JACOBS AECOM
JOINT VENTURE

BaT project

Environmental Impact Statement

Technical Report 2 – Air Quality

August 2014

JACOBS AECOM JV

TECHNICAL REPORT 2

AIR QUALITY

AUGUST 2014

Contents

1. Air quality assessment

1.1 Introduction

1.1.1 Overview

This report describes the existing air quality within the study corridor and assesses the potential benefits and impacts on air quality attributable to the construction and operation of the Bus and Train Project (the Project).

1.1.2 Methodology

The methodology used to undertake the air quality assessment involved:

- identifying the emissions to air during construction and operation
- reviewing the Australian air quality legislation including the Environmental Protection (EPP) (Air) Policy 2008 and National Environment Protection Measure (NEPM) for Ambient Air Quality
- describing the dispersion meteorology of the study area by reviewing meteorological data from the Bureau of Meteorology (BoM) and data from the Department of Environment and Heritage Protection (DEHP) air quality monitoring network
- describing the existing air quality environment by identifying the major sources of air emissions and reviewing air quality data from DEHP
- estimating dust emissions from each of the construction worksites by combining information on the proposed construction activities with National Pollutant Inventory emission factors
- estimating ventilation outlet emissions from each of the portal and station sites
- modelling construction and operational emissions with the air dispersion model known as CALPUFF and comparing results with the ambient air quality guidelines in the EPP(Air) and other relevant objectives
- describing potential air quality impacts resulting from construction and operation of the Project
- identifying suitable mitigation measures to minimise or avoid potential air quality impacts.

1.1.3 Potential air quality issues

The Project runs from Dutton Park in the south to Spring Hill in the north. Specifically, the Project would connect with the Eastern Busway in Woolloongabba and the Northern Busway in Herston, and with the Gold Coast Line at Dutton Park and the Exhibition Line in Spring Hill.

The Project has the potential to generate air quality impacts during construction through:

- dust from construction activities, including excavation and materials handling
- exhaust emissions from diesel powered construction equipment. The Project also has a potential to generate air quality impacts during operation through:
  - exhaust emissions via ventilation outlets from compressed natural gas (CNG) and diesel buses
  - changes in regional transport emissions from changes in motor vehicle use, due to the availability and access to the underground rail and bus services.

The sources of construction and operational emissions to air in the study area are described below.

1.1.4 Construction emissions

Introduction

The potential air quality issues in relation to the construction and tunnel works relate to dust generated from excavation and material handling. In addition, there is also potential for some odour emissions due to excavation of material and exhaust emissions from diesel powered equipment.

The final approach to construction would depend on the final design of the Project and the environmental management plan developed by the Construction Contractor in accordance with the appropriate approval conditions. The greatest potential for dust impacts during construction of the Project are likely to be from the following activities:

- graders working unpaved areas and dozers moving material
- wind erosion from exposed surfaces
- wheel generated dust from vehicles travelling along unpaved or dirty paved surfaces
- handling and transport of spoil.

In addition, there is potential for impacts from particulate emissions associated with blasting activities, which is not the base case considered in this assessment.

The potential for air quality impacts from each of the five primary construction worksites is presented in **Table 1-1**. The locations of the five primary construction worksites are shown in **Figure 1-1** to Error! Reference source not found..

Table 1-1 Potential for air quality impacts at tunnelling construction worksites

Construction worksite	Description of activities
Southern Connection	The site would be used for construction of: • the south portal and Tunnel Boring Machine (TBM) launch box and removal of spoil from the tunnel construction of the new track/ busway • realignment of existing track/ busway.
Woolloongabba Station	The construction worksite would be used for: • construction of the cut and cover box and station cavern for the Woolloongabba Station • construction of the Woolloongabba Station access points and fitout.
George Street Station	The construction worksite would be used for: • construction of the cut and cover box and station cavern for the George Street Station • construction of the George Street Station access points and fitout.
Roma Street Station	The construction worksite would be used for: • construction of the cut and cover box and station cavern for the Roma Street Station • construction of the Roma Street Station access points and fitout.
Northern Connection	This construction worksite would be used for: • construction of the north portal, dive structure and cut and cover tunnel sections • construction of the new track/ busway and infrastructure, including a bridge over the rail corridor and the Inner City Bypass (ICB) • retrieval of the TBM.

The major components of construction required for each of the Project construction worksites that may generate emissions to the air within the study corridor include:

- construction worksite establishment and demolition activities
- tunnelling activities and associated excavation
- shaft excavation
- spoil removal
- surface road and bridge works
- emissions from construction equipment, generators and other plant equipment.

Construction worksite establishment and demolition activities

The initial steps in construction worksite establishment include the demolition of buildings and removal of kerbs, roadways and fencing.

Particular consideration would be given to the demolition of buildings (such as at the Dutton Park Station) that may contain harmful substances such as asbestos fibres. In such cases, controls would be implemented to satisfy Part 13 of the Workplace Health and Safety Regulation 2008 for the protection of construction workers on-site. It is expected that these measures would also be sufficient to adequately manage potential off-site impacts.

Surface earthworks and excavations are associated with establishing the construction worksites for activities located at the five primary sites as well as the infrastructure supporting sites at Dutton Park and Spring Hill.

Tunnelling activities and other excavation encountered during construction

Tunnelling would be carried out using purpose built tunnel boring machines (TBMs) between the southern and northern portals.

Surface excavations would be conducted by excavators and front end loaders down to rock level, with rock breakers and piling rigs used on rock.

The construction of Woolloongabba Station, George Street Station and the Roma Street Station would use a cut and cover method with pile walls or similar retaining structures.

Once initial surface earthworks has been completed to establish the sites, all excavation and rock breaking activities would be expected to be undertaken within an acoustic enclosure or shed. The enclosures would be fitted with a fabric filter for the removal of particulate matter at the two inner city construction worksite locations (Roma Street Station and George Street Station) for the mitigation of dust impacts at nearby sensitive receptors (refer to **section 1.2.1**).

Potentially harmful silica dust may be encountered during the excavation through certain types of geological formations. Where silica dust is encountered, controls would be implemented to satisfy relevant occupational health and safety requirements. It is expected that these measures would also be sufficient to adequately manage potential off-site impacts from silica dust.

Potential odours could also arise from the excavation of contaminated material. Where contamination or putrescible material in soil and/or groundwater is of a volatile nature or produces gas, there is the potential for odour to arise. **Section 1.4** details measures for managing potential odour problems encountered during construction.

Spoil removal

An estimated total of 3.5Mt of spoil is likely to be produced, with a total volume of 2.4 million m^3 (1.5 million m^3 in-situ). It is proposed that spoil would be removed by road. Spoil haulage is proposed to occur 24 hours a day, seven days a week from those sites with direct access to arterial roads, ie the Southern connection TBM service site, Woolloongabba Station, and the Northern connection construction worksite. For other sites, spoil haulage would generally occur between 6.30am and 6.30pm Monday to Saturday, apart from the Brisbane Central Business District (CBD) where haulage may occur up to 10.00pm on Monday to Friday.

The movement and handling of excavated spoil would be performed within enclosed purpose-built work sheds to minimise dust impacts at the five construction worksites (refer to **section 1.4**).

Surface road and bridge works

Traditional construction methods using excavators, graders, compaction equipment and pavement equipment would be utilised for surface road works and the bridge construction at Spring Hill. The potential air quality impacts of these activities are expected to be similar to those outlined earlier for construction worksite establishment and demolition activities and would be managed in accordance with the measures outlined in **section 1.4**.

In order to manage potential dust issues associated with concrete batching, the concrete required for the construction of the stations and road surfaces would be pre-mixed off-site and delivered in trucks in preference to sourcing from an on-site concrete batching plant. In some cases, pre-cast concrete panels may be delivered to the construction worksites.

Use of associated construction equipment, generators and other plant

Each construction worksite would be served by supporting equipment and plant including excavators, cranes, piling rigs, compaction plants, bulldozers and trucks. In case of power outages, generators would provide power to temporary ventilation equipment. The proposed construction activities, indicative equipment and air emission sources are presented in **Table 1-11**.

Pollutants of interest

In summary, the main air pollutants from the construction phase of the Project are therefore:

- Total Suspended Particulate (TSP)
- Particulate Matter 10 (PM_{10})
- deposited dust.

Deposited dust and TSP have the potential to cause nuisance impacts, rather than impacts on human health.

1.1.5 Operational emissions

Introduction

Air within the tunnel and stations would be exhausted to the surface by ventilation systems at the underground stations and at the south and north portal. Ventilation at stations would be powered by four $50m^3$/s fans. The fans would draw in and exhaust air from the station plaza. Contaminants in exhaust air would be similar to station and tunnel air quality, however, these are likely to be at lower concentrations, due to the increased volume of air.

Five ventilation outlets are proposed for the control of the tunnel emissions. As shown in **Figure 1-1** to Error! Reference source not found., each proposed outlet is therefore approximately located at the south and north portal and the three station sites.

Pollutants of interest

The ventilation outlet air would contain substances, due to emissions from buses:

- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)
- Particulate matter as PM_{10}
- Particulate matter as $PM_{2.5}$
- ultrafine particles (ie particles smaller than 0.1µm)
- volatile organic compounds including (but not necessarily limited to): benzene, toluene, xylene, 1,3-butadiene.

At the time of writing, there are no Australian or State standards for ultrafine particulate matter which are applied for assessment of specific projects. Particulate matter smaller than 2.5µm in equivalent aerodynamic diameter (that is $PM_{2.5}$) in an urban environment is comprised predominantly of combustion-related emission particles of this size and is used as a surrogate for assessment of ultrafine particulate matter.

The National Environment Protection Measure (NEPM) classifies benzene, formaldehyde, toluene and xylene as air toxics. Air toxics are defined as gaseous, aerosol or particulate pollutants and exist at relatively low concentrations in urban air sheds, with significantly elevated levels only occurring near specific sources such as industrial sites, heavily trafficked roads and areas impacted by wood smoke (NEPC, 2003).

Most of the air toxics from vehicles arise from the by-products of the combustion process when fuel is burnt in the engine and then emitted via the exhaust system, and from evaporation of the fuel itself.

The air toxics are subset of volatile organic compounds that have the potential to cause nuisance odour complaints. They have the general odour characteristics of aromatic and sweet smelling with varying odour thresholds. Typically these aromatic hydrocarbons produce their most pungent odour when in liquid form (as a laboratory solvent) and not the by-product of combustion. The concentration of air toxics as a result of the Project are expected to be significantly lower than each compound's detection and recognition threshold and are very unlikely to result in nuisance odour complaints.

The air toxic emissions are not expected to be released in quantities from the Project that will result in ground level impacts from these pollutants and have not been addressed further in the air quality assessment. While not a pollutant, there is also potential for small increases in temperature in close proximity to the extraction points of the ventilation outlets. The heat is primarily generated by the vehicle exhaust in the tunnel and is directly proportional to the vehicle density within the tunnel.

LEGEND

Vents

- Vent inlet
- Vent outlet

- BaT rail centreline
- Property boundary
- Transport corridor
- Construction worksite

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-1

Construction worksites - 1 of 3

0 0.1 0.2
Kilometres
1:7,500 (at A4)
Projection: GDA 1994 MGA56

N

LEGEND

Vents

Vent inlet

Vent outlet

BaT rail centreline

Property boundary

Transport corridor

Construction worksite

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-2

Construction worksites - 2 of 3

0 0.1 0.2
Kilometres
1:7,500 (at A4)
Projection: GDA 1994 MGA56

N

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LEGEND

Vents

- Vent inlet
- Vent outlet

- BaT rail centreline
- Property boundary
- Transport corridor
- Construction worksite

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-3

Construction worksites - 3 of 3

0 0.1 0.2
Kilometres
1:7,500 (at A4)
Projection: GDA 1994 MGA56

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1.1.6 Legislative and policy framework

The *Environmental Protection Act 1994* provides for the management of the air environment in Queensland. Air quality objectives are specified by the Queensland Department of Environment and Heritage Protection (DEHP) in the Queensland Environmental Protection (Air) Policy 2008 (EPP (Air)). The purpose of the EPP (Air) is to protect the air quality environment for human health and wellbeing, the health and biodiversity of ecosystems, the aesthetics of the environment and for agricultural use.

The air quality objectives in the EPP (Air) relevant to the Project are presented in **Table 1-2**.

Table 1-2 Air quality objectives relevant to the Project

Pollutant	Air quality objective	Averaging period	Allowable exceedances
Total Suspended Particulates (TSP)	90µg/m^3	Annual	-
Particulates as PM_{10} (<10µm)	50µg/m^3	24 hours	5 per year
Particulates as $PM_{2.5}$ (<2.5µm)	25µg/m^3	24 hours	-
	8µg/m^3	Annual	-
Nitrogen dioxide (NO_2)	250µg/m^3	1 hour	1 day each year
	62µg/m^3	1 year	-
Carbon monoxide (CO)	11,000µg/m^3	8 hours	-

The National Environment Protection Measure (NEPM) for Ambient Air Quality was released in 2003 by the National Environment Protection Council (NEPC, 2003). The NEPM sets national standards for the six key air pollutants, being, carbon monoxide, ozone, sulphur dioxide, nitrogen dioxide, lead and particles. The EPP (Air) has adopted the NEPM (Air) standards as air quality objectives.

The NEPM also provides advisory reporting standards for $PM_{2.5}$.These are 25µg/m^3 for a maximum 24 hour average period and 8µg/m^3 as an annual averaging period. Both of these standards are consistent with the objectives for $PM_{2.5}$ set out in the EPP (Air).

Coarse particulates (>10 µm) have the greater potential to generate potential nuisance. The EPP (Air) does not provide specific objectives for nuisance impacts of particulates. The following objectives are adopted for the management of potential nuisance impacts for the Project:

- dust deposition rate of 4 g/m^2/30 days or 130 mg/m^2/day averaged over a 30 day period
- TSP concentration of 90 µg/m^3 (annual average) (EPP (Air)).

1.2 Existing environment

This section identifies the nearest sensitive receptors to the Project and describes the local environment, including meteorology and ambient air quality.

1.2.1 Sensitive receptors

Sensitive receptors are defined by DEHP (2013):

- a dwelling, mobile home or caravan park, residential marina or other residential premises
- a motel, hotel or hostel
- a kindergarten, school, university or other educational institution
- a medical centre or hospital

- a protected area
- a public park or gardens
- a commercial place or part of the place potentially affected.

It includes the curtilage of such any place and any place known or likely to become a sensitive place in the future.

Due to the urban nature of the Project, sensitive receptors occur throughout each section of the study corridor. Although the majority of the sensitive receptors are universal across the Project, each of the work, station and portal sites have specific key receptors which are directly related to individual construction worksites and/or operational activities.

The key sensitive receptors for each section have been characterised as:

- hospital and associated dwellings (eg Leukaemia Foundation for the Southern Connection site)
- residential areas (suburban communities) with some commercial, education facilities (high schools) and community/open space areas contributing to the key receptors for the Woolloongabba site
- open space (Victoria Park) and education facilities (high schools) with some localised residential dwellings for the Spring Hill site
- higher density residential/ commercial, open space (such as the Roma Street Parkland and 21 Mary Street) for the Roma Street and George Street sites.

The locations of approximately 1,300 sensitive receptors are presented in **Figure 1-4**.

LEGEND

- Sensitive receptor
- Study corridor
- Construction worksite

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-4

Locations of sensitive receptors

N

0 0.5 1
Kilometres
1:30,000 (at A4)
Projection: GDA 1994 MGA56

Aerial Photo: Brisbane City Council 2012

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The nearest air quality sensitive receptors to the construction worksites and station/ portal sites are presented in **Table 1-3**. Particularly sensitive receptors such as hospitals and education facilities are also identified in the table.

Table 1-3 Sensitive receptors

Construction worksites	Sensitive receptors	Approximate distance from construction worksite boundary (m)
Southern Connection	EcoSciences Building - commercial	20
	Princess Alexandra Hospital (PA Hospital)	10
	Rawnsley Street - residential	40
	Annerley Road - residential	230
	Dutton Park Primary School	170
	Leukaemia Support Village	20
Woolloongabba Station	Vulture Street - residential	30
	Vulture Street - commercial	50
	Main Street - residential	115
	St Nicholas Cathedral	20
	Main Street - commercial	25
	Stanley Street - commercial	60
	St Joseph's Primary School	140
George Street Station	Mary Street – residential	5
	Mary Street – commercial	20
	Mary Street – commercial	40
	George Street – commercial	5
	George Street – commercial	20
	George Street – residential	60
	George Street – commercial	25
	Synagogue	40
Roma Street Station	Wickham Terrace - residential	95
	Brisbane Private Hospital	240
	Albert Street – residential	100
	Brisbane Dental Hospital	380
	Roma Street Station - commercial	50
	Holiday Inn - residential	220
	Parkland Crescent - residential	5
Northern Connection	Gregory Terrace - residential	150
	St Joseph's College	90
	Centenary Aquatic Centre	90
	Gregory Terrace - residential	200
	Gregory Terrace - commercial	175

Construction worksites	Sensitive receptors	Approximate distance from construction worksite boundary (m)
	Bowen Bridge Road - commercial	15
	Brisbane Girls Grammar	180
	Brisbane Boys Grammar	380
	Royal Brisbane and Women's Hospital (RBWH)	125

1.2.2 Meteorology

The dispersion of air emissions following release from a source varies depending on the local terrain and the prevailing meteorological conditions.

