particulate matter has been linked to a variety of health effects, such as respiratory problems (such as coughing, aggravated asthma, chronic bronchitis) and non-fatal heart attacks. Furthermore, if the particles contain toxic materials (such as lead, cadmium, zinc) or live organisms (such as bacteria or fungi), toxic effects or infection can occur from the inhalation of the dust.

Particulate matter is considered to be a primary pollutant of concern by DECCW and the National Environmental Protection Council.

4.2 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g. oil, gas, coal and wood). CO is absorbed through the lungs of humans, where it reacts to reduce the blood's oxygen-carrying capacity. In urban areas, motor vehicles account for up to 90 percent of all CO emissions. The concentrations of CO at which adverse effects are expected to occur are quite high (being over 200 times higher than the PM_{10} criteria as shown in **Table 3**); as such, CO emissions associated with the proposed works are not expected to adversely affect the health of sensitive receptors or the environment and were not modelled in this assessment.

4.3 Heavy Metals and Other Pollutants

A variety of contaminants were detected at the site as part of contaminated land investigations. The pollutants detected at site for which the DECCW specifies air quality impact assessment criteria are discussed below[5].

4.3.1 Arsenic

Arsenic is a naturally occurring substance that is found in both inorganic (which is the more toxic form) and organic forms. Arsenic compounds exist in the atmosphere as gases or small particles that settle in soil or water and can enter the body by inhalation or ingestion. Arsenic is toxic to water and land organisms, including humans. Consumption of low levels of arsenic can cause a range of chronic and acute health effects in humans including pain, nausea and vomiting, damage to kidneys and blood vessels, decreased production of blood cells, and abnormal heart rhythms, while ingestion of sufficiently high levels can result in death. Inorganic arsenic is a recognised human carcinogen.

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan - Barangaroo - Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.3.2 Barium

Barium is a naturally occurring earth metal found in rocks, minerals, soils, air, natural waters and fossil fuels. The solubility of barium salts varies, but typically increases with decreasing pH. It is used for a variety of industrial uses, such as manufacturing of alloys, valves and paints, as an insecticide and rodenticide, and as a contrast agent in medical examinations.

Barium can be ingested or inhaled. Ingestion of barium can be toxic or lethal in humans, typically from cardiac or respiratory failure. Symptoms of barium poisoning include acute gastroenteritis, loss of reflexes and muscular paralysis. Absorption of barium through the gastrointestinal tract varies is thought to be significantly higher in children. Inhalation can result in symptoms such as sore throat coughing shortness of breath and vomiting. Barium compounds may accumulate in the lungs, while absorbed barium can enter the bloodstream and deposit in bone.

Barium compounds can be toxic in animals. Acute ingestion effects include salivation, nausea, diarrhoea, tachycardia, twitching, and paralysis of respiratory muscle, which can lead to death. Topical exposure can cause mild skin irritation and severe irritation of eyes, while ingestion affects reproduction in male and female rats. Effects of barium on terrestrial plants or wildlife are not known. High concentrations may adversely affect some aquatic organisms (IPCS International Programme on Chemical Safety - Health and Safety Guide No. 46; http://www.inchem.org/documents/hsg/hsg/hsg046.htm; accessed 19 May 2010).

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.3.3 Beryllium

Beryllium is a naturally occurring element found in low levels in background air, water and food, and can be transported as particulate matter or as a dissolved compound in water. Beryllium and its compounds are present in combustion emissions, such as those from coal-fired power stations.

Not all forms of beryllium are equally toxic, and beryllium is less toxic in hard water compared to soft water. Acute exposure can lead to death in animals, birds, and plants, with high acute toxicity to aquatic life. Chronic toxic effects can include reproductive problems, reduced fertility and changes in appearance in behaviour or appearance.

---

[5] Source: http://www.npi.gov.au/substances/factsheets.html unless otherwise specified.

Beryllium is considered to be a probable human carcinogen by Worksafe Australia. Inhalation of beryllium dust or fumes can inflame the lungs (chemical pneumonitis) and irritate the respiratory tract, and allergies/hypersensitivity can develop after repeated or prolonged exposure to low levels of contaminated dust particles, leading to chronic beryllium disease, which is associated with symptoms such as coughing, weight loss and weakness. Repeated or prolonged contact of beryllium with the skin can cause skin sensitisation and rashes or ulcers. While ingestion of beryllium is not thought to cause harmful effects in humans as little beryllium is able to move into the blood stream from the digestive system, Worksafe Australia classifies beryllium as toxic if swallowed.

Airborne beryllium dust settles to the soil, where it is typically fixed in water soluble forms that are not bioavailable to plants. Beryllium in particulate form tends to settle to the bottom of water bodies, with natural water systems containing very little dissolved beryllium.

This pollutant was not identified as pollutant of concern in the ‘Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010’. It was, however, assessed for completeness from an air quality perspective.

4.3.4 Cadmium

Cadmium is a naturally-occurring element found in the earth’s crust. The combustion of coal and other fossil fuels can result in airborne emissions of cadmium compounds, but are typically confined to the local area surrounding the emissions source, with a lifespan of 5 -15 days in particle form. Cadmium can be inhaled or ingested.

Cadmium is considered to be a probable carcinogen, with evidence suggesting it causes cancers of the kidney and prostate in humans, and lung and testicular cancer in animals. It is a known teratogen (i.e. can cause defects or malformations in developing embryos/foetuses) and may cause reproductive damage. Repeated exposure to low concentrations of cadmium can cause permanent kidney damage, while high exposures can cause rapid respiratory damage resulting in shortness of breath, chest pain and fluid build-up in the lungs, as well as gastrointestinal symptoms such as nausea, vomiting, cramps and diarrhoea. Long-term exposure can result in symptoms such as anaemia, fatigue, and loss of the sense of smell. The general public is typically exposed to cadmium through food, since food material tend to take up and retain cadmium, and smoking of tobacco.

The toxicity of cadmium is affected by water hardness in freshwater, with greater toxicity associated with softer water. Cadmium is highly toxic to aquatic life in both the short and long-term. Cadmium is highly persistent in the environment, and bioaccumulates in aquatic animals. Cadmium is less bioavailable when bound to sediments in water.

4.3.5 Chromium VI

When chromium VI is released into the atmosphere as particulate matter from the manufacture/disposal of products or the combustion of fossil fuels, it is entrained in the air for up to ten days before settling in soil and water, adhering strongly to soil particles, where only small amounts dissolve.

While chromium III is an essential element, compounds of chromium VI are usually highly toxic. Inhalation of chromium VI can damage and cause adverse health symptoms of the respiratory and gastrointestinal systems, potentially leading to asthma and other allergic reactions. Long-term exposure to airborne chromium VI can adversely affect the immune system and cause cancer. Dermal contact can lead to skin ulcers, redness and swelling.

Chromium VI can have high to moderate acute toxic effects on plants, birds and land animals, resulting in low growth rates or death. Chromium VI is persistent and is thought to bioaccumulate in aquatic life.

This pollutant was not identified as pollutant of concern in the ‘Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010’. It was, however, assessed for completeness from an air quality perspective.

4.3.6 Copper

Copper is a naturally occurring substance that is an essential trace element for both animals and plants. Copper can be inhaled or ingested. Most copper released to air, water, sediment and soil strongly binds to other particles, which greatly reduces its toxicity.

Exposure to high levels of copper can, however, be harmful, and cause irritation to the nasal passages, mouth, eyes and throat, while ingestion of high concentrations can cause nausea, vomiting, liver and kidney damage and, possibly, death. Free copper (II) ions have potentially very toxic acute and chronic effects on aquatic life. Copper is classified as a hazardous substance by the office of the Australian Safety and Compensation Council.

4.3.7 Cyanide

Cyanide is a naturally occurring element that is essential for a healthy diet (as cyanocobalmin, or vitamin B12). Compounds are released into the atmosphere (from natural or human processes) as gaseous or particulate matter, which settles into the soil or water, with most compounds being water soluble. Cyanides break down in a matter of days in water but are persistent in air. Exposure can occur from ingestion of food or water or smoking, or air pollution from silver and gold mining operations, chemical processing facilities, steel and iron industries, high motor vehicle traffic areas and the like. Pesticides and rodenticides can also contain cyanide.

It is very toxic to humans, and exposure by inhalation can cause rapid death. Brief exposures to lower concentrations may result in symptoms such as shortness of breath, convulsions and unconsciousness, while long-term exposure to low concentrations can result in deafness, vision and coordination problems. Exposure to high levels for short periods can result in damage to the respiratory, cardiovascular and central nervous systems and quickly cause death. As cyanide was only detected in very small concentrations at the site (i.e. at concentrations approximately 1,000 times less than relevant assessment criteria[6]), cyanide is not expected to be a significant issue at the site.

Cyanides are also highly toxic to aquatic life, birds and animals over short periods. While cyanides have high chronic toxicity to aquatic life, insufficient data exist to determine chronic toxicity to land organisms. Cyanides are not expected to bioaccumulate.

This pollutant was not identified as pollutant of concern in the ‘Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010’. It was, however, assessed for completeness from an air quality perspective.

4.3.8 Lead

Lead is a naturally occurring substance that can enter the body by inhalation or ingestion, and primarily affects the nervous system. Exposure to lead causes symptoms such as paralysis, anaemia, abdominal pain, brain and kidney damage and death. Lead can affect reproduction as well as the mental and physical development of children. While lead does not decompose, lead compounds are changed by sunlight, air and water. Lead may be released as particles into the atmosphere, including through windblown dust and bush fires. Lead usually attaches to particles of organic matter, clay, soil or sand, and can accumulate in tissues.

4.3.9 Manganese

Manganese is an essential element for all life forms, naturally present in air, soil, water and food. It is predominantly used to produce ferromanganese, or metallic manganese, which is used in the production of a variety of steels, cast iron and alloy materials and in battery and fertiliser manufacturing. It can be transported as particulate matter in the atmosphere or as dissolved compounds in natural waters.

Relatively large doses of manganese can be tolerated. It can be inhaled or ingested, with significant absorption from dermal contact possible with organo-manganese compounds. Exposure to manganese primarily occurs through food. Occupational exposure to high levels of manganese can result in a disease called manganism, caused by damage to the central nervous system, resulting in psychological, neurological and behavioural problems. Bronchitis can occur after inhalation of manganese dust. Manganese and its compounds are moderately acutely and chronically toxic to aquatic life, but most plant forms have a very high tolerance.

Airborne manganese particles settle and accumulate in the upper part of the soil; the level of bioavailability to plants depends on the form of the manganese compounds and pH value of the soil. Iron-manganese oxides in

[6] NEPC. (1999). National Environment Protection (Assessment of Site Contamination) Measure (NEPM). National Environment Protection Council.

waters can carry many other inorganic and organic pollutants, making them sources and sinks of them in aquatic sediments.

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.3.10 Mercury

Mercury is a naturally occurring element found in rocks and ores. Mercury chloride acts like a particle, while elemental mercury may be found as a gas in the atmosphere. It is naturally released into the atmosphere by evaporation from soils and water and volcanic eruptions. Significant anthropogenic sources of mercury are the burning of fossil fuels, municipal landfills, sewage, metal refining and chemical manufacturing.

Mercury can enter the body through inhalation, ingestion or dermal contact. The nervous system is very sensitive to all forms of mercury. Exposure can potentially causing permanent damage to the brain, eyes, kidneys and developing foetuses, and can cause fluid build-up in the lungs that can be fatal. Dermal contact can burns to the skin.

Mercury is highly toxic to aquatic life, with both acute and chronic effects. Mercury accumulates in body tissue; consumption of contaminated fish can poison humans and possibly birds and land animals. It is also highly persistent in water and the environment.

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.3.11 Nickel

Nickel is an abundant, naturally-occurring element found in soil, water and food, typically found in combination with other elements such as arsenic, antimony and sulphur. Nickel is emitted to atmosphere from both natural and anthropogenic sources, such as combustion of fossil fuels, steel production, municipal waste incineration and sewage treatment. Nickel can be transported as particulate matter or dissolved in water bodies.

Nickel is carried in air as a fine particulate, which is washed out of the air by rain, into soil and water. Much environmental nickel is found in soils and sediments, and is kept soluble by organic matter in polluted environments.

Nickel and its compounds can be inhaled or ingested, with food and water being the primary sources of exposure for most people, as well as tobacco smoke. Dermal contact, such as from jewellery containing nickel, can also create reactions. Human sensitivity to nickel varies – sensitive individuals can experience allergic reactions to exposure, while non-sensitised people require significant exposure to show adverse health effects. Inhalation of high concentrations of nickel can result in effects on the respiratory system, potentially causing sinus cancer, and nickel dust irritates the eyes, nose and throat.

While trace amounts of nickel are essential for normal growth and reproduction of some species, nickel and its compounds can be highly toxic to aquatic life, with greater toxicity occurring with softer water. Nickel does not appear to bioaccumulate.

4.3.12 Zinc

Zinc is a naturally occurring element found in all foods as well as rocks, soil, air, water, plants, animals and humans. Trace amounts are essential for human health. It is found in a variety of compounds, the properties of which vary greatly. The metal has a strong tendency to form complexes with inorganic and organic compounds. Zinc is primarily used in galvanising to form a protective coating for iron and steel, but is also used in a range of manufacturing, industrial and pharmaceutical applications such as fungicides, antiseptics, water-repellents, lubricants and concrete.

Zinc attaches to dust particles in the air and to soil and sediment particles, and can be inhaled or ingested. Excessive zinc ingestion can lead to nausea, vomiting, anaemia, and damage to the pancreas. Zinc dust irritates mucous membranes, while solid zinc compounds can irritate the skin and eyes. Zinc and its salts generally have high acute and chronic toxicity to aquatic life in polluted waters, with toxicity affected by water hardness and pH.

4.4 Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as oxides of nitrogen (NO_x). NO_x is a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient NO_x. NO_2 can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. NO_2 can also cause damage to plants, especially in the present of other pollutants such as O_3 and SO_2. NO_x are also primary ingredients in the reactions that lead to photochemical smog formation.

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.5 Odour

Odour is a sensory response to the inhalation of one or more chemicals in the air we breathe. A person's perception of an odour can vary significantly depending on the sensitivity of the person, the acuteness of the person's sense of smell and the connotations that the odour bestows on that person. Odour primarily affects a person's quality of life and can have a large range of adverse effects including stress and other physical symptoms.

Ambient odour is not monitored by the DECCW nor by industry, however odour emissions need to be taken into account in any air pollution assessment, as many air pollution complaints in residential (and sometimes industrial) areas often relate to odour. Many industries in and around the assessment area contain potential odour sources.

The odorous compounds detected at the site, namely ethylbenzene, naphthalene and xylenes, are classified as volatile organic compounds (VOCs). Ethylbenzene and xylenes are discussed in **Section 4.6.1** (BTEX), while naphthalene is discussed in **Section 4.6.2** with the polycyclic aromatic hydrocarbons (PAHs).

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.6 Volatile Organic Compounds

Organic compounds with a vapour pressure at 20 °C exceeding 0.13 kPa are referred to as volatile organic compounds (VOCs). VOCs have been implicated as a major precursor in the production of photochemical smog, which causes atmospheric haze, eye irritation and respiratory problems. VOC emissions are typical for oil processing, petrochemical and chemical plants and include emissions from point sources (storage tanks and filling stations vents) and fugitive emissions from pipelines and process equipment leaks. A variety of VOCs were detected at the site, which may be released during the proposed excavation, handling and processing activities.

Two main categories of VOCs are BTEX and PAHs, which are discussed below[7].

4.6.1 BTEX

The acronym BTEX refers to four primary VOCs: benzene, toluene, ethylbenzene and xylenes.

Benzene

Benzene is an airborne substance that is a precursor to photochemical smog. It can be washed out of the air by rain, but then evaporated back into the air. It will decompose in soil or water when oxygen is present. Benzene exposure commonly occurs through inhalation of air containing the substance. It can also enter the body through

[7] Source: http://www.npi.gov.au/substances/factsheets.html unless otherwise specified.

the skin, although it is poorly absorbed this way. Low levels of benzene exposure result from tobacco smoke and car exhaust.

Benzene is considered to be a toxic health hazard and a carcinogen. It has high acute toxic effects on aquatic life and long-term effects on marine life and agricultural crops. Human exposure to very high levels for even brief periods of time can potentially result in death, while lower level exposure can cause skin and eye irritation, drowsiness, dizziness, headaches and vomiting, damage to the immune system, leukaemia and birth defects.

Toluene

Toluene (methylbenzene) is a highly volatile chemical that quickly evaporates to a gas if released as a liquid. After a few days, the substance breaks down in air into chemicals that are harmful to human health, and is also broken down by bacteria in soil and water. Due to relatively fast degradation, toluene emissions are typically confined to the local area in which it is emitted. Toluene is a component of petrol and paints, and is also found in tobacco smoke. Human exposure typically occurs through breathing contaminated air, but toluene can also be ingested or absorbed through the skin (in liquid form). Toluene usually leaves the body within twelve hours.

Short-term exposure to high levels of toluene can cause dizziness, sleepiness, unconsciousness and sometimes death. Long-term exposure can cause kidney damage and permanent brain damage that can lead to speech, vision and hearing problems, as well as loss of muscle and memory functions. The substance can cause membrane damage in plant leaves, and is moderately toxic to aquatic life with long-term exposure.

This pollutant was not identified as pollutant of concern in the ‘Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010’. It was, however, assessed for completeness from an air quality perspective.

Ethylbenzene

Ethylbenzene is a highly volatile substance, so is typically present in air. After around three days in the air, the compound breaks down into chemicals found in smog. Ethylbenzene rapidly enters the body through the lungs and digestive tract. The substance has both acute and chronic toxic effects on animals and plants, including shortened lifespan, reproductive problems and behaviour changes. Exposure to high concentrations can cause dizziness, paralysis, breathing difficulties and death. Chronic health effects in humans can last for months or years. Ethylbenzene is present in petroleum, pesticides, cleaning products and solvents.

This pollutant was not identified as pollutant of concern in the ‘Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010’. It was, however, assessed for completeness from an air quality perspective.

Xylenes

Xylenes are flammable liquids that are moderately soluble in water. They are quickly degraded by sunlight when released to air, and rapidly evaporate when released to soil or water. They are used as solvents and in petrol and chemical manufacturing.

Xylenes can enter the body through inhalation or skin absorption (liquid form), and can cause irritation of the eyes and nose, stomach problems, memory and concentration problems, nausea and dizziness. High-level exposure can cause death. The substances have high acute and chronic toxicity to aquatic life and can adversely affect crops.

4.6.2 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are organic compounds that contain at least two fused benzene rings that are formed by the incomplete combustion of fossil fuels and other organic materials. They travel through the atmosphere as a gas or attached to dust particles. Some PAHs readily evaporate into the air. The compounds can break down over days or weeks by reacting with sunlight and other chemicals in air, but do not dissolve easily in water. PAHs are moderately persistent in the environment and can bioaccumulate.

PAHs can be inhaled or ingested, and can also be absorbed through the skin. Exposure can cause irritation of eyes and nose and other mucous membranes, headaches, nausea, damage to blood cells, liver and kidneys, and death (in very high levels). A number of PAHs are listed as probably or possibly carcinogenic to humans by the International Agency for Research on Cancer. They can have high acute and chronic toxicity effects on animals and aquatic life, with some also affecting agricultural and ornamental crops. Benzo[α]pyrene is one of the most toxic PAHs, and, as it typically found in the atmosphere with other PAHs, is often used as an indicator for the PAH group of pollutants.

Naphthalene

Naphthalene is the primary PAH of potential concern at the Barangaroo site due to its volatile nature and strong, offensive odour. It is produced from coal tar and petroleum, and is used for the production of chemicals, dyes and as a moth-repellent. It can be absorbed through inhalation, ingestion and dermal contact. Short-term exposure can cause lesions of blood cells (haemolysis), while long-term exposure can result in chronic haemolytic anaemia. Inhalation can generate symptoms such as headache, confusion, nausea, vomiting and sweating. Skin irritation and dermatitis can result from dermal contact. Naphthalene exposure can cause cataracts in the eyes, while ingestion can cause abdominal cramps, nausea, vomiting, diarrhoea and death in young infants. It is considered possible carcinogenic to humans and carcinogenic in animals. The substance is very toxic to aquatic organisms. Naphthalene may cause long-term effects in the aquatic environment[8].

This pollutant was not identified as pollutant of concern in the 'Remediation Action Plan – Barangaroo- Other Remediation Works (South) Area AECOM May 2010'. It was, however, assessed for completeness from an air quality perspective.

4.7 Impact Assessment Criteria

The DECCW has specified ground level concentration criteria that are intended to minimise the adverse effects of airborne pollutants on sensitive receptors (DEC, 2005). The ambient air quality criteria for the pollutants considered in this assessment are shown in **Table 3** (combustion products and soil contaminants) and **Table 4** (odour).

Table 3: DECCW Impact Assessment Criteria

Pollutant	Averaging Period	Criteria
Combustion Products and Dust		
NO_2	1 hour	246 µg/m^3
	Annual	62 µg/m^3
PM_{10}	24 hours	50 µg/m^3
	Annual	30 µg/m^3
TSP	Annual	90 µg/m^3
Soil Contaminants (expected as a component of dust)		
Arsenic	1 hour	0.00009 mg/m^3
Barium	1 hour	0.009 mg/m^3
Benzene	1 hour	0.029 mg/m^3
Beryllium	1 hour	0.000004 mg/m^3
Cadmium	1 hour	0.000018 mg/m^3
Chromium III	1 hour	0.009 mg/m^3
Copper (as fumes)	1 hour	0.0037 mg/m^3
Cyanide	1 hour	0.09 mg/m^3
Ethylbenzene	1 hour	8.0 mg/m^3

[8] International Programme on Chemical Safety Poisons Information Monograph 363; http://www.inchem.org/documents/pims/chemical/pim363.htm; accessed 19 May 2010

Pollutant	Averaging Period	Criteria
Iron oxide fumes	1 hour	0.09 mg/m^3
Lead	Annual	0.5 µg/m^3
Manganese	1 hour	0.018 mg/m^3
Mercury (organic)	1 hour	0.00018 mg/m^3
Naphthalene*	1 hour	0.001294 mg/m^3
Nickel	1 hour	0.00018 mg/m^3
Polycyclic aromatic compounds (PAHs) (as benzo[α}pyrene)	1 hour	0.004 mg/m^3
Xylenes	1 hour	0.19 mg/m^3
Zinc (as zinc chloride fumes)	1 hour	0.018 mg/m^3
* Derived from DECCW Potency Equivalency Factors source document		

It should be noted that not all pollutants listed above have been modelled. Ethylbenzene, naphthalene and xylenes were modelled as odour as explained in **Section 6.2.4**.

The DECCW's odour assessment criteria[9] are shown in **Table 4**. These criteria take into account individual sensitivity to odour in the community, and use a statistical approach based on population size. As population size increases, the likelihood of sensitive individuals being within that population also increases; as such, areas with larger populations require more stringent criteria.

Table 4: Impact Assessment Criteria - Complex Odours

Population	Criteria (OU)*
Urban ($\geq$ ~2000) and/or schools and hospitals	2
~ 500	3
~ 125	4
~ 30	5
~ 10	6
Single residence ($\leq$ ~2)	7
*99th percentile nose response time	

An odour assessment criterion of 2 OU was adopted for this assessment due to the urban environment of the project site.

[9] Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW), 2005.

"This page has been left blank intentionally"

5.0 Existing Environment

5.1 Introduction

The main environmental factors that can influence the level of air pollutants in ambient air are:

- Existing air quality, affected by local and/or regional sources of air pollution;
- Meteorological characteristics, such as still air and inversions (where cold air is trapped below warm air), that can slow down the removal of pollutants and, therefore, increase the effects of air pollution; and
- Terrain features, such as valleys that can influence the transport of the pollutants.

