The Northern Road Upgrade, Glenmore Parkway to Jamison Road

NSW Roads and Maritime Services

Air Quality Technical Study

F0 | v2

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Project Manager:	Tim Colman
Author:	Luke Spencer
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Jacobs Australia Pty Limited

710 Hunter Street
Newcastle West NSW 2302 Australia
PO Box 2147 Dangar NSW 2309 Australia
T +61 2 4979 2600
F +61 2 4979 2666
www.jacobs.com

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F0v0	14/07/2016	Final Report addressing comments from internal technical and external client review	L Spencer		T Colman
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Contents

Executive summary

Introduction and purpose of this report

As a part of the Western Sydney Infrastructure Plan, the NSW Roads and Maritime Services is seeking approval to upgrade The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith.

This document provides an assessment of potential air quality impacts associated with the construction and operational phases of this project. The objectives of this assessment were to:

- Identify potential air quality impacts associated with the construction and operational phases of the project
- Develop suitable mitigation measures to prevent the generation of dust during construction and to manage potential impacts during operation.

Impacts were assessed with reference to the following guidelines:

- *Approved Methods for Modelling and Assessment of Air pollutants in NSW* (Approved methods), (Department of Environment and Conservation, 2005).
- *Variation to the National Environment Protection (Ambient Air Quality) Measure*, (National Environment Protection Council, 2016).

Assessment overview and key findings

To determine potential impacts to air quality at surrounding receivers during construction a qualitative, risk-based assessment was undertaken. The assessment identified that phases of construction involving the handling, disturbance and management of materials presented the greatest risks. Receivers in the direction of prevailing wind conditions from the site located close to the proposal were identified as being most likely to be affected by dust impacts during construction.

Impacts to roadside air quality at surrounding receivers as a result of the operation of the proposed upgrade were evaluated by quantitative modelling, using the Roads and Maritime *Tool for Roadside Air Quality* (TRAQ) CALINE-based dispersion model. Predictions from this assessment found that for the timeframes assessed, any changes in local air quality at surrounding receivers would be minimal and within the existing range of air quality variations within the area.

Conclusions and next steps

To manage potential impacts during construction, several mitigation and management measures were recommended including appropriate work practices and scheduling, consultation/co-ordination of works around the planned airport site with the airport contractor(s), equipment selection, monitoring and preventative controls; and residual ratings were calculated. 'Moderate' risk ratings remained for several phases of construction. It was recommended that these measures were incorporated into a Construction Environmental Management Plan (CEMP).

Regarding operations, impacts associated with the project were predicted to be minimal and not materially different from the relevant 'existing road' scenarios, as well as being within relevant assessment criteria (with the exception of annually-averaged $PM_{2.5}$ concentrations which were a result of existing, elevated local background concentrations) at surrounding receivers. Post-construction traffic monitoring was recommended to verify that traffic volumes and characteristics are not materially different from the forecast numbers assessed.

1. Introduction

Roads and Maritime Services (Roads and Maritime) proposes to upgrade The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith ('the proposal'). The proposal is located about 47 kilometres (km) west of the Sydney Central Business District (CBD). The proposal would upgrade The Northern Road to an eight-lane divided road, with three general traffic lanes and a kerbside bus lane in each direction, separated by a raised concrete median. Beyond Jamison Road, The Northern Road continues north as a six lane road.

The Northern Road is classified as a State Road and forms part of route A9, which connects Campbelltown to Windsor. The Northern Road also provides connections between the Western Sydney Priority Growth Area, the Western Sydney Employment Area, the M4 Motorway, and the site for the proposed western Sydney airport at Badgerys Creek.

The section of The Northern Road between Glenmore Parkway and Jamison Road is currently a four lane road, largely divided by a narrow median. Between 200 metres south of Smith Street and 200 metres north of Frogmore Road there is a 1.3 km section that is undivided. There are five signalised, and six unsignalised intersections, as well as various uncontrolled property accesses along this section of The Northern Road. At some unsignalised intersections and property accesses, right turn movements can be made across a painted median.

Roads and Maritime is upgrading The Northern Road as part of the Australian and NSW governments' Western Sydney Infrastructure Plan, which will deliver $3.6 billion in road infrastructure improvements over the next 10 years. The proposal was announced in April 2014 by the (then) Prime Minister as part of the Western Sydney Infrastructure Plan's program of works to support the proposed western Sydney airport at Badgerys Creek.

It is anticipated that construction of the proposal would start in early 2017 and would be open to traffic by mid-2020.