This section describes the existing meteorology and climatic data recorded by two BoM meteorological monitoring stations at:

- Brisbane Airport (located 10km to the northeast of the northern section of the study corridor)
- Archerfield Airport (located 8km to the south-west of the southern section of the study corridor).

The dispersion modelling meteorology is also compared with the existing meteorology and climatic data recorded at the two stations in **section 1.3.3**.

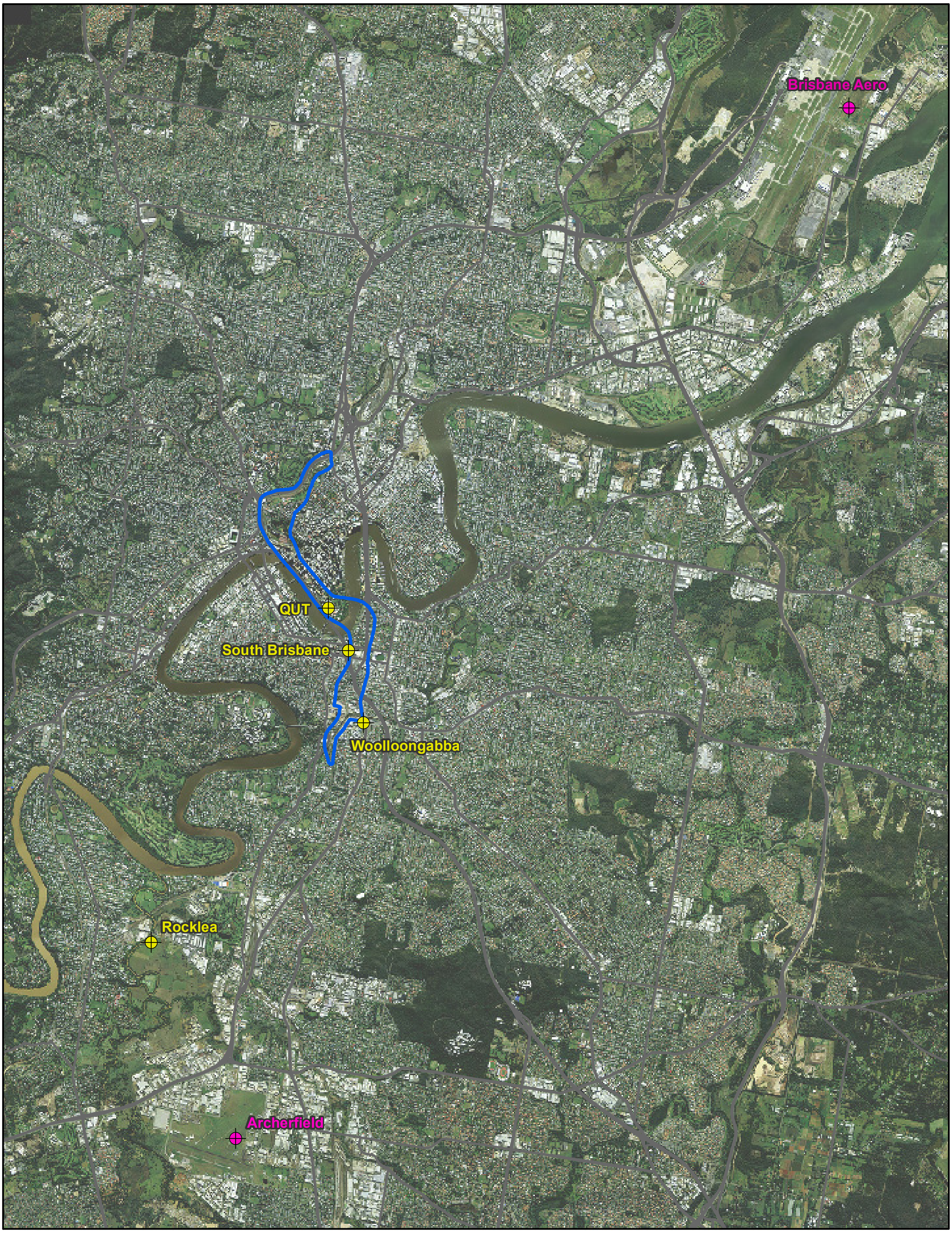
The locations of these meteorological stations, as well as air quality monitoring stations are presented in **Figure 1-5**.

Existing meteorological conditions (Brisbane Airport)

The Brisbane Airport meteorological station is located approximately 12km northeast of the northern portal. Wind patterns for the Brisbane Airport for 2009 to 2013 are shown in **Figure 1-6**.

The key Project related aspects of the dispersion meteorology at Brisbane Airport are:

- the dominant wind directions throughout the year are from the south-west/south-southwest and north/north-northeast
- winds during summer are predominantly from the east-southeast and the north-northeast with an average wind speed of 4.1m/s
- winds during autumn and winter are predominantly from the south-west/ south-southwest with an average wind speed of 3.8m/s in autumn winter
- winds during spring are predominantly from the north/north-northeast with an average wind speed of 4.6m/s
- strong winds are most frequent from the north and north-northeast during spring and summer
- calm conditions (wind speed less than 0.5m/s) occur 1.6 per cent of the year and are most common during winter (1.7 per cent).



LEGEND

- BoM meteorological station
- DEHP monitoring station
- Highway/main road
- Study corridor

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-5

Locations of BoM meteorological stations and DEHP monitoring stations

N

0 1 2
Kilometres
1:100,000 (at A4)
Projection: GDA 1994 MGA56

Aerial Photo: AusImage 2009

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Figure 1-6 Annual and seasonal windroses for Brisbane Airport 2009-2013

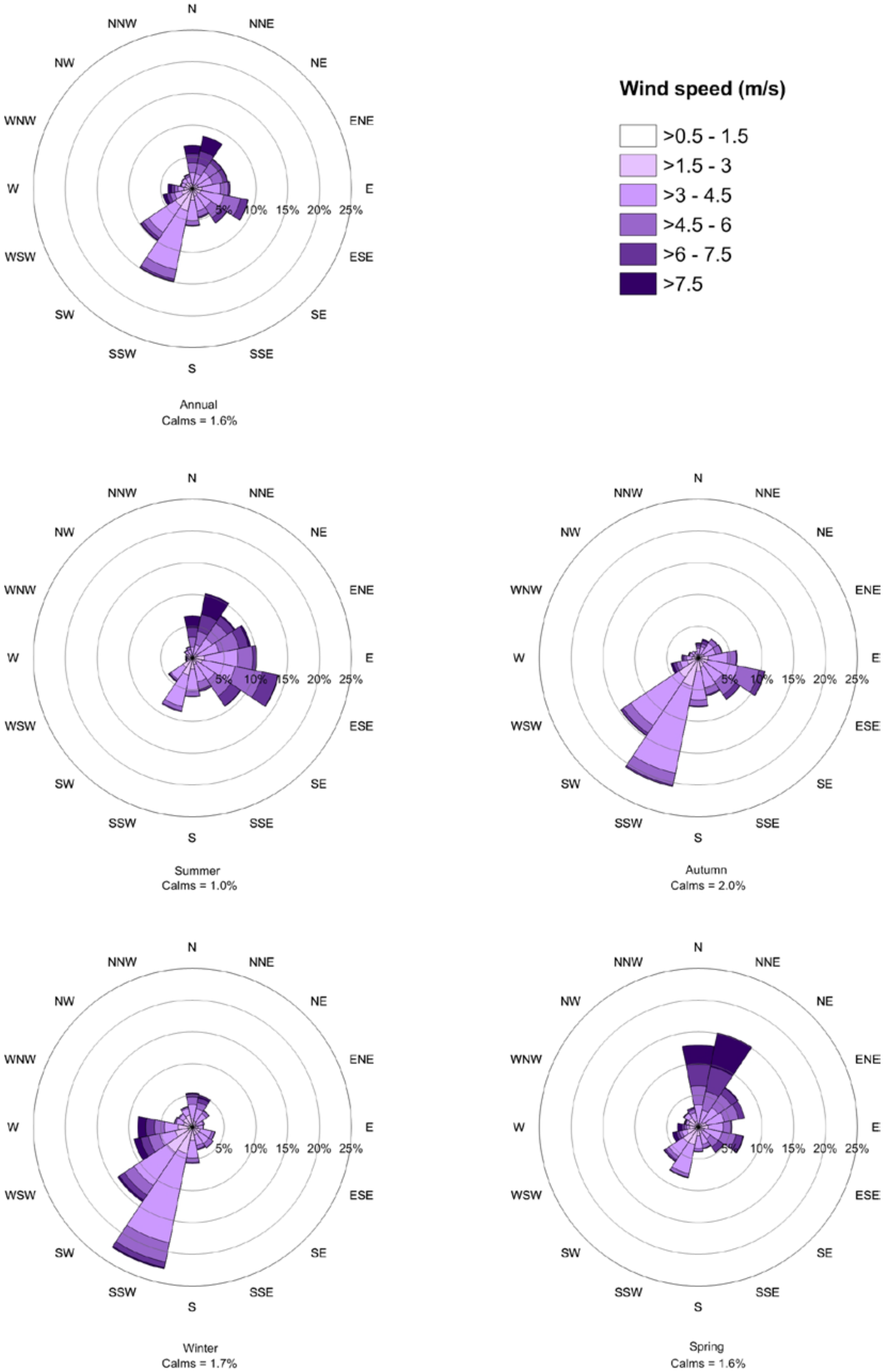


Table 1-4 provides a summary of the temperature, humidity and rainfall data for the Brisbane Airport meteorological station from 1994 to 2014.

Brisbane Airport typically has warm days during summer with average maximum daytime temperatures around 29°C in January and February, falling to 21°C in June and July. Temperatures overnight are mild during summer and cool during the winter months, with average minimum daily temperatures of 9°C in July, rising to 21°C in January and February.

Highest rainfall is generally recorded during summer months with monthly rain averaging above 90mm/ month from November to February and also in May. Mean monthly rainfall is low from July to September with average monthly rainfall less than 40mm.

Table 1-4 Climatic data for Brisbane Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean daily maximum temperature (°C)	29	29	28	26	24	21	21	22	24	25	27	28	**25**
Mean daily minimum temperature (°C)	21	21	19	16	13	11	9	10	13	16	18	20	**16**
Mean rainfall (mm)	139	126	100	79	107	69	31	39	33	76	96	131	**1016**
Number of rain days	13	13	13	11	10	9	7	5	6	9	11	12	**118**
Mean 9 am air temp (°C)	26	26	25	22	19	16	15	17	21	23	24	26	**22**
Mean 9 am relative humidity (%)	66	68	67	67	68	70	65	60	59	59	62	64	**65**
Mean 3 pm air temp (°C)	27	28	26	25	22	20	20	20	23	24	25	27	**24**
Mean 3 pm relative humidity (%)	63	63	61	58	56	55	50	50	55	58	61	62	**58**

Existing meteorological conditions (Archerfield Airport)

The Archerfield Airport meteorological station is located 8km to the south-west of the southern portal and is representative of conditions in the southern part of the study corridor. Wind patterns for Archerfield Airport form 2009 to 2013 are shown in **Figure 1-7**. The key features of the dispersion meteorology at Archerfield Airport are:

- the dominant wind directions throughout the year are from the south, east-southeast and north-northeast
- winds during summer are predominantly from the east-southeast and the north-northeast with an average wind speed of 4.0m/s
- winds during autumn and winter are predominantly from the south-southwest/ southwest with an average wind speed of 3.1m/s in autumn and 3m/s in winter
- winds during spring are predominantly from the north/north-northeast with an average wind speed of 3.7m/s
- strong winds are most frequent from the north and north-northeast during spring and summer although strong westerly winds occur during winter
- calm conditions (wind speed less than 0.5m/s) occur 10.2 per cent of the year and are most common during winter (12.6 per cent).

Figure 1-7 Annual and seasonal windroses for Archerfield Airport 2009-2013

Table 1-5 provides a summary of the temperature, humidity and rainfall data for the Archerfield Airport meteorological station from 1939 to 2010.

Archerfield Airport typically has warm days during summer with average maximum daytime temperatures around 30°C in January and February falling to 21°C in June and July. Overnight temperatures are mild during summer and cool during the winter months, with average minimum daily temperatures of 7°C in July, rising to almost 20°C in January and February.

Table 1-5 Climatic data for Archerfield Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean daily maximum temperature (°C)	30	30	29	26	24	21	21	23	25	27	28	30	26
Mean daily minimum temperature (°C)	20	20	18	15	12	9	8	8	11	14	17	19	14
Mean rainfall (mm)	138	153	124	81	74	66	49	37	36	78	100	127	1064
Number of rain days	11	12	13	10	9	7	6	6	6	9	10	11	110
Mean 9 am air temp (°C)	26	25	24	21	17	14	13	15	19	22	24	25	20
Mean 9 am relative humidity (%)	66	70	70	71	74	74	71	67	62	60	61	64	67
Mean 3 pm air temp (°C)	29	28	27	25	23	21	20	21	24	25	26	28	25
Mean 3 pm relative humidity (%)	55	58	56	54	53	51	45	43	45	50	53	54	51

Dispersion modelling meteorology

A three dimensional meteorological field was required for the air dispersion modelling that includes a wind field generator accounting for slope flows, terrain effects and terrain blocking effects . CALMET produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables for each hour of the modelling period. In the absence of site specific meteorological data for the project site, provided three years of meteorological datasets (2011, 2012 and 2013) were prepared using the CALMET meteorological model and compared to the BoM observations for selection of the year representative of local conditions and to provide further information on the local meteorological influences. The comparison demonstrated that there is little variation in wind patterns from year to year and the 2012 dataset from the CALMET model was selected. Details of the modelling approach and dataset are provided in **section 1.3.3**. The following outputs from the CALMET derived meteorological dataset for the Project are adopted to describe the local meteorology:

- wind speed and wind direction
- mixing height
- stability class.

Wind speed and direction

The annual and seasonal windroses for the CALMET derived dataset for 2012 are provided in **Figure 1-8**. The windroses for the dataset show the prevailing winds for the Project location as south-east to south-west during the autumn and winter months and northeast to southeast during summer and spring which are consistent with the data measured at the Brisbane Airport and Archerfield Airport BoM stations. In addition, the strongest wind speeds (ie >4.5m/s).are from the south to south-east direction.

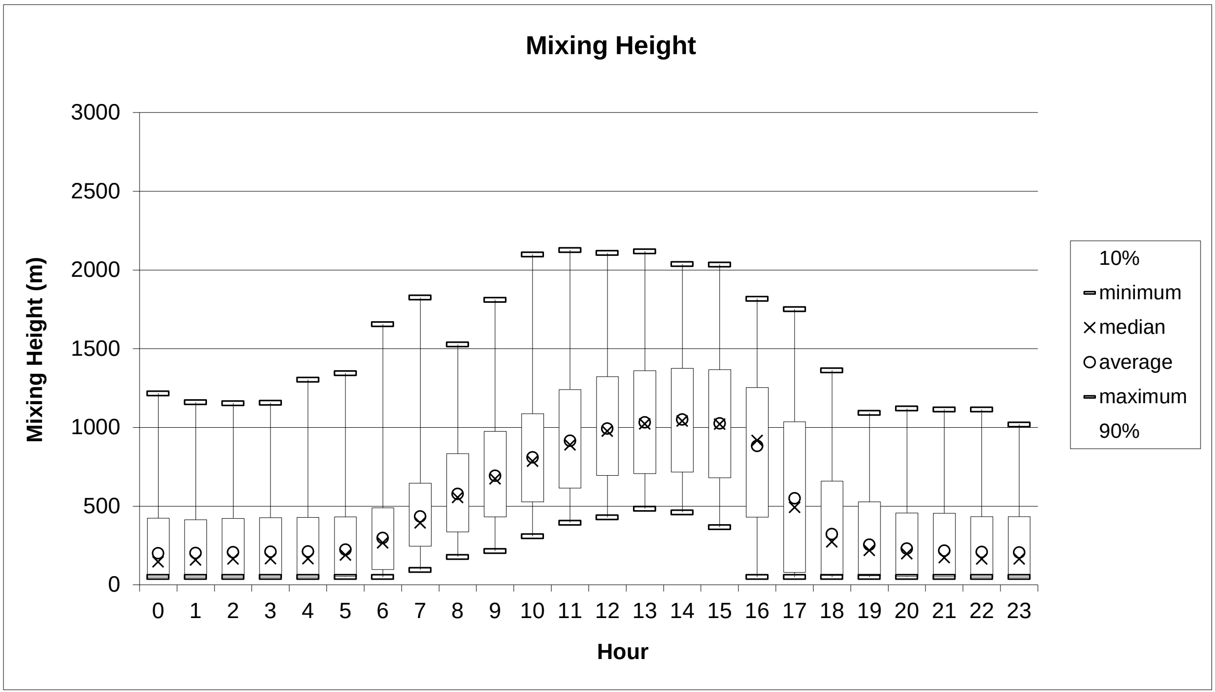
Figure 1-8 Annual and seasonal windroses for CALMET derived dataset for 2012

Mixing height

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

The diurnal variation of mixing height is summarised in **Figure 1-9**. On average, mixing heights are lower during the night and early morning hours (<500m), increasing after sunrise to a maximum of 2,100m by mid-afternoon and generally decreasing sharply with sunset.