These features are described in the following sections.

5.2 Regional Air Quality

The DECCW operates a network of air quality monitoring stations around the state. The closest stations to the site are located at Rozelle, Randwick and Earlwood. Rozelle is the closest station to the site (approximately 3.5 km to the west). The Rozelle air quality monitoring station is located in the grounds of Rozelle Hospital, off Balmain Road, Rozelle. It is situated in a residential area in the Parramatta River Valley at an elevation of 22 m, and monitors the following pollutants and parameters:

- Ozone (O_3);
- Oxides of nitrogen (NO, NO_2 & NO_x);
- Carbon monoxide (CO);
- Fine particles (by nephelometry);
- Fine particles (PM_{10} using a tapered element oscillating microbalance);
- Wind speed, wind direction and sigma theta;
- Ambient temperature;
- Relative humidity; and
- Solar radiation.

The Randwick monitoring station is located in the grounds of the Randwick Army Barracks, on the corner of Avoca and Bundock Streets, Randwick, approximately 8.5 km south-southeast of Barangaroo. The monitoring station is at an elevation of 28 m. In addition to the parameters monitored at Rozelle, the Randwick station also records concentrations of sulfur dioxide, but does not monitor solar radiation.

The Earlwood monitoring station is located in Beaman Park, off Riverview Road, Earlwood, approximately 8.5 km southwest of Barangaroo. It is situated in a residential area in the Cook's River Valley at an elevation of 7 m. It monitors the same parameters as the Randwick station, as well as $PM_{2.5}$, measured using a tapered element oscillating microbalance.

The Barangaroo site and the above DECCW monitoring stations are located within the urban centre of the Sydney basin close to the Sydney CBD. The monitoring sites are all surrounded by medium- to high-density residential and commercial developments and are close to major arterial roads, as is Barangaroo. As such, data recorded at these stations are considered to be generally representative of ambient pollutant concentrations at the site.

Data recorded at the three stations between 1 January 2008 and 31 December 2008 (most recent quality-assured data available from DECCW) were compiled as shown in **Table 5**. The maximum pollutant concentrations measured were taken as conservative background pollutant concentrations for use in the cumulative assessment.

To allow an estimation of background TSP concentrations (which are not measured at any of the three monitoring stations), the ratio of PM_{10} to TSP was calculated from the Rozelle and Earlwood DECCW monitoring station data (two closest DECCW monitoring stations that recorded TSP and PM_{10}) for the year 2004 (last recorded year that these stations measured TSP). The ratio of PM_{10} to TSP for 2004 was calculated to be 49 % at Rozelle and 43 % at Earlwood (i.e. 49 % to 43 % of TSP in the region monitored by Rozelle and Earlwood is PM_{10}). To ensure the assessment was conservative, the lowest ratio of PM_{10} to TSP was assumed (i.e. 43 %), resulting in the highest likely ambient TSP concentration estimation for the Barangaroo site. This ratio was applied to the PM_{10} concentrations measured at the three DECCW monitoring stations for the 2008 data to develop estimated TSP concentrations.

One of the averaging periods for CO is 15 minutes. The following power law was used to convert the hourly averaged results to the 15 minute averaging period:

$$C_s = C_k(t_k/t_s)^p \qquad \text{(Schnelle and Dey, 1999)}$$

Where:

C_s = *concentration for time* t_s

C_k = *concentration for time* t_k

t_k = *longer averaging time*

t_s = *shorter averaging time*

p = power (assumed value of 0.17)

The background concentrations used in the AQIA are summarised in **Table 5**. It should be noted that contemporaneous assessments of PM_{10} and NO_2 were conducted as part of the modelling assessment, which added actual measured pollutant concentrations for each hour to maximum concentrations predicted by the dispersion modelling; as such, the maximum values provided in **Table 5** were not used in the cumulative assessment and should be considered as indicative concentrations only.

Table 5: Ambient Pollutant Concentrations, DECCW Monitoring Stations

Air Emission	Averaging Period	Background Concentration (µg/m³)			Assessment Criteria (µg/m³)
		Rozelle	Randwick	Earlwood	
Nitrogen dioxide[1]	1 hour maximum	75.2	77.1	77.1	246
	Annual	20.7	16.6	19.8	62
TSP	Annual	40.5	40.5	44.7	90
PM_{10}	24 hour maximum	43.1	36.3	**50.6**	50
	Annual	17.4	17.4	19.2	30
Ozone[3]	1 hour maximum	109.8	119.6	123.5	214
	1 hour maximum	93.6	112.7	109.8	171
	Annual	27.1	34.6	27.2	-

Bold data denotes exceedence of DECCW criteria
[1] NO_2 contemporaneous background data used to predict background concentrations using the OLM detailed in **Section 6.6**.
[2] TSP calculated by applying TSP to PM_{10} ratio to PM_{10} hourly results as previously described
[3] Ozone concentrations used for NO_2 contemporaneous assessment calculations. Ozone was not modelled as a pollutant.
- Entry denotes no data available for this pollutant at that particular monitoring location.

The maximum calculated TSP concentration was assumed as the existing background level of TSP for this assessment (i.e. 44.7 µg/m³). Further details regarding the data sets are provided in the following sections.

5.2.1 PM_{10}

The only pollutant with recorded exceedences of the assessment criteria was 24 hour average PM_{10} (which occurred at Earlwood, and not Rozelle). **Figure 3** shows a plot of the PM_{10} concentrations recorded at Rozelle in 2008.

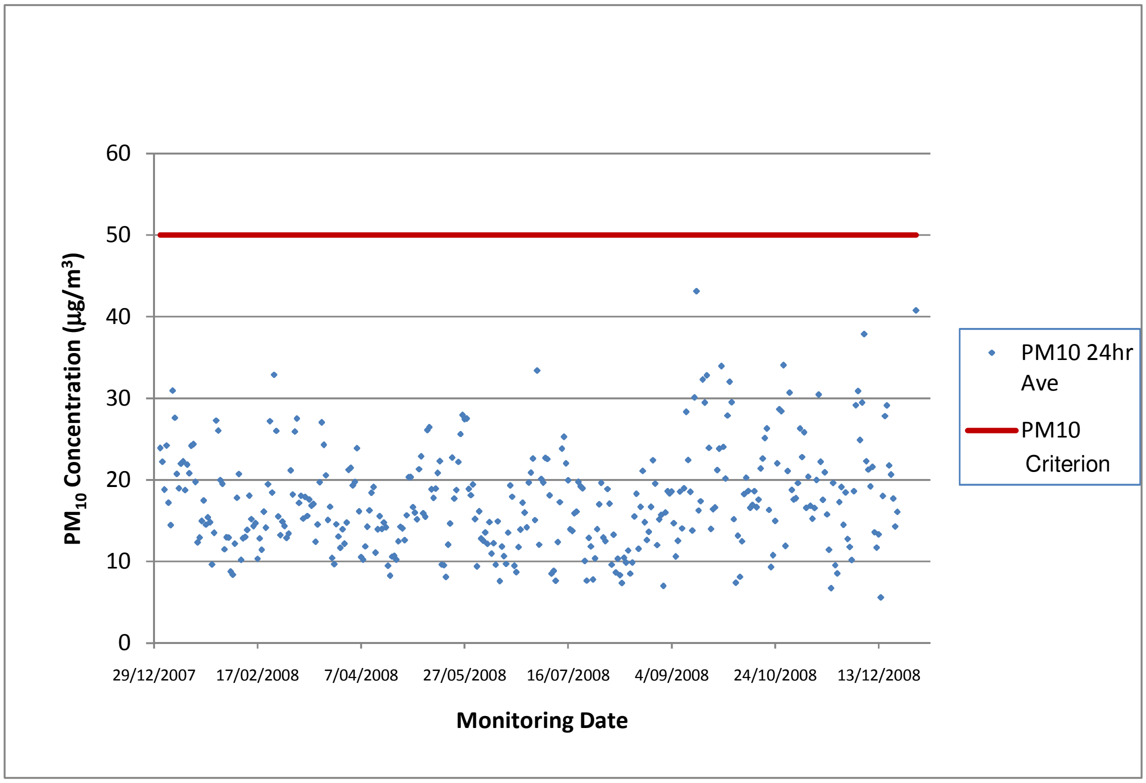


Figure 2: 24 Hour Average PM_{10} Monitoring Data, Rozelle, 2008

Figure 3 shows that the PM_{10} concentrations at Rozelle are predominantly low, with concentrations typically within the range of 10 to 25 µg/m^3. To ensure the assessment accurately reflected the true cumulative PM_{10} concentration throughout the modelled year, a contemporaneous assessment for PM_{10} was undertaken (as described in **Section 6.5**) using data recorded at Rozelle (the closest station to the site). Gaps in the Rozelle data were supplemented by data from the relevant period from Randwick or Earlwood (in that order). A summary of the data availability for the three monitoring sites is shown in **Table 6**.

Table 6: DECCW Monitoring Station Data Availability

Pollutant	Averaging Period	Monitoring Station 2008 Data Availability (%)		
		Rozelle	Randwick	Earlwood
NO_2	1 hour	79	88	83
PM_{10}	24 hour	98	97	100

5.2.2 NO_2

Hourly average ambient NO_2 concentrations recorded at Rozelle during 2008 were all well below the assessment criterion (as shown in **Figure 4**). A contemporaneous assessment of NO_2 was undertaken to ensure the NO_X conversion to NO_2 (via the OLM outlined in **Section 6.6**) and the subsequent calculation of cumulative NO_2 concentrations was as accurate as possible given the available data. The hourly average measured NO_2 values from the Rozelle site were used for the contemporaneous assessment of the NO_X emissions from the Barangaroo site. As with PM_{10}, data gaps were filled with appropriate data from Randwick or, if not available, Earlwood.

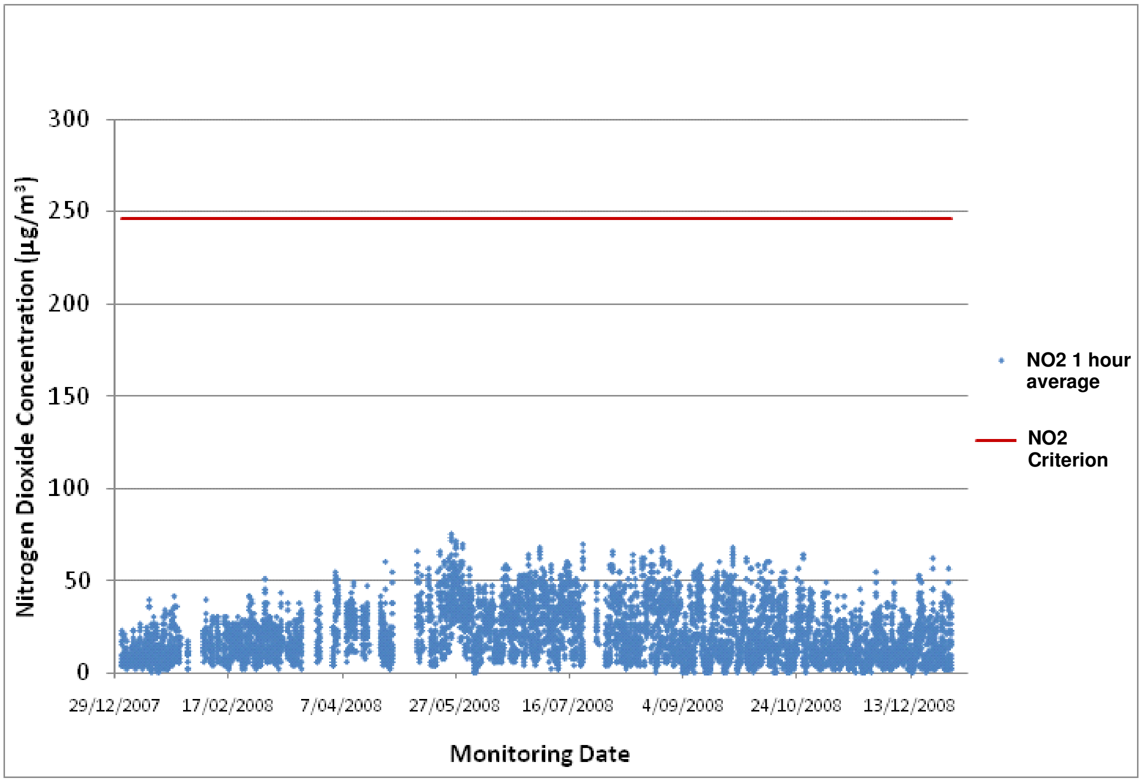


Figure 3: 1 Hour Average NO_2 Monitoring Data, Rozelle, 2008

5.2.3 Odour

Ambient odour monitoring is not typically undertaken, and no publically available data were identified for the area surrounding the site. It should be noted that odours from different sources are not typically cumulative; that is, odours from the contaminated soils at the site would be expected to be quite different to that from other surrounding sources, as the odours are likely to have different character. As such, background odour concentrations were assumed to be negligible.

5.2.4 Other Pollutants

Ambient concentrations of other pollutants assessed (i.e. heavy metals, cyanide, and VOCs) were also assumed to be negligible for the purpose of this assessment.

5.3 Climate

The BOM collects meteorological data from various sites in the Sydney Basin. The station at Observatory Hill is less than 200 m from the eastern boundary of the Barangaroo site, while Fort Denison is approximately 2 km to the east of the site. The meteorological data collected from these two stations is complementary and, together, provides an indication of the climate in the immediate area around Barangaroo. Long term data averages recorded between 1859 and May, 2010 are summarised in **Appendix A**.

Average maximum temperatures in summer range from 25.9 °C to 25.2 °C, while minimum temperatures range from 17.5 °C to 18.8 °C. In winter, the average maximum temperature ranges from 16.3 °C to 17.8 °C and the average minimum temperature ranges from 8.0 °C to 9.3 °C.

The annual average humidity reading collected at 9 am from the site is 69 %, and at 3 pm the annual average is 57 %. Rainfall data collected at Observatory Hill shows, on average, that the wettest months are January to June, with average rainfall of greater than 100 mm for each of the intervening months.

Further analysis of the meteorological data is provided in **Section 7.2.1** and **Appendix B**.

6.0 Air Dispersion Modelling Methodology

6.1 Overview

Dispersion modelling was undertaken to predict the potential effects of the proposed excavation, construction, remediation and emplacement works associated with the enabling and preparatory phases of works contemplated under Concept Plan Amendment (MP06_0162 MOD 4). The following sections outline details of the dispersion model used and its inputs (specifically meteorology, terrain, building parameters, modelling scenarios, source characteristics and an emissions inventory), sensitive receptor locations, and methodology as to how pollutant concentrations were estimated.

The modelling was conducted in accordance and/or in consideration of the following statutory documents:

- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005);
- Assessment and Management of Odour from Stationary Sources in NSW: Technical Framework (DEC, 2006a);
- Assessment and Management of Odour from Stationary Sources in NSW: Technical Notes (DEC, 2006b); and
- Protection of the Environment Operations (Clean Air) Regulation 2002.

Assessment of the DECCW Declaration Area will be the subject of a future Project Application.

6.2 Dispersion Model

The CALPUFF air dispersion model was used in the AQIA in accordance with the DECCW Approved Methods (DEC, 2005). CALPUFF is a non steady-state, three-dimensional Gaussian puff model developed for the US Environmental Protection Agency (USEPA) for use in situations where basic Gaussian plume models are not effective, such as areas with complex meteorological or topographical conditions, including coastal areas with re-circulating sea breezes.

Input parameters used in the CALPUFF dispersion modelling are summarised in **Table 7**.

Table 7: CALPUFF Input Parameters

Parameter	Input
CALPUFF Version	6.262 2010
Modelling Domain	3 km x 3 km
Modelling Grid Resolution	20 m
Number of Sensitive Receptors	56
Terrain Data	Included in CALMET
Building Wake Data	Not included in model
Dispersion Algorithm	PG (Rural, ISC curves) & MP Coeff. (urban)
Hours Modelled	8760 hours (365 days)
Meteorological Data Period	1 January 2008 – 31 December 2008

CALPUFF requires the following data to determine the dispersion of pollutants:

- Meteorology;
- Terrain;
- Modelling scenarios;
- Source characteristics; and
- Emissions inventory.

The above inputs are addressed separately in the following sections.

6.2.1 Dispersion Model Meteorology

Meteorology in the area surrounding the site is affected by several factors such as terrain and land use. Wind speed and direction are largely affected by topography at the small scale, while factors such as synoptic scale winds (which are modified by sea breezes near the coast in the daytime), affect wind speed and direction on the larger scale.

As the site is located in a coastal environment, varying wind patterns would be expected due to onshore and offshore winds. Meteorological and topographical data were used to develop the CALMET wind fields to ensure the data used in the dispersion modelling were representative of local conditions.

The CALMET meteorological model uses actual meteorological observations to generate three dimensional wind fields on an hourly time step at a grid of points covering the area under investigation. Topographical features and land use factors are then used to further refine the wind fields, which are subsequently used in the CALPUFF dispersion model.

Meteorological data were obtained from two sources in the area immediately surrounding the Barangaroo site. Hourly averaged meteorological data for 2008 were sourced from the Rozelle monitoring station (operated by the DECCW) and the Fort Denison and Observatory Hill meteorological stations operated by the Bureau of Meteorology (BOM) for the following parameters:

- Observatory Hill - rainfall and temperature;
- Fort Denison - wind speed and direction; and
- Rozelle - wind speed, wind direction, sigma theta, temperature, relative humidity, and solar radiation.

These data were used as input to CALMET as surface file data. In order to determine whether these data were representative of general conditions at the Barangaroo site, they were compared to long-term climate averages obtained from the Observatory Hill and Fort Denison meteorological stations as discussed in **Appendix B**.

The CSIRO-developed prognostic model, TAPM (The Air Pollution Model), was used to define the upper air meteorology for the area surrounding Barangaroo. To ensure the meteorological data were as representative as possible of the local environment, TAPM data were generated for 36 points on a grid including the Barangaroo site. Surface and upper air files were generated for all of the 36 nodes and entered into the CALMET model together with the surface files for Rozelle, Observatory Hill and Fort Denison.

In order to assess whether the generated meteorological data were representative of long-term average conditions in the area, selected long term climate parameters from the BOM monitoring stations were compared against the CALMET dataset as shown in **Appendix B**.

Following the analysis of the data found in **Appendix B**, the meteorological data was considered to be representative of meteorology in the area surrounding Barangaroo and considered acceptable for use in the dispersion modelling.

6.2.2 Terrain

The NASA Shuttle Radar Topographic Mission (SRTM) provides digital elevation data (DEMs) for over 80 % of the globe. The SRTM data are available as 3 arc second DEMs, which provide a resolution of approximately 90 m. The vertical error of the DEMs is reported to be less than 16 m.

Digital terrain data required by CALMET were obtained for an area of approximately 7.2 km x 7.2 km (corresponding to the innermost grid of the TAPM meteorological data modelling), approximately centred on the site, from the global SRTM database. The 90 m resolution data was included in the CALMET GEO.dat input file and used along with the TAPM, DECCW and BOM meteorological data for determination of the three dimensional modelling meteorological data file required by CALPUFF.

6.2.3 Modelling Scenarios

Five modelling scenarios were initially assessed in the AQIA as outlined in **Table 8**.

Table 8: Modelling Scenarios

Scenario	Description
1	Excavation/construction of perimeter retention systems and piling
2	Worst-case (all dust and combustion sources occurring simultaneously, excluding Scenario 1 sources)
3	Contaminated sources only (to enable calculation of contaminants at sensitive receptor locations)
4	Odour assessment of Scenario 1 works
5	Odour assessment of Scenario 2 works

Modelling was initially undertaken for all sources identified from Lend Lease's preliminary description of expected project activities. The resulting predicted pollutant concentrations were not considered to be realistic, and have been attributed to the use of default emission factors obtained from the NPI; as such, further examination of the expected sources was undertaken to develop more realistic emission profiles.

The following changes to the original emission sources were made following consultation with the DECCW:

- Bulldozer emissions were removed as the bulldozers are expected to be used sparingly during excavation activities, and the moisture content of the soil is expected to be such that no significant dust would be generated (much of the excavation activities would be below sea level);
- Emissions from the excavation activities (wind erosion and materials handling) would not be expected due to the wet nature of the material being excavated from the pits.
- Truck haul emissions are not expected due to the wet nature of the material being hauled and the expected wet internal unpaved haul roads.
- Soil stockpiled awaiting emplacement. The material awaiting treatment was considered moist enough to not generate dust emissions; treated material was assumed to contain less moisture and possibly generate dust emissions through wind erosion.

The above assumptions were applied to all modelled results from scenarios 2 and 3, which represent the worst case expected dust and contaminated soil emissions from the site.

Emission sources included in each modelling scenario are outlined in **Table 11**.

"This page has been left blank intentionally"

Table 9: Emission Sources for each Modelling Scenario

Emission Sources	Number	Scenario				
		1	2	3	4	5
		Dust &/or Combustion Products	Dust &/or Combustion Products	Dust (contamination)	Odour (Scenario 1)	Odour (Scenario 2)
Piling operation						
80t drill rigs	2	X				
80t cranes	2	X				
30t excavators	2	X			X	X
Bulk excavation						
Bulldozer D11	1		X			X
80t mobile crane	1		X			
Drilling rig for anchors	1		X			
30t excavators (with a hammer)	4		X		X	X
60t excavators (with a hammer)	2		X			X
Trucks	5	X (1 only)	X		X	X
Loading to trucks	2	X (1 only)	X			X
Loader	1	X (1 only)	X		X	X
Haul road	5	*	X			
Wind erosion	1	X	X		X	X
Archaeological material stockpile	1	X			X	

Emission Sources	Number	Scenario				
		1	2	3	4	5
		Dust &/or Combustion Products	Dust &/or Combustion Products	Dust (contamination)	Odour (Scenario 1)	Odour (Scenario 2)
Soil treatment						
Pugmill/treatment tent	1		X			X
Odour tent	1		X			X
FEL with backhoe on back - contaminated material	1		X			X
FEL with backhoe on back - treated material	1		X			
Contaminated material stockpile loading	1		X			X
Contaminated material stockpile management	1		X			X
Contaminated material stockpile wind erosion	1		X	X		X
Treated material stockpile management	1		X			
Treated material stockpile wind erosion	1		X			
Trucks	2		X			
Headland Park emplacement activities						
Bulldozer	1		X			
Excavator	1		X			
Concrete crusher	1		X			
Concrete stockpile	1		X			
Wind erosion - active area	1		X			
Trucks	3		X			
Trucks dumping overburden	1		X			

* Haul road assumed to be paved at this stage of works; as such, no wheel-generated dust expected.

6.2.4 Source Characteristics

Emission sources used in the dispersion modelling consisted of volume, area and point sources.

The source characteristics for each of the volume sources are provided in **Table 10**. Haulage trucks were modelled as line sources (i.e. separated volume sources).