1.1 Description of the proposal

Roads and Maritime proposes to upgrade about four kilometres of The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith. The main features of the proposal are:

- An eight-lane divided road (three general traffic lanes and a kerbside bus lane in each direction) from just south of Glenmore Parkway, Glenmore Park to Jamison Road, South Penrith
- An upgrade to the M4 Motorway interchange, including:
  - Construction of a new two-span bridge over the M4 Motorway, located to the east of the existing bridge alignment
  - Replacement of the existing two sets of traffic lights at the M4 Motorway interchange, with a single set of traffic lights to control all movements at the interchange
  - Widening of ramps to accommodate future Smart Motorway requirements
  - Demolition of the existing bridge over the M4 Motorway
- New traffic lights on The Northern Road at:
  - The Glenmore Parkway and Wentworth Road intersection
  - The Frogmore Road and Tukara Road intersection
- Altered intersection arrangements at:
  - The Northern Road and Homestead Road (left-in, left-out only)
  - The Northern Road and Castle Road (left-in, left-out only)

- Upgrade of The Northern Road and Glenmore Parkway / Wentworth Road intersection, comprising:
  - Traffic lights to replace the existing roundabout, allowing all movements
  - Separate left-turn lanes on all approach roads to the intersection
  - Additional left-turn and right-turn capacity from both approach roads onto The Northern Road
  - A new dedicated access road into the Penrith Golf and Recreation Club, meeting Glenmore Parkway at a new T-intersection about 175 metres west of The Northern Road, with all left and right turn movements allowed
  - A new single-lane roundabout on Glenmore Parkway west of the proposed new Golf Club access road, to facilitate U-turn movements for traffic entering or leaving Fairwater Court and Garswood Road
- Changes to local roads, including:
  - Extension of Cross Road to provide a new local connection between Wentworth Road and Homestead Road
  - A new roundabout on Frogmore Road, west of the existing intersection with Simeon Road providing access to Penrith Christian School
  - Removal of the existing roundabout at Maxwell Street and Aspen Street, and replacement with a new four-leg roundabout realigned to include Hilliger Road, with traffic lights on the Aspen Street leg only
- New pedestrian and cyclist facilities, including:
  - A three-metre wide shared path along the western side of The Northern Road between Glenmore Parkway and Jamison Road
  - A three-metre wide shared path along the eastern side of The Northern Road between Wentworth Road and Bringelly Road
  - A 1.5 metre wide footpath on the eastern side of The Northern Road between Bringelly Road and Jamison Road
- New or additional pedestrian crossing signals at:
  - The Northern Road intersection with Glenmore Parkway and Wentworth Road
  - The M4 Motorway interchange
  - The Northern Road intersection with Frogmore Road and Tukara Road
  - The Northern Road intersection with Maxwell Street and Bringelly Road
  - The intersection of The Northern Road and Jamison Road
- New retaining walls along:
  - The eastern side of The Northern Road, south of Homestead Road
  - Both sides of the M4 Motorway beneath the proposed bridge (reinforced soil walls)
  - The northern side of the eastbound M4 on-ramp, towards the eastern end of the ramp
  - The western side of The Northern Road, south of Tukara Road
  - The eastern side of The Northern Road adjacent to the Flower Power Garden Centre, south of Castle Road
  - The eastern side of The Northern Road, south of Bringelly Road
  - The eastern and western side of The Northern Road at numerous locations between Maxwell Street / Bringelly Road and Smith Street
  - The southern side of Smith Street, west of the intersection with The Northern Road
  - The eastern and western side of The Northern Road at numerous locations between Smith Street and Jamison Road
- Upgrade of drainage infrastructure, including:

  - New or upgraded cross-drainage structures to replace existing cross-drainage where required
  - New longitudinal drainage including open concrete or grass-lined catch drains, grassed swales, pits and pipes
- New noise barriers at the following locations:
  - A noise mound along the northern side of the eastbound M4 Motorway off-ramp (the mound would be about 670 metres long and six metres high)
  - A noise wall along the eastbound M4 Motorway off-ramp from the end of the noise mound, continuing north along the western side of The Northern Road to Aspen Street (the wall would be about one kilometre long and up to 4.5 metres high)
  - A noise wall along the eastbound M4 Motorway on-ramp, between the motorway and the buildings at the Penrith Christian School (the wall would be about 325 metres long and up to 4.5 metres high)
- Two permanent variable message signs (VMS) on The Northern Road near the M4 Motorway interchange
- New street lighting
- New landscaping
- Relocation of utility services and construction/installation of new utility services
- Relocation of some bus stops and construction of new bus stops
- Changes to property accesses along The Northern Road to left-in, left-out only
- Adjustments to private properties to accommodate the proposal, including driveways, front yards, retaining walls, utility connections and fencing
- Establishment and use of temporary site compounds during construction.

It is anticipated that construction of the proposal would start during 2017 and is expected to be completed by mid-2020.

1.2 Location and context

The proposal is located in the Penrith local government area. The area is mostly flat to undulating in topography.