Figure 1-9 Diurnal variation in mixing height for the CALMET derived data



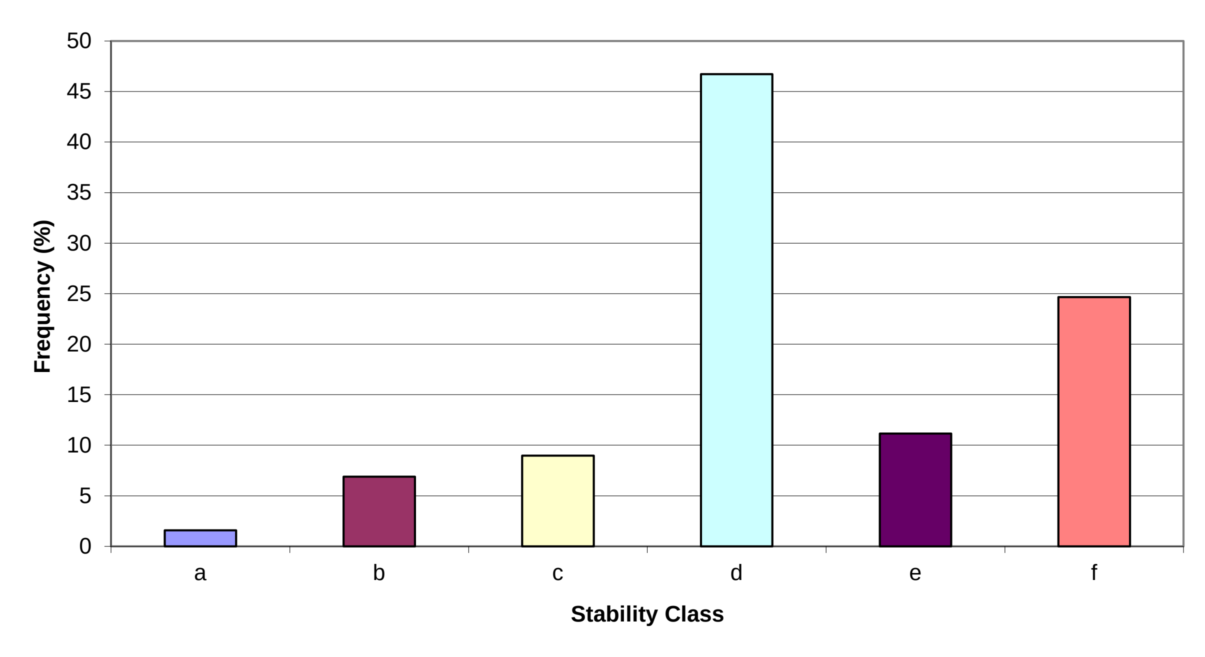
Stability class

The Pasquill-Gifford stability classification scheme denotes six stability classes from A to F. Class A is described as highly unstable and occurs during the day 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. 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 stability class percentages from the CALMET derived meteorological data for the Project is shown in **Figure 1-10**. Neutral to stable atmospheric conditions associated with light to moderate winds are shown by the high percentage of D (46 per cent) and F classes (24 per cent). These stability class percentages are consistent with expectations for the Project location.

Figure 1-10 Stability class parameters for CALMET derived data



1.2.3 Regional air quality

The air quality of the study corridor is influenced by both regional air pollution and localised sources. The ambient air quality within the study corridor has been described by:

- identifying the regional influences on air quality in South East Queensland
- reviewing ambient air quality data recorded by the DEHP and other available sources
- identifying localised sources of air emissions in the study corridor
- establishing background air quality levels for the study corridor.

Regional influences on air quality

In 2004, the then Queensland Environmental Protection Agency (EPA) and Brisbane City Council prepared an air emissions inventory for South East Queensland and identified the following key regional influences on air quality:

- particulate matter from dust storms (infrequent)
- particulate matter from bushfires and controlled burns (occurs once or twice per year in cooler months)
- vehicle exhaust emissions including Oxides of Nitrogen , PM_{10}, $PM_{2.5}$, Carbon Monoxide and Sulphur Dioxide
- biogenic emissions of volatile organic compounds which can be a precursor to the formation of photochemical smog.

The air quality in the study corridor has been described by analysing monitoring data collected by the DEHP (formerly known as EPA) at Brisbane CBD (Queensland University of Technology (QUT), Gardens Point), South Brisbane, Woolloongabba and Rocklea.

Brisbane CBD (QUT, Gardens Point) monitoring station

The Brisbane CBD (QUT) monitoring station is located in an elevated position at the QUT, Gardens Point campus. The site measures PM_{10} concentrations and meteorological data. Statistics for daily PM_{10} concentrations from 2008 to 2012 are summarised in **Table 1-6**. At the time of writing, published data for all of 2103 was not available. PM_{10} concentrations recorded at the station were below the air quality goal of less than five exceedances per year of the daily concentration of 50µg/m^3, except in 2009 when major regional dust storms resulted in seven exceedances.

Table 1-6 Ambient air quality monitoring data at Brisbane CBD (QUT) from 2008 to 2012

Pollutant	Air quality objective	Averaging period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95th percentile	99th percentile	Maximum
PM_{10}	50µg/m^3	24 hours	18	19	33	57	6,459 (10)

Data in parenthesis represent the number of exceedances of the objectives during the five year period.

South Brisbane monitoring station

The South Brisbane monitoring station is located nearby the Riverside Expressway. The site measures PM_{10}, $PM_{2.5}$, CO and NO_2 concentrations and meteorological data. Summary statistics for air quality monitoring data from the South Brisbane monitoring station from 2008 to 2012 are provided in **Table 1-7**. At the time of writing, published data for all of 2103 was not available.

Table 1-7 Ambient air quality monitoring data at South Brisbane from 2008 to 2012

Pollutant	Air quality objective	Averaging period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95th percentile	99th percentile	Maximum
PM_{10}	50µg/m^3	24 hours	19	20	31	54	5,969 (18)
$PM_{2.5}$	25µg/m^3	24 hours	7.8	8.6	15	21	59 (4)
CO	10,000µg/m^3	8 hours	240	260	640	1,240	2,070
NO_2	250µg/m^3	1 hour	30	38	59	73	100

Data in parenthesis represent the number of exceedances of the objectives during the five year period.

Rocklea monitoring station

The Rocklea monitoring station was established in 1978 and is located in an open area surrounded by industry and residential uses. The Rocklea monitoring station measures PM_{10}, $PM_{2.5}$, Nitrogen dioxide (NO_2), ozone (O_3) and meteorological data. Air quality monitoring data from Rocklea monitoring station from 2008 to 2012 are summarised in **Table 1-8**. At the time of writing, published data for all of 2103 was not available.

Measurement data recorded at the Rocklea station are below the air quality goals for PM_{10} and NO_2 concentrations, except in 2009 when major dust storms resulted in ten exceedances of the PM_{10} goal of 50µg/m^3.

Exceedances of the 24 hour ambient air quality goal for $PM_{2.5}$ were recorded in 2008 and 2009. The annual goal for $PM_{2.5}$ was exceeded on eight occasions in 2009 due to major dust storms.

Table 1-8 Ambient air quality monitoring data at Rocklea from 2008 to 2012

Pollutant	Air quality objective	Averaging period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95th percentile	99th percentile	Maximum
PM_{10}	50µg/m^3	24 hours	18	20	33	51	455 (11)
$PM_{2.5}$	25µg/m^3	24 hours	7.8	9	26	24	159
NO_2	250µg/m^3	1 hour	15	19	39	55	96 (11)

Data in parenthesis represent the number of exceedances of the objectives during the five year period.

Woolloongabba monitoring station

The Woolloongabba monitoring station has been operating since 1998 and is sited very close to the kerb of a busy main road to monitor air pollution from traffic sources. Measurement data at this station are heavily influenced by freshly generated traffic emissions and above what may be classified as representative of urban background. In addition, the station is sited next to the side of a building which may cause discrepancies in measured winds and air quality monitoring data. Data from this station have therefore not been included in the estimation of background for the Project. Air quality monitoring data from the Woolloongabba monitoring station from 2008 to 2012 are summarised in **Table 1-9**.

Table 1-9 Ambient air quality monitoring data at Woolloongabba 2008 to 2012

Pollutant	Air Quality Objective	Averaging Period	Pollutant concentrations (µg/m^3)				
			Average	70th percentile	95th percentile	99th percentile	Maximum
PM_{10}	50µg/m^3	24 hours	16	19	33	35	851 (11)
$PM_{2.5}$	25µg/m^3	24 hours	8.4	9.5	15.4	21.2	110 (11)
CO	10,000µg/m^3	8 hours	280	336	964	1,355	3,375
NO_2	250µg/m^3	1 hour	34	41	65	82	137

1.2.4 Local air quality

This section identifies air emissions within the study corridor and establishes background air quality levels for the air quality impact assessment. Localised air emissions sources in the study corridor include:

- motor vehicle emissions from major roads including the ICB, Lutwyche Road, Riverside Expressway, the Pacific Motorway, Ipswich Road and Fairfield Road
- transport infrastructure, including rail yards and a bus depot
- localised building construction activities.

Given the absence of major industrial air emissions sources within the study corridor, the local air quality monitoring data has been used to establish the background air quality data. The adopted background air quality concentrations for the study corridor are provided in **Table 1-10**.

A 70th percentile concentration is adopted for the assessment of background air quality. This approach is consistent with the approach suggested by the Victorian EPA (VEPA), where the 70th percentile of background data is used to determine the potential for the relevant assessment objectives to be exceeded (VEPA 2006). For the assessment of annual average model predictions, the background levels were based on annual average measurement data.

The adopted background air quality concentrations in **Table 1-10** are considered conservative levels. That is, on most days in most parts of the study corridor, concentrations would be expected to be lower than these values.

Table 1-10 Adopted background air quality concentrations

Pollutant	Averaging period	Air quality objective	Adopted background concentration
TSP	1 year	90µg/m^3	36µg/m^3
PM_{10}	24 hours	50µg/m^3	20µg/m^3
$PM_{2.5}$	24 hours	25µg/m^3	9µg/m^3
	1 year	8µg/m^3	7.8µg/m^3
Dust deposition	1 year	130mg/m^2/day	60mg/m^2/day
NO_2	1 hour	250µg/m^3	19µg/m^3
	annual	62µg/m^3	15µg/m^3
CO	8 hours	11,000µg/m^3	260µg/m^3

1.2.5 Summary of existing environment

The key features of the existing air quality environment in the Project area are as follows:

- there is generally good air quality with concentrations of most pollutants well below the air quality objectives
- regional sources (such as controlled burns or dust storms) may contribute to exceedances of the objectives for PM_{10} and $PM_{2.5}$ from time to time
- dispersion meteorology is characterised by winds from the north-east during summer and spring and winds from the south-west during autumn and winter.

1.3 Impact assessment

1.3.1 Introduction

This section includes a discussion and assessment of:

- estimating air emissions from each of the construction worksites and ventilation outlets
- meteorological modelling for the derivation of a representative dataset suitable for use in air dispersion modelling
- air dispersion modelling of dust and particulate matter from high risk construction activities
- air dispersion modelling of particulate matter and combustion gases from the operation of the tunnel ventilation outlets
- assessing the potential air quality impacts from construction works and operation of the Project
- a discussion of management of the emissions including mitigation and monitoring.

1.3.2 Emissions estimation

Construction

Dust emissions from construction would vary in accordance with the intensity of construction activities. In general, dust emissions from construction are greatest during periods of significant earth moving activities.

Dust emissions from the 'worst-case' scenarios have been calculated for each construction worksite based upon forecast maximum activities. Emissions were estimated using emission factors in the 'Emission Estimation Technique Manual for Mining version 3.1' (NPI, 2012) due to the similarity of tunnelling to that of mining during tunnelling activities. The uncontrolled emission factors used in this estimation and the proposed emission controls such as an acoustics enclosure or shed at the five construction worksites, hoardings and water sprays, are presented in **Table 1-11**. In addition, emission controls proposed and presented in **Table 1-11** for the two inner city construction worksite locations (Roma Street Station and George Street Station) also include enclosure equipped with fabric filters.

Two scenarios have been modelled in the assessment:

- Scenario 1 - represents the base case where primary surface excavation activities are carried out using rock breakers and piling rigs
- Scenario 2 - represents an alternative case where primary surface excavation activities are carried out using drill and blast methods. This scenario was modelled for Woolloongabba Station, George Street Station and Roma Street Station.

Table 1-11 Uncontrolled emissions factors used in the construction assessment (NPI, 2012)

Construction activity	Unit	TSP	PM_{10}
Base Case			
Excavators/FEL on spoil	kg/tonne	0.025	0.0012
Bulldozers on spoil/excavated material	kg/hour	1.63	0.33
Wheel generated dust	kg/vkt	4.23	1.26
Wind erosion	kg/ha/hour	0.4	0.2
Loading trucks	kg/tonne	1×10^{-4}	5×10^{-5}
Unloading trucks (deliveries)	kg/tonne	1×10^{-4}	5×10^{-5}
Rock breakers	kg/tonne	1.63	0.33
Piling rigs	kg/tonne	1.63	0.33
Scenario 2[1]			
Drilling	kg/hole	0.59	0.31
Blasting	kg/blast	0.22	0.11

[1] Scenario 2 is inclusive of emissions estimated for Scenario 1.

A number of assumptions were made in estimating the emissions as follows:

- surface excavation activities would be carried out for 12 hours per day, 6 days a week
- surface excavation and site establishment activities would be performed by excavators, bulldozers and front end loaders at each of the five construction worksites

- primary excavation activities would be performed by road header or rock hammer and piling rig within a fully enclosed acoustics shed or enclosure The enclosures would be fitted with a fabric filter for the removal of airborne particulate matter and dust at the two inner city construction worksite locations (Roma Street Station and George Street Station)
- spoil haulage is proposed to occur 24 hours a day, seven days a week from those sites with direct access to arterial roads, ie southern connection, Woolloongabba station, and northern connection construction worksites. For other sites, spoil haulage would generally occur between 6.30am and 6.30pm Monday to Saturday, apart from the George Street where haulage may occur up to 10.00pm on Monday to Friday
- emissions from spoil movement activities are estimated based on a moisture content of 12 per cent (SKM Aurecon CRR JV, 2011) and the default silt content of 10 per cent (NPI, 2012)
- locations of the five primary construction worksites including proposed haulage routes are shown in **Figure 1-1** to **Figure 1-3**.

In addition, while the base case scenario for the modelling is proposed as exclusive of blasting and drilling, these activities have been adopted for an alternative scenario modelling on the following assumptions:

- blasting occurs twice per day (at 10.00am and 2.00pm) with a blast size of 100m^2
- drill pattern for blasting is assumed to require 1 drill hole for each 1.5m^2 blast area.

Preliminary modelling of air quality impacts (with basic mitigation only) at a selection of construction worksites indicated impacts from dust deposition and PM_{10} would exceed air quality objectives at some receptors. Preliminary predictions and potential exceedances at worst affected receptors are shown in **Table 1-12**.