Table 10: Volume Source Characteristics

Source	Source ID	Effective height (m)	Base elevation (m)	Initial sigma y (m)	Initial sigma z (m)
Emplacement area					
Trucks dumping	EMPTPO	3	3	5	3
Stockpile management	EMPSPM	2	3	3	1
Concrete crusher	EMPCC	3	3	2	3
Bulldozer	EMPBBDZ	2	3	3	2
Wheel-generated dust	EMPWD1-4	1	3	2	1
Vehicle emissions	EMPVE	3	3	1	3
Treatment area					
Untreated stockpile – trucks dumping overburden	USSTDO	3	3	5	3
Untreated stockpile management	USSSPM	2	3	3	1
Treated stockpile management	TSSPN	2	3	3	1
Vehicle emissions	SSVE	3	3	1	3
Excavation area					
Drill rig 1*	DRG1	3	3	1	3
Drill rig 2*	DRG2	3	3	1	3
Construction vehicle emissions*	CPVE	3	3	1	3
Excavator 1*	EXC1	3	3	2	1
Excavator 2*	EXC2	3	3	2	1
Excavator – deep carpark	DCPEXC	2	3	3	2
Loading to trucks	DCPLTO	3	3	2	3
Deep carpark - bulldozer	DCPBDZ	2	3	3	2
Excavator – shallow carpark	SCPEXC	2	3	3	2
Wheel-generated dust	EXWD1-4	1	3	2	1
Combustion truck emissions – paved area	PB1-7	1	3	2	1
Combustion emissions – excavation area (excluding trucks)	CPB	2	3	2	2
* Scenario 1 sources					

Exposed areas, such as the excavation and emplacement areas and the stockpiles, were modelled as area sources. Details are provided in **Table 11**.

Table 11: Area Source Characteristics – Wind Erosion

Source	Source ID	Effective Height (m)	Base Elevation (m)	Initial Sigma z (m)
Emplacement area	EMPAREA	1	3	1
Untreated soil stockpile	USS	2	3	1
Treated soil stockpile	TSS	2	3	1
Deep carpark	DCP	1	3	1
Shallow carpark	SCP	1	3	1
Diaphragm wall area*	DWAREA	1	3	1
Archaeological stockpile*	ASTK	2	3	1
* Scenario 1 sources only				

The point source (stack) characteristics for the soil treatment tents are provided in **Table 12**. As the remediation system has yet to be determined, actual parameters were not available. As such, these parameters were all estimated based on typical best practice values and regulatory limits.

Table 12: Point Source Characteristics

Stack Parameter	Units	Stacks 1 and 2
Base elevation	m	3
Height	m	30
Exit diameter	m	1.7
Exit area	m^2	2.22
Temperature	K	293
Exit velocity	m/s	15
Flow rate	m^3/s	33.33

Odour emissions characteristics were estimated from data published from the Homebush Bay site remediation works (Egis Consulting, 2002[10]). Data representing emissions from the excavation activities, wind erosion from the excavation pit, and vaporisation from contaminated stockpiles are presented in the **Table 13**. These data were used together with site contamination data to calculate possible odour emissions associated with the proposed works on site.

[10] Egis Consulting Australia Pty Ltd. (2002). Former Lednez Site and Homebush Bay Remediation Environment Impact Assessment – Air Quality Human Health Risk Assessment.

Table 13: Odour Flux Estimates

Chemical	Reference Data			Site Data	
	Soil Concentration* (mg/kg)	Odour Flux* ($OU/m^2/s$)	Odour Flux to Soil Concentration ratio^	Maximum Soil Concentration (mg/kg)#	Site Odour Flux ($OU/m^2/s$)^
Excavation					
Ethylbenzene	56.3	3.12E-02	5.54E-04	10.5	5.82E-03
Naphthalene	1150	1.40E-03	1.22E-06	948	1.15E-03
Xylenes	33.0	1.43E-04	4.33E-06	83.2	3.61E-04
Sum of Components					7.33E-03
Peak-to-mean ratio+ of 2.5					**1.83E-02**
Excavation Area Wind Erosion					
Ethylbenzene	56.3	1.64E-03	2.91E-05	10.5	3.06E-04
Naphthalene	1150	2.43E-03	2.11E-06	948	2.00E-03
Xylenes	56.3	9.78E-06	1.74E-07	83.2	1.45E-05
Sum of Components					2.32E-03
Peak-to-mean ratio of 2.5					**5.81E-03**
Stockpile Vapourisation					
Ethylbenzene	150.0	8.22E-03	5.48E-05	10.5	5.75E-04
Naphthalene	6600	1.32E-02	2.00E-06	948	1.90E-03
Xylenes	420.0	1.24E-04	2.95E-07	83.2	2.46E-05
Sum of Components					2.50E-03
Peak-to-mean ratio of 2.5					**6.24E-03**

*Source: Egis Consulting, 2002, Appendix C, Tables 2 and 4
^ Calculated
# AECOM (2010). Remedial Action Plan, Barangaroo – Other Remediation Works (South) Area. 20 May 2010
+ Peak to mean ratio converts hourly modelling results to a one second nose response time as required for odour assessments

6.2.5 Emissions Inventory

Emissions from activities such as wind erosion, stockpiling, materials handling and wheel-generated dust were estimated using emission factors and equations in the following National Pollutant Inventory Emission Estimation Technique manuals:

- Concrete Batching and Concrete Product Manufacturing, 1999;
- Combustion Engines, Version 3.0, 2008;
- Fugitive Emissions, 1999;
- Mining, Version 2.3, 2001; and
- Mining and Processing of Non-Metallic Minerals, Version 2, 2000.

Additional emission factors for specific construction plant and equipment were sourced from a report on a large construction project[11]. A detailed emissions inventory showing detailed calculations is provided in **Appendix C**. Emission rates used in Scenario 1 (excavation/construction of diaphragm walls and pilings) and Scenario 4 (odour associated with the Scenario 1 works) are provided in **Table 14**.

Table 14: Pollutant Emission Rates – Odour, TSP, PM_{10} and NO_X– Scenarios 1 and 4

Description	Emission rates				
	Odour ($OU.m^3/s$)	TSP	PM_{10}	NO_X	Units*
Drill rig emissions - piling operations	-	5E-2	3E-2	0.42	g/s
Excavator emissions - diaphragm wall excavation	1.83E-2	6E-4	3E-4	0.42	g/s
Construction vehicle emissions	-	1.4E-1	1.4E-1	0.42	g/s
Wind erosion - archaeological stockpile	6.24E-3	7E-6	4E-6	-	$g/m^2/s$
Wind erosion - diaphragm wall	-	7E-6	4E-6	-	$g/m^2/s$
* Units relate to TSP, PM_{10} and NO_X emissions only; odour is measured in $OU.m^3/s$					

Emission rates used for Scenario 2 (worst-case emissions) and Scenario 5 (odour associated with Scenario 2) are provided in **Table 15**. Emissions associated with Scenario 3 (contaminated sources only) are indicated in italic text.

Table 15: Pollutant Emission Rates – Odour, TSP, PM_{10} and NO_X– Scenarios 2, 3 and 5

Source	Description	Emission rates				
		Odour ($OU.m^3/s$)	TSP	PM_{10}	NO_X	Units*
Emplacement area	Wind erosion	-	7E-6	4E-6	-	$g/m^2/s$
	Trucks dumping overburden	-	5E-3	2E-3	-	g/s
	Stockpile management (excavator)	-	1.7E-2	8E-3	-	g/s
	Wheel-generated dust (unsealed roads)[1]	-	3.9E-1	1.2E-1	3E-2	g/s
	Bulldozer	-	1.89	4.3E-1	-	g/s
	Concrete crusher	-	6E-6	6E-6	-	g/s
	Vehicle emissions	-	3.9E-2	3.9E-2	6.29E-1	g/s
Soil treatment tents [4]		1.9E4	*6.7E-1*	*3.3E-1*	-	g/s
Untreated soil stockpile	Wind erosion	6.2E-3	*7E-6*	*4E-6*	-	$g/m^2/s$
	Trucks dumping overburden	1.83E-1	*1E-4*	*5E-5*	-	g/s
	Stockpile management	1.83E-1	*2E-4*	*1E-4*	-	g/s
Treated stockpile	Wind erosion	-	7E-6	4E-6	-	$g/m^2/s$
	Stockpile management	-	4E-3	2E-3	-	g/s
Stockpile vehicle emissions		-	4.5E-2	4.5E-2	6.17E-1	g/s

[11] Pacific Institute (2001) The Cadiz Valley Groundwater Storage Project; http://www.pacinst.org/reports/cadiz/feir/volumes/vol1/appendix/v1a_c1.pdf

Source	Description	Emission rates				
		Odour ($OU.m^3/s$)	TSP	PM_{10}	NO_X	Units*
Excavations - deep carpark	Wind erosion	6.2E-3	7E-6	4E-6	-	$g/m^2/s$
	Excavation[2]	1.83E-1	2.7E-2	1.3E-2	-	g/s
	Loading to trucks[3]	1.83E-1	1.8E-2	8E-3	-	g/s
	Bulldozer	1.83E-1	6E-1	1.2E-1	-	g/s
Excavations - shallow loading bay	Wind erosion	6.2E-3	7E-6	4E-6	-	$g/m^2/s$
	Excavation[2]	1.83E-1	2.4E-2	1.1E-2	-	g/s
Haul Road - excavation area (wheel-generated dust)[1]		-	4.14E-1	1.21E-1	3E-2	g/s
Paved vehicle emissions - 7 sources		-	2E-3	2E-3	2.9E-2	g/s
Carpark vehicle emissions - all vehicle and plant emissions combined		-	2.3E-1	2.3E-1	3.39	g/s

* Units relate to TSP, PM_{10} and NO_X emissions only; odour is measured in $OU.m^3/s$
[1] emission rate for each of four volume sources
[2] combined emission rate for three excavators
[3] combined emission rate for two trucks
[4] emissions per tent

6.3 Sensitive Receptors

Sensitive receptors are identified by the DECCW as anywhere someone works or resides or may work or reside, including residential areas, hospitals, hotels, shopping centres, play grounds, recreational centres, and the like. The primary sensitive receptors associated with the site are residences located along Hickson Road, which are approximately 20 m from the site boundary.

The location of sensitive receptors included in the modelling are detailed in **Tables 18** and **19** and shown on **Figure 5**.

Table 16: Sensitive Receptors – Ground Level

Receptor No.	Coordinates (m)		Address	Classification
	X	Y		
1	333.703	6252.36	4 Towns Place, Barangaroo	Commercial
3	333.64	6252.26	9 Towns Place, Barangaroo	Residential
5	333.64	6252.26	2 Rhodens Lane, Barangaroo	Residential
7	333.64	6252.26	Clyne Reserve	Public
8	333.748	6251.3	20 Merriman St, Millers Point	Commercial
10	333.748	6251.3	27 Bettington St, Barangaroo	Commercial
12	333.748	6251.3	25 Hickson Rd, Barangaroo	Commercial
14	333.748	6251.3	12A High St, Millers Point	Residential
16	333.748	6251.3	9A High Street, Millers Point	Residential
18	333.748	6251.3	38 High Street, Millers Point	Residential
20	333.748	6251.3	76 High Street, Millers Point	Residential

Receptor No.	Coordinates (m)		Address	Classification
	X	Y		
22	333.748	6251.3	High Steps, Millers Point	Residential
24	333.748	6251.3	Lend Lease (Millers Point)	Commercial
26	333.748	6251.3	127 Kent Street, Millers Point	Commercial
31	333.69	6251.304	Child Care Centre	Commercial
33	333.69	6251.304	38 Hickson Road, Millers Point	Residential
35	333.69	6251.304	8 Jenkins Street, Millers Point	Commercial
40	333.748	6251.3	Barangaroo Display North End	Commercial
46	333.748	6251.3	Maritime Trade Towers North	Commercial
51	333.748	6251.3	Maritime Trade Towers South	Commercial
55	333.69	6251.304	Moreton's Hotel	Commercial
57	333.69	6251.304	Westpac Place	Commercial
60	333.748	6251.3	KPMG	Commercial
63	333.69	6251.304	Proposed Bovis Site Office	Commercial
64	333.59	6251.854	Macquarie Bank Centre	Commercial
67	333.59	6251.854	King Street Wharf North End	Commercial
69	333.59	6251.854	Passenger Terminal	Commercial
71	333.266	6251.472	Ballarat Park	Commercial
72	333.136	6251.611	Jones Bay Wharf	Public
73	333.122	6251.942	Balmain South-East	Public
74	333.171	6252.612	Goat Island South-East	Public
75	333.823	6252.97	Blues Point Reserve South	Public
86	333.54	6251.815	Site walkways	Residential
90	333.617	6252.03	Site walkways	Public
91	333.707	6252.042	Site walkways	Public
92	333.642	6251.812	Site walkways	Public
93	333.701	6251.818	Site walkways	Public
94	333.726	6251.905	Site walkways	Public
95	333.659	6251.566	Site walkways	Public
96	333.766	6251.5	Site walkways	Public

Table 17: Sensitive Receptors – Flagpole (Elevated)

Receptor No.	Coordinates (m)		Address	Height above ground (m)	Classification
	X	Y			
2	333.703	6252.358	4 Towns Place, Barangaroo	8	Commercial
4	333.715	6252.285	9 Towns Place, Barangaroo	5	Residential
6	333.686	6252.27	2 Rhodens Lane, Barangaroo	8	Residential
9	333.664	6252.165	20 Merriman St, Millers Point	5	Unknown
11	333.664	6252.126	27 Bettington St, Barangaroo	5	Commercial
13	333.683	6252.085	25 Hickson Rd, Barangaroo	14	Commercial
15	333.759	6252.02	12A High St, Millers Point	5	Residential
17	333.764	6251.943	9A High Street, Millers Point	5	Residential
19	333.77	6251.877	38 High Street, Millers Point	5	Residential
21	333.775	6251.812	76 High Street, Millers Point	5	Residential
23	333.77	6251.78	High Steps, Millers Point	5	Residential
25	333.771	6251.727	Lend Lease	20	Commercial
27	333.806	6251.718	127 Kent Street, Millers Point	20	Commercial
28	333.806	6251.718	127 Kent Street, Millers Point	40	Commercial
29	333.806	6251.718	127 Kent Street, Millers Point	60	Commercial
30	333.806	6251.718	127 Kent Street, Millers Point	80	Commercial
32	333.773	6251.683	Child Care Centre	20	Commercial
34	333.779	6251.61	38 Hickson Road, Millers Point	20	Residential
36	333.808	6251.604	8 Jenkins Street, Millers Point	15	Commercial
37	333.808	6251.604	8 Jenkins Street, Millers Point	30	Commercial
38	333.808	6251.604	8 Jenkins Street, Millers Point	45	Commercial
39	333.808	6251.604	8 Jenkins Street, Millers Point	60	Commercial
41	333.734	6251.572	Barangaroo Display North End	5	Commercial
45	333.791	6251.49	Hickson Street, Barangaroo	15	Commercial
47	333.815	6251.505	Maritime Trade Towers North	15	Commercial
48	333.815	6251.505	Maritime Trade Towers North	30	Commercial
49	333.815	6251.505	Maritime Trade Towers North	45	Commercial
50	333.815	6251.505	Maritime Trade Towers North	60	Commercial
52	333.825	6251.427	Maritime Trade Towers South	15	Commercial
53	333.825	6251.427	Maritime Trade Towers South	30	Commercial
54	333.825	6251.427	Maritime Trade Towers South	50	Commercial
56	333.808	6251.353	Moreton's Hotel	10	Commercial
58	333.826	6251.257	Westpac Place	20	Commercial

Receptor No.	Coordinates (m)		Address	Height above ground (m)	Classification
	X	Y			
59	333.826	6251.257	Westpac Place	40	Commercial
61	333.748	6251.3	KPMG	15	Commercial
62	333.748	6251.3	KPMG	30	Commercial
65	333.708	6251.257	Macquarie Bank Centre	10	Commercial
66	333.708	6251.257	Macquarie Bank Centre	20	Commercial
68	333.647	6251.256	King Street Wharf North End	8	Commercial
70	333.396	6251.259	Sydney Wharf	5	Public

6.4 Assessment of Contaminants

The maximum detected concentrations of pollutants found in the soils at the site were used to conduct a worst-case assessment of potential concentrations at sensitive receptor locations for Scenarios 1 and 3. The maximum detected concentrations were multiplied by the maximum predicted ground level dust concentration as a method of determining the percentage of dust at each receptor that was comprised of the individual pollutants. For lead, the annual GLC was used; hourly concentrations were used for all other pollutants. TSP was assessed to provide a worst-case assessment.

6.5 Prediction of Cumulative Impacts

DEC (2005) specifies that AQIAs are to assess the cumulative impact of a proposal against their impact assessment criteria. This involves adding existing background pollutant levels and expected pollutant levels from other concurrent developments to maximum pollutant concentrations predicted by dispersion modelling. The modelling results include emissions from neighbouring construction works not under the control of the proponent (e.g. concrete crushing at Headland Park). No other major construction activities in the immediate area were identified. As such, the cumulative assessment simply comprised the addition of data described in **Section 5.2** (assumed ambient pollutant concentrations) for TSP to predicted pollutant concentrations, and compared to the relevant criteria. For PM_{10} and NO_2, contemporaneous assessments were made using hourly data for the modelling period from the DECCW's Rozelle monitoring station.

6.6 Ozone Limiting Method (OLM)

Nitrogen oxides are produced in most combustion processes and are formed during the oxidation of nitrogen in fuel and nitrogen in the air. During high-temperature processes, a variety of oxides are formed including nitric oxide (NO) and nitrogen dioxide (NO_2). Generally, at the point of emission, NO will comprise the greatest proportion of the emission with 95 % by volume of the NO_X. The remaining NO_X will consist of NO_2. Ultimately, however, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen.

The USEPA's Ozone Limiting Method (OLM) was used to predict ground-level concentrations of NO_2. The OLM is based on the assumption that approximately 10 % of the initial NO_X emissions are emitted as NO_2. If the ozone (O_3) concentration is greater than 90 % of the predicted NOx concentrations, all the NO_X is assumed to be converted to NO_2,otherwise NO_2 concentrations are predicted using the equation $NO_2 = 46/48 * O_3 + 0.1 * NO_X$. This method assumes instant conversion of NO to NO_2 in the plume, which overestimates concentrations close to the source since conversion usually occurs over periods of hours. This method is described in detail in DEC (2005).

Background O_3 data from the Rozelle monitoring station (refer to **Section 5.2**) were used to convert the modelled NO_2 concentrations in accordance with the DECCW approved OLM (Method 2, Level 2 Assessment; DEC, 2005).

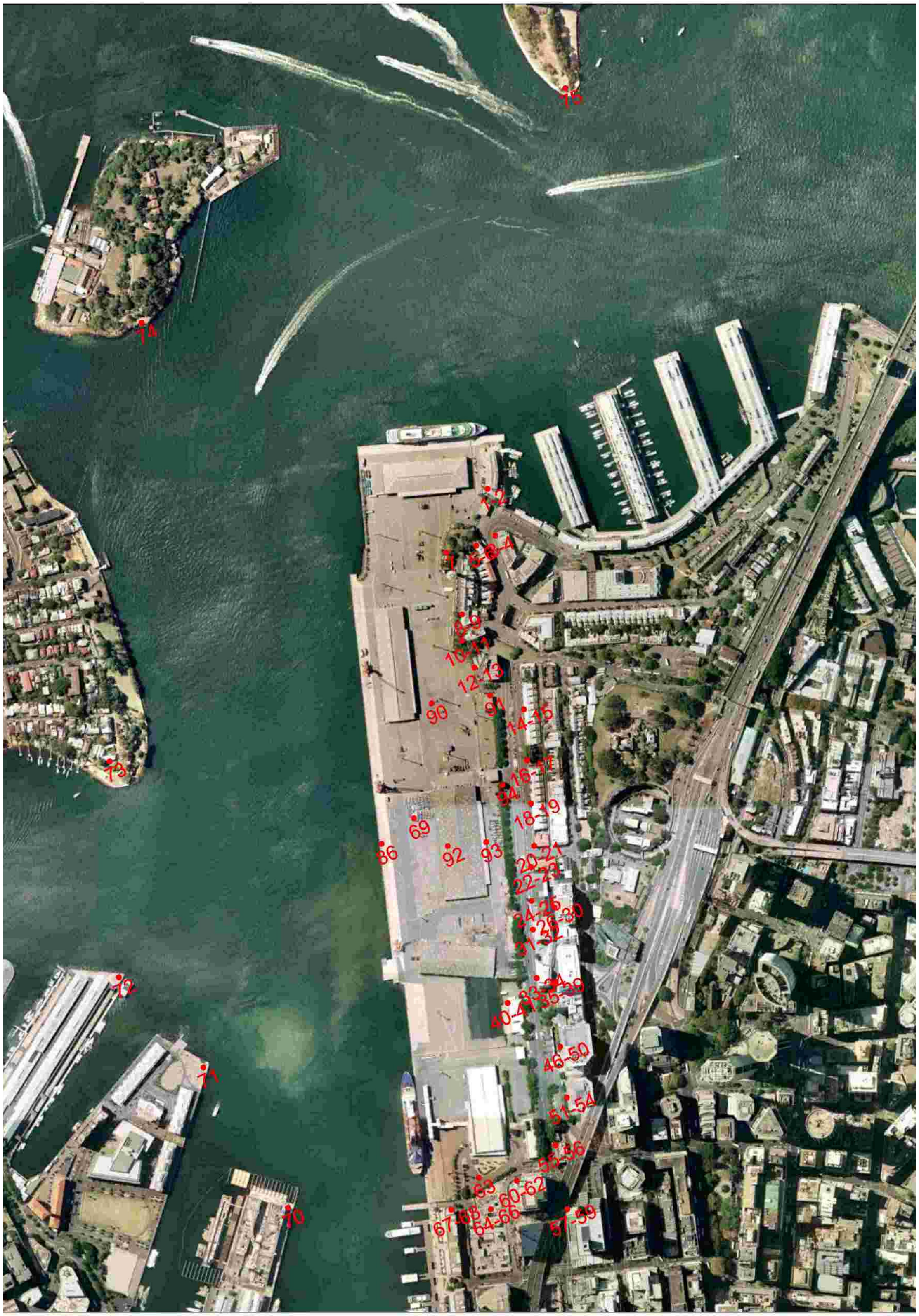


Figure 4: Sensitive Receptor Locations

"This page has been left blank intentionally"

7.0 Air Dispersion Modelling Results

Predicted pollutant concentrations resulting from each of the five modelled scenarios are provided in **Tables 20 – 25** as outlined below:

- **Table 20** – Ground level pollutant concentrations for Scenario 1 (basement retention system excavation) and 4 odour associated with Scenario 1;
- **Table 21** – Flagpole pollutant concentrations for Scenarios 1 and 4;
- **Table 22** - Ground level pollutant concentrations for Scenario 2 (worst case excavation) and 5 (odour associated with Scenario 2);
- **Table 23** - Flagpole pollutant concentrations for Scenarios 2 and 5; and
- **Tables 24** and **25**, which present the predicted ground level and flagpole concentrations of contaminants contained within TSP from Scenario 2 (i.e. the worst case total dust levels associated with the excavation activities).

Exceedences of the DECCW impact assessment criteria are highlighted in bold text. Results are summarised below.

<u>Scenario 1</u>

Modelling of the basement retention system excavation predicted a number of exceedences of 24 hour PM_{10} at ground level and flagpole receptors, with the highest predicted concentration at a sensitive receptor of 115 $\mu g/m^3$ atReceptor 51 (Maritime Trade Towers South). No exceedences of annual PM_{10}, TSP or NO_2 were predicted. Exceedences of 1 hour NO_2 were predicted at nine ground level receptors and one flagpole receptor; the maximum predicted concentration was 546 $\mu g/m^3$ at Receptor 55 (Moreton's Hotel).

<u>Scenario 2</u>

The dispersion modelling results of the bulk excavation activities (Scenario 2) predicted elevated levels of 24 hour PM_{10} at a number of ground level and flagpole receptors, with the highest cumulative concentration of 151 $\mu g/m^3$ predicted at Receptor 46 (Maritime Trade Towers South). Exceedences of the annual PM_{10} criterion were predicted at three ground level receptor locations (5,7 and 8), with the maximum predicted concentration of 44.5 $\mu g/m^3$ exceeding the DECCW criterion by 14.5 $\mu g/m^3$. No exceedences of annual PM_{10} at flagpole receptors were predicted.