Table 1-12 Summary of preliminary modelling exceedances

Construction worksite	Exceedances modelled without specific controls		
	24 hr PM_{10}	TSP	Dust deposition
Objective	**50 µg/m^3**	**90 µg/m^3**	**130 mg/m^2/day**
Southern Connection	64 (**14**)	-	280 (**150**)
George Street Station	58 (**8**)	-	451
Roma Street Station	55 (**5**)	155 (**65**)	1424 (**1296**)

As a result, a potential mitigation regime was developed for each site to control emissions to meet air quality objectives. The mitigation options modelled included a selection of:

- acoustic enclosures or sheds at areas with higher intensity of activity (load out areas/shaft excavations)
- hoardings around general work areas
- hardstand on roads
- basic standard controls.

The specific modelled mitigation regime for each construction worksite is outlined in **Table 1-13**.

The Project has to ability to increase the level of dust control depending on the specific activity and prevailing weather (temperature, wind and precipitation) conditions. A more comprehensive range of the potential control options is provided in **section 1.4**.

While the controls modelled are extensive, they are not the only method by which dust control can be achieved for the project. Should an alternative construction approach, or mitigation regime become preferred (such as more intensive water spraying, activity specific extraction hoods, covering or sealing exposed surfaces) dust control would be required to meet air quality objectives. Effectiveness of any mitigation regime could be confirmed through air quality monitoring proposed in **section 1.4**.

Table 1-13 Modelled mitigation options

Potential mitigation and control factors (per cent reduction)	Construction worksites/ areas						
	Dutton Park south	Dutton Park north	Woolloongabba	George Street	Roma Street	Spring Hill south	Spring Hill north
Enclosure (70%)	Yes	Yes	Yes	-	-	-	-
Enclosure equipped with fabric filters (99%)	-	-	-	Yes	Yes	-	-
Sealed/ hardstand roads (100%)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hoardings (30%)	-	-	-	-	-	Yes	Yes
Base standard dust controls (eg water spraying, wheel wash-down)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The following limitations should also be considered when interpreting the construction air quality assessment:

- the construction scenario assessed is a snapshot of typical activities that could be expected to occur during maximum (ie worst case) construction worksite activities
- emission factors are generally long-term averages, whereas actual emissions would vary on a short-term time scale
- estimated dust emission rates are based on an assumption that basic dust emission controls are utilised on many of the dust emitting processes. **Section 1.4** identifies mitigation measures to minimise dust nuisance from construction activities.

The estimated TSP and PM_{10} emissions in kg/day for the various construction activities with controls at each construction worksite are provided in **Table 1-14** and **Table 1-15**. The estimated dust emission rates were entered into the dispersion model to predict TSP and PM_{10} concentrations and dust deposition rates. The predicted TSP and PM_{10} concentrations and dust deposition rates were compared with the ambient air quality objectives outlined in the EPP (Air).

Table 1-14 Estimated TSP emissions (kg/ day) from construction worksites with controls applied

	Dutton Park south	Dutton Park north	Woolloongabba	George Street	Roma Street	Spring Hill south	Spring Hill north
Base Case							
Excavators/FEL on spoil[1]	0.05	0.11	3.20	0.003	0.004	-	0.06
Bulldozers on excavated material[1]	4.6	4.6	-	-	-	4.6	-
Wheel generated dust[1]	-	-	-	-	-	-	-
Wind erosion	10.14	9.60	13.92	0.88	1.14	10.37	33.60
Loading trucks[1]	0.56	0.12	0.11	0.004	0.003	0.01	-
Unloading trucks (deliveries)[1]	0.03	-	0.04	0.06	0.06	0.17	-
Rock breakers	4.6	4.6	4.6	0.08	0.15	4.6	-
Piling rigs	4.6	4.6	4.6	0.08	0.15	4.6	-
Total (base case)	**24.58**	**23.13**	**26.47**	**1.19**	**1.51**	**24.35**	**33.66**
Scenario 2							
Drilling[1]	-	-	3.20	3.20	3.20	-	-
Blasting[1]	-	-	3.20	3.20	3.20	-	-
Total (Scenario 2)			**32.87**	**7.59**	**7.91**		

[1] no emissions were modelled where controls of 100% (eg activities under total enclosure and sealed roads) are applied.

Table 1-15 Estimated PM_{10} emissions (kg/ day) from construction worksites

	Dutton Park south	Dutton Park north	Woolloongabba	George Street	Roma Street	Spring Hill south	Spring Hill north
Base Case							
Excavators/FEL on spoil	0.02	0.05	0.06	0.06	0.002	-	0.03
Bulldozers on excavated material	0.94	0.94	-	-	-	0.94	-
Wheel generated dust	-	-	-	-	-	-	-
Wind erosion	5.10	4.84	7.00	0.44	0.57	5.18	16.8
Loading trucks	0.29	0.06	0.05	0.06	0.001	0.01	-
Unloading trucks (deliveries)	0.02	-	0.03	0.002	0.04	0.12	-
Rock breakers	0.94	0.94	0.94	0.02	0.04	0.94	-
Piling rigs	0.94	0.94	0.94	0.02	0.04	0.94	-

	Dutton Park south	Dutton Park north	Woolloongabba	George Street	Roma Street	Spring Hill south	Spring Hill north
Total (base case)	**8.25**	**7.77**	**9.02**	**0.60**	**0.69**	**8.13**	**16.83**
Scenario 2							
Drilling	-	-	1.73	1.73	1.73	-	-
Blasting	-	-	1.64	1.64	1.64	-	-
Total (Scenario 2)			**12.39**	**3.4**	**3.43**		

[1] no emissions were modelled where controls of 100% (eg activities under total enclosure and sealed roads) are applied

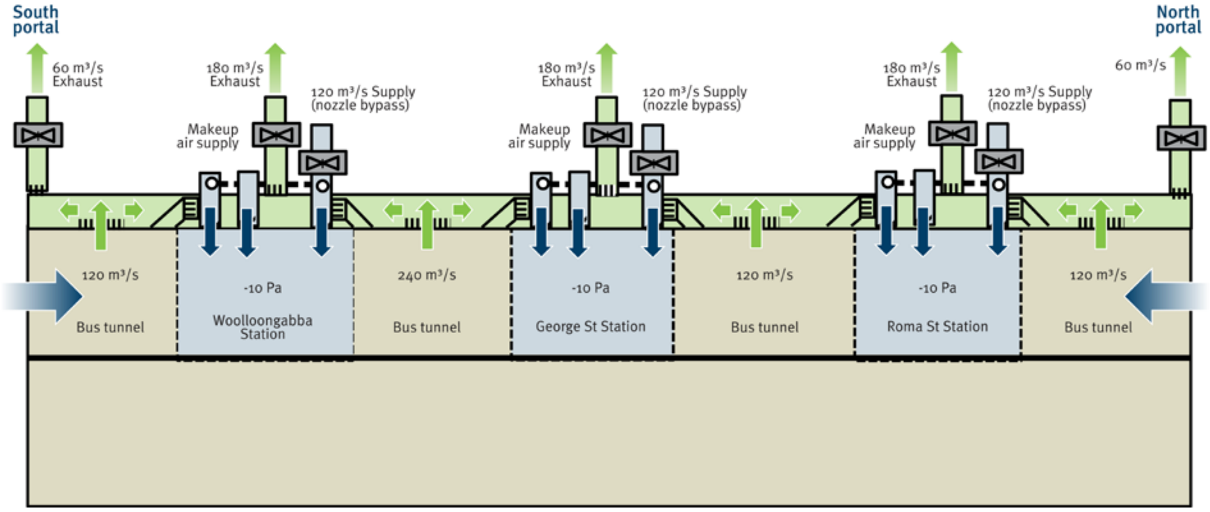
Operation

The ventilation strategy for the Project, shown schematically in **Figure 1-11** is based on extraction of vitiated tunnel air at strategically located dampers, into the roof duct which leads to stacks located at the stations and portals. A commensurate volume of fresh air is supplied through the speed control of supply fans located at each of the stations. Control is based on maintenance of tunnel pressure at -10Pa across the platform screen doors and the requirement for an air inflow velocity of approximately 1m/s at the portals. Negative pressure in the tunnel ensures that exhaust fumes are not drawn into the passenger waiting areas as well as ensuring that a large volume of conditioned station air does not escape into the tunnel when the platform screen doors are opened.

Heat and emission generation are in direct proportion to the vehicle density. Peak tunnel air pollutant levels and air temperatures, at the extraction points, were calculated assuming maximum traffic density in both directions at speeds in the range zero to 70km/h for the maximum extraction rates shown. These extraction rates were determined on the basis of limiting the peak tunnel air temperature rise to 6°C. When ambient air temperatures are low and higher tunnel air temperature rises are acceptable, the extraction rates can be reduced to approximately half the values shown. In this case, air quality criteria associated with vehicle pollutants determine the required extraction rate. For buses, the dominant pollutant is NO_2 whose concentration should not exceed 1ppm.

In the calculations it was assumed that the roof duct flows were balanced so that half the flow at each extraction point was diverted to each of the adjacent stacks and that there was no heat loss from the air in the roof duct. Equal flow split is not essential. In practice the flow split may be varied on the basis on sharing of fan load or the need to appropriately share emissions to atmosphere at each of the stacks.

Figure 1-11 BaT ventilation schematic



The estimations of emissions from the operational phase of the Project are based upon the following assumptions:

- as a conservative estimate, all particles emitted from the ventilation outlets are PM2.5.
- emissions are estimated during peak tunnel air pollutant levels (ie maximum emissions) for comparison with short term average objectives (ie one hour NO2 and 24 hour PM2.5 as outlined in **section 1.1.6**).
- emissions are estimated during normal tunnel air pollutant levels for comparison with annual average objectives (ie annual average NO2 and PM2.5 as outlined in **section 1.1.6**).
- vehicle speeds within the tunnel and entering and exiting the tunnel portals are 60km/h.

Impacts from multiple ventilation outlet height and location scenarios were considered and modelled as part of this air quality assessment. The purpose of modelling these multiple scenarios was to inform the design team of any risks or opportunities associated with the location and height of the ventilation outlets relevant to air quality impacts. In addition, the location and heights of the outlets included considerations of impacts on temperature from the exhaust emissions at the receptors.

The ventilation outlet characteristics provided in **Table 1-16** and shown in **Figure 1-1** to represent the Project's ventilation design scenario as of 21 May 2104. The estimated pollutant emissions data for the five ventilation outlets during forecasted peak operation of the Project is outlined in **Table 1-17**. Emissions during the forecasted peak operation are considered to those likely to generate maximum impacts and assessment. The estimated pollutant emissions data for the five ventilation outlets during forecasted normal operation of the Project are outlined in **Table 1-18**.

Table 1-16 Ventilation outlet characteristics

Site	Height (m)	Diameter (m)	Temp (K)	Flowrate (m^3/s)
Southern Connection	8	4.4	298	60
Woolloongabba	15	5.6	298	340
George Street	25	5.6	298	340
Roma Street	5	5.6	298	340
Northern Connection	10	4.4	298	60

Source: Stacey Agnew

Table 1-17 Ventilation outlet emissions data for peak operation

Site	Emission rate (g/s)		
	NO_x	CO	$PM_{2.5}$
Southern Connection	0.038	0.150	0.015
Woolloongabba	0.090	0.375	0.036
George Street	0.093	0.425	0.040
Roma Street	0.065	0.313	0.030
North Connection	0.025	0.113	0.011

Source: Stacey Agnew

Table 1-18 Ventilation outlet emissions data for normal operation

Site	Emission rate (g/s)		
	NO_x	CO	$PM_{2.5}$
Southern Connection	0.0098	0.039	0.0039
Woolloongabba	0.023	0.10	0.0094
George Street	0.024	0.11	0.011
Roma Street	0.017	0.081	0.079
Northern Connection	0.0065	0.029	0.0029

Source: Stacey Agnew

1.3.3 Meteorological modelling

Meteorology varies across the study corridor, particularly wind patterns due to local terrain. The meteorology has been incorporated into the assessment by considering data from relevant BoM automatic weather stations (AWS) and extrapolating this data to other areas using a prognostic wind-field model. The result is a three-dimensional, time-varying wind-field.

On a relatively small scale, local winds are affected by the topography. At larger scales, winds are affected by synoptic scale winds, which are modified by convective processes in the daytime and also by a complex pattern of regional drainage flows, which is governed by sloping terrain.

This air quality assessment has made use of the CALPUFF dispersion model. The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model.

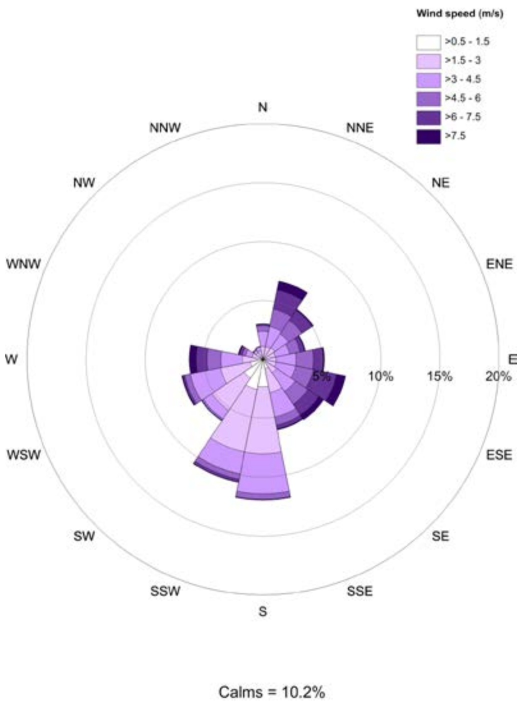
Surface meteorological data, including 10 minute records of wind speed, wind direction, relative humidity and temperature, were sourced from the BoM automatic weather stations at Brisbane Airport and Archerfield Airport. These sites provide coverage of the north-eastern and south-western regions of the study corridor and are not adversely affected by complex local terrain or building environments.

Wind patterns for the Brisbane Airport and Archerfield Airport sites were reviewed by preparing wind-roses shown in **Figure 1-12**. The plot shows the frequency (length of petals) of winds from a particular direction and the strength (colour of petals) of these winds.

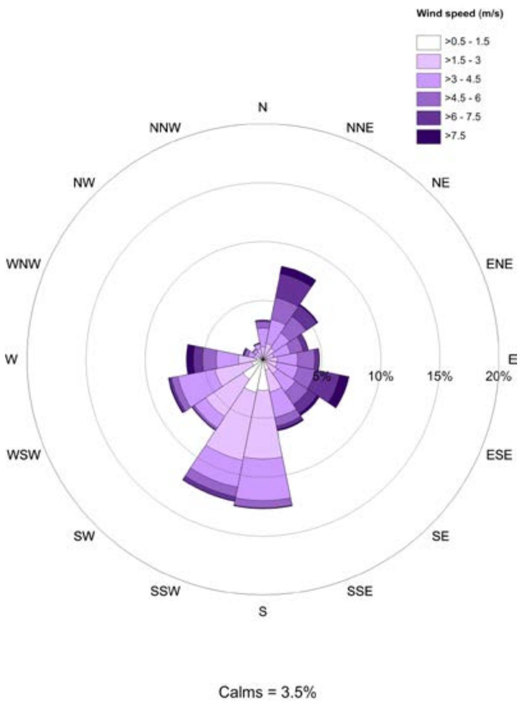
The wind roses show that at Archerfield Airport, the most common winds are from the south. A slightly different pattern of winds is observed at Brisbane Airport where the most common winds are from the south-west. It was found that 2012 was the year with the most complete meteorological records (for both sites) and wind roses for 2012 have also been included in **Figure 1-12**. The wind patterns for 2012 show consistency with the longer term (2009-2013) patterns and it was therefore concluded that 2102 is a representative meteorological year. Data for 2012 have been the focus of the meteorological modelling.