<u>Scenario 3</u>

Scenario concerned potential contaminants contained within excavated material and the prediction of concentrations of those contaminants at sensitive receptor locations. No exceedences of any of the pollutants detected on site were predicted by the dispersion modelling.

<u>Scenarios 4 and 5</u>

No exceedences of the odour criterion adopted for this assessment (2 OU) were predicted for either the diaphragm wall works (Scenario 2) or the bulk excavation and emplacement activities (Scenario 4).

"This page has been left blank intentionally"

Table 18: Predicted Ground Level Pollutant Concentrations – Scenarios 1 and 4

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
1	1	0	0.8	43.2	0.05	17.5	0.001	0.1	44.8	75.2	20.2
3	2	0	1.0	43.2	0.06	17.6	0.001	0.1	44.8	75.2	20.2
5	3	0	1.0	43.2	0.06	17.6	0.001	0.1	44.8	75.2	20.2
7	4	0	1.1	43.1	0.07	17.6	0.001	0.1	44.8	75.2	20.2
8	5	0	1.5	43.2	0.09	17.6	0.002	0.1	44.8	75.2	20.3
10	6	0	1.7	43.2	0.11	17.6	0.002	0.2	44.9	75.2	20.4
12	7	0	2.0	43.2	0.13	17.6	0.003	0.2	44.9	75.6	20.5
14	8	0	2.8	43.6	0.19	17.7	0.003	0.3	45.0	80.9	20.6
16	9	0	4.4	44.1	0.35	17.8	0.008	0.5	45.2	88.8	20.8
18	10	0	6.4	44.5	0.58	18.1	0.015	0.9	45.6	98.7	21.0
20	11	0	11.8	45.5	0.98	18.5	0.019	1.5	46.2	118.8	21.2
22	12	0	15.0	46.4	1.35	18.8	0.022	2.0	46.7	133.0	21.4
24	13	0	21.3	47.3	2.21	19.7	0.024	3.4	48.1	181.0	21.7
26	14	0	21.7	46.8	1.95	19.4	0.020	3.0	47.7	181.8	21.7
31	15	0	21.9	46.8	2.88	20.4	0.026	4.4	49.1	227.3	22.0
33	16	0	43.1	**57.9**	3.59	21.1	0.028	5.3	50.0	**450.6**	22.8
35	17	0	27.9	49.4	3.03	20.5	0.023	4.4	49.1	**368.5**	22.6
40	18	0	54.5	**69.7**	6.00	23.5	0.041	8.8	53.5	**411.0**	24.2
46	21	0	70.2	**87.6**	5.45	22.9	0.030	7.0	51.7	**456.0**	25.7
51	22	0	87.2	**115.0**	8.06	25.6	0.022	9.4	54.1	**445.8**	30.7

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
55	23	0	47.6	**68.7**	4.86	22.4	0.016	6.5	51.2	**546.1**	29.0
57	24	0	25.3	**50.6**	1.59	19.1	0.010	2.1	46.8	**277.7**	22.6
60	25	0	20.5	45.8	1.59	19.1	0.012	2.3	47.0	**430.1**	22.9
63	26	0	17.3	43.1	1.35	18.8	0.012	2.0	46.7	**337.2**	23.8
64	27	0	14.6	43.1	0.74	18.2	0.009	1.0	45.7	201.3	21.6
67	28	0	10.5	43.1	0.68	18.2	0.008	1.0	45.7	163.7	22.1
69	29	0	8.5	43.1	0.66	18.2	0.012	1.0	45.7	90.3	21.3
71	31	0	3.2	43.1	0.48	18.0	0.009	0.8	45.5	100.1	20.9
72	32	0	2.8	43.1	0.36	17.9	0.007	0.6	45.3	103.4	21.0
73	33	0	2.9	43.1	0.19	17.7	0.003	0.3	45.0	104.1	20.8
74	34	0	0.4	43.1	0.03	17.5	0.001	0.1	44.8	75.2	20.1
75	35	0	0.4	43.1	0.02	17.5	0.000	0.0	44.7	75.2	20.0
86	46	0	11.8	43.1	1.23	18.7	0.021	2.0	46.7	98.3	21.4
90	50	0	2.7	43.1	0.18	17.7	0.003	0.3	45.0	75.2	20.7
91	51	0	2.3	43.3	0.15	17.6	0.003	0.2	44.9	77.7	20.5
92	52	0	12.4	43.8	0.91	18.4	0.017	1.4	46.1	100.6	21.4
93	53	0	10.4	45.7	0.95	18.4	0.023	1.4	46.1	119.1	21.3
94	54	0	5.4	44.3	0.40	17.9	0.009	0.6	45.3	91.6	20.9
Criteria			***-***	***50.0***	***-***	***30.0***	***2***	***-***	***90.0***	***246***	***62***
***Exceedences noted in bold**											

Table 19: Predicted Flagpole Pollutant Concentrations – Scenarios 1 and 4

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
2	1	8	13.9	45.9	1.18	18.7	0.019	1.8	63.4	129.7	21.3
4	2	5	0.7	43.2	0.05	17.5	0.001	0.1	62.2	75.2	20.2
6	3	8	6.1	43.3	0.32	17.8	0.001	0.4	62.5	105.0	21.0
9	5	5	1.0	43.2	0.06	17.6	0.001	0.1	62.3	75.2	20.2
11	6	5	1.0	43.2	0.06	17.6	0.001	0.1	62.3	75.2	20.2
13	7	14	0.1	43.1	0.00	17.5	0.000	0.0	62.2	75.2	19.9
15	8	5	1.5	43.2	0.09	17.6	0.002	0.1	62.3	75.2	20.3
17	9	5	1.7	43.2	0.11	17.6	0.002	0.1	62.3	75.2	20.4
19	10	5	1.9	43.2	0.11	17.6	0.002	0.2	62.3	75.2	20.5
21	11	5	2.6	43.6	0.18	17.7	0.003	0.3	62.4	79.3	20.6
23	12	5	4.0	44.0	0.33	17.8	0.007	0.5	62.5	85.7	20.8
25	13	20	0.2	43.1	0.01	17.5	0.000	0.0	62.2	75.2	20.0
27	14	20	0.1	43.1	0.00	17.5	0.000	0.0	62.2	75.2	20.0
28	14	40	25.2	49.0	2.43	19.9	0.010	3.2	64.6	239.9	25.2
29	14	60	12.7	43.1	0.63	18.1	0.007	0.9	62.8	158.9	21.5
30	14	80	3.0	43.1	0.35	17.8	0.006	0.5	62.5	113.1	21.8
32	15	20	45.5	**61.6**	4.21	21.7	0.031	5.9	66.4	**354.9**	23.8
34	16	20	14.3	45.4	1.15	18.6	0.007	1.5	63.3	131.7	22.4
36	17	15	5.7	43.3	0.33	17.8	0.001	0.4	62.5	109.5	21.1
37	17	30	0.2	43.1	0.01	17.5	0.000	0.0	62.2	77.5	20.0

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
38	17	45	1.8	43.1	0.13	17.6	0.001	0.2	62.3	91.4	20.4
39	17	60	8.8	43.1	0.48	18.0	0.005	0.7	62.7	141.8	21.3
41	18	5	6.2	44.4	0.54	18.0	0.013	0.8	62.7	94.6	21.0
47	21	15	6.6	43.5	0.34	17.8	0.001	0.4	62.5	105.2	21.2
48	21	30	13.2	48.2	1.38	18.9	0.008	1.7	63.6	116.5	23.2
49	21	45	10.9	43.1	0.81	18.3	0.007	1.1	63.0	141.6	21.8
50	21	60	8.6	43.1	0.61	18.1	0.007	0.9	62.8	137.3	22.0
52	22	15	9.7	45.0	0.82	18.3	0.005	1.1	63.0	158.3	21.5
53	22	30	1.0	43.1	0.06	17.6	0.001	0.1	62.3	103.8	20.0
54	22	50	6.0	43.1	0.42	17.9	0.002	0.5	62.6	130.6	21.2
56	23	10	0.3	43.2	0.02	17.5	0.000	0.0	62.2	75.2	20.1
58	24	20	0.6	43.2	0.04	17.5	0.000	0.1	62.2	101.8	20.1
59	24	40	7.7	43.1	0.48	18.0	0.005	0.6	62.7	104.9	21.1
61	25	15	0.5	43.2	0.04	17.5	0.000	0.1	62.2	78.3	20.2
62	25	30	0.3	43.1	0.01	17.5	0.000	0.0	62.2	92.5	20.0
65	27	10	0.1	43.1	0.00	17.5	0.000	0.0	62.2	75.2	20.0
66	27	20	0.3	43.1	0.01	17.5	0.000	0.0	62.2	88.5	20.0
68	28	8	7.1	43.5	0.33	17.8	0.001	0.4	62.5	96.8	21.1
70	30	5	11.1	45.2	0.88	18.4	0.016	1.3	63.1	116.5	21.2
Criteria			**-**	***50.0***	**-**	***30.0***	***2***	**-**	***90.0***	***246***	***62***
***Exceedences noted in bold**											

Table 20: Predicted Ground Level Pollutant Concentrations – Scenarios 2 and 5

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU) (99%)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative		Predicted	Cumulative		
1	1	0	46.6	**64.7**	6.18	23.7	0.2	16.7	61.4	138.8	22.7
3	2	0	36.6	**64.1**	10.27	27.8	0.2	25.9	70.6	107.1	23.7
5	3	0	**57.9**	**75.7**	15.91	**33.4**	0.2	40.2	84.9	125.3	24.3
7	4	0	**98.6**	**122.4**	26.98	**44.5**	0.2	73.7	**118.4**	**290.8**	25.7
8	5	0	**74.7**	**92.5**	13.63	**31.1**	0.3	31.4	76.1	108.5	23.0
10	6	0	**54.3**	**74.2**	10.83	28.3	0.3	21.8	66.5	221.3	27.1
12	7	0	29.7	**55.0**	3.29	20.8	0.4	7.3	52.0	109.1	22.5
14	8	0	23.1	43.9	1.66	19.2	0.4	3.4	48.1	120.1	23.1
16	9	0	11.4	44.0	1.37	18.9	0.3	2.4	47.1	154.7	23.6
18	10	0	8.7	44.6	1.39	18.9	0.3	2.1	46.8	244.9	23.9
20	11	0	11.4	45.1	1.63	19.1	0.4	2.1	46.8	**263.7**	24.8
22	12	0	16.4	44.7	1.85	19.3	0.2	2.2	46.9	**298.3**	25.2
24	13	0	23.3	46.7	2.47	20.0	0.0	2.7	47.4	**426.0**	26.0
26	14	0	30.5	47.9	2.28	19.8	0.0	2.5	47.2	**608.6**	25.6
31	15	0	38.5	**53.3**	3.10	20.6	0.1	3.4	48.1	**477.1**	27.4
33	16	0	**59.7**	**70.1**	3.86	21.4	0.1	4.0	48.7	**1245.7**	27.9
35	17	0	41.8	**61.6**	3.16	20.7	0.1	3.3	48.0	**753.6**	26.6
40	18	0	**100.7**	**115.5**	5.69	23.2	0.1	5.8	50.5	**1434.8**	31.0
46	21	0	**136.6**	**151.0**	8.05	25.5	0.1	7.9	52.6	**2229.1**	34.2

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
51	22	0	**102.4**	**124.8**	7.59	25.1	0.1	7.5	52.2	**1503.4**	33.1
55	23	0	**67.4**	**77.0**	3.48	21.0	0.1	3.5	48.2	**1061.1**	26.1
57	24	0	20.4	43.1	0.95	18.4	0.2	1.1	45.8	**557.2**	22.0
60	25	0	23.7	43.1	0.92	18.4	0.3	1.1	45.8	**624.5**	21.9
63	26	0	22.1	43.1	0.88	18.4	0.3	1.0	45.7	**414.2**	21.9
64	27	0	18.0	43.1	0.68	18.2	0.3	0.9	45.6	**400.4**	21.5
67	28	0	14.6	43.1	0.57	18.1	0.3	0.7	45.4	**362.0**	21.4
69	29	0	10.2	43.1	1.19	18.7	0.6	1.9	46.6	133.6	23.0
71	31	0	4.5	43.1	0.64	18.1	0.4	1.1	45.8	112.9	22.5
72	32	0	7.6	43.1	0.89	18.4	0.4	1.3	46.0	140.5	23.1
73	33	0	6.4	43.1	0.69	18.2	0.4	1.3	46.0	113.5	21.7
74	34	0	10.7	43.1	0.66	18.2	0.1	1.6	46.3	84.5	20.8
75	35	0	3.3	43.3	0.16	17.7	0.1	0.4	45.1	75.2	20.2
86	46	0	12.2	43.1	1.29	18.8	0.3	1.9	46.6	165.6	23.4
90	50	0	16.6	43.1	1.89	19.4	0.4	3.9	48.6	110.6	23.5
91	51	0	19.9	44.7	2.12	19.6	0.4	10.6	55.3	143.5	23.8
92	52	0	11.5	43.3	1.41	18.9	0.2	8.5	53.2	190.0	25.5
93	53	0	12.5	44.4	1.59	19.1	0.3	8.0	52.7	228.1	24.7
94	54	0	10.7	43.9	1.13	18.6	0.3	6.1	50.8	168.1	22.8
Criteria			***-***	***50.0***	***-***	***30.0***	***2***	***-***	***90.0***	***246***	***62***
***Exceedences noted in bold**											

Table 21: Predicted Flagpole Pollutant Concentrations – Scenarios 2 and 5

Receptor No.	Building No.	Receptor Height (m)	PM_{10} (µg/m^3)				Odour (OU)	TSP (µg/m^3)		NO_2 (µg/m^3)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative	(99%)	Predicted	Cumulative		
2	1	8	4.1	43.1	0.42	17.92	0.3	0.6	45.3	**253.9**	24.4
4	2	5	26.6	**54.0**	5.44	22.94	0.2	16.3	61.0	113.6	22.5
6	3	8	29.7	**52.8**	3.61	21.10	0.2	10.5	55.2	167.0	21.9
9	5	5	49.8	**75.1**	5.53	23.02	0.3	15.4	60.1	106.6	23.6
11	6	5	43.6	**68.9**	3.73	21.22	0.3	9.2	53.9	106.8	24.1
13	7	14	16.7	43.1	0.60	18.10	0.3	0.8	45.5	75.2	20.0
15	8	5	17.8	43.9	1.43	18.93	0.4	3.1	47.8	107.9	22.9
17	9	5	8.9	44.0	1.11	18.61	0.3	2.1	46.8	113.0	23.3
19	10	5	8.3	44.3	1.13	18.62	0.3	1.8	46.5	104.9	22.1
21	11	5	10.6	44.9	1.37	18.87	0.4	1.9	46.6	112.2	22.7
23	12	5	14.4	44.6	1.58	19.08	0.2	2.0	46.7	139.7	22.9
25	13	20	12.5	43.1	1.20	18.70	0.1	1.4	46.1	97.9	20.0
27	14	20	12.6	43.1	0.73	18.23	0.3	0.9	45.6	84.9	20.0
28	14	40	23.5	**60.0**	2.27	19.76	2.9	4.7	49.4	**558.7**	23.7
29	14	60	20.2	**53.1**	1.20	18.70	2.3	2.5	47.2	**327.4**	21.4
30	14	80	10.5	43.1	0.41	17.90	0.4	0.9	45.6	120.2	22.4
32	15	20	6.5	44.0	0.64	18.14	0.2	1.0	45.7	**1123.1**	28.8
34	16	20	4.5	43.8	0.49	17.99	0.1	0.7	45.4	**270.0**	23.3
36	17	15	21.2	46.5	1.72	19.22	0.4	4.3	49.0	145.5	22.1
37	17	30	9.5	43.2	0.86	18.35	1.3	1.8	46.5	102.7	20.0

Receptor No.	Building No.	Receptor Height (m)	PM10 (µg/m³)				Odour (OU) (99%)	TSP (µg/m³)		NO_2 (µg/m³)	
			Max. 24 Hour Average		Max. Annual Average			Max. Annual Average		Max. 1 Hour Average (OLM)	Max. Annual Average (OLM)
			Predicted	Cumulative	Predicted	Cumulative		Predicted	Cumulative		
38	17	45	16.3	45.0	1.46	18.96	2.5	3.0	47.7	100.5	20.7
39	17	60	16.6	43.1	1.09	18.59	2.2	2.2	46.9	203.4	21.2
41	18	5	**77.5**	**92.4**	4.42	21.92	0.1	4.5	49.2	226.9	23.2
47	21	15	10.4	45.0	1.01	18.50	0.2	1.3	46.0	140.0	21.6
48	21	30	6.0	43.1	0.41	17.91	0.7	0.8	45.5	238.4	22.9
49	21	45	13.4	43.1	0.83	18.32	1.7	1.7	46.4	175.3	21.6
50	21	60	15.0	43.1	0.82	18.32	1.8	1.7	46.4	139.4	21.4
52	22	15	11.7	45.3	0.96	18.45	0.1	1.1	45.8	212.0	22.6
53	22	30	7.6	43.1	0.41	17.90	0.7	0.8	45.5	107.9	20.3
54	22	50	13.4	43.1	0.66	18.16	1.5	1.4	46.1	155.3	21.3
56	23	10	7.6	43.1	0.52	18.01	0.3	0.7	45.4	79.4	20.2
58	24	20	8.2	43.1	0.54	18.03	0.3	0.7	45.4	107.6	20.2
59	24	40	6.8	43.1	0.43	17.93	0.4	0.7	45.4	196.7	21.2
61	25	15	17.1	46.0	1.19	18.69	0.1	1.3	46.0	103.9	20.3
62	25	30	10.5	43.1	0.60	18.09	0.4	0.8	45.5	104.4	20.0
65	27	10	34.1	**50.8**	1.94	19.43	0.1	2.0	46.7	75.2	20.0
66	27	20	13.9	43.1	0.53	18.03	0.3	0.7	45.4	105.0	20.0
68	28	8	26.7	**53.7**	6.57	24.07	0.2	20.6	65.3	198.9	22.0
70	30	5	**91.0**	**107.7**	6.39	23.88	0.1	6.4	51.1	226.4	24.0
Criteria			***-***	***50.0***	***-***	***30.0***	***2***	***-***	***90.0***	***246***	***62***
***Exceedences noted in bold**											

Table 22: Ground Level Receptor Contamination Results – Scenario 2, TSP

Receptor No.	Building No.	Receptor Height (m)	Arsenic	Barium	Benzene	Beryllium	Cadmium	Chromium IV	Copper (as fumes)	Cyanide	Ethyl-benzene	Iron oxide fumes	Lead	Manganese	Mercury (organic)	Naphthalene	Nickel	PAHs (as B[α]P)	Xylenes	Zinc (as zinc chloride fumes)
			Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Annual Average (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)	Hourly max. (µg/m³)
1	1	0	9.72E-09	7.97E-08	3.77E-09	7.78E-10	3.89E-10	1.57E-08	8.26E-08	4.28E-10	2.04E-09	4.39E-06	2.64E-06	1.49E-07	1.77E-09	1.84E-07	7.78E-09	2.99E-07	1.62E-08	3.67E-07
3	2	0	1.23E-08	1.01E-07	4.76E-09	9.82E-10	4.91E-10	1.99E-08	1.04E-07	5.40E-10	2.58E-09	5.55E-06	3.21E-06	1.88E-07	2.23E-09	2.33E-07	9.82E-09	3.77E-07	2.04E-08	4.64E-07
5	3	0	1.27E-08	1.04E-07	4.94E-09	1.02E-09	5.09E-10	2.06E-08	1.08E-07	5.60E-10	2.67E-09	5.75E-06	3.40E-06	1.95E-07	2.32E-09	2.41E-07	1.02E-08	3.91E-07	2.12E-08	4.81E-07
7	4	0	1.41E-08	1.16E-07	5.49E-09	1.13E-09	5.66E-10	2.29E-08	1.20E-07	6.22E-10	2.97E-09	6.39E-06	3.58E-06	2.17E-07	2.57E-09	2.68E-07	1.13E-08	4.35E-07	2.35E-08	5.35E-07
8	5	0	1.74E-08	1.42E-07	6.74E-09	1.39E-09	6.95E-10	2.82E-08	1.48E-07	7.65E-10	3.65E-09	7.85E-06	5.01E-06	2.67E-07	3.16E-09	3.29E-07	1.39E-08	5.34E-07	2.89E-08	6.57E-07
10	6	0	2.15E-08	1.76E-07	8.33E-09	1.72E-09	8.59E-10	3.48E-08	1.82E-07	9.44E-10	4.51E-09	9.70E-06	5.96E-06	3.30E-07	3.91E-09	4.07E-07	1.72E-08	6.59E-07	3.57E-08	8.11E-07
12	7	0	2.35E-08	1.93E-07	9.12E-09	1.88E-09	9.40E-10	3.81E-08	2.00E-07	1.03E-09	4.94E-09	1.06E-05	7.02E-06	3.61E-07	4.28E-09	4.46E-07	1.88E-08	7.22E-07	3.91E-08	8.88E-07
14	8	0	3.54E-08	2.90E-07	1.37E-08	2.83E-09	1.41E-09	5.73E-08	3.01E-07	1.56E-09	7.43E-09	1.60E-05	8.89E-06	5.43E-07	6.44E-09	6.71E-07	2.83E-08	1.09E-06	5.88E-08	1.34E-06
16	9	0	6.44E-08	5.28E-07	2.50E-08	5.15E-09	2.58E-09	1.04E-07	5.48E-07	2.83E-09	1.35E-08	2.91E-05	1.46E-05	9.90E-07	1.17E-08	1.22E-06	5.15E-08	1.98E-06	1.07E-07	2.44E-06
18	10	0	9.52E-08	7.81E-07	3.70E-08	7.62E-09	3.81E-09	1.54E-07	8.10E-07	4.19E-09	2.00E-08	4.30E-05	2.40E-05	1.46E-06	1.73E-08	1.81E-06	7.62E-08	2.93E-06	1.58E-07	3.60E-06
20	11	0	1.14E-07	9.31E-07	4.40E-08	9.08E-09	4.54E-09	1.84E-07	9.65E-07	5.00E-09	2.38E-08	5.13E-05	3.67E-05	1.74E-06	2.07E-08	2.15E-06	9.08E-08	3.49E-06	1.89E-07	4.29E-06
22	12	0	1.51E-07	1.24E-06	5.85E-08	1.21E-08	6.03E-09	2.44E-07	1.28E-06	6.63E-09	3.17E-08	6.82E-05	4.45E-05	2.32E-06	2.74E-08	2.86E-06	1.21E-07	4.63E-06	2.51E-07	5.70E-06
24	13	0	1.92E-07	1.58E-06	7.45E-08	1.54E-08	7.68E-09	3.11E-07	1.63E-06	8.45E-09	4.03E-08	8.68E-05	5.88E-05	2.95E-06	3.50E-08	3.64E-06	1.54E-07	5.90E-06	3.20E-07	7.26E-06
26	14	0	1.35E-07	1.11E-06	5.25E-08	1.08E-08	5.41E-09	2.19E-07	1.15E-06	5.96E-09	2.84E-08	6.12E-05	5.67E-05	2.08E-06	2.46E-08	2.57E-06	1.08E-07	4.16E-06	2.25E-07	5.12E-06
31	15	0	1.77E-07	1.45E-06	6.85E-08	1.41E-08	7.06E-09	2.86E-07	1.50E-06	7.77E-09	3.71E-08	7.98E-05	8.65E-05	2.71E-06	3.21E-08	3.35E-06	1.41E-07	5.42E-06	2.94E-07	6.67E-06
33	16	0	2.28E-07	1.87E-06	8.83E-08	1.82E-08	9.10E-09	3.69E-07	1.93E-06	1.00E-08	4.78E-08	1.03E-04	2.06E-04	3.50E-06	4.14E-08	4.31E-06	1.82E-07	6.99E-06	3.79E-07	8.60E-06
35	17	0	2.01E-07	1.65E-06	7.81E-08	1.61E-08	8.05E-09	3.26E-07	1.71E-06	8.86E-09	4.23E-08	9.10E-05	1.83E-04	3.09E-06	3.66E-08	3.82E-06	1.61E-07	6.19E-06	3.35E-07	7.61E-06
40	18	0	3.02E-07	2.48E-06	1.17E-07	2.42E-08	1.21E-08	4.90E-07	2.57E-06	1.33E-08	6.35E-08	1.37E-04	4.64E-04	4.64E-06	5.50E-08	5.73E-06	2.42E-07	9.29E-06	5.03E-07	1.14E-05
46	21	0	1.81E-07	1.48E-06	7.01E-08	1.44E-08	7.22E-09	2.93E-07	1.53E-06	7.95E-09	3.79E-08	8.16E-05	1.79E-04	2.77E-06	3.29E-08	3.42E-06	1.44E-07	5.55E-06	3.00E-07	6.83E-06
51	22	0	2.17E-07	1.78E-06	8.41E-08	1.73E-08	8.67E-09	3.51E-07	1.84E-06	9.54E-09	4.55E-08	9.80E-05	6.62E-05	3.33E-06	3.94E-08	4.11E-06	1.73E-07	6.66E-06	3.61E-07	8.19E-06
55	23	0	1.28E-07	1.05E-06	4.98E-08	1.03E-08	5.14E-09	2.08E-07	1.09E-06	5.65E-09	2.70E-08	5.80E-05	4.19E-05	1.97E-06	2.34E-08	2.43E-06	1.03E-07	3.94E-06	2.14E-07	4.85E-06
57	24	0	8.42E-08	6.90E-07	3.27E-08	6.74E-09	3.37E-09	1.36E-07	7.16E-07	3.70E-09	1.77E-08	3.81E-05	2.72E-05	1.29E-06	1.53E-08	1.60E-06	6.74E-08	2.59E-06	1.40E-07	3.18E-06
60	25	0	1.33E-07	1.09E-06	5.16E-08	1.06E-08	5.32E-09	2.15E-07	1.13E-06	5.85E-09	2.79E-08	6.01E-05	4.09E-05	2.04E-06	2.42E-08	2.52E-06	1.06E-07	4.08E-06	2.21E-07	5.03E-06
63	26	0	9.96E-08	8.17E-07	3.87E-08	7.97E-09	3.99E-09	1.61E-07	8.47E-07	4.38E-09	2.09E-08	4.50E-05	4.10E-05	1.53E-06	1.81E-08	1.89E-06	7.97E-08	3.06E-06	1.66E-07	3.77E-06
64	27	0	7.87E-08	6.45E-07	3.05E-08	6.30E-09	3.15E-09	1.27E-07	6.69E-07	3.46E-09	1.65E-08	3.56E-05	3.02E-05	1.21E-06	1.43E-08	1.49E-06	6.30E-08	2.42E-06	1.31E-07	2.97E-06
67	28	0	1.22E-07	1.00E-06	4.74E-08	9.77E-09	4.89E-09	1.98E-07	1.04E-06	5.37E-09	2.56E-08	5.52E-05	2.95E-05	1.88E-06	2.22E-08	2.32E-06	9.77E-08	3.75E-06	2.03E-07	4.62E-06
69	29	0	1.12E-07	9.19E-07	4.35E-08	8.96E-09	4.48E-09	1.81E-07	9.52E-07	4.93E-09	2.35E-08	5.06E-05	4.19E-05	1.72E-06	2.04E-08	2.12E-06	8.96E-08	3.44E-06	1.86E-07	4.23E-06
71	31	0	7.37E-08	6.04E-07	2.86E-08	5.89E-09	2.95E-09	1.19E-07	6.26E-07	3.24E-09	1.55E-08	3.33E-05	5.13E-05	1.13E-06	1.34E-08	1.40E-06	5.89E-08	2.26E-06	1.23E-07	2.79E-06
72	32	0	5.31E-08	4.35E-07	2.06E-08	4.25E-09	2.12E-09	8.60E-08	4.51E-07	2.34E-09	1.11E-08	2.40E-05	2.78E-05	8.16E-07	9.66E-09	1.01E-06	4.25E-08	1.63E-06	8.83E-08	2.01E-06
73	33	0	2.06E-08	1.69E-07	7.98E-09	1.65E-09	8.23E-10	3.33E-08	1.75E-07	9.05E-10	4.32E-09	9.30E-06	8.88E-06	3.16E-07	3.74E-09	3.90E-07	1.65E-08	6.32E-07	3.42E-08	7.77E-07
74	34	0	9.43E-09	7.73E-08	3.66E-09	7.54E-10	3.77E-10	1.53E-08	8.02E-08	4.15E-10	1.98E-09	4.26E-06	2.37E-06	1.45E-07	1.72E-09	1.79E-07	7.54E-09	2.90E-07	1.57E-08	3.56E-07