Figure 1-12 Wind roses for Archerfield and Brisbane Airport

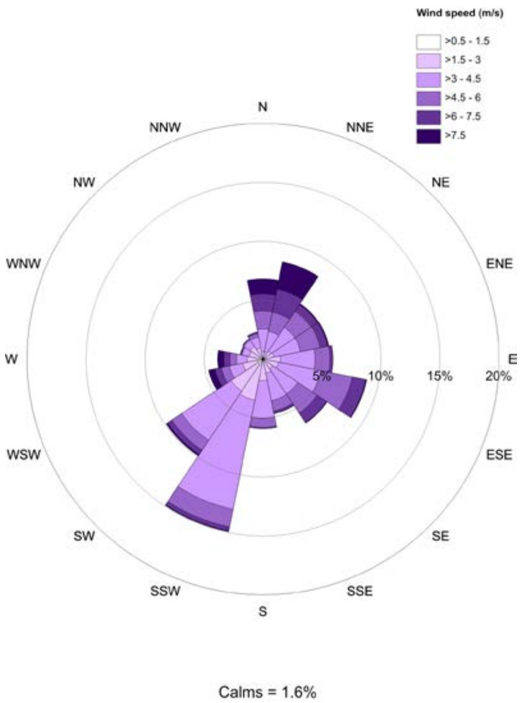
Archerfield Airport (2009-2013)



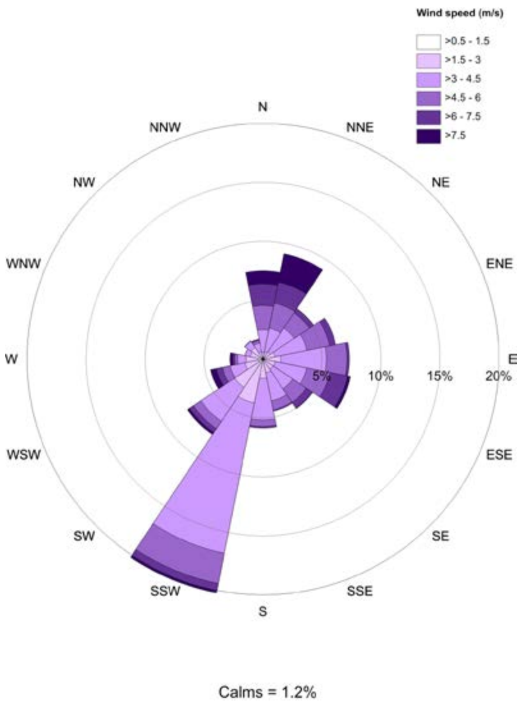
Archerfield Airport (2012)



Brisbane Airport (2009-2013)



Brisbane Airport (2012)



Upper-air temperature, wind speed, wind direction, pressure and height data are also required by the CALMET model. In this instance, upper air data from the BoM Brisbane Airport site were obtained and processed into a form suitable for CALMET. In addition, the CSIRO's prognostic model known as TAPM (The Air Pollution Model) was used to generate the necessary three-dimensional meteorological information that was used as CALMET's initial guess wind-field.

A summary of the data and parameters used as part of the meteorological component of the air quality assessment is shown in **Table 1-19**.

Table 1-19 Summary of meteorological parameters

TAPM (v4.0.5)	
Number of grids (spacing)	4 (30km, 10km, 3km, 1km)
Number of grids point	41 (north-south) x 41 (east-west) x 25 (vertical)
Year of analysis	1 January 2012 to 31 December 2012, with two "spin-up" days. The spin-up days allows the meteorological variables to adjust to the model terrain and land use.
Centre of analysis	Brisbane (27°28' S, 153°1' E)
Meteorological data assimilation	None
CALMET (v.6.334)	
Meteorological grid domain (outer)	30km x 30km x 0.5km grid resolution (60 x 60 x 11 grid dimensions)
Meteorological grid domain (inner)	8km x 12km x 0.1km grid resolution (80 x 120 x 11 grid dimensions)
Meteorological stations	Two stations: Archerfield Airport, using hourly records of temperature, wind speed, wind direction and relative humidity. Brisbane Airport, using hourly records of temperature, wind speed, wind direction and relative humidity. Barometric pressure, cloud cover and ceiling height data generated for Archerfield Airport and Brisbane Airport by the TAPM simulation.
Upper air meteorological station	3D windfields from TAPM input as an initial guess to CALMET
Simulation length	8,784 hours (1 January 2012 to 31 December 2012)

The two BoM meteorological monitoring stations were selected because:

- both had Automatic Weather Stations installed which record meteorological data every minute
- the locations covered the extents of the modelling domain
- they are sited in accordance with AS 3580.14-2011: Meteorological monitoring for ambient air quality monitoring applications.

Terrain information was extracted from the NASA Shuttle Research Topography Mission (SRTM) database, which has global coverage at approximately 90m resolution. Land use data were extracted from aerial imagery.

The impact of building wake effects on plume dispersion has also been included in the modelling for buildings and structures located around the construction worksites in the vicinity of the ventilation outlets. The heights and locations of these structures were entered into the Building Profile Input Program (BPIP) utility. The wind direction-specific building widths and heights calculated by BPIP for each stack were then entered into the CALPUFF model.

1.3.4 Air dispersion modelling

Concentrations and deposition levels for the primary pollutants associated with the construction and operation of the Project were predicted using the CALPUFF (Version 6.42) air dispersion model. CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere.

The CALPUFF model differs from traditional Gaussian plume models (such as AUSPLUME) in that it can model spatially varying wind and turbulence fields that are important in complex terrain, long-range transport and near calm conditions. It is the preferred model of the United States Environmental Protection Agency for the long-range transport of pollutants and for complex terrain (TRC 2007).

The modelling was performed using the meteorological information provided by the CALMET model and the estimated emissions from **section 1.3.2**. The model was used in this study to predict the particle and gaseous concentrations and dust deposition levels in the vicinity of the five construction worksites. Dispersion coefficients used turbulence computed from micrometeorology and partial plume path was used for terrain adjustment. The main data and parameters for the CALPUFF modelling is summarised in **Table 1-20**.

Table 1-20 : Model settings for CALPUFF

Parameter	Value
Model version	6.42
Computational grid domain	60 x 60
Nesting factor	10
Chemical transformation	None
Dry deposition	Construction: yes. Operation: no
Wind speed profile	ISC Urban
Puff element	Puff
Dispersion option	Turbulence from micrometeorology
Time step	3600 seconds
Terrain adjustment	Partial plume path
Number of discrete receptors	1,304

The dispersion modelling options assumed that:

- emissions were volume and area sources across each of the Project construction worksites
- ventilation outlet emissions were point sources across the operation of the Project
- emissions were emitted every hour of every day between 4.00am and 8.00pm, apart from blasting emissions which occurred for two hours (at 10.00am and 2.00pm) each day
- dust deposition rates were determined from the highest monthly average
- geometric mean diameter for total suspended particulates (TSP), coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) 17µm, 7µm and 2µm respectively
- geometric standard deviation for TSP, PM_{10} and $PM_{2.5}$ is 2µm and 1µm respectively.

1.3.5 Local area impacts

The following section summarises the model predictions at the most affected sensitive receptors from construction and operational emissions associated with the Project (in isolation and inclusive of background or cumulative impacts). The predictions are separated for the five construction worksites and ventilation outlet local areas. As discussed in **section 1.2.1**, approximately 1,300 sensitive receptors were modelled in the assessment. In addition, where relevant, a selection of sensitive receptors closest to the ventilation outlets at George Street and Roma Street were modelled at different heights above ground (eg 10m, 20m, 30m, 40m and 50m) representing apartments or workplaces within tall buildings. For presentation purposes, the closest sensitive receptors in each direction to each construction worksite/ventilation outlet are categorised and the results of the modelling are provided for the worst affected (or greatest predictions) of these sensitive receptors. In addition, particularly sensitive receptors such as hospitals and schools are also included.

Contour plots showing the spatial distribution of the model predictions of impacts from the construction emissions are displayed in **Figure 1-13** to **Figure 1-27**. Contour plots are not provided for the operational impacts because these are very low compared with background.

Results are discussed and compared with air quality objectives in **section 1.1.6**. The air quality assessment objectives relate to the total concentration of air pollutants in the air (ie cumulative) and not just the contribution from the project-specific sources. Cumulative impacts are assessed by comparison of the model predictions for the construction and operation phases of the Project with the air quality objectives.

Southern connection

Construction

The model predictions for the construction scenario at the sensitive receptors in the vicinity of the southern connection construction worksite are presented in **Table 1-21**.

As shown in **Figure 1-14** and **Table 1-21**, model predictions of cumulative air quality impacts from the southern connection construction worksite (including background) are predicted to be below air quality objectives for all airborne particulate pollutants at all sensitive receptors modelled. Greatest impacts to the north of the construction worksites were predicted to occur at the Rawnsley Street residential area (approximately 80m from each of the construction worksites). These impacts were predicted to be below air quality objectives for all modelled pollutants.

During construction the loading out of spoil to trucks from the TBM operation is approximately 40m from the metropolitan linen services, general energy services and general support services buildings within the PA Hospital campus. For this activity, spoil will be transported via conveyors and will be unloaded within an acoustic enclosure, which also provides for significant dust control. With the proposed controls, levels are predicted to be close to but below the dust deposition air quality objectives at the general support services building. Given the proximity to this receptor and the sensitive of the broader PA Hospital campus, proposed management measures include real-time dust monitoring. This allows adaptive management strategies to be implemented where meteorological monitoring suggests adverse wind conditions or dust monitoring indicates levels at or near to exceeding air quality objectives. Additional management strategies may include additional watering regime on roads, stockpiles and haul truck load out areas.

Table 1-21 Predicted particle concentrations and dust deposition at the closest sensitive receptors to Southern connection construction worksite – construction scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)	
ID	Description	Ann	Max	5th	Max	Ave	Ann	Max	5th	Max	Ave
SC1	Ecosciences building – commercial	0.6	3.7	1.8	11	7	36.6	23.7	21.8	71	67
SC2	PA Hospital	2.9	14.7	10.9	68	23	38.9	34.7	30.9	128	83
SC3	Rawnsley Street – residential	3.4	10.8	6.2	30	17	39.4	30.8	26.2	90	77
SC4	Annerley Road – residential	0.6	4	1.7	4	2	36.6	24.0	21.7	64	62
SC5	Dutton Park Primary School	0.4	2.1	1.2	5	3	36.4	22.1	21.2	65	63
SC6	Leukaemia Foundation ESA Village	0.6	4.2	1.8	21	16	36.6	24.2	21.8	81	76
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Operation

The model predictions for the operational stage of the Project at the sensitive receptors in the vicinity of the proposed Dutton Park ventilation outlet for the 8m outlet height scenario presented in **Table 1-22**.

Model predictions of cumulative air quality impacts from the ventilation outlet at a height of 8m (including background) are predicted to be below air quality objectives for all pollutants modelled. The contribution to air quality levels from the operation of the Project is predicted to be much lower than the conservative regional background levels adopted for the modelling.

Table 1-22 Predicted particle and gas concentrations at the closest sensitive receptors to Dutton Park – operational scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
SC1	Ecosciences building – commercial	0.60	0.01	4.2	0.03	10.1	9.6	7.81	23.2	15.0 3	270
SC2	PA Hospital	0.095	0.00	1.615	0.00	1.965	9.1	7.80	20.6	15.0 0	262.0

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
SC3	Rawnsley Street – residential	0.57	0.02	3.14	0.04	7.83	9.6	7.82	22.1	15.04	267.8
SC4	Annerley Road – residential	0.36	0.01	2.25	0.02	6.11	9.4	7.81	21.3	15.02	266.1
SC5	Dutton Park Primary School	0.41	0.01	2.65	0.03	5.31	9.4	7.81	21.7	15.03	265.3
SC6	Leukaemia Foundation ESA Village	0.57	0.02	3.77	0.04	11.34	9.6	7.82	22.8	15.04	271.3
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**25**	**8**	**250**	**62**	**11,000**

Woolloongabba Station

Construction

The model predictions for the construction scenario at the sensitive receptors in the vicinity of the Woolloongabba Station construction worksite for the Project's construction scenarios without and with blasting are presented in **Table 1-23** and **Table 1-24**.

No exceedances of air quality objectives are predicted by the modelling at any of the sensitive receptors modelled from emissions associated with the two construction scenarios (without and with blasting) at the Woolloongabba site (refer to **Table 1-23** and **Table 1-24**). The contribution of the construction emissions to the model predictions are low representing approximately an order of magnitude lower than the background levels. Impacts from the construction scenario with application of blasting for excavation of rock are predicted to be slightly higher for all pollutants modelled.

Table 1-23 Predicted particle concentrations and dust deposition at the closest sensitive receptors to Woolloongabba – construction scenario 1 (no blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m^3)	24 hour PM_{10} (µg/m^3)		Monthly dust (mg/m^2/day)		TSP (µg/m^3)	24 hour PM_{10} (µg/m^3)		Monthly dust (mg/m^2/day)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
W1	Vulture Street – residential	1.5	5.8	3.9	14	8	37.5	25.8	23.9	74	68
W2	Vulture Street – commercial	1.8	7.4	5	18	11	37.8	27.4	25.0	78	71
W3	Main Street – residential	0.9	5.5	2.5	8	4	36.9	25.5	22.5	68	64

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)	
ID	Description	Annual	Max	5^{th}	Max	Ave	Annual	Max	5^{th}	Max	Ave
W4	St Nicholas Cathedral	1.6	5.9	4.3	15	8	37.6	25.9	24.3	75	68
W5	Main Street – commercial	2.1	7.2	6.7	35	12	38.1	27.2	26.7	95	72
W6	Stanley Street – commercial	1.4	8.3	5.7	18	8	37.4	28.3	25.7	78	68
W7	St Joseph's Primary School	0.7	3.7	2.5	7	4	36.7	23.7	22.5	67	64
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Table 1-24 Predicted particle concentrations and dust deposition at the closest sensitive receptors to Woolloongabba – construction scenario 2 (with blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly Dust ($mg/m^2/day$)		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly Dust ($mg/m^2/day$)	
ID	Description	Annual	Max	5^{th}	Max	Ave	Annual	Max	5^{th}	Max	Ave
W1	Vulture Street – residential	1.7	6.7	4.8	16	9	37.7	26.7	24.8	76	69
W2	Vulture Street – commercial	2	8.7	5.6	20	12	38.0	28.7	25.6	80	72
W3	Main Street – residential	1	6.3	2.9	9	5	37.0	26.3	22.9	69	65
W4	St Nicholas Cathedral	0.8	4.4	2.9	18	10	36.8	24.4	22.9	78	70
W5	Main Street – commercial	2.7	9.2	9.0	45	15	38.7	29.2	29.0	105	75
W6	Stanley Street – commercial	2.2	9.2	6.5	34	14	38.2	29.2	26.5	94	74
W7	St Joseph's Primary School	0.8	4.4	2.9	8	5	36.8	24.4	22.9	68	65
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Operation

The model predictions for the operational stage of the Project at the sensitive receptors in the vicinity of the proposed Woolloongabba Station ventilation outlet is presented in **Table 1-25**. Model predictions of cumulative air quality impacts from the operational emissions from the ventilation outlet (including background) at Woolloongabba Station are predicted to be below air quality objectives for 24 hour and annual average $PM_{2.5}$ and CO and NO_2.

Table 1-25 Predicted particle and gas concentrations at the closest sensitive receptors to Woolloongabba – operational scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
W1	Vulture Street – residential	0.46	0.02	8.29	0.06	6.92	9.5	7.82	27.3	15.06	266.9
W2	Vulture Street – commercial	0.69	0.03	8.58	0.07	8.38	9.7	7.83	27.6	15.07	268.4
W3	Main Street – residential	0.69	0.03	7.18	0.08	9.28	9.7	7.83	26.2	15.08	269.3
W4	St Nicholas Cathedral	0.33	0.02	6.43	0.05	7.44	9.3	7.82	25.4	15.05	267.4
W5	Main Street – commercial	0.90	0.02	3.78	0.06	10.45	9.9	7.82	22.8	15.06	270.4
W6	Stanley Street – commercial	1.01	0.03	10.04	0.07	14.18	10.0	7.83	29.0	15.07	274.2
W7	St Joseph's Primary School	0.34	0.02	2.59	0.04	5.49	9.3	7.82	21.6	15.04	265.5
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**25**	**8**	**250**	**62**	**11,000**

George Street Station

Construction

The model predictions for the construction scenario at the sensitive receptors in the vicinity of the George Street station for the Project's construction scenarios without and with blasting are presented in **Table 1-26** and **Table 1-27**.

As noted in **section 1.1.6**, air quality objectives for the modelling assessment were adopted primarily from the EPP (Air). The purpose of the EPP (Air) is to protect the air quality environment for human health and wellbeing, the health and biodiversity of ecosystems, the aesthetics of the environment and for agricultural use. There are no exceedances of the TSP and PM_{10} air quality objectives predicted by the modelling at the sensitive receptors.

Coarse particulates (>10µm) have the greater potential to generate potential nuisance primarily as deposited dust and are not considered a health issue. The EPP (Air) does not provide specific objectives for nuisance impacts of particulates. A dust deposition objective of 130mg/m^2/day as a maximum monthly average has been adopted here for the management of potential nuisance impacts for the Project. No exceedances of the dust deposition objective are predicted either modelling scenario at the modelled sensitive receptors.

The modelling has incorporated various dust mitigation measures (discussed in **section 1.4**) including the installation of an acoustics shed or enclosure equipped with a fabric filter for the removal of airborne particulate matter and dust at the George Street construction worksite. Further measures proposed for the control and management of the dust emissions at the George Street construction worksite are discussed in **section 1.4**. Given the proximity of the construction worksite to the sensitive receptors, these measures include real-time dust monitoring at the worst-affected sensitive receptors which allows adaptive management strategies to be implemented when meteorological monitoring suggests adverse wind conditions or dust monitoring indicates levels at or near to exceeding air quality objectives. Additional management strategies may include additional watering regime on roads, stockpiles and haul truck load out areas.

Table 1-26 Predicted particle concentrations and dust deposition at the closest sensitive receptors to George Street – construction scenario 1 (no blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m^3)	PM_{10} (µg/m^3)		Dust (mg/m^2/day)		TSP (µg/m^3)	PM_{10} (µg/m^3)		Dust (mg/m^2/day)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
GS1	Mary Street – residential	2.0	6.1	4.5	39	14	38.0	26.1	24.5	99	74
GS2	Mary Street – commercial	0.9	2.1	1.9	15	6	36.9	22.1	21.9	75	66
GS3	Mary Street – commercial	0.8	1.5	1.3	9	5	36.8	21.5	21.3	69	65
GS4	George Street – commercial	2.5	6.6	3.9	34	17	38.5	26.6	23.9	94	77
GS5	George Street – commercial	1.5	2.8	2.0	21	11	37.5	22.8	22.0	81	71
GS6	George Street – residential	0.4	1.2	0.7	6	3	36.4	21.2	20.7	66	63
GS7	George Street – commercial	1.2	3.4	1.9	14	8	37.2	23.4	21.9	74	68
GS8	Synagogue	0.5	1.8	1.5	11	3	36.5	21.8	21.5	71	63
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Table 1-27 Predicted particle concentrations and dust deposition at the closest sensitive receptors to George Street – construction scenario 2 (with blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)		TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
GS1	Mary Street – residential	2.4	8.0	5.6	49	17	38.4	28.0	25.6	109	77
GS2	Mary Street – commercial	1.0	2.7	2.4	20	7	37.0	22.7	22.4	80	67
GS3	Mary Street – commercial	0.9	2.0	1.6	12	6	36.9	22.0	21.6	72	66
GS4	George Street – commercial	3.1	9.6	5.6	45	21	39.1	29.6	25.6	105	81
GS5	George Street – commercial	1.9	3.7	2.9	27	14	37.9	23.7	22.9	87	74
GS6	George Street – residential	0.5	1.4	0.9	7	4	36.5	21.4	20.9	67	64
GS7	George Street – commercial	0.9	2.0	1.6	12	6	36.9	22.0	21.6	72	66
GS8	Synagogue	0.6	2.3	1.9	14	4	26.6	22.3	21.9	74	64
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Operation

The model predictions for the operational stage of the Project at the sensitive receptors in the vicinity of the proposed George Street ventilation outlet are presented in **Table 1-28**.

Model predictions of cumulative air quality impacts from the operational emissions from the ventilation outlet (including background) at George Street are predicted to be below air quality objectives for 24 hour average $PM_{2.5}$ and CO and NO_2. Annual average $PM_{2.5}$ are predicted to be just below the objective for annual average $PM_{2.5}$ of 8µg/m^3 at the sensitive receptors. These predictions are modelled including a conservative background of 7.8µg/m^3. The contribution to air quality levels from the operation of the Project is predicted to be much lower (approximately 0.13µg/m^3) than the regional background levels adopted for the modelling.

Table 1-28 Predicted particle and gas concentrations at the closest sensitive receptors to George Street – operational scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
GS1	Mary Street – residential	0.99	0.07	14.95	0.16	18.69	10.0	7.87	33.9	15.16	278.7

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
	at 0m										
GS1	Mary Street – residential at 25m	0.99	0.07	15.43	0.16	18.69	10.0	7.87	34.4	15.16	278.7
GS1	Mary Street – residential at 50m	2.32	0.12	35.36	0.29	55.64	11.3	7.92	54.4	15.29	315.6
GS2	Mary Street – commercial at 0m	1.39	0.13	53.90	0.31	38.51	10.4	7.93	72.9	15.31	298.5
GS2	Mary Street – commercial at 25m	1.40	0.13	54.43	0.31	38.82	10.4	7.93	73.4	15.31	298.8
GS2	Mary Street – commercial at 50m	1.41	0.13	54.94	0.31	39.11	10.4	7.93	73.9	15.31	299.1
GS3	Mary Street – commercial at 0m	0.84	0.03	20.49	0.07	14.13	9.8	7.83	39.5	15.07	274.1
GS3	Mary Street – commercial at 25m	0.84	0.03	21.20	0.07	14.17	9.8	7.83	40.2	15.07	274.2
GS3	Mary Street – commercial at 50m	0.84	0.03	21.93	0.07	14.58	9.8	7.83	40.9	15.07	274.6
GS4	George Street – commercial at 0m	0.9	0.05	7.5	0.10	14.5	9.9	7.85	26.5	15.10	274.5
GS4	George Street – commercial at 25m	0.9	0.05	7.5	0.10	14.5	9.9	7.85	26.5	15.10	274.5
GS4	George Street – commercial at 50m	2.1	0.05	33.0	0.13	46.0	11.1	7.85	52.0	15.13	306.0

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)
ID	**Description**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**
GS5	George Street – commercial at 0m	1.30	0.07	6.48	0.16	19.03	10.3	7.87	25.5	15.16	279.0
GS5	George Street – commercial at 25m	1.30	0.07	6.48	0.16	19.03	10.3	7.87	25.5	15.16	279.0
GS5	George Street – commercial at 50m	1.30	0.07	6.48	0.16	19.03	10.3	7.87	25.5	15.16	279.0
GS6	George Street – commercial at 0m	1.30	0.09	6.69	0.21	19.80	10.30	7.89	25.7	15.21	279.8
GS6	George Street – commercial at 25m	1.30	0.09	6.69	0.21	19.80	10.30	7.89	25.7	15.21	279.8
GS6	George Street – commercial at 50m	1.30	0.10	6.69	0.23	19.80	10.30	7.90	25.7	15.23	279.8
GS7	Synagogue at 0m	0.86	0.05	19.07	0.11	18.02	9.9	7.85	38.1	15.11	278.0
GS7	Synagogue at 25m	0.86	0.05	19.63	0.11	18.02	9.9	7.85	38.6	15.11	278.0
GS7	Synagogue at 50m	0.86	0.05	20.19	0.12	18.02	9.9	7.85	39.2	15.12	278.0
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**25**	**8**	**250**	**62**	**11,000**

Roma Street Station

Construction

The model predictions for the construction scenario at the sensitive receptors in the vicinity of the Roma Street construction worksite for the Project's construction scenarios without and with blasting are presented in **Table 1-29** and **Table 1-30**. There are no exceedances of the TSP and PM_{10} or dust deposition objectives predicted by the modelling at the sensitive receptors. Similar to George Street Station, the modelling has incorporated various dust mitigation measures (discussed in **section 1.4**) including the installation of an acoustics shed or enclosure equipped with a fabric filter for the removal of airborne particulate matter and dust.

Further measures proposed for the control and management of the dust emissions at the Roma Street Station construction worksite are discussed in **section 1.4**. Given the proximity of the construction worksite to the sensitive receptors, these measures include real-time dust monitoring at the worst-affected sensitive receptor (the Parkland Crescent residential building) which allows adaptive management strategies to be implemented when meteorological monitoring suggests adverse wind conditions or dust monitoring indicates levels at or near to exceeding air quality objectives. Additional management strategies may include additional watering regime on roads, stockpiles and haul truck load out areas.

Table 1-29 Predicted particle concentrations and dust deposition at the closest sensitive receptors to Roma Street – construction scenario 1 (without blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m3)	24 hour PM10 (µg/m3)		Dust (mg/m2/day)		TSP (µg/m3)	24 hour PM10 (µg/m3)		Dust (mg/m2/day)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
RS1	Wickham Terrace – residential	0.1	0.3	0.2	1	0.3	36.1	20.3	20.2	61	60.3
RS2	Brisbane Private Hospital	0	0.1	0.1	0.2	0.1	36.0	20.1	20.1	60.2	60.1
RS3	Brisbane Dental Hospital	0	0.1	0.1	0.1	0	36.0	20.1	20.1	60.1	60
RS4	Roma Street station – commercial	0.1	0.6	0.4	0.9	0.5	36.1	20.6	20.4	60.9	60.5
RS5	Holiday Inn – residential	0	0.2	0.1	0.2	0.1	36.0	20.2	20.1	60.2	60.1
RS6	Parkland Crescent – residential facing east	1.9	3.6	2.5	13	15	37.9	23.6	22.5	85	73
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Table 1-30 Predicted particle concentrations and dust deposition at the closest sensitive receptors to Roma Street – construction scenario 2 (with blasting)

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m3)	24 hour PM10 (µg/m3)		Monthly dust (mg/m2/day)		TSP (µg/m3)	24 hour PM10 (µg/m3)		Monthly dust (mg/m2/day)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
RS1	Wickham Terrace – residential	0.1	0.3	0.3	1	0.4	36.1	20.3	20.3	61	60.4
RS2	Brisbane Private	0	0.2	0.1	0.3	0.1	36.0	20.2	20.1	60.3	60.1

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m3)	24 hour PM10 (µg/m3)		Monthly dust (mg/m2/day)		TSP (µg/m3)	24 hour PM10 (µg/m3)		Monthly dust (mg/m2/day)	
ID	Description	Annual	Max	5th	Max	Ave	Annual	Max	5th	Max	Ave
	Hospital										
RS3	Brisbane Dental Hospital	0	0.1	0.1	0.1	0	36.0	20.1	20.1	60.1	60
RS4	Roma Street station – commercial	0.1	0.8	0.5	1.2	0.6	36.1	20.8	20.5	61.2	60.6
RS5	Holiday Inn – residential	0	0.2	0.1	0.2	0.1	36.0	20.2	20.1	60.2	60.1
RS6	Parkland Crescent – residential	2.3	4.4	3.3	31	16	38.3	24.4	23.3	91	76
	Objectives	n/a	n/a	n/a	n/a	n/a	90	n/a	50	130	n/a

Operation

The model predictions for the operational stage of the Project at the sensitive receptors in the vicinity of the proposed Roma Street ventilation outlet are presented in **Table 1-31**. Model predictions of cumulative air quality impacts from the operational emissions from the ventilation outlet (including background) at Roma Street are predicted to be well below air quality objectives at the sensitive receptors for all pollutants modelled with the exception of annual average $PM_{2.5.}$ Concentrations of these particles are predicted to be just below the objectives of 8µg/m^3 at the Parkland Crescent residential receptor (7.85 µg/m^3).

These predictions are modelled including a conservative background of 7.8µg/m^3. The contribution to air quality levels from the operation of the Project is predicted to be much lower (approximately 0.0.05µg/m^3) than the regional background levels (7.8µg/m^3) adopted for the modelling.

Table 1-31 Predicted particle and gas concentrations at the closest sensitive receptors to Roma Street – operational scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
RS1	Wickham Terrace – residential	0.29	0.01	2.14	0.02	7.39	9.3	7.81	21.1	15.02	267.4
RS2	Brisbane Private Hospital	0.15	0.00	1.22	0.01	2.56	9.1	7.80	20.2	15.01	262.6

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m³)		NO_2 (µg/m³)		CO (µg/m³)	$PM_{2.5}$ (µg/m³)		NO_2 (µg/m³)		CO (µg/m³)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
RS3	Brisbane Dental Hospital	0.09	0.00	1.40	0.00	2.78	9.1	7.80	20.4	15.00	262.8
RS4	Roma Street station – commercial	0.33	0.01	4.50	0.02	6.64	9.3	7.81	23.5	15.02	266.6
RS5	Holiday Inn – residential	0.46	0.01	5.59	0.01	10.38	9.5	7.81	24.6	15.01	270.4
RS6	Parkland Crescent – residential east at 0m	0.99	0.05	6.07	0.12	17.51	10.0	7.85	25.1	15.12	277.5
RS6	Parkland Crescent – residential east at 10m	1.01	0.05	6.13	0.12	17.77	10.0	7.85	25.1	15.12	277.8
RS6	Parkland Crescent – residential east at 20m	1.01	0.05	6.13	0.12	17.77	10.0	7.85	25.1	15.12	277.8
RS6	Parkland Crescent – residential east at 30m	1.01	0.05	6.13	0.12	17.77	10.0	7.85	25.1	15.12	277.8
RS6	Parkland Crescent – residential east at 40m	1.01	0.05	6.13	0.12	17.77	10.0	7.85	25.1	15.12	277.8
RS7	Parkland Crescent – residential south at 0m	0.52	0.03	2.51	0.07	8.52	9.5	7.83	21.5	15.07	268.5
RS7	Parkland Crescent – residential south at 10m	0.52	0.03	2.51	0.07	8.52	9.5	7.83	21.5	15.07	268.5
RS7	Parkland Crescent – residential south at 20m	0.52	0.03	2.51	0.07	8.52	9.5	7.83	21.5	15.07	268.5
RS7	Parkland Crescent –	0.52	0.03	2.51	0.07	8.52	9.5	7.83	21.5	15.07	268.5

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m³)		NO_2 (µg/m³)		CO (µg/m³)	$PM_{2.5}$ (µg/m³)		NO_2 (µg/m³)		CO (µg/m³)
ID	Description	24 hr	Ann	1 hr	Ann	8 hr	24 hr	Ann	1 hr	Ann	8 hr
	residential south at 30m										
RS7	Parkland Crescent – residential south at 40m	0.53	0.03	3.97	0.07	8.55	9.5	7.83	23.0	15.07	268.5
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**25**	**8**	**250**	**62**	**11,000**

Northern Connection

Construction

The model predictions for the construction scenario at the sensitive receptors in the vicinity of the Northern Connection construction worksite for the Project's construction scenario are presented in **Table 1-32**.

The model predictions of cumulative impacts on air quality from the construction activities at the sensitive receptors are below air quality objectives for all of the pollutants modelled at the Northern connection site. As shown in **Figure 1-26**, impacts predicted to exceed the objectives for 24 hour average PM_{10} are within the boundary of the proposed construction worksite (the TBM retrieval site).

Table 1-32 Predicted particle concentrations and dust deposition at the closest sensitive receptors to the Northern connection – construction scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP (µg/m³)	24 hour PM_{10} (µg/m³)		Monthly dust (mg/m²/day)		TSP (µg/m³)	24 hour PM_{10} (µg/m³)		Monthly dust (mg/m²/day)	
ID	Description	Ann	Max	5th	Max	Ave	Ann	Max	5th	Max	Ave
NC1	Gregory Terrace – residential	1.2	13.4	9.3	19	6	37.2	33.4	29.3	79	66
NC2	St Joseph's College	1.5	14.9	10.3	25	8	37.5	34.9	30.3	85	68
NC3	Centenary Aquatic Centre	0.7	4.8	3.4	8	4	36.7	24.8	23.4	68	64
NC4	Gregory Terrace – residential	1	10.7	6.8	13	5	37.0	30.7	26.8	73	65
NC5	Gregory Terrace – commercial	1.7	10	5.9	21	9	37.7	30.0	25.9	81	69

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)		TSP ($\mu g/m^3$)	24 hour PM_{10} ($\mu g/m^3$)		Monthly dust ($mg/m^2/day$)	
ID	**Description**	**Ann**	**Max**	**5th**	**Max**	**Ave**	**Ann**	**Max**	**5th**	**Max**	**Ave**
NC6	Bowen Bridge Road – commercial	0.6	5.6	4.1	9	3	36.6	25.6	24.1	69	63
NC7	Brisbane Girls Grammar	0.3	4.8	2.1	4	2	36.3	24.8	22.1	64	62
NC8	RBWH	1.2	8.0	4.3	17	6	37.2	28.0	24.3	77	66
NC9	Mental Illness Fellowship	2.0	10.4	5.8	25	11	38.0	30.4	25.8	85	71
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**90**	**n/a**	**50**	**130**	**n/a**

Operation

The model predictions for the operational stage of the Project at the sensitive receptors in the vicinity of the proposed northern ventilation outlet are presented in **Table 1-33**.

Model predictions of cumulative air quality impacts from the operational emissions from the ventilation outlet (including background) are well below air quality objectives at the sensitive receptors for all pollutants modelled.