Receptor No.	Building No.	Receptor Height (m)	Arsenic	Barium	Benzene	Beryllium	Cadmium	Chromium IV	Copper (as fumes)	Cyanide	Ethyl-benzene	Iron oxide fumes	Lead	Manganese	Mercury (organic)	Naphthalene	Nickel	PAHs (as B[α]P)	Xylenes	Zinc (as zinc chloride fumes)
			Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)
75	35	0	4.65E-09	3.82E-08	1.81E-09	3.72E-10	1.86E-10	7.54E-09	3.95E-08	2.05E-10	9.77E-10	2.10E-06	8.94E-07	7.15E-08	8.47E-10	8.82E-08	3.72E-09	1.43E-07	7.74E-09	1.76E-07
86	46	0	1.14E-07	9.33E-07	4.41E-08	9.10E-09	4.55E-09	1.84E-07	9.67E-07	5.00E-09	2.39E-08	5.14E-05	6.71E-05	1.75E-06	2.07E-08	2.16E-06	9.10E-08	3.49E-06	1.89E-07	4.30E-06
90	50	0	3.87E-08	3.17E-07	1.50E-08	3.10E-09	1.55E-09	6.27E-08	3.29E-07	1.70E-09	8.13E-09	1.75E-05	9.72E-06	5.95E-07	7.05E-09	7.34E-07	3.10E-08	1.19E-06	6.44E-08	1.46E-06
91	51	0	2.67E-08	2.19E-07	1.04E-08	2.13E-09	1.07E-09	4.32E-08	2.27E-07	1.17E-09	5.60E-09	1.21E-05	8.27E-06	4.10E-07	4.86E-09	5.06E-07	2.13E-08	8.20E-07	4.44E-08	1.01E-06
92	52	0	1.80E-07	1.48E-06	6.98E-08	1.44E-08	7.20E-09	2.92E-07	1.53E-06	7.92E-09	3.78E-08	8.14E-05	5.04E-05	2.77E-06	3.28E-08	3.41E-06	1.44E-07	5.53E-06	3.00E-07	6.80E-06
93	53	0	1.38E-07	1.13E-06	5.34E-08	1.10E-08	5.51E-09	2.23E-07	1.17E-06	6.06E-09	2.89E-08	6.22E-05	4.11E-05	2.11E-06	2.50E-08	2.61E-06	1.10E-07	4.23E-06	2.29E-07	5.20E-06
94	54	0	6.40E-08	5.25E-07	2.48E-08	5.12E-09	2.56E-09	1.04E-07	5.44E-07	2.82E-09	1.34E-08	2.89E-05	1.75E-05	9.83E-07	1.17E-08	1.21E-06	5.12E-08	1.97E-06	1.07E-07	2.42E-06
Criteria			***9.00E-05***	***9.00E-03***	***2.90E-02***	***4.00E-06***	***1.80E-05***	***9.00E-03***	***3.70E-03***	***9.00E-02***	***8.00E+00***	***9.00E-02***	***5.00E-01***	***1.80E-02***	***1.80E-04***	***1.29E-03***	***1.80E-04***	***4.00E-03***	***1.90E-01***	***1.80E-02***

Table 23: Flagpole Receptor Contamination Results – Scenario 2, TSP

Receptor No.	Building No.	Receptor Height (m)	Arsenic	Barium	Benzene	Beryllium	Cadmium	Chromium IV	Copper (as fumes)	Cyanide	Ethyl-benzene	Iron oxide fumes	Lead	Manganese	Mercury (organic)	Naphthalene	Nickel	PAHs (as B[α]P)	Xylenes	Zinc (as zinc chloride fumes)
			Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)	Hourly max. ($\mu g/m^3$)
2	1	8	8.51E-09	6.98E-08	3.30E-09	6.81E-10	3.40E-10	1.38E-08	7.23E-08	3.74E-10	1.79E-09	3.85E-06	2.50E-06	1.31E-07	1.55E-09	1.61E-07	6.81E-09	2.61E-07	1.42E-08	3.22E-07
4	2	5	1.06E-08	8.72E-08	4.13E-09	8.51E-10	4.25E-10	1.72E-08	9.04E-08	4.68E-10	2.23E-09	4.81E-06	3.11E-06	1.63E-07	1.94E-09	2.02E-07	8.51E-09	3.27E-07	1.77E-08	4.02E-07
6	3	8	1.02E-08	8.37E-08	3.96E-09	8.16E-10	4.08E-10	1.65E-08	8.67E-08	4.49E-10	2.14E-09	4.61E-06	3.18E-06	1.57E-07	1.86E-09	1.93E-07	8.16E-09	3.13E-07	1.70E-08	3.86E-07
9	5	5	1.72E-08	1.41E-07	6.67E-09	1.38E-09	6.88E-10	2.79E-08	1.46E-07	7.57E-10	3.61E-09	7.77E-06	4.83E-06	2.64E-07	3.13E-09	3.26E-07	1.38E-08	5.28E-07	2.86E-08	6.50E-07
11	6	5	2.12E-08	1.74E-07	8.22E-09	1.69E-09	8.47E-10	3.43E-08	1.80E-07	9.32E-10	4.45E-09	9.57E-06	5.73E-06	3.25E-07	3.85E-09	4.02E-07	1.69E-08	6.51E-07	3.52E-08	8.01E-07
13	7	14	2.05E-08	1.68E-07	7.97E-09	1.64E-09	8.22E-10	3.33E-08	1.75E-07	9.04E-10	4.31E-09	9.28E-06	5.89E-06	3.15E-07	3.74E-09	3.89E-07	1.64E-08	6.31E-07	3.42E-08	7.76E-07
15	8	5	3.46E-08	2.84E-07	1.34E-08	2.77E-09	1.39E-09	5.61E-08	2.95E-07	1.52E-09	7.28E-09	1.57E-05	8.43E-06	5.32E-07	6.31E-09	6.57E-07	2.77E-08	1.06E-06	5.77E-08	1.31E-06
17	9	5	6.15E-08	5.04E-07	2.39E-08	4.92E-09	2.46E-09	9.96E-08	5.23E-07	2.71E-09	1.29E-08	2.78E-05	1.37E-05	9.45E-07	1.12E-08	1.17E-06	4.92E-08	1.89E-06	1.02E-07	2.32E-06
19	10	5	8.97E-08	7.35E-07	3.48E-08	7.17E-09	3.59E-09	1.45E-07	7.62E-07	3.95E-09	1.88E-08	4.05E-05	2.19E-05	1.38E-06	1.63E-08	1.70E-06	7.17E-08	2.75E-06	1.49E-07	3.39E-06
21	11	5	1.05E-07	8.61E-07	4.07E-08	8.40E-09	4.20E-09	1.70E-07	8.92E-07	4.62E-09	2.20E-08	4.75E-05	3.26E-05	1.61E-06	1.91E-08	1.99E-06	8.40E-08	3.23E-06	1.75E-07	3.97E-06
23	12	5	1.37E-07	1.13E-06	5.33E-08	1.10E-08	5.50E-09	2.23E-07	1.17E-06	6.05E-09	2.89E-08	6.21E-05	3.87E-05	2.11E-06	2.50E-08	2.61E-06	1.10E-07	4.22E-06	2.29E-07	5.20E-06
25	13	20	2.92E-08	2.39E-07	1.13E-08	2.33E-09	1.17E-09	4.72E-08	2.48E-07	1.28E-09	6.12E-09	1.32E-05	8.15E-06	4.48E-07	5.31E-09	5.53E-07	2.33E-08	8.96E-07	4.85E-08	1.10E-06
27	14	20	2.51E-08	2.06E-07	9.75E-09	2.01E-09	1.01E-09	4.07E-08	2.14E-07	1.11E-09	5.28E-09	1.14E-05	9.10E-06	3.86E-07	4.58E-09	4.77E-07	2.01E-08	7.72E-07	4.18E-08	9.50E-07
28	14	40	1.73E-09	1.42E-08	6.73E-10	1.39E-10	6.94E-11	2.81E-09	1.47E-08	7.63E-11	3.64E-10	7.84E-07	1.57E-07	2.66E-08	3.16E-10	3.29E-08	1.39E-09	5.33E-08	2.89E-09	6.55E-08
29	14	60	9.41E-10	7.71E-09	3.65E-10	7.53E-11	3.76E-11	1.52E-09	8.00E-09	4.14E-11	1.98E-10	4.25E-07	3.76E-08	1.44E-08	1.71E-10	1.78E-08	7.53E-10	2.89E-08	1.57E-09	3.56E-08
30	14	80	6.29E-10	5.16E-09	2.44E-10	5.03E-11	2.51E-11	1.02E-09	5.34E-09	2.77E-11	1.32E-10	2.84E-07	2.00E-08	9.66E-09	1.14E-10	1.19E-08	5.03E-10	1.93E-08	1.05E-09	2.38E-08
32	15	20	1.77E-08	1.45E-07	6.87E-09	1.42E-09	7.09E-10	2.87E-08	1.51E-07	7.79E-10	3.72E-09	8.01E-06	7.69E-06	2.72E-07	3.22E-09	3.36E-07	1.42E-08	5.44E-07	2.95E-08	6.70E-07

Receptor No.	Building No.	Receptor Height (m)	Arsenic	Barium	Benzene	Beryllium	Cadmium	Chromium IV	Copper (as fumes)	Cyanide	Ethyl-benzene	Iron oxide fumes	Lead	Manganese	Mercury (organic)	Naphthalene	Nickel	PAHs (as B[α]P)	Xylenes	Zinc (as zinc chloride fumes)
			Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Annual Average (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)	Hourly max. (μg/m^3)
34	16	20	1.08E-08	8.87E-08	4.20E-09	8.66E-10	4.33E-10	1.75E-08	9.20E-08	4.76E-10	2.27E-09	4.89E-06	9.19E-06	1.66E-07	1.97E-09	2.05E-07	8.66E-09	3.32E-07	1.80E-08	4.09E-07
36	17	15	4.79E-08	3.93E-07	1.86E-08	3.83E-09	1.92E-09	7.76E-08	4.07E-07	2.11E-09	1.01E-08	2.17E-05	4.03E-05	7.36E-07	8.72E-09	9.08E-07	3.83E-08	1.47E-06	7.97E-08	1.81E-06
37	17	30	6.13E-09	5.03E-08	2.38E-09	4.91E-10	2.45E-10	9.94E-09	5.21E-08	2.70E-10	1.29E-09	2.77E-06	8.15E-07	9.42E-08	1.12E-09	1.16E-07	4.91E-09	1.88E-07	1.02E-08	2.32E-07
38	17	45	3.44E-09	2.82E-08	1.33E-09	2.75E-10	1.37E-10	5.57E-09	2.92E-08	1.51E-10	7.22E-10	1.55E-06	1.72E-07	5.28E-08	6.25E-10	6.52E-08	2.75E-09	1.06E-07	5.72E-09	1.30E-07
39	17	60	1.79E-09	1.47E-08	6.94E-10	1.43E-10	7.15E-11	2.90E-09	1.52E-08	7.87E-11	3.75E-10	8.08E-07	8.02E-08	2.75E-08	3.25E-10	3.39E-08	1.43E-09	5.49E-08	2.98E-09	6.76E-08
41	18	5	2.16E-07	1.77E-06	8.40E-08	1.73E-08	8.65E-09	3.51E-07	1.84E-06	9.52E-09	4.54E-08	9.78E-05	3.28E-04	3.32E-06	3.94E-08	4.10E-06	1.73E-07	6.65E-06	3.60E-07	8.18E-06
47	21	15	4.86E-08	3.99E-07	1.89E-08	3.89E-09	1.95E-09	7.88E-08	4.13E-07	2.14E-09	1.02E-08	2.20E-05	5.01E-05	7.47E-07	8.85E-09	9.22E-07	3.89E-08	1.49E-06	8.09E-08	1.84E-06
48	21	30	1.36E-08	1.12E-07	5.28E-09	1.09E-09	5.45E-10	2.21E-08	1.16E-07	5.99E-10	2.86E-09	6.16E-06	4.57E-06	2.09E-07	2.48E-09	2.58E-07	1.09E-08	4.18E-07	2.27E-08	5.15E-07
49	21	45	1.28E-08	1.05E-07	4.97E-09	1.02E-09	5.12E-10	2.07E-08	1.09E-07	5.63E-10	2.69E-09	5.79E-06	2.09E-06	1.97E-07	2.33E-09	2.43E-07	1.02E-08	3.93E-07	2.13E-08	4.84E-07
50	21	60	5.43E-09	4.45E-08	2.11E-09	4.34E-10	2.17E-10	8.80E-09	4.62E-08	2.39E-10	1.14E-09	2.45E-06	1.17E-06	8.34E-08	9.88E-10	1.03E-07	4.34E-09	1.67E-07	9.04E-09	2.05E-07
52	22	15	5.56E-08	4.56E-07	2.16E-08	4.45E-09	2.22E-09	9.01E-08	4.73E-07	2.45E-09	1.17E-08	2.51E-05	3.18E-05	8.54E-07	1.01E-08	1.05E-06	4.45E-08	1.71E-06	9.26E-08	2.10E-06
53	22	30	1.88E-08	1.54E-07	7.31E-09	1.51E-09	7.53E-10	3.05E-08	1.60E-07	8.28E-10	3.95E-09	8.51E-06	1.13E-05	2.89E-07	3.43E-09	3.57E-07	1.51E-08	5.78E-07	3.13E-08	7.12E-07
54	22	50	1.84E-08	1.51E-07	7.15E-09	1.47E-09	7.37E-10	2.98E-08	1.57E-07	8.10E-10	3.87E-09	8.32E-06	3.98E-06	2.83E-07	3.35E-09	3.49E-07	1.47E-08	5.66E-07	3.06E-08	6.96E-07
56	23	10	6.97E-08	5.72E-07	2.70E-08	5.58E-09	2.79E-09	1.13E-07	5.93E-07	3.07E-09	1.46E-08	3.15E-05	3.01E-05	1.07E-06	1.27E-08	1.32E-06	5.58E-08	2.14E-06	1.16E-07	2.64E-06
58	24	20	3.48E-08	2.85E-07	1.35E-08	2.78E-09	1.39E-09	5.63E-08	2.95E-07	1.53E-09	7.30E-09	1.57E-05	1.55E-05	5.34E-07	6.33E-09	6.59E-07	2.78E-08	1.07E-06	5.78E-08	1.31E-06
59	24	40	1.30E-08	1.07E-07	5.05E-09	1.04E-09	5.21E-10	2.11E-08	1.11E-07	5.73E-10	2.74E-09	5.89E-06	6.64E-06	2.00E-07	2.37E-09	2.47E-07	1.04E-08	4.00E-07	2.17E-08	4.92E-07
61	25	15	6.11E-08	5.01E-07	2.37E-08	4.89E-09	2.44E-09	9.89E-08	5.19E-07	2.69E-09	1.28E-08	2.76E-05	2.42E-05	9.38E-07	1.11E-08	1.16E-06	4.89E-08	1.88E-06	1.02E-07	2.31E-06
62	25	30	2.59E-08	2.12E-07	1.00E-08	2.07E-09	1.04E-09	4.19E-08	2.20E-07	1.14E-09	5.44E-09	1.17E-05	1.21E-05	3.98E-07	4.71E-09	4.91E-07	2.07E-08	7.95E-07	4.31E-08	9.79E-07
65	27	10	5.83E-08	4.78E-07	2.26E-08	4.66E-09	2.33E-09	9.44E-08	4.95E-07	2.56E-09	1.22E-08	2.63E-05	2.18E-05	8.95E-07	1.06E-08	1.11E-06	4.66E-08	1.79E-06	9.70E-08	2.20E-06
66	27	20	4.20E-08	3.45E-07	1.63E-08	3.36E-09	1.68E-09	6.81E-08	3.57E-07	1.85E-09	8.82E-09	1.90E-05	1.61E-05	6.45E-07	7.65E-09	7.97E-07	3.36E-08	1.29E-06	6.99E-08	1.59E-06
68	28	8	6.39E-08	5.24E-07	2.48E-08	5.11E-09	2.56E-09	1.03E-07	5.43E-07	2.81E-09	1.34E-08	2.89E-05	1.88E-05	9.81E-07	1.16E-08	1.21E-06	5.11E-08	1.96E-06	1.06E-07	2.41E-06
70	30	5	3.80E-08	3.12E-07	1.47E-08	3.04E-09	1.52E-09	6.16E-08	3.23E-07	1.67E-09	7.98E-09	1.72E-05	2.72E-05	5.84E-07	6.92E-09	7.21E-07	3.04E-08	1.17E-06	6.32E-08	1.44E-06
Criteria			***9.00E-05***	***9.00E-03***	***2.90E-02***	***4.00E-06***	***1.80E-05***	***9.00E-03***	***3.70E-03***	***9.00E-02***	***8.00E+00***	***9.00E-02***	***5.00E-01***	***1.80E-02***	***1.80E-04***	***1.29E-03***	***1.80E-04***	***4.00E-03***	***1.90E-01***	***1.80E-02***

"This page has been left blank intentionally"

7.1 Limitations of Dispersion Modelling

Best efforts were made to estimate the likely numbers and operational parameters (including fuel type and consumption etc.) of plant and equipment in the AQIA. The numbers used were based on information available at the time of preparation of this report, and may change to reflect the detailed design of the excavation and emplacement activities. Furthermore, there is also a degree of uncertainty in the results associated with assumptions made for activities for which no data were available; for example, the soil treatment tent stack parameters. Conservative assumptions were made in the modelling for such parameters, which may differ from those implemented once the actual treatment process and plant to be used are determined.

If major changes are proposed to pollutant emitting activities during excavation or emplacement, further modelling may be required to assess the impacts of those changes on local air quality.

7.2 Impact Assessment

The proposed modifications to the currently approved Concept Plan for the Barangaroo project are not expected to generate additional air quality or odour impacts; as such, this assessment addressed the worst-case works associated with the project, which were expected to result from the enabling and preparatory phases of works contemplated under Concept Plan Amendment (MP06_0162 MOD 4). Given the limitations of the dispersion modelling and the extensive assumptions that were required to undertake the modelling (due to limitations on the known excavation activities), pollutant concentrations were predicted for the activities proposed for the enabling and preparatory phases of works contemplated under Concept Plan Amendment (MP06_0162 MOD 4). All compliances and exceedences need to be considered with the recognition that the predicted emissions are based around assumptions, and not around known work schedules.

Short-term exceedences of PM_{10} (24 hours) and NO_2 (1 hour) levels were predicted by the dispersion modelling as a result of the basement retention system excavations and the bulk excavation emplacement works (emplacement works by others and not part of the Barangaroo Site Excavation and Preparation Works), with exceedences of the annual TSP criterion also predicted at three ground level receptors for the bulk excavation scenario.

It should be noted, however, that activities such as truck movements, and stockpile loading and unloading are likely to be of an intermittent nature, and together with equipment ‘down-time’ caused by maintenance, shift breaks, public holidays etc., it is considered unlikely that all pollutant emitting activities would occur simultaneously during the worst case meteorological conditions required to cause the maximum predicted pollutant concentrations. In order to minimise and mitigate any impacts of the activities on sensitive receptors, a number of recommended measures are detailed in **Section 9.0**, which should be incorporated into the CEMP prepared for the proposed works.

The exceedences were primarily predicted at receptors located the closest to the site (i.e. those located across Hickson Road and adjacent to the emplacement activities proposed at Headland Park). The exceedences primarily affected commercial properties, which are likely to be serviced by air conditioning. As such, actual effects on people within those buildings would be determined by the locations of the air conditioning intake valves. A review should be made of the potentially affected buildings to determine whether intake valves are located on the sides of buildings closest to the Barangaroo site; if not, emissions from the site are not likely to significantly affect air quality within the buildings. Exceptions to this are the Bond building and the child care centre, which are open to the air. It may be possible to arrange for enclosure (or partial enclosure) of these elements in consultation with stakeholders to minimise these impacts.

The exceedences noted at the closest receptors (located approximately 30 m from the property boundary across Hickson Road) are higher than would be expected for a development such as this (particularly for NO_2), and the predicted results need to be verified by means of a real time monitoring program once the activities associated with the enabling and preparatory phases of works contemplated under Concept Plan Amendment (MP06_0162 MOD 4) commence. If the monitoring results confirm the predicted concentrations, additional mitigation measures may needed to reduce the emitted pollutant concentrations in accordance with those outlined in **Section 9**. Once again, It may be possible to arrange for enclosure (or partial enclosure) of these elements in consultation with stakeholders to minimise these impacts.

While no exceedences of the odour criterion of contaminants were predicted to occur, monitoring of these parameters is recommended to verify the modelling results. Proposed monitoring strategies for the site are outlined in **Section 10.0**.

“This page has been left blank intentionally”

8.0 Mitigation Measures

8.1 Construction

Mitigation measures recommended by the Remediation Action Plan (AECOM, 2010) are outlined in the following sections. These measures should be incorporated, where applicable, into future Construction Environmental Management Plans prepared for the various stages of the works.

Assessment of the DECCW Declaration Area will be the subject of a future Project Application.

8.1.1 Dust

Care should be taken to manage wind-blown dust at the site during excavation and earthworks activities associated with the enabling and preparatory works phases. Dust can be generated through a range of means and activities, including erosion of exposed areas, agitation and movement of materials, and wheel-generated dust from vehicle movements.

Appropriate management of dust is required to ensure that it is minimised and/or prevented. Dust management practices will include:

- Excavation in the excavation enclosure for the contaminated areas where practicable;
- Minimising exposed/excavation areas;
- Pre testing and validating such that direct transport and placement of excavated material within the Headland Park can be undertaken directly following on from bulk excavation;
- Covering surfaces where appropriate;
- Managing the rate of in-ground dewatering ahead of bulk excavation such that material excavated from the basement is moist at the time of exposure;
- Utilisation of solid hoardings to 2.4 m height to the site perimeter and adjacent key receptors;
- Minimising dust-generating activities during times of high wind speeds;
- Sweeping and watering utilising a water cart of materials handling, transport and haul routes;
- Maintaining site entry points through sweeping and watering down;
- Dust suppression using water sprays, hand spraying, chemical wetting agents, and/or hydromulch; and
- Dust monitoring.

Should unacceptable levels of dust be detected during the remediation works, an investigation should be conducted to determine the source/s of the dust and to evaluate the appropriate measures to be implemented. Measures may include the following actions:

- Increased use of a water cart or water sprays to suppress dust in open areas;
- Installation of temporary sheeting to cover localised exposed areas and stockpiles;
- Managing the rate of in-ground dewatering ahead of bulk excavation such that material excavated from the basement is moist at the time of exposure;
- Covering soil stockpiles that will remain on the Site for more than 24 hours (where practical);
- Consolidation of material stockpiles;
- Use of chemical dust-suppressants provided the chemicals do not pose a contamination or occupational health and safety hazard;
- Use of alternative coverings such as hydromulch to stabilise the surface of open disturbed areas;
- Use of additional dust suppression features on items of dust generating plant and equipment;
- Securely covering all loads entering or exiting the Barangaroo Site; and
- Securing work approval hours that permit emergency dust suppression on non work days, if the need arises.

8.1.2 Volatile Gases and Odours

Should unacceptable levels of volatile gases be detected at the site boundaries or in the surrounding area during the project, an investigation will be conducted to determine the source of the emissions, and to evaluate the appropriate measures to be implemented. These measures may include the following actions:

- Alteration in the works program to minimise in the extent of disturbed open areas;
- Prompt removal and treatment of heavily contaminated materials that have been exposed and are identified to have caused the emissions;
- Use of fine mist sprays around the Remediation Area;
- Conducting the work in more favourable weather conditions;
- Use of alternate work practices to minimise the period of impact of the emissions;
- Use of additional features to control emissions from plant and equipment;
- Use of alternate work practices such as using modified equipment;
- Relocation of offending plant and equipment to less sensitive on-site areas;
- Reducing the number of plant and equipment items on-site; and
- Use of a deodorant within water sprays at locations on-site and at Site boundaries provided the chemicals do not pose a contamination or OHS hazard.

8.1.3 General Operating Procedures

Additional mitigation and work practices that should be implemented at the site are described in Table 26.

Table 24: Pollutant Minimisation Strategies

Trigger	Impact	Pollutants	Control Measure
Fuel combustion emissions from vehicles and equipment	Increased risk to human health	NO_x CO PM_{10} TSP BTEX	Turn engines off whilst parked onsite
			Vehicular access confined to designated access roads
			Equipment, plant and machinery regularly tuned, modified or maintained to minimise visible smoke and emissions
			Site speed limits implemented
			Minimising haul road lengths
Fugitive dust and odour from exposed surfaces and vehicles	Nuisance (dust and odour) Discoloration of buildings or structures Increased risk to human health	PM_{10} TSP Odour	Covering exposed surfaces at the end of each shift and during dry / windy conditions
			Covering loads during transport
			Erection of windbreak barriers on the Site boundary
			Watering of exposed surfaces and roads
			Surface stabilisation to minimise wind blown dust
			Control roadway use i.e. defined road access to minimise dust
			Regular clean up of spills
			Implement a complaints management system
			Adjust work practices (as required) based on wind observations
			Adjust work practices (as required) based on real time dust monitoring results
			Instantaneous dust monitoring at the boundary
Hazardous and other air pollutants	Increased risk to human health	NO_x	Covering exposed surfaces at the end of each shift and during dry / windy conditions

Trigger	Impact	Pollutants	Control Measure
(from disturbance of potentially contaminated ground)	Nuisance (dust and odour)	CO PM_{10} TSP Odour BTEX	Covering loads during transport
			Erection of windbreak barriers at the site boundary
			Watering of exposed surfaces and roads
			Surface stabilisation to minimise wind blown dust

8.2 Operation

Emissions associated with operation of the proposed development will be highly dependent upon the nature of the tenants of the buildings to be constructed. Non-residential tenants are unlikely to operate facilities that require licensing under the Protection of the Environment Operations Act 1997. Any plant or equipment operated at the site will, however, be subject to the requirements of the Protection of the Environment Operations (Clean Air) Regulation 2002, which specifies emission concentration limits for non-scheduled premises as outlined in **Table 25**. Industry standard design and construction techniques are expected to be utilised in all developments across all land uses to address and treat exhaust points such that emissions meet the requirements of relevant Australian Standards. Furthermore, the non-residential tenants will be required to maintain any plant in an efficient condition and operate the plant in a proper and efficient manner (s 124 of the Protection of the Environment Operations Act 1997).

Table 25: Standards of Concentration for Non-Scheduled Premises

Air Impurity	Activity/Plant	Concentration
Solid particles	Any activity or plant (except those listed below)	100 mg/m^3
	Any activity or plant in which, or in connection with which, solid fuel is burnt	Ringelmann 1 or 20 % opacity
	Any activity or plant in which, or in connection with which, liquid or gaseous fuel is burnt	Ringelmann 1 or 20 % opacity
Smoke	Any activity or plant in connection with which solid fuel is burnt (in relation to marine vessels or premises)	
	- in approved circumstances	Ringelmann 3 or 60 % opacity
	- in other circumstances	Ringelmann 1 or 20 % opacity
	Any activity or plant in connection with which liquid or gaseous fuel is burnt	
	- in approved circumstances	Ringelmann 3 or 60 % opacity
	- in other circumstances	Ringelmann 1 or 20 % opacity

"This page has been left blank intentionally"

9.0 Recommended Air Quality Monitoring Program

Monitoring of the pollutant concentrations both at the boundary of the development and at selected sensitive receptors surrounding can be undertaken during various stage of the Barangaroo re-development. The objective of the monitoring is to:

- Allow a real time assessment of the various activities on the site, which can then be related back to operational changes to reduce off-site impacts; and to
- Allow reactive dust mitigation measures to be implemented based on real time monitoring data.

The air quality monitoring of the Barangaroo development site would generally be undertaken in accordance with the following guidelines and Australian Standards:

- The DECCW's Approved methods for sampling and analysis of air pollutants in New South Wales;
- AS/NZS 3580.9.3:2003 Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - Total suspended particulate matter (TSP) - High volume sampler gravimetric method;
- AS 3580.9.8-2008 Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - PM_{10} continuous direct mass method using a tapered element oscillating microbalance analyser;
- AS/NZS 3580.1.1:2007 Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment; and
- AS 2923-1987 Ambient air - Guide for measurement of horizontal wind for air quality applications.

The monitoring activities outlined below are recommended based on the results of the dispersion modelling. These activities can be incorporated into a Construction Environmental Management Plan (CEMP) prepared for the site prior to the commencement of works. Indicative monitoring locations are shown on **Figure 5**.

Monitoring data for the real time pollutants (PM_{10}, NO_2 and to a lesser degree, VOC and odour) would be linked to the excavation operations. Trigger levels for the various pollutants would be incorporated into the CEMP, which would in turn trigger additional actions within the excavation and soil treatment areas. The trigger levels and corresponding actions would be further defined as part of the CEMP.

Retention System Excavation Activities

- Monitoring of TSP [using a high volume air samplers (HVAS)] and PM_{10} (continuously, using a TEOM) at the closest, most sensitive receptor (provisionally set as day care Centre at 30 The Bond);
- Analysis of TSP HVAS paper for heavy metal content;
- Monitoring of NO_2 at the closest, most sensitive receptor (day care centre at 30 The Bond);
- Monitoring of odour at various locations (nominally set at 10 sites, which will be confirmed once more detailed information is known about site activities) around the boundary and at a number of locations off-site to gauge the relative odour performance of the facility. The odour performance characteristics would be defined by an odour management plan that would form part of the CEMP;
- Monitoring of VOC concentrations by means of PID at the same locations as the odour measurement collection points (set at 10 at this stage of the project) and at a number of on-site locations (nominally 6 locations) to allow tracking of potential VOC sources and plumes (locations to be determined following confirmation of construction activities).

Basement Carpark Excavation Activities

- Monitoring of TSP (HVAS) and PM_{10} (TEOM) at the:
  - Passenger Terminal;
  - Day care centre at 30 The Bond, Hickson Road; and
  - Closest receptor to the Headland Park Emplacement area (by others) ;

Analysis of TSP HVAS paper for heavy metal content at the southern locations (i.e. 30 the Bond and International Shipping Terminal);

- Monitoring of NO_2 at the day care centre at 30 The Bond;

- Monitoring of odour at various locations (nominally set at 10 sites, which will be confirmed once more detailed information is known about site activities) around the boundary and at a number of locations off-site to gauge the relative odour performance of the facility. The odour performance characteristics would be defined by an odour management plan that would form part of the CEMP
- Monitoring of VOC concentrations by means of PID at the same locations as the odour measurement collection points (set at 10 at this stage of the project) and at a number of on-site locations (nominally 6 locations) to allow tracking of potential VOC sources and plumes (locations to be determined following confirmation of construction activities).

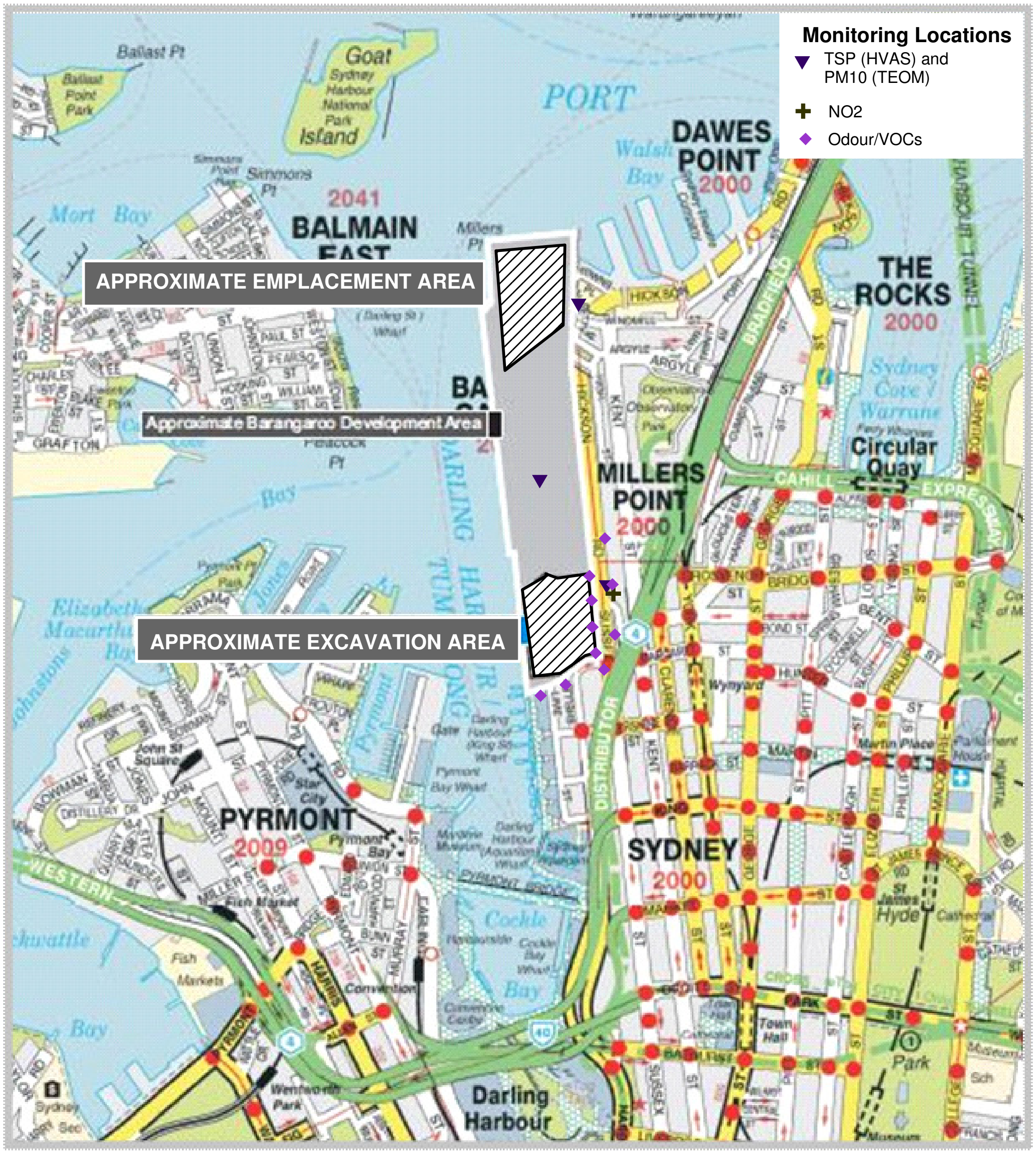


Figure 5: Indicative Pollutant Monitoring Locations

10.0 Conclusion

This air quality impact assessment was prepared to assess effects on air quality arising from site preparatory and enabling phases of works associated with bulk excavation, remediation and construction activities under the proposed Barangaroo Concept Plan Amendment (MP 06_0162 MOD 4).

While the proposed Barangaroo South Site Concept Plan modifications include increased GFA, redistribution of land uses, increased height, Landmark building and reconfiguration of Public Domain, the likely sources of emissions (dust, odour etc) remain the same as for the current Approved Concept Plan. The Barangaroo South Site Concept Plan Amendment is not, therefore, expected to result in additional air quality or odour impacts. This air quality impact assessment has considered the worst-case impacts associated with the development as a whole (excluding the DECCW Declaration Area, which will be the subject of a future Project Application), which are likely to be the works associated with the enabling and preparatory phases of development including:

- Removal of existing services and installation of temporary services;
- Excavation and installation of basement excavation retention systems and associated activities;
- Bulk excavation of approximately 500,000 m^3 of soil (fill) and rock and associated activities;
- Remediation of contaminated material from the bulk excavation works;
- Haulage of material to the soil treatment area;
- Haulage of suitable material to Headland Park for emplacement by others;
- Emplacement of suitable material within the Public Domain and Headland Park (NB while these potential Headland Park works are considered in this AQIA, it is noted they would be conducted and assessed by Barangaroo Delivery Authority under a separate project application); and
- Construction of basement car parking areas.

Dispersion modelling using CALPUFF and meteorological data generated for the site using TAPM (based on local meteorological data) was used to estimate concentrations of particulates (TSP and PM_{10}), NO_2, odour and contaminants potentially contained within soil (primarily heavy metals, VOCs and PAHs) to be excavated, handled and treated as part of the works. No exceedences of odour or contaminants were predicted.

Based on the various assumptions listed in this document , exceedences of particulate levels and NO_2 were predicted at close sensitive receptor locations, primarily commercial properties. In order to prevent the site activities from affecting neighbouring properties, a monitoring program was recommended that includes continuous monitoring of PM_{10} levels, which will allow reactive management of elevated dust concentrations, and monitoring of TSP concentrations using high volume air samplers, which will additionally allow the analysis of heavy metals concentrations to validate the modelling results. Furthermore, the proposed monitoring program also includes odour monitoring along the boundary of the bulk excavation works and at adjacent sensitive receptor locations, again to validate the modelling results and ensure no adverse effects on neighbouring properties. The proposed monitoring plan should be incorporated into the CEMP prepared for the site.

Provided the onsite activities are implemented in a manner consistent with the assumptions made by this modelling report (in accordance with proven and industry standard dust and odour management techniques), there exists the risk that, under certain conditions, exceedences of DECCW criteria may occur for selected pollutants (TSP, PM_{10} and NO_2). With the application of a strict reactive air pollutant monitoring program and the implementation of additional mitigation measures in the event measured pollutants levels exceed their criteria, it is, however, expected that adverse impacts on surrounding sensitive receptors will not occur.

Construction as part of the proposed modified Concept Plan (and as part of the Barangaroo Project as a whole) must meet the requirements of the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Clean Air) Regulation 2002. Adherence to those requirements should serve to mitigate any adverse air quality impacts associated with the proposed modification to the approved Concept Plan.

AECOM has concluded that the proposed Concept Plan Amendment will not result in any substantial additional impacts beyond those contemplated in the Approved Concept Plan.

"This page has been left blank intentionally"

Appendix A

Climate Averages

"This page has been left blank intentionally"

Average Climate Data – Observatory Hill and Fort Denison, 1859 – 2010 (May)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average temperature													
Maximum (^{0}C)	25.9	25.8	24.7	22.4	19.4	16.9	16.3	17.8	20	22.1	23.6	25.2	21.7
Minimum (^{0}C)	18.7	18.8	17.5	14.7	11.5	9.3	8	8.9	11.1	13.5	15.6	17.5	13.8
Average wind speed													
9 am (km/h)	8.6	8.2	7.9	8.8	10.5	11.9	13.1	13.3	12.4	12.2	11	9.8	10.6
3 pm (km/h)	17.9	16.8	15.2	13.8	12.7	13.6	15.3	17.6	18.3	19.1	19.4	19.5	16.6
Average relative humidity													
9 am (%)	71	74	74	72	73	74	71	66	62	61	66	67	69
3 pm (%)	62	64	62	59	57	57	51	49	51	56	58	59	57
Rainfall													
Mean rainfall (mm)	101.5	118.7	128.9	125.8	120.7	130.6	97.3	81.2	69.1	77.6	83.1	77.8	1212

Appendix B

Meteorological Data Analyses

"This page has been left blank intentionally"

B.1 Introduction

The following appendix discusses the characteristics associated with the meteorological data used for the Barangaroo dispersion modelling. The characteristics examined include the following:

- Wind speed and direction;
- Stability Class; and
- Mixing height.

B.2 Wind speed and direction

Long term average wind rose diagrams for data collected at the Bureau of Meteorology station at Fort Denison shows the frequency of occurrence of winds by direction and strength (refer **Figures B1** and **B2**). Morning winds are lighter than average and dominated by north-westerly flows, representing a land breeze generated on clear nights with light prevailing wind conditions, most common in winter. Winds from the east coming from the coast in the afternoon are generally stronger than the land breeze winds. By afternoon, winds are stronger and most frequently from the southeast to northeast, representing both common synoptic scale influences and some sea breeze effects, respectively. Significant seasonal differences in the wind conditions measured at the site are apparent - the winds are predominantly from the north-east to south direction in the warmer months (i.e. summer and spring), while north-westerly winds dominate in the cooler months.

The Rozelle DECCW meteorological data shows a different pattern to the data from the Sydney BOM site. The Rozelle site is characterised by strong southerly or light north-westerly winds throughout the year with the diurnal pattern dominated by light north-westerlies during the morning tending to stronger southerlies during the afternoon. This pattern is replicated throughout the year with strong southerly winds dominating during summer with strong north-westerlies during winter (refer **Figures B3**).

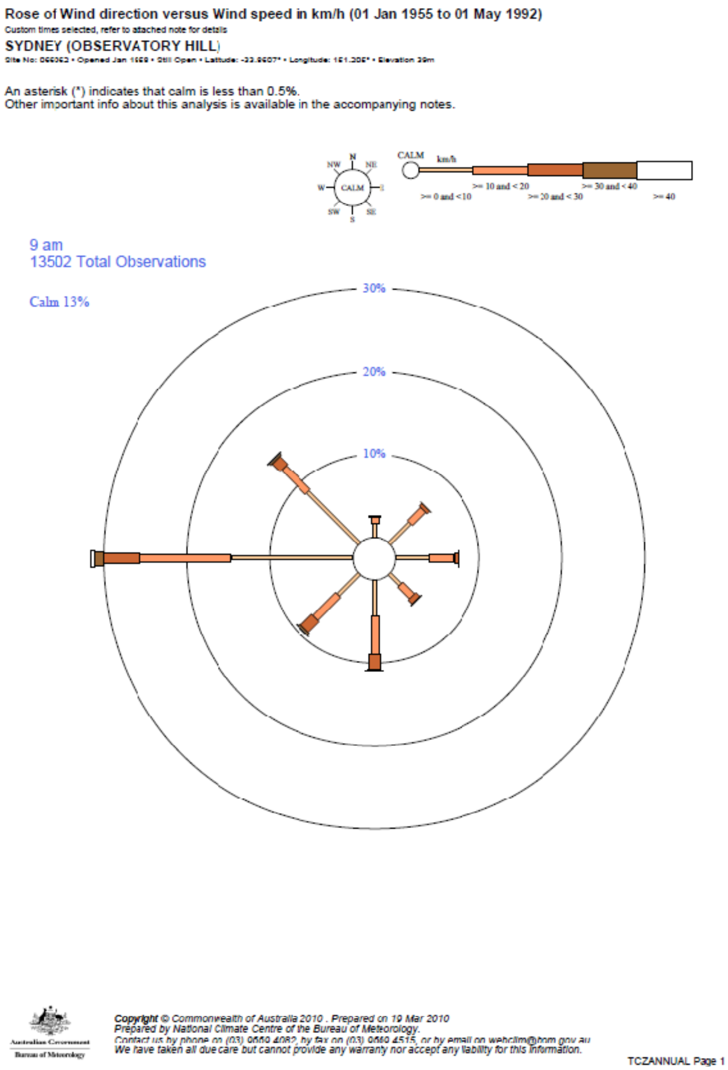
Wind rose compiled from the meteorological data developed for the Barangaroo site from CALMET (1 January 2008 to 31 December 2008) are provided below (wind roses shown in **Figure B4** and **B5**). The following trends in data were observed:

- Annual wind patterns are dominated by winds from the west and east to northeast (counter-clockwise). The average wind was 3.1 m/s with a calm wind percentage of 0.5% (winds less than 0.5 m/s);
- Summer wind patterns are dominated by winds from the east to northeast, with minor winds from the southeast and west. The average wind was 2.92 m/s with a calm wind percentage of 0.6%;
- Autumn wind patterns are dominated by winds from the west, southeast and northeast. The average wind was 2.66 m/s with a calm wind percentage of 0.82%;
- Winter wind patterns are dominated by winds from the west. The average wind was 0.23 m/s with a calm wind percentage of 0.23%; and
- Spring wind patterns are dominated by winds from the east southeast to northeast with a minor portion of winds also from the west to north northwest. The average wind was 3.1m/s with a calm wind percentage of 0.37%.