Table 1-33 Predicted particle and gas concentrations at the closest sensitive receptors to the Northern connection – operational scenario

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		CO ($\mu g/m^3$)
ID	**Description**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**
NC1	Gregory Terrace – residential	0.31	0.02	1.48	0.04	4.51	9.31	7.82	20.5	15.04	264.9
NC2	St Joseph's College	0.26	0.01	1.74	0.02	3.50	9.26	7.81	20.7	15.02	263.5
NC3	Centenary Aquatic Centre	0.11	0.01	1.32	0.02	1.86	9.11	7.81	20.3	15.02	261.9
NC4	Gregory Terrace – residential	0.11	0.01	1.22	0.02	2.83	9.11	7.81	20.2	15.02	262.8
NC5	Gregory Terrace –	0.24	0.02	1.65	0.05	5.35	9.24	7.82	20.7	15.05	265.3

Sensitive receptors		Model predictions for the Project in isolation					Cumulative model predictions				
		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)	$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)		CO (µg/m^3)
ID	**Description**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**	**24 hr**	**Ann**	**1 hr**	**Ann**	**8 hr**
	commercial										
NC6	Bowen Bridge Road – commercial	0.05	0.004	0.52	0.01	1.40	9.05	7.80	19.5	15.01	261.4
NC7	Brisbane Girls Grammar	0.25	0.02	1.57	0.05	4.90	9.25	7.82	20.6	15.05	264.9
NC8	RBWH	0.03	0.003	0.30	0.01	0.81	9.03	7.80	19.3	15.01	260.8
NC9	Mental Illness Fellowship	0.04	0.03	0.33	0.01	0.70	9.03	7.80	19.3	15.01	260.7
	Objectives	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**25**	**8**	**250**	**62**	**11,000**

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

Dust deposition 1 month

Air quality objective (130 mg/m²/day)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-13

Maximum monthly dust deposition model predictions of cumulative impacts Southern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_DustDeposition_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

PM_{10} 24 hour average

Air quality objective (50 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-14

24 hour average PM_{10} model predictions of cumulative impacts Southern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_PM10_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

TSP 1 year

Air quality objective (90 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-15

Annual average TSP model predictions of cumulative impacts Southern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_TSP_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

Dust deposition 1 month

Air quality objective (130 mg/m^2/day)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

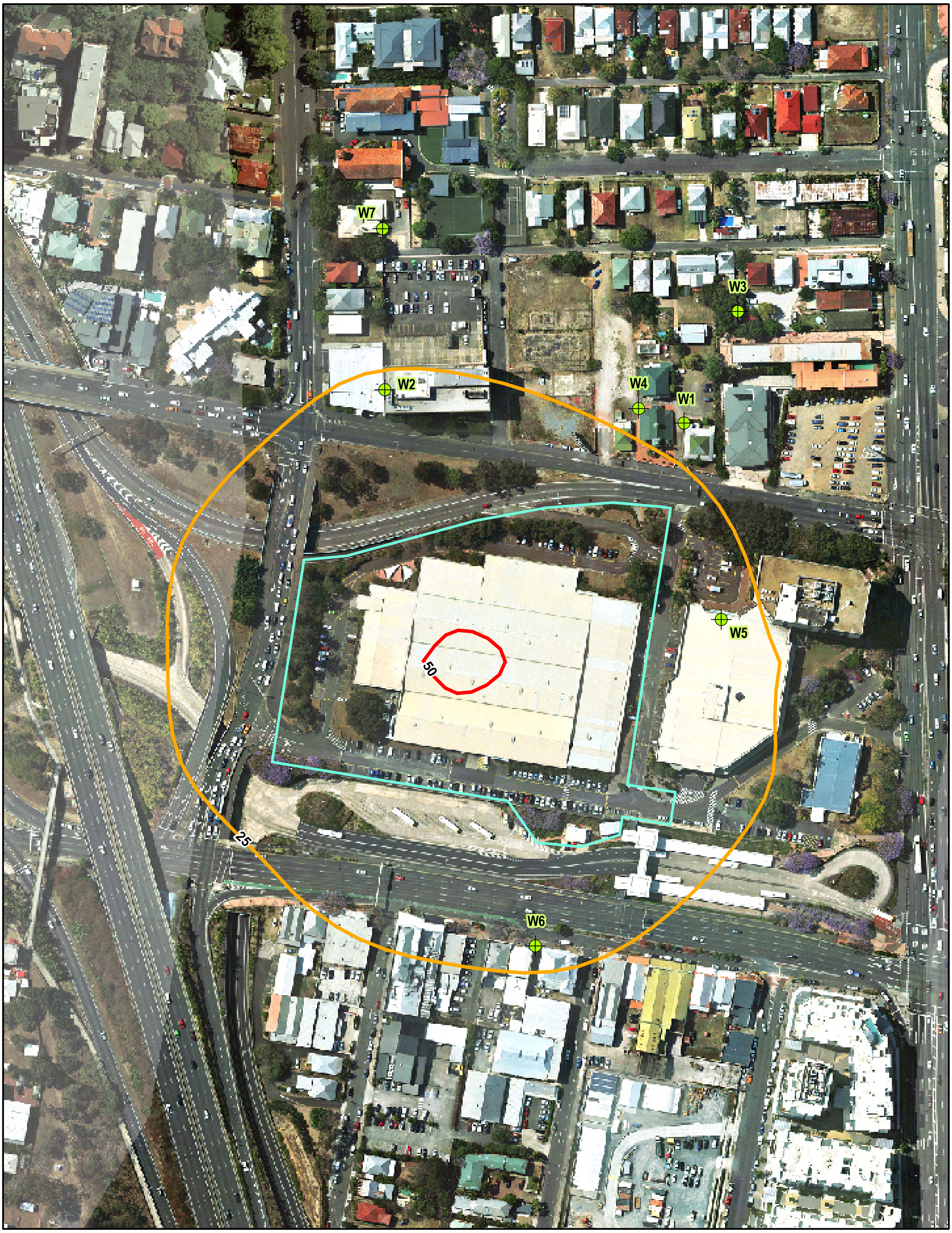
FIGURE 1-16

Maximum monthly dust deposition model predictions of cumulative impacts Woolloongabba construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_DustDeposition_MapBk.mxd Date: 14/08/2014



LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

PM_{10} 24 hour average

Air quality objective (50 µg/m^3)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-17

24 hour average PM_{10} model predictions of cumulative impacts Woolloongabba construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

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LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

TSP 1 year

Air quality objective (90 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-18

Annual average TSP model predictions of cumulative impacts Woolloongabba construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

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LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

Dust deposition 1 month

Air quality objective (130 mg/m²/day)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-19

Maximum monthly dust deposition model predictions of cumulative impacts George Street construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQuality\TechReport\AirQualityTechRpt_Figure1-X_DustDeposition_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

PM_{10} 24 hour average

Air quality objective (50 µg/m^3)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-20

24 hour average PM_{10} model predictions of cumulative impacts
George Street construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQuality\TechReport\AirQualityTechRpt_Figure1-X_PM10_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

TSP 1 year

Air quality objective (90 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-21

Annual average TSP model predictions of cumulative impacts George Street construction worksite – scenario 1

N

0 0.025 0.05
Kilometres
1:2,500 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQuality\TechReport\AirQualityTechRpt_Figure1-X_TSP_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

Dust deposition 1 month

Air quality objective (130 mg/m^2/day)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-22

Maximum monthly dust deposition model predictions of cumulative impacts Roma Street construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_DustDeposition_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

PM_{10} 24 hour average

Air quality objective (50 µg/m^3)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-23

24 hour average PM_{10} model predictions of cumulative impacts
Roma Street construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_PM10_MapBk.mxd Date: 14/08/2014

LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

TSP 1 year

Air quality objective (90 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

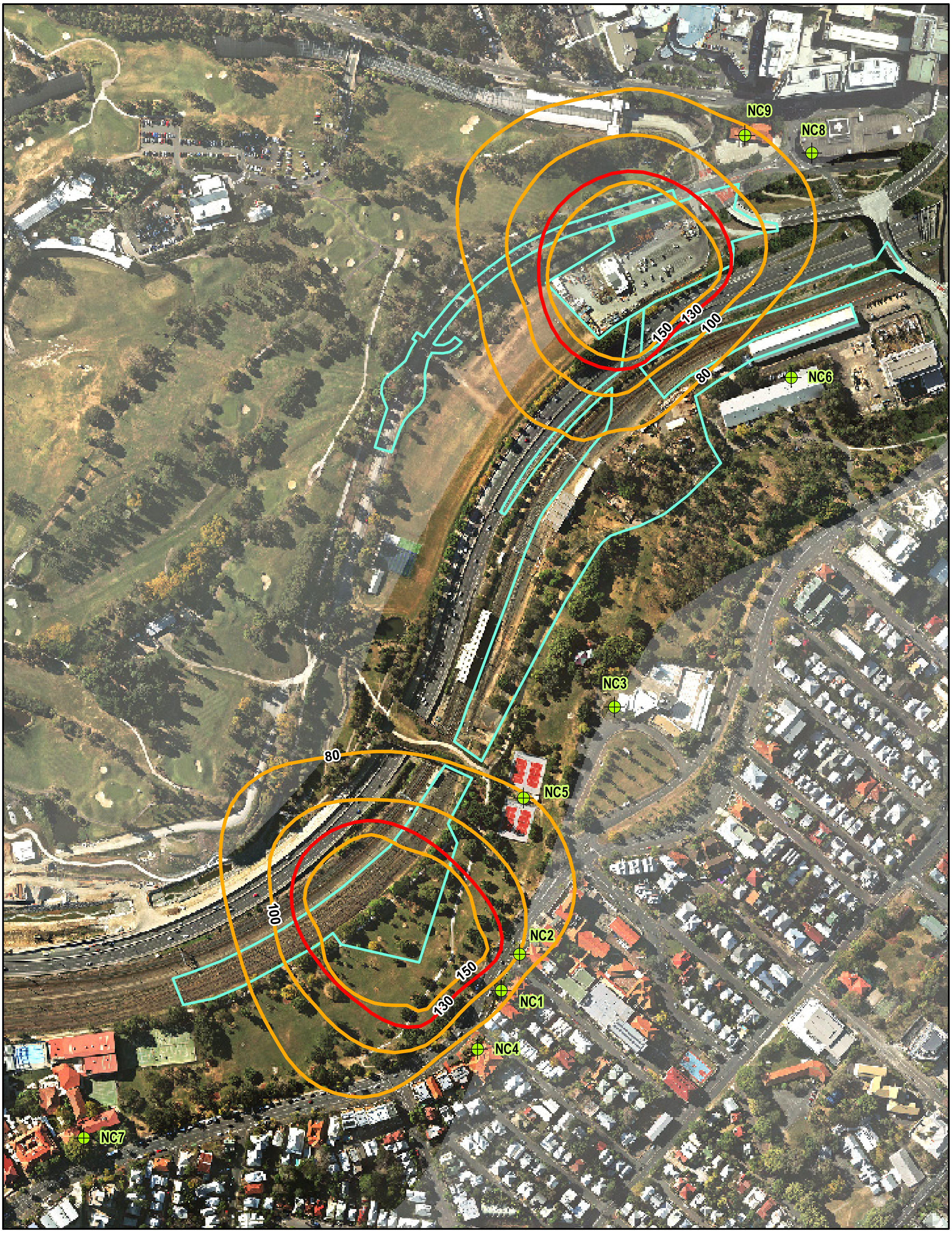
FIGURE 1-24

Annual average TSP model predictions of cumulative impacts Roma Street construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_TSP_MapBk.mxd Date: 14/08/2014



LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

Dust deposition 1 month

Air quality objective (130 mg/m^2/day)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

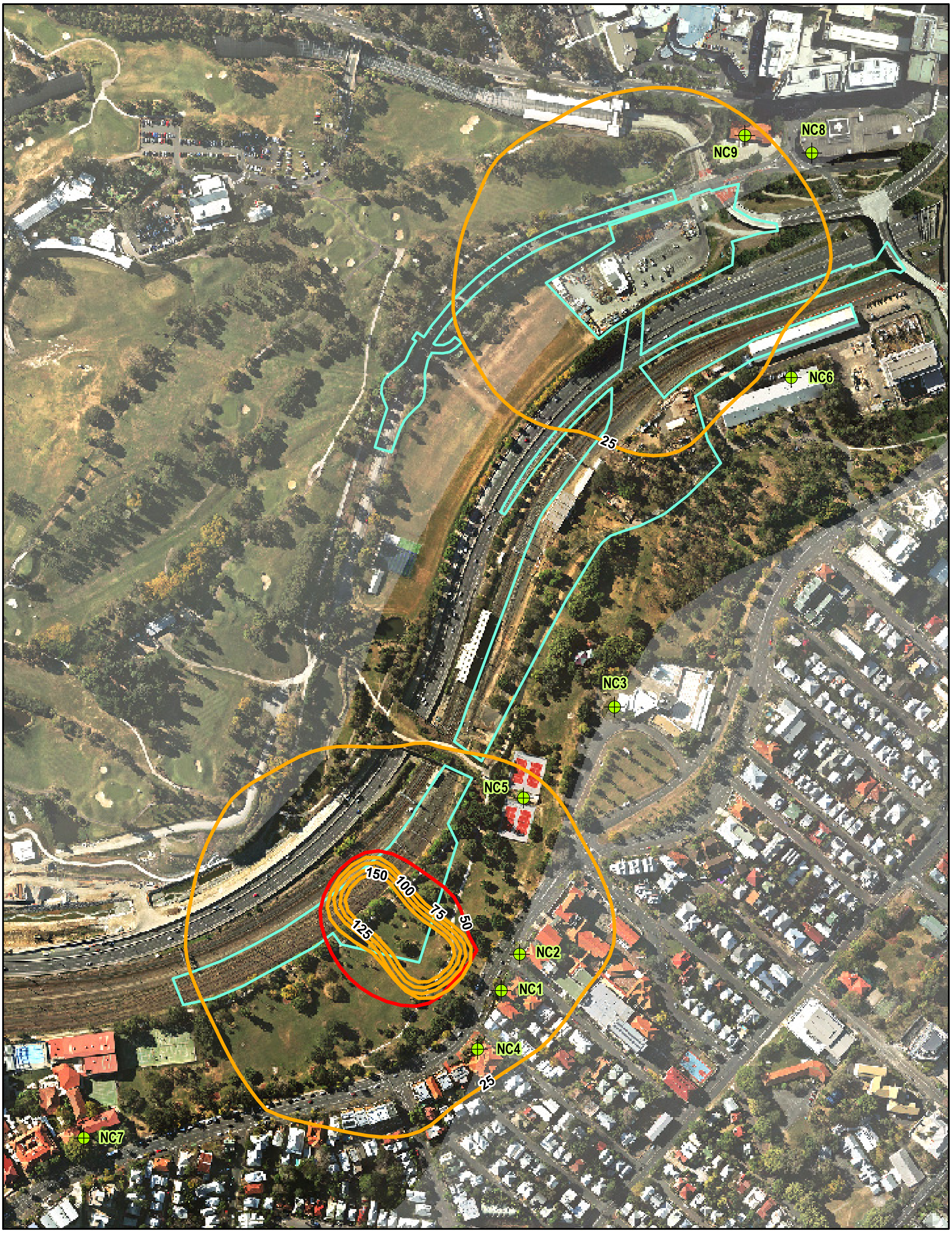
FIGURE 1-25

Maximum monthly dust deposition model predictions of cumulative impacts Northern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_DustDeposition_MapBk.mxd Date: 14/08/2014



LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

PM_{10} 24 hour average

Air quality objective (50 µg/m^3)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