The wind roses for the Barangaroo site are dominated by winds from the west and east, which are closely aligned with the observed diurnal wind patterns observed for the 9 am and 3 pm winds at Fort Denison (refer **Figures B1** and **B2**. On this basis, receptors situated to the east of the Barangaroo site, and to a lesser degree to the southwest of the Barangaroo site, are likely to be the most significantly affected receptors. The closest receptors, located to the east of the Barangaroo site, would be expected to be more affected by potential pollution from the works during the autumn and winter months, where air flows are predominantly westerly.

The frequency distribution of hourly averaged wind speed values from the Barangaroo data is shown below in **Figure B6**. Wind speeds around 2 - 4 m/s are most common, with medium to strong winds (> 4 m/s) occurring approximately 24% of the time.

“This page has been left blank intentionally”



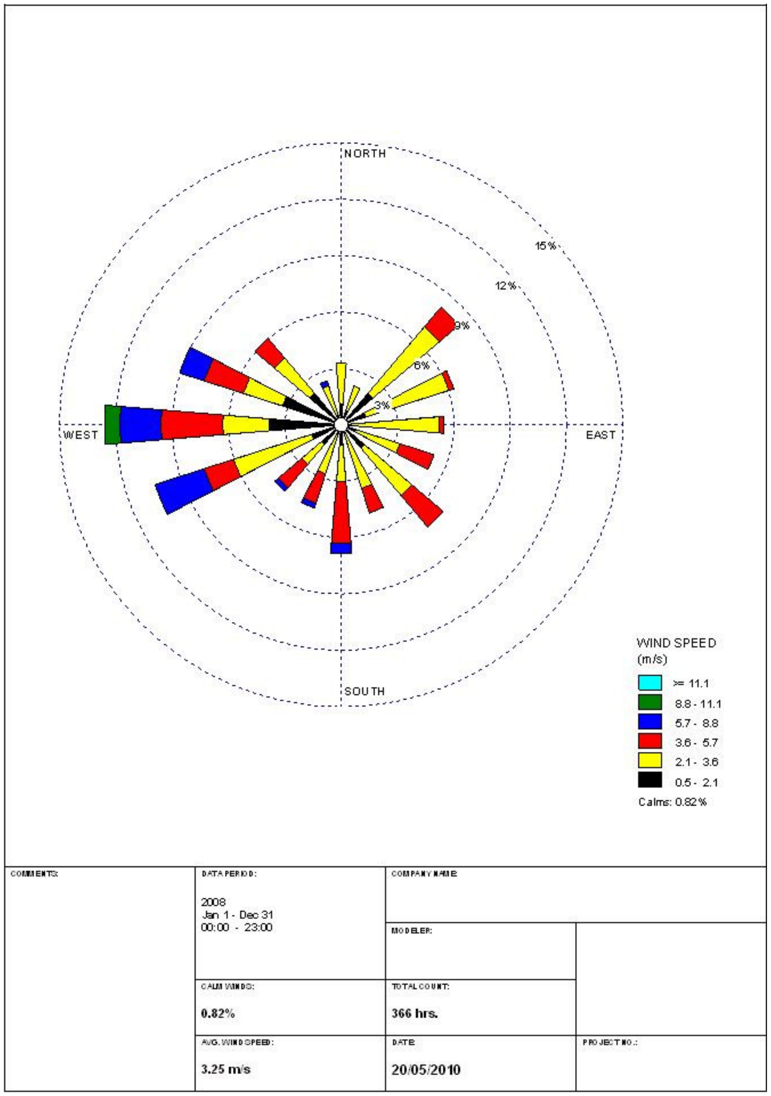
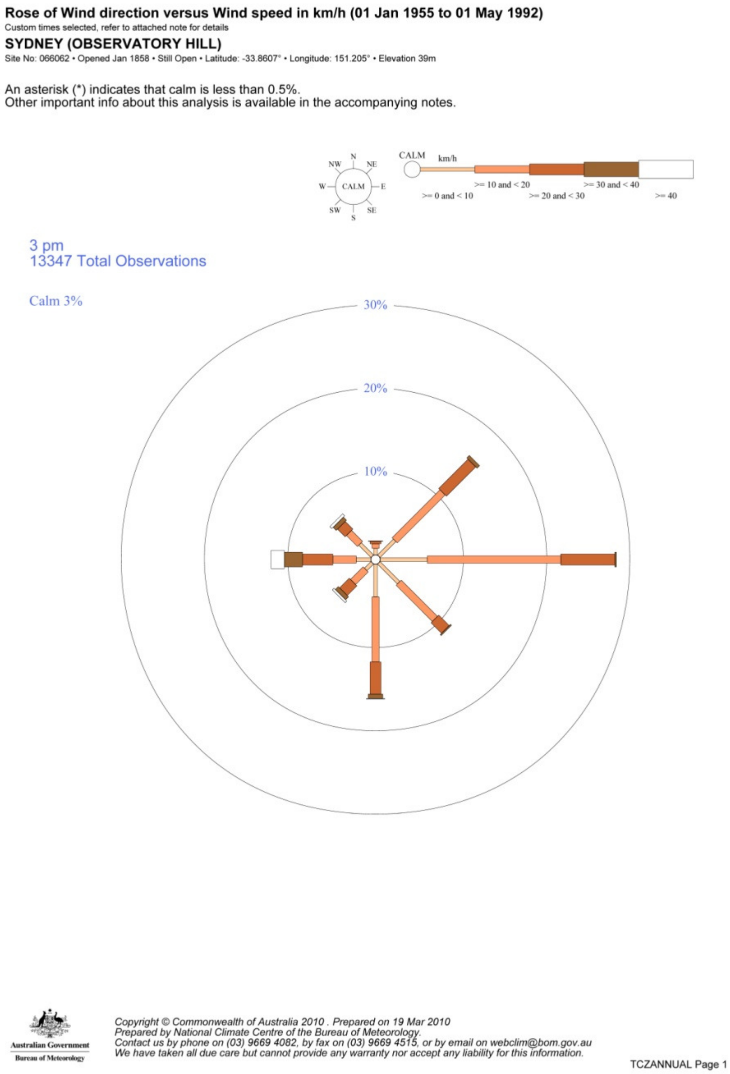


Figure B1: 9am Wind Rose for BOM Fort Denison (left Windrose) and Barangaroo (right Windrose) CALMET Data Meteorological Data



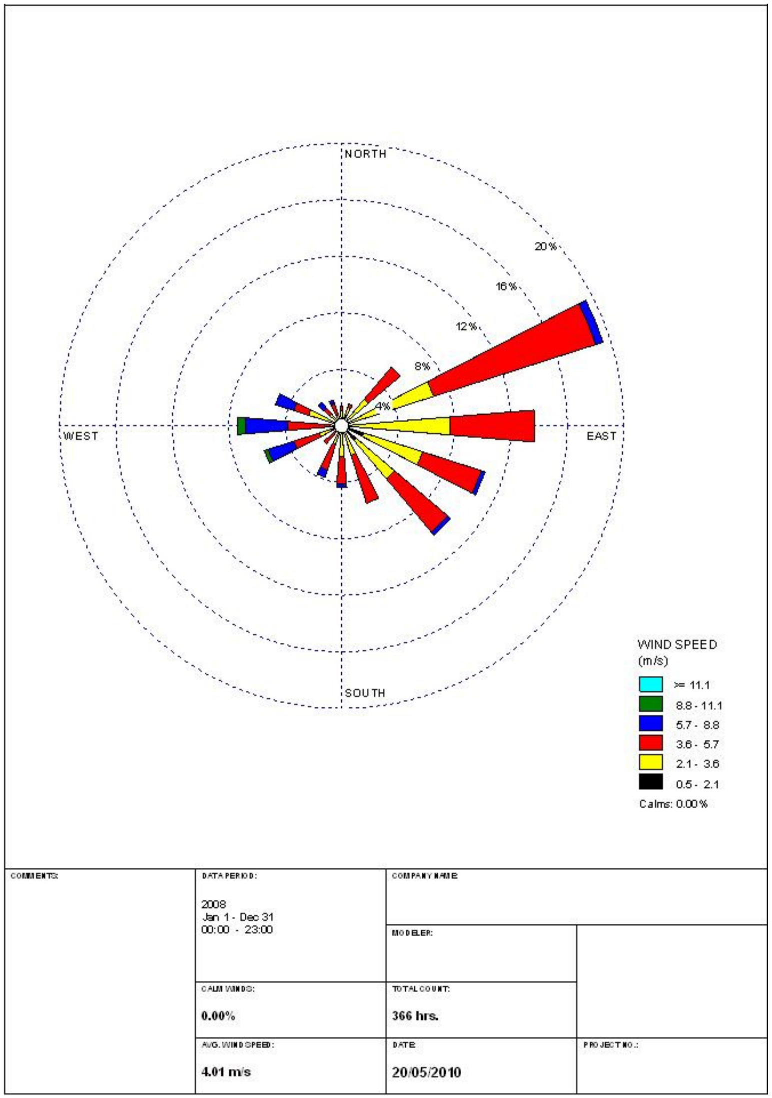
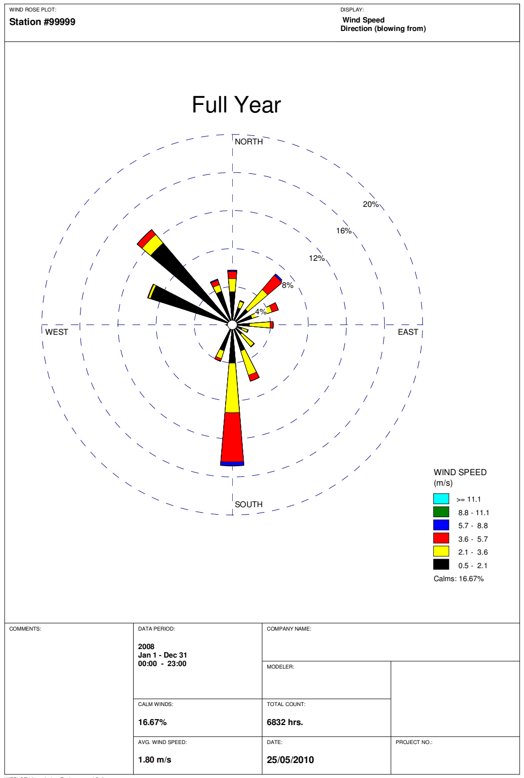
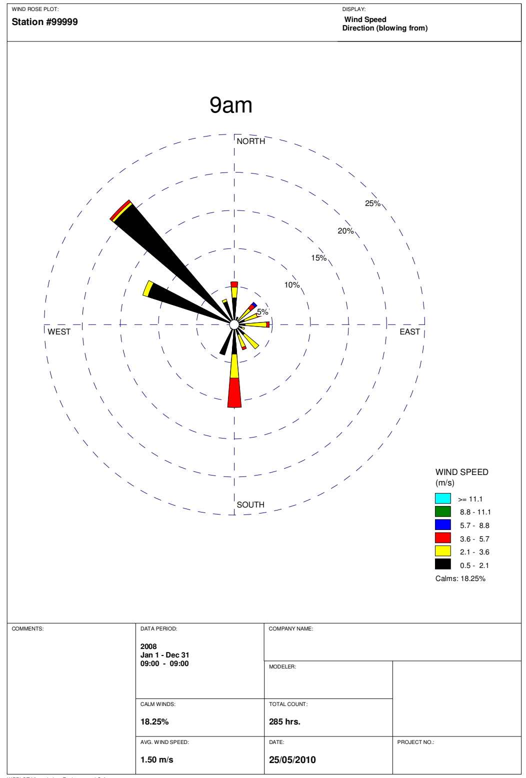


Figure B2: 3pm Wind Rose for BOM Fort Denison (left Windrose) and Barangaroo (right Windrose) CALMET Data Meteorological Data





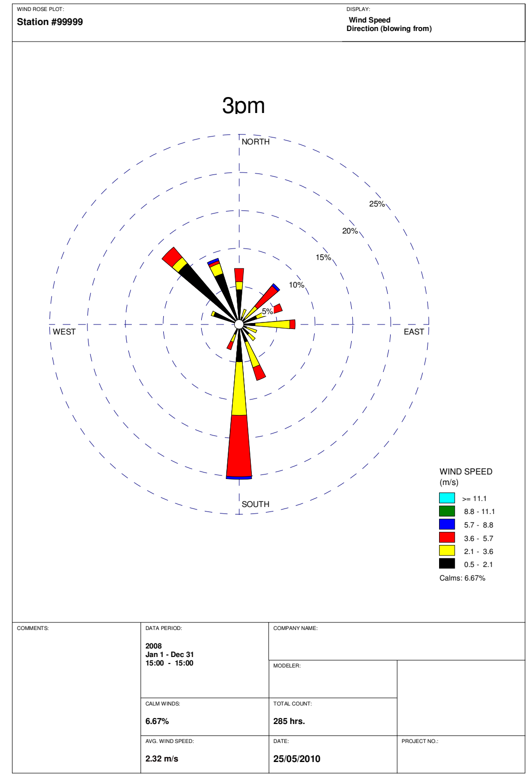


Figure B3: Wind Rose for DECCW Rozelle Meteorological Data

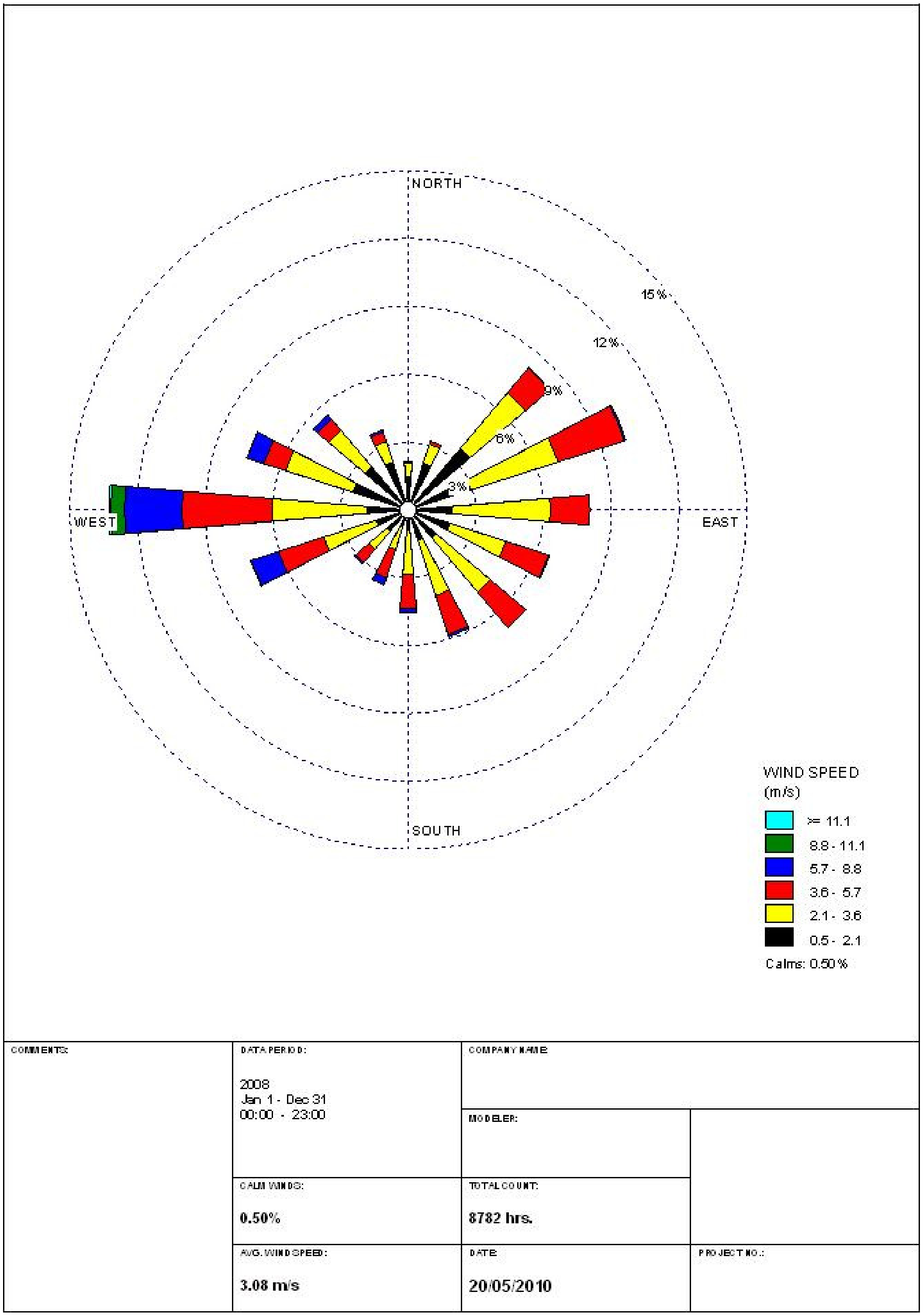


Figure B4: 3pm Wind Rose for Barangaroo CALMET Data Meteorological Data Full Year

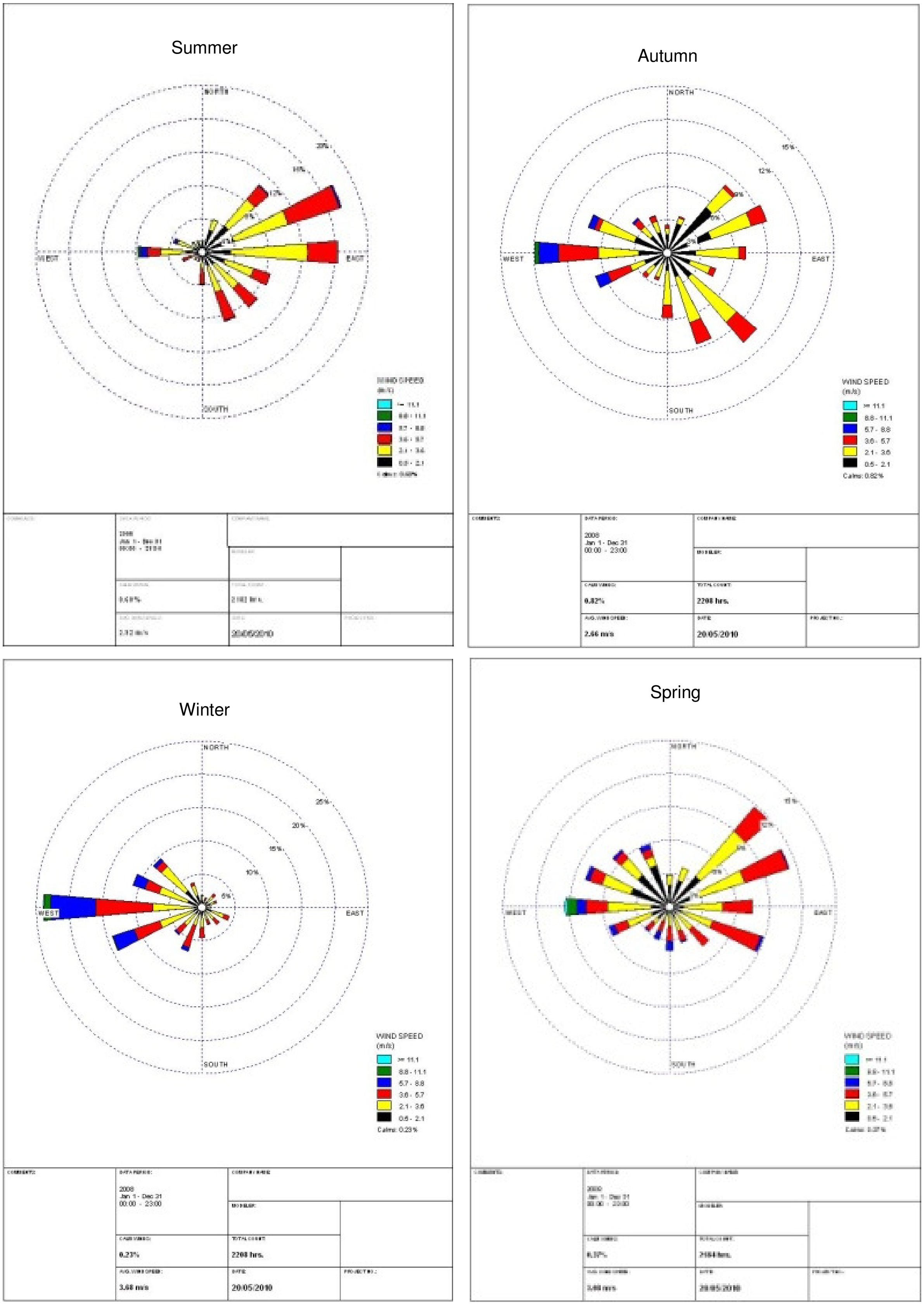


Figure B5: Seasonal Wind Roses for Barangaroo CALMET Data Meteorological Data

“This page has been left blank intentionally”

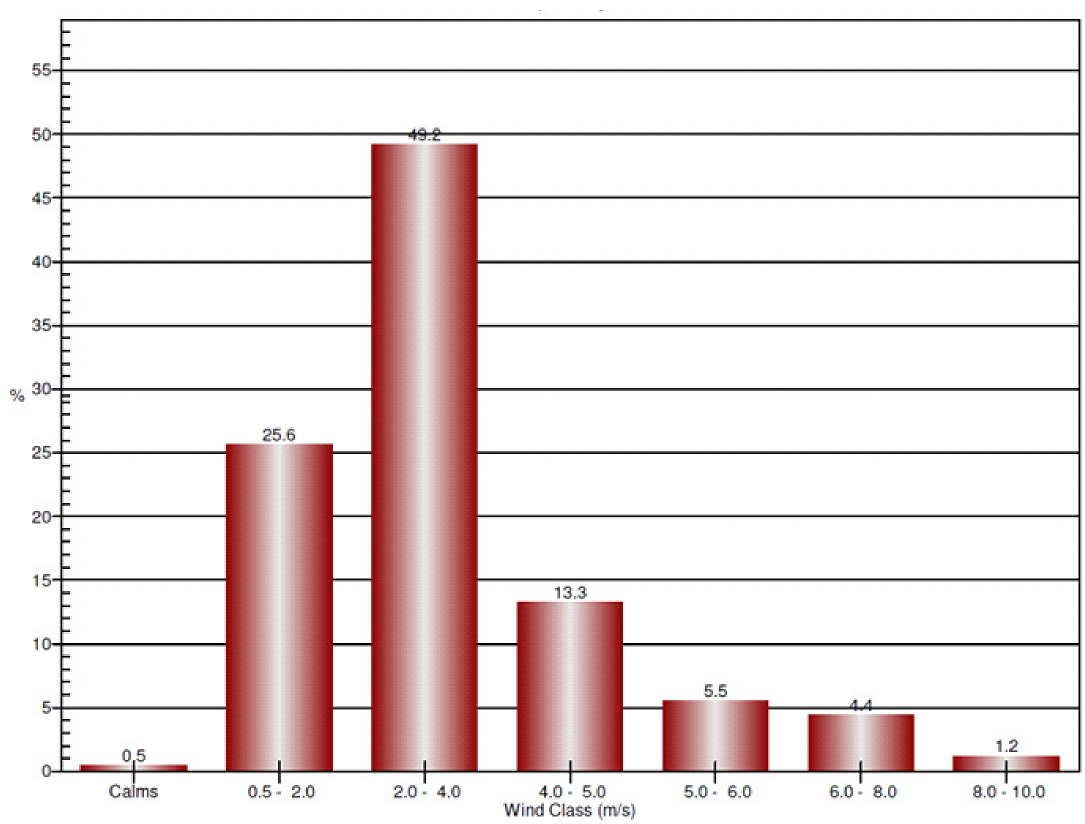


Figure B6: Frequency Distribution of Wind Speed for Barangaroo, January – December 2008

"This page has been left blank intentionally"

B.3 Stability Class

An important aspect of plume dispersion is the atmospheric turbulence level in the region of the plume, near the ground in this case. Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds. The frequency distribution of estimated stability classes in the meteorological file is shown in **Figure B7**. The data show a total of 45% of hours with either E or F class. This is consistent with the expected occurrence of slightly stable conditions at such a location, given the coastal location.