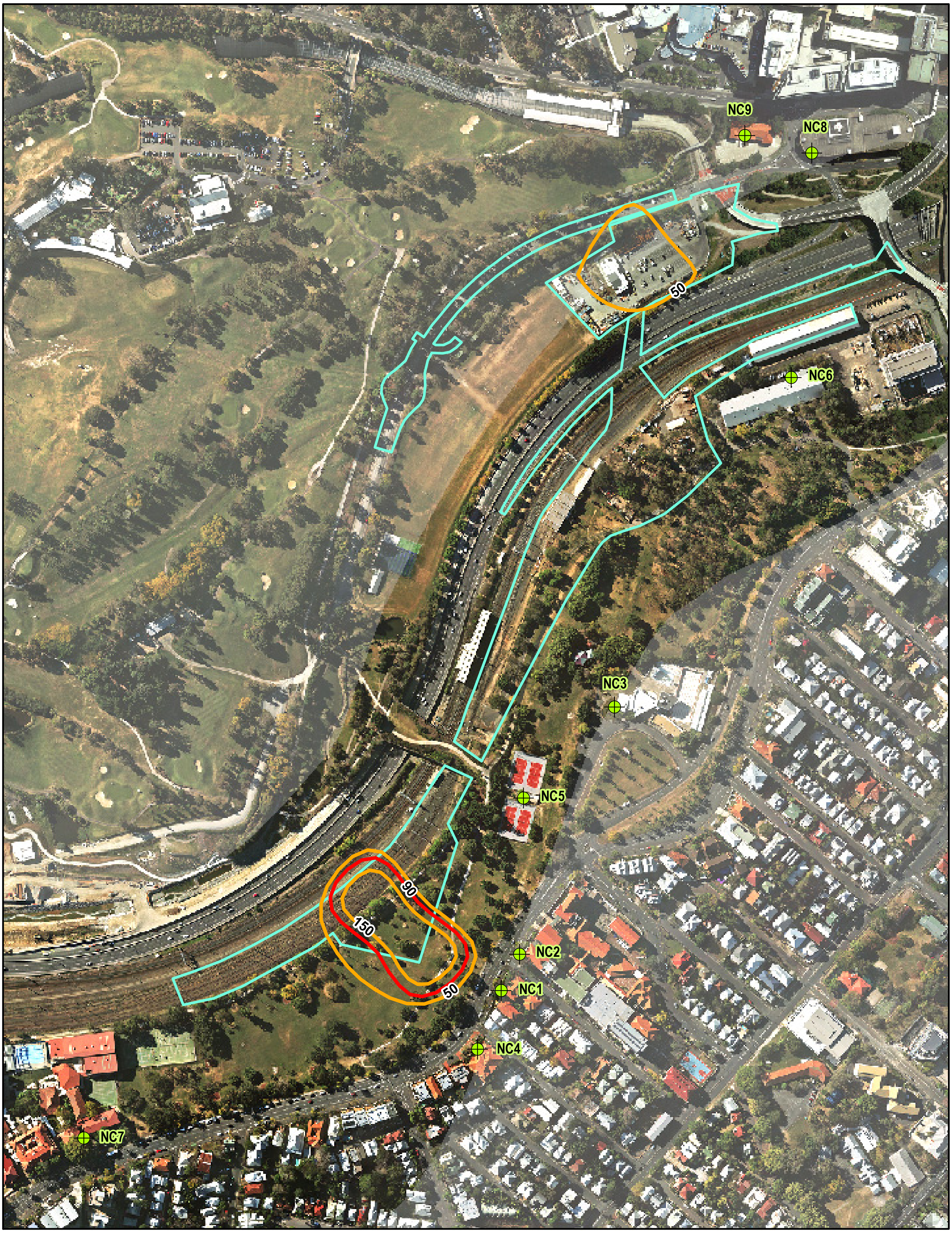
FIGURE 1-26

24 hour average PM_{10} model predictions of cumulative impacts Northern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

G:\QENV2\Projects\QE06863\Spatial\ArcGIS\Figures\Final_EIS_Figures\10_AirQualityTechReport\AirQualityTechRpt_Figure1-X_PM10_MapBk.mxd Date: 14/08/2014



LEGEND

Sensitive receptor

Construction worksite

Air Quality Contours

TSP 1 year

Air quality objective (90 µg/m³)

Aerial Photo: Brisbane City Council 2012

BUS AND TRAIN PROJECT
ENVIRONMENTAL IMPACT STATEMENT

FIGURE 1-27

Annual average TSP model predictions of cumulative impacts
Northern Connection construction worksite – scenario 1

N

0 0.05 0.1
Kilometres
1:5,000 (at A4)
Projection: GDA 1994 MGA56

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1.3.6 Evaluation of significance

Introduction

Exposure to ambient air pollution has been linked to a number of health impacts mainly related to the respiratory tract and pulmonary functions. The ambient air quality objectives established in the EPP (Air) have been set to protect human health and wellbeing.

Construction impacts

Particles generated through construction works (eg excavation and materials handling) are predominantly due to the crushing or abrasion of rock, and most of the emission particle size will be larger than $PM_{2.5}$, which are of most concern in terms of health impacts.

Air quality objectives for the modelling assessment were adopted primarily from the EPP (Air). The purpose of the EPP (Air) is to protect the air quality environment for human health and wellbeing, the health and biodiversity of ecosystems, the aesthetics of the environment and for agricultural use. There are no exceedances of the TSP and PM_{10} air quality objectives predicted by the modelling at the sensitive receptors for the Project's construction scenarios modelled. The potential for an increase in human health risk due to the construction of the Project at nearby sensitive receptors is considered to be low.

Coarse particulates (>10µm) have the greater potential to generate potential nuisance primarily as deposited dust and are not considered a health issue. The EPP (Air) does not provide specific objectives for nuisance impacts of particulates. A dust deposition objective of 130mg/m^2/day as a maximum monthly average has been adopted here for the management of potential nuisance impacts for the Project. No exceedances of the dust deposition objective are predicted for the Project's construction modelling scenarios at the modelled sensitive receptors.

Operational impacts

Particles generated through combustion and exhausted to the surface by ventilation systems are likely to be much smaller but much less concentrated because of the large volumes of exhaust air. The predicted $PM_{2.5}$ and gaseous pollutant concentrations during the operation of the Project are generally well below the ambient air quality objectives in the EPP (Air). The exceptions to this are cumulative predictions of annual $PM_{2.5}$ which are just below the EPP (Air) objective of 8µg/m^3 and includes a background level of 7.8µg/m^3. The contribution to air quality levels from the operation of the Project is predicted to be much lower (to a maximum of approximately 0.2µg/m^3) than the regional background levels adopted for the modelling. The health risk due to the operation of the Project at nearby sensitive receptors is therefore considered to be low.

As far as practical, the selection of the ventilation outlet sites is such that a maximum distance (horizontal and vertical) is established between emission point and receptor locations. Potential heat generated at the extraction point (up to 6°C above ambient temperature) can therefore sufficiently disperse before impacting upon the amenity of the surrounding existing receptors. Any future developments in close proximity to the ventilation outlets would need to account for the potential for thermal emissions from the ventilation outlets.

1.3.7 Benefits of the Project

With the Project in place, the transport modelling forecasts that the northbound bus services during the peak hour across the river remains stable to 2021 (442), with a small increase to 482 in 2031. The most significant growth in bus and rail is in the tunnel itself, with reductions (compared to today) on the Merivale Bridge (rail), Victoria Bridge (bus) and Captain Cook Bridge (bus).

Above the tunnel, the air quality is expected to be better than if an open air road section was situated at the same location. Emissions from vehicles travelling on surface roads are released at ground-level closer to the sensitive receptors than those emissions from a ventilation outlet that are typically released at height. The point of emission level (at the outlet height) from the tunnel therefore above allows a greater potential for the dispersion of the pollutants and reduction of ground level pollutant concentrations because of the distance of the receptors from the source.

The forecasted reductions compared to today of bus travel on the Victoria Bridge (bus) and Captain Cook Bridge (bus would result in a reduction in the ground level emissions and improvement in air quality at these locations from the buses that would have travelled along these bridges without the Project. Air dispersion modelling of the emissions from the ventilation outlets during the operation of the Project has predicted that impacts from the Project are negligible compared with existing background levels of all pollutants modelled. An overall (slight) improvement in regional air quality would be expected from the Project compared to a 'without' Project scenario.

1.3.8 Summary of potential impacts

Construction impacts

As is common with construction activities, the Project has the potential to impact upon dust levels in local areas surrounding each of the five construction worksites primarily from the following activities:

- graders working unpaved areas and dozers moving material
- wind erosion from exposed surfaces
- wheel generated dust from vehicles travelling along unpaved or dirty paved surfaces
- handling, loading and transport of spoil.

This section has assessed the impacts of these and other construction activities associated with the Project upon the local areas surrounding the five construction worksites. There are no exceedances of the TSP, PM_{10} or dust deposition objectives predicted by the modelling at the sensitive receptors for the Project's construction scenarios modelled. Nevertheless, emissions from the construction activities will need to be appropriately managed to avoid or minimise potential nuisance impacts. The measures to control emissions are outlined in **section 1.4**.

Operational impacts

Impacts from the operation of the Project were assessed by modelling of emissions from five ventilation outlets proposed for the control of the air emissions within the tunnel and stations. The modelling included a comparison of predictions of particulate matter (as $PM_{2.5}$), CO, NOx (in isolation and with background) with relevant air quality objectives.

The contribution to air quality levels from the operation of the Project was predicted to be much lower than the conservative regional background levels adopted for the modelling for all five proposed ventilation outlet sites.

1.4 Impact management

1.4.1 Management of impacts

This section identifies mitigation measures which have been regularly and successfully applied to similar large scale projects in order to minimise the potential for nuisance dust impacts during construction. Impacts and proposed mitigations to aid in the development of the Environmental Management Plan are listed in **Table 1-34**.

Table 1-34 Impacts and proposed mitigations

Impact location	Project phase	Management measure
All construction worksite locations	Construction	Installation of hoardings or barriers on the site perimeters to help mitigate dust impacts. Installation of acoustic (shed or enclosure) for the primary excavation activities and handling excavated spoil within enclosed work area, where possible. Work sheds would cover the excavated areas and would allow access and egress of trucks and truck loading operations and stockpiling of excavated tunnel material. Regular watering of exposed areas within the construction worksites. Sealing of access roads within the construction worksites and ensuring sealed access roads into construction worksites are kept relatively dust free by regular sweeping and washing, wherever needed Monitoring meteorological conditions at construction worksites and spoil placement sites, particularly wind speed and direction and where winds are approach threshold speeds, take measures to avoid impacts of dust or odour on adjacent properties Conducting demolition activities using appropriate dust controls, such as water sprays Installing truck wheel wash stations in construction worksites where space allows Covering trucks transporting excavated material, to minimise wind-blown dust during transport Cleaning down loaded trucks prior to exiting construction worksites, to ensure loose material is not tracked onto the adjacent road network Implementation of measures for the control of dust (eg vacuum and watering) during the removal of equipment in particular, the acoustic sheds at the construction worksites. Develop and implement a complaints management system that addresses: effective management of dust generation including: • effective monitoring of impacts • effective communication with the local community on issues associated with construction activities • a clearly identified point of contact should the community have comments or complaints • a well-defined process to ensure that any issues are dealt with promptly and to a satisfactory level • a well-defined system of recording any incidents or complaints.

Impact location	Project phase	Management measure
		Reasonable and practicable measures to address the potential impact of odour on adjacent properties would be implemented as part of the construction EMP. These include: • identifying and determining the potential for odour impacts at off-site sensitive receptors • conducting works with odorous soils when wind directions are unlikely to affect sensitive receptors • covering odorous, excavated soil stockpiled either on a construction worksite or a spoil placement site to reduce odour impacts. The effects of diesel exhaust emissions would be minimised by the following measures: • avoiding queuing of the construction traffic vehicle fleet in the streets adjacent to the construction worksites which would in turn minimise the amount of exhaust emissions generated during the construction works • marshalling and queuing for trucks and construction worksite vehicles away from residential areas and other sensitive receptors, where possible • directing exhaust emissions from mobile and stationary plant away from the ground and sensitive receptors, where possible • minimising the use and intensity of use of diesel engines For stationary plant and equipment, ensuring all diesel motors are fitted with emission control measures and are regularly maintained to manufacturers' specifications.
Southern Connection	Construction	Installation of an acoustic shed (or enclosure) above the TBM workbox within the northern construction worksite. Model predictions were below air quality objectives at all sensitive receptors modelled in close proximity to the Dutton Park construction worksite. However, given the sensitivity of the receiving environment. Additional monitoring measures are proposed for this site include: • real-time dust monitoring at a locations adjacent to the worst affected sensitive receptors (further details are discussed in the paragraphs proceeding this table).
George Street Station	Construction	Installation of an acoustic (shed or enclosure) equipped with a fabric filter for the removal of airborne particulate matter and dust from the primary excavation activities at the George Street construction worksite. Model predictions were below air quality objectives at all sensitive receptors modelled in close proximity to the George Street construction worksite. Additional monitoring measures proposed for this site include: • real-time dust monitoring at a location adjacent to the worst affected sensitive receptors (further details are discussed in the paragraphs proceeding this table).
Roma Street Station	Construction	Installation of an acoustic (shed or enclosure) equipped with a fabric filter for the removal of airborne particulate matter and dust from the primary excavation activities at the Roma Street construction worksite.

Impact location	Project phase	Management measure
		Model predictions were below air quality objectives at all sensitive receptors modelled in close proximity to the Roma Street construction worksite, in particular to the closest residential receptor on Parkland Crescent. Additional management and monitoring measures proposed for this site include: • maintaining as far as practical distance from the receptor and any soil disturbance activities (eg vehicle movements) • real-time dust monitoring at a location adjacent to the Parkland Crescent sensitive receptor (further details are discussed in the paragraphs proceeding this table).

1.4.2 Monitoring of air quality impacts

Regular monitoring of TSP, PM_{10} and dust deposition levels at the worst affected sensitive receptors adjacent to construction worksites and locations representative of the work space would provide a basis for compliance with appropriate objectives. In addition, real-time monitoring allows adaptive management strategies to be implemented when meteorological monitoring suggests adverse wind conditions or dust monitoring at sensitive receptors indicates levels are near to exceeding air quality objectives.

Indicative dust sampling and real-time dust monitoring locations around the main construction worksites are provided in **Table 1-35**.

Table 1-35 Indicative dust monitoring locations

Construction worksite	Indicative Dust Monitoring Locations
Southern Connection	• Real-time dust and meteorological monitoring at the PA Hospital and Leukaemia Foundation • Dust deposition sampling in each direction from the construction worksite
Roma Street Station	• Real-time dust and meteorological monitoring at the Parkland Crescent residential building. • Dust deposition sampling in each direction from the construction worksite
Woolloongabba Station	• Dust deposition sampling in each direction from the construction worksite
George Street Station	• Real-time dust and meteorological monitoring at the worst affected George Street commercial location • Dust deposition sampling in each direction from the construction worksite
Northern Connection	• Dust deposition sampling in each direction from the construction worksite

Air quality monitoring data used to characterise the existing air environment in the study corridor is summarised in **section 1.2.3**. As shown in **Figure 1-5**, three air quality monitoring stations (QUT Gardens Point, South Brisbane and Woolloongabba) are currently operated as part of the South East Queensland Air Monitoring network within the study corridor. In addition, monitoring of external air in the vicinity of the Clem Jones tunnel (Clem 7) is undertaken at four stations adjacent to the Clem 7 northern and southern ventilation outlets. The continued operation of the monitoring stations from these two networks will provide sufficient information to identify and quantify changes to ambient air quality in the study corridor resulting from the operation of the Project.

1.5 Summary

This technical report describes the existing air quality within the study corridor and assesses the potential benefits and impacts on air quality attributable to the Project. The primary emissions from the construction of the Project are dust related as airborne and deposited particulate matter. The operation of the tunnel has the potential to generate air quality impacts associated with emissions from buses including combustion related gases and particulate matter.

An air dispersion modelling assessment of the impacts from the construction and operation of the Project has been undertaken. The air dispersion modelling conducted for this assessment has been based on the modelling approach using a combination of TAPM and CALMET as a meteorological pre-processor to the air dispersion model, known as CALPUFF. The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model.

Two scenarios were modelled for the construction phase of the Project representing activities at the five primary construction worksites (Southern connection, Woolloongabba Station, George Street Station, Roma Street Station and Northern Connection):

- a base case where primary excavation activities would be performed by road header or rock hammer and piling rig within a fully enclosed acoustics shed at the five construction worksites.
- an alternative scenario using blasting and drilling activities for primary excavation.

Emissions from the operation of the Project were also modelled via ventilation outlets based upon extraction of emissions within the tunnel such that the concentrations of air pollutants are below maximum allowable levels. In addition, tunnel operating conditions were modelled under peak vehicle flows representative of maximum emissions and normal operating conditions representative of average emissions.

Concentrations and deposition levels for the primary pollutants associated with the construction and operation of the Project were compared with EPP (Air) objectives for an assessment of human health and nuisance effects.

No predictions above objectives were determined from construction activities at any of the construction worksites for the base case or alternative scenarios. Given the proximity of some of the construction worksite to the sensitive receptors, management measures including real-time dust monitoring at the worst-affected sensitive receptor are proposed which allows adaptive management strategies to be implemented when meteorological monitoring suggests adverse wind conditions or dust monitoring indicates levels at or near to exceeding air quality objectives. Additional management strategies may include additional watering regime on roads, stockpiles and haul truck load out areas.

The contribution to air quality levels from the operation of the Project was predicted to be much lower than the conservative regional background levels adopted for the modelling for all five proposed ventilation outlet sites and is therefore not considered a risk to human health. An overall (slight) improvement in regional air quality would be expected from the Project compared to a without Project scenario.

Mitigation measures are also proposed for managing potential dust and odour nuisance, including the establishment of monitoring, communication and complaints systems.

1.6 References

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