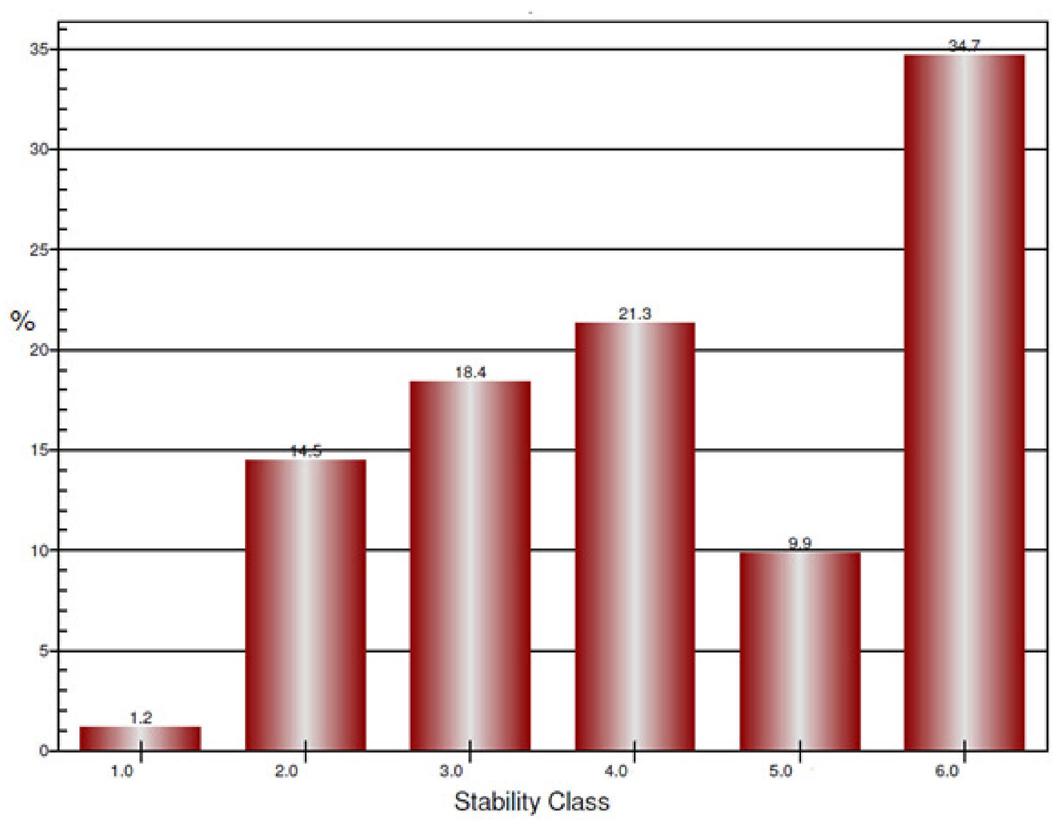


Figure B7: Frequency Distribution of Stability Class from TAPM-CALMET Output

"This page has been left blank intentionally"

B.4 Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions.

CALMET was used to calculate mixing heights at Barangaroo. The diurnal variation of mixing height is summarised in **Figure B8**. Mixing heights are lower during the night and early morning hours (~ 250 m), increasing after sunrise to a maximum of 1200 -1300 m by mid-afternoon. This pattern of a small diurnal cycle is consistent with the coastal site.

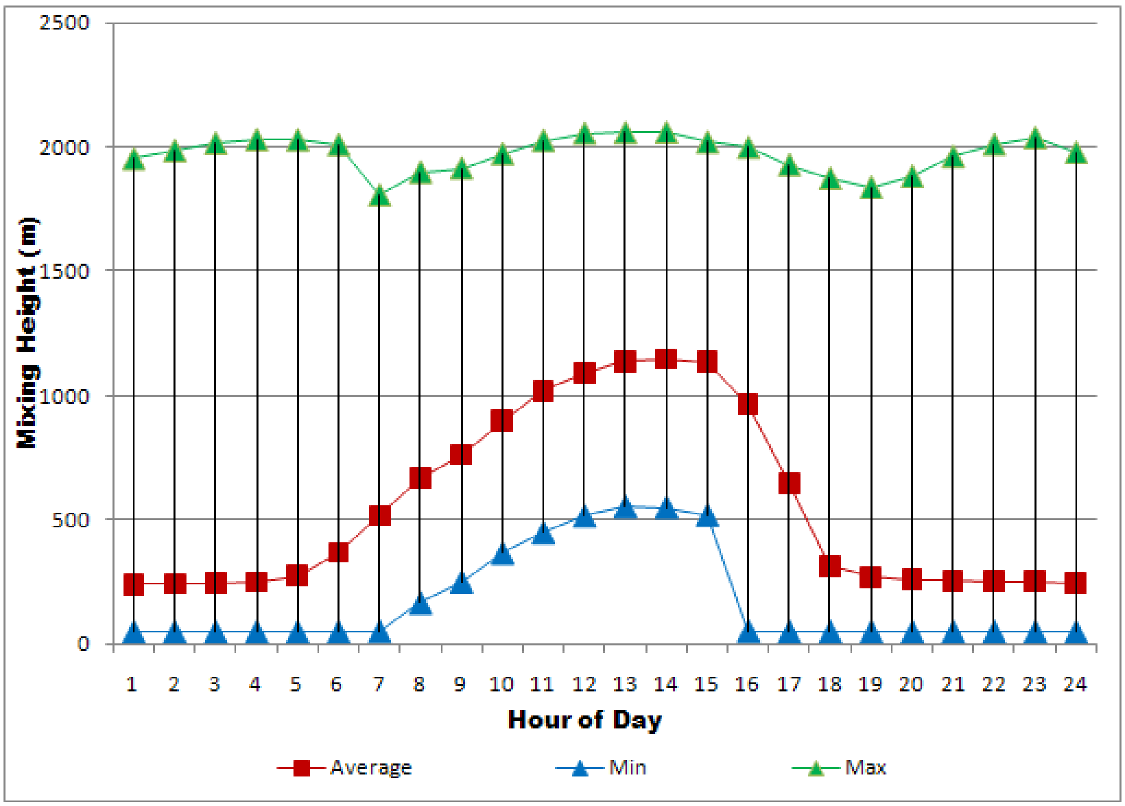


Figure F8: Hourly Mixing Height from TAPM-CALMET Output

"This page has been left blank intentionally"

Appendix C

Emissions Inventory

"This page has been left blank intentionally"

NPI INFORMATION

Table 1 - Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines (NPI Manual - Mining and Processing of Non-Metallic Minerals, v2, 2000, pp 38-39)

Operation/Activity	TSP Default Emission Factor	PM10 Default Emission Factor	Units	
Excavators/FEL (on overburden)	0.025	0.012	kg/t	
Trucks (dumping overburden)	0.012	0.0043	kg/t	
Wheel generated dust from unpaved roads	3.88	0.96	kg/VKT	(VKT = vehicle kilometres travelled)
Loading stockpiles	0.004	0.0017	kg/t	
Unloading from stockpiles	0.03	0.013	kg/t	
Miscellaneous transfer points	0.00032	0.00015	kg/t	
Wind erosion	0.4	0.2	kg/ha/h	1 hectare = 10,000 m

Control technologies (Emissions Estimation Technique for Mining and Processing of Non-Metallic Minerals, v2 (2000)

ACTIVITY	EFFECTIVENESS (%)	TECHNOLOGY
loading trucks	0	no control
unloading trucks	70	water sprays
hauling	50	level 1 watering (2 litres/m2/h)
	75	level 2 watering (>2 litres/m2/h)
loading stockpiles	50	water sprays
unloading stockpiles	50	water sprays
wind erosion from stockpiles	50	water sprays
all activities	30	wind breaks

Open area wind erosion **Table 12, NPI Fugitive Emissions - page 31**

Control method	Factor reduction (%)
watering - periodic spraying	35
watering - wind activated spraying system	65
chemical wetting agents or foam	70
continuous chemical spray onto input material	70
surface crusting agents	80

Source: USEPA, 1995

Table 1 - Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines (NPI Manual - Mining and Processing of Non-Metallic Minerals, v2, 2000, pp 38-39)

Excavators/FEL (on overburden)	TSP Equation	PM10 Default Emission Factor	Units	
k	0.74	0.35		
U (Mean Wind Speed)	3.6	3.6	m/s	
M (Moisture Content)	8	8	%	default values displayed
EF	0.00032	0.00015	kg/t	
Wheel generated dust from unpaved roads	**TSP Equation**	**PM10 Default Emission Factor**	**Units**	
k	2.82	0.733		NPI Provided
s (silt content)	10	10	%	NPI Provided
W (vehicle gross mass)	48	48	t	Assumed
M (Moisture Content)	4	4	%	Calculated 99 Percentile of samples taken from contaminated sites activities
EF	2.94	0.78	VKT	

UNTREATED SOIL STOCKPILE

Emission Sources

Wind erosion

Source characteristics

Area	800	m2	measured from Google earth
Volume	2,000	m3	provided by Lend Lease 4000m3 stockpile volume Figure "Feb 2011 General Arrangment"
Total project expected throughput	4,000	m3	provided by Lend Lease
Density of material	2	t/m3	agreed by Lend Lease

Coordinates	Easting (km)	Northing (km)	Elevation (m) (Google earth)
upper left	333.616	6,251.596	5
upper right	333.632	6,251.596	5
lower right	333.631	6251.58	5
lower left	333.616	6251.58	5

Wind erosion

Area 800 m2

0.08 ha

	TSP	PM10	Units		
EF	0.4	0.2	kg/ha/h		
Uncontrolled ER	0.03	0.02	kg/h		
	0.0089	0.0044	g/s		
Mitigation	80	80	%	assumed surface crusting agents	Table 12, NPI Fugitive Emissions - page 31
	0.0018	0.0009	g/s		
	30	30	%	wind breaks	
Controlled ER	0.0012	0.0006	g/s		
ER	**0.0000016**	**0.0000008**	**g/m2/s**		

Summary

Source	Emission rate (g/s) TSP	PM10	Units
Wind erosion	0.000002	0.000001	g/m2/s

SOIL TREATMENT TENTS

Data on which Stack Details are Based

Length of Tent 1	50	m
Width of Tent 1	40	m
Height of Tent 1	15	m
Volume of Tent	30000	m3
No Air Changes per hour	4	changes per hour
Tent Volumetric Flow Rate	120000	m3/hr
Length of Tent 2	50	m
Width of Tent 2	40	m
Height of Tent 2	15	m
Volume of Tent 2	30000	m3
No Air Changes per hour	4	changes per hour
Tent Volumetric Flow Rate	120000	m3/hr

Stack source characteristics (stack for Tent 1)			Coordinates	
Height	30	m	333.592	6251.652
Diameter	1.7	m		
Area	2.22	m2		
Temperature	293	K		
Exit velocity	15	m/s		
Volumetric flow rate	33.33	m3/s		

Stack source characteristics (stack for Tent 2)			Coordinates	
Height	30	m	333.609	6251.723
Diameter	1.7	m		
Area	2.22	m2		
Temperature	293	K		
Exit velocity	15	m/s		
Volumetric flow rate	33.33	m3/s		

Emissions per tent assumed same emissions from each tent

Pollutant	Concentration (mg/kg)		
In-stack particulate concentration - TSP	20	mg/Nm^3	Assumed
	0.67	g/s	
In-stack particulate concentration - PM10	0.33	g/s	
In-stack odour concentration	250	OU/m3	Assumed

SOIL TREATMENT TENTS

Data on which Stack Details are Based

Length of Tent 1	50	m
Width of Tent 1	40	m
Height of Tent 1	15	m
Volume of Tent	30000	m3
No Air Changes per hour	4	changes per hour
Tent Volumetric Flow Rate	120000	m3/hr
Length of Tent 2	50	m
Width of Tent 2	40	m
Height of Tent 2	15	m
Volume of Tent 2	30000	m3
No Air Changes per hour	4	changes per hour
Tent Volumetric Flow Rate	120000	m3/hr

Stack source characteristics (stack for Tent 1)			Coordinates	
Height	30	m	333.592	6251.652
Diameter	1.7	m		
Area	2.22	m2		
Temperature	293	K		
Exit velocity	15	m/s		
Volumetric flow rate	33.33	m3/s		

Stack source characteristics (stack for Tent 2)			Coordinates	
Height	30	m	333.609	6251.723
Diameter	1.7	m		
Area	2.22	m2		
Temperature	293	K		
Exit velocity	15	m/s		
Volumetric flow rate	33.33	m3/s		

Emissions per tent assumed same emissions from each tent

Pollutant	Concentration (mg/kg)		
In-stack particulate concentration - TSP	20	mg/Nm^3	Assumed
	0.67	g/s	
In-stack particulate concentration - PM10	0.33	g/s	
In-stack odour concentration	250	OU/m3/s	Assumed

VEHICLE EMISSIONS

Vehicles
Rigid trucks

Number	30		
Capacity	27	tonnes	
Operating hours	10	h/day	
Operating days	312	days per year	
Total volume of material moved	387,167	m^3	
Density of Soil	2	t/m3	
Mass of Soil Transported	774,335	t	
Number of trips required	28,679		
Length of haul roads - unpaved	1,100	m	
Length of haul road - paved	1,060	m	distance between Stage 1A excavation area and Headland Park emplacement area multiplied by two (return trip); measured from Google Earth
Round trip distance	2,160	m	
Total km travelled	61,947	km	assumed activities completed over course of one year

Excavators

Number	6		Provided by Lend Lease
Bucket capacity	2	m^3	assumed average bucket capacity
Engine power	185	kW	based on an XCG 3301C-8 Excavator with bucket capacity 1.45 m3 http://www.traderscity.com/board/products-1/offers-to-sell-and-export-1/xcg330lc-8-excavator-with-bucket-capacity-1-45-m3-40295/

Area	Sources	Coordinates		Base Elevation (m)	Effective Height (m)*	Description
Excavation area (unpaved)	EX01	333.71	6251.491	6	5	rigid truck, sources spread over full haul distance
	EX02	333.749	6251.397	5	5	rigid truck, sources spread over full haul distance
	EX03	333.652	6251.407	5	5	rigid truck, sources spread over full haul distance
	EX04	333.649	6251.502	5	5	rigid truck, sources spread over full haul distance
Paved area	PV1	333.658	6251.586	5	5	rigid truck, sources spread over full haul distance
	PV2	333.674	6251.692	5	5	rigid truck, sources spread over full haul distance
	PV3	333.691	6251.765	5	5	rigid truck, sources spread over full haul distance
	PV4	333.724	6251.85	5	5	rigid truck, sources spread over full haul distance
	PV5	333.7	6251.95	5	5	rigid truck, sources spread over full haul distance
	PV6	333.663	6251.029	5	5	rigid truck, sources spread over full haul distance
	PV7	333.645	6252.123	5	5	rigid truck, sources spread over full haul distance
Emplacement area (unpaved)	EMPW01	333.606	6252.208	5	5	rigid truck, sources spread over full haul distance
	EMPW02	333.575	6252.322	5	5	rigid truck, sources spread over full haul distance
	EMPW03	333.644	6252.33	5	5	rigid truck, sources spread over full haul distance
	EMPW04	333.621	6252.232	5	5	rigid truck, sources spread over full haul distance
Excavators	E1	333.756	6251.547	6	3	Excavator, CP4
	E2	333.714	6251.562	5	3	Excavator, CP1
	E3	333.684	6251.518	5	3	Excavator, B2
	E4	333.631	6251.583	5	3	Excavator, contaminated tar stockpile
	E5	333.633	6251.673	5	3	Excavator, treated tar stockpile
	E6	333.624	6252.222	6	3	Excavator, Headland Park emplacement

*assumed height of exhausts

VEHICLE EMISSIONS CONTINUED

Excavator Emissions - Calculated per Excavator

E = P x LF x EFi

P	185 kW	average rated engine power
LF	0.5	load factor for track-type loader; NPI EET Manual for Combustion Engines, Version 3.0, 2008, Table 5

Pollutant	EF (kg/kWh)	Emissions (kg/h)	Emissions (g/s)
NOX	0.012	1.110	0.308
PM10	0.00088	0.08140	0.023

Source: Table 32: Emission factors (kg/kWh) for diesel industrial vehicle (track type loader) exhaust emissions

Rigid Truck Emissions

Pollutant	Emissions (g/km)*	Emission rate (g/year)	Emission rate (g/s)	Volume Source Emission Rate (g/s)	
					Emissions were spread evenly across fifteen volume sources
NOX	7.836	485,415	0.043	0.003	
PM10	0.523	32,398	0.003	0.0002	

*Source: SKM. (2002). M5 East Freeway Sub-Regional Air Quality Management Plan - rigid truck (diesel) emissions

Drill Rigs

Pollutant	EF (lb/hr)	Emissions (g/s)	
NOX	3.762	0.474	conversion of lb/hour to g/s as per Google
PM10	0.235	0.030	

1 lb/hour = 0.125997881 g/s

*Source: Pacific Institute (2001) The Cadiz Valley Groundwater Storage Project http://www.pacinst.org/reports/cadiz/feir/volumes/vol1/appendix/v1a_c1.pdf

Crane

Pollutant	EF (lb/hr)	Emissions (g/s)
NOX	1.919	0.242
PM10	0.125	0.016

*Source: Pacific Institute (2001) The Cadiz Valley Groundwater Storage Project http://www.pacinst.org/reports/cadiz/feir/volumes/vol1/appendix/v1a_c1.pdf

Wheeled Dozer

E = P x LF x EFi

P	175 kW	average rated engine power
LF	0.55	load factor for track-type loader; NPI EET Manual for Combustion Engines, Version 3.0, 2008, Table 5

Pollutant	EF (kg/kWh)	Emissions (kg/h)	Emissions (g/s)
NOX	0.0109	1.049	0.291
PM10	0.000551	0.053	0.015

Source: Table 6: 2002 Emission factors (kg/kWh) for diesel industrial vehicle exhaust emissions

VEHICLE EMISSIONS CONTINUED

TOTAL PILING-ASSOCIATED VEHICLE EMISSIONS

Pollutant	Total emission rate (g/s)	Sources		
NOX	2.09	2 x drill rigs	1 x truck	**ALL EXCLUDING HAULAGE TRUCKS**
PM10	0.14	2 x cranes	2 x excavators	

TOTAL CONSTRUCTION CARPARK EMISSIONS

Pollutant	Emissions (g/s)	Sources	
NOX	3.390	6 x excavators	2 x cranes
PM10	0.226	1 x drill rig	2 x wheeled dozers

TOTAL CONSTRUCTION EMPLACEMENT VEHICLE EMISSIONS

Pollutant	Emissions (g/s)	Sources	
NOX	0.603	1 x excavator	1 x wheeled dozer
PM10	0.038	1 x rigid truck represents concrete crusher	

TOTAL SOILTREATMENT VEHICLE EMISSIONS

Pollutant	Emissions (g/s)	Sources
NOX	0.617	2 x excavators
PM10	0.045	

RETENTION SYSTEM Excavation

Assumed no wind erosion due to deep channel-like nature of excavations

Emission Sources

Drill rigs
Excavator

Operating hours	10	h/day		
Operating days	312	days per year		
Perimeter of diaphragm wall	660	m	measured from Google Earth	
width of diaphrahm wall	1	m	From the draft RAP (AECOM, 2010)	
depth of diaphragm wall	10	m	estimated average depth to bedrock	
density of excavated material	2	t/m3		
Drill rigs				
Number of holes	3,300		estimated	conservative - more likely to be around half this according to advice provided by a structural engineer

Drill rig emissions - Piling operations

	TSP	PM10	Units	
EF	0.59	0.31	kg/hole	
Uncontrolled ER	1,947	1,023	kg	
	0.17	0.09	g/s	
Mitigation	70	70	%	Table 3 - Estimated control factors for various mining operations, EET for Mining, v2.3 2001
Controlled ER	0.05	0.03	g/s	
Mitigation	30	30	%	wind breaks
Controlled ER	0.04	0.02	g/s	

Source: Table 1, NPI EET for Mining

Excavator

Excavation of diaphragm wall	6	months
	156	days
Hours active per day	10	hours
Piling operations material mass	13,200	t
	8.5	t/h

Excavators/FEL (on overburden)	TSP Equation	PM10 Default Emission Factor	Units		
k	0.74	0.35		EF = k * 0.0016 * (U/2.2)^1.3 * (M/2)^-1.4	EET for Mining, Table 1, pg 11
U (Mean Wind Speed)	3.6	3.6	m/s		
M (Moisture Content)	9.7	9.7	%	99 percentile of all moisture content	
EF	0.00025	0.00012	kg/t		

Source: Table 1 - Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines (NPI Manual - Mining and Processing of Non-Metallic Minerals, v2, 2000, pp 38-39)

Excavator Emissions - Diaphragm Wall Excavation

	TSP	PM10	Units	
EF	0.0002	0.0001	kg/t	
Uncontrolled ER	0.0021	0.0010	kg/h	
	0.0006	0.0003	g/s	
Mitigation	30	30	%	wind breaks
Controlled ER	0.0004	0.0002	g/s	

Summary

	Emission rate		
Source	TSP	PM10	Units
Drill rig emissions - Piling operations	0.036	0.019	g/s
Excavator Emissions - Diaphragm Wall Excavation	0.0006	0.0003	g/s

Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
Ireland	+353 1631 9356
Italy	+39-02-3180 77 1
Japan	+813-3541 5926
Malaysia	+603-7725-0380
Netherlands	+31 10 2120 744
Philippines	+632 910 6226
Scotland	+44 (0) 1224-624624
Singapore	+65 6295 5752
Thailand	+662 642 6161
Turkey	+90-312-428-3667
United States	+1 978-589-3200
Venezuela	+58-212-762-63 39

Australian Locations

Adelaide
Brisbane
Canberra
Darwin
Melbourne
Newcastle
Perth
Sydney
Singleton

www.aecom.com