The study area is generally divided into distinct geographies. To the east of The Northern Road and south of Bringelly Road, the study area is predominately semi-rural or rural residential in character. The remaining areas to the west of The Northern Road, and north of Bringelly Road are characterised by low density residential development comprising the southern suburbs of the City of Penrith. It also includes some commercial, educational, community and recreational land uses.

The proposal crosses the M4 Motorway at roughly equal distance between Mulgoa Road and Mamre Road. The Northern Road is the main collector to and from the M4 Motorway through the area.

1.3 Purpose of this report

The purpose of this report is to provide an assessment of potential air quality impacts associated with the construction and operation of the proposal. This report is intended to support *The Northern Road Glenmore Parkway, Glenmore Park to Jamison Road, Penrith – Review of Environmental Factors* being prepared to assess the overall environmental impacts associated with the proposal.

In achieving this purpose, the main objectives of this assessment were to:

- Identify potential air quality issues associated with the construction and operation of the proposal

- Develop suitable mitigation measures to prevent the generation of dust during construction and to manage potential impacts during operation.

This report provides information on the following:

- Methods of assessment to evaluate impacts during construction and operation
- The existing environment including prevailing meteorological and ambient air quality conditions, and identification of nearby sensitive receivers
- Details of the relevant policies and guidelines considered as part of this assessment
- Applicable air quality criteria
- Potential air quality impacts during the construction and operation of the proposal
- Recommended mitigation measures to be implemented to effectively manage potential impacts.

2. Methodology

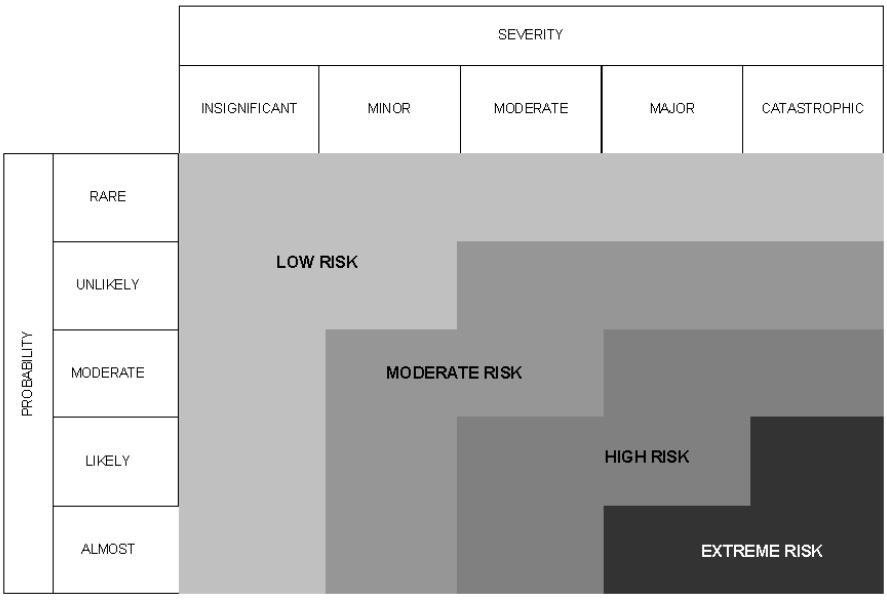
This section of the report describes the methods applied in this study to assess potential air quality impacts during construction and operation of the proposal.

2.1 Construction

During construction, the primary risk to local air quality is the generation of dust. That is, particulate matter in the form of total suspended solids (TSP) or particulate matter with a smaller aerodynamic diameter (PM_{10} and $PM_{2.5}$). Airborne particulate matter has the potential to cause adverse health or nuisance impacts if not properly managed.

To identify and appropriately manage the generation of dust emissions during construction, a risk-based qualitative assessment method was applied. This approach is summarised below in Table 2-1.

Table 2-1 Methodology for assessment of air quality impacts during construction

Task	Methodology
Identification of local receivers, prevailing meteorological and ambient air quality conditions	Publically available imagery was reviewed to determine the location of nearby receivers in relation to the study area. To characterise prevailing weather conditions, long-term climate data including temperature, rainfall, wind speed and direction data was reviewed from the nearest monitoring station operated by the Bureau of Meteorology (BoM) at Penrith Lakes (station number 67113). Background air quality conditions around the proposal were estimated from data collected at the nearest NSW Office of Environment and Heritage (OEH) ambient air quality monitoring stations located at St Marys, Bringelly, Prospect and Liverpool.
Determination of initial risk ratings for each phase of construction	Potential air quality impacts were qualitatively assessed for each phase of construction associated with the proposal. The likelihood (probability) and consequence (severity) of activities resulting in air quality impacts were evaluated to develop initial risk ratings. This was completed using *Environmental risk management procedure ILC-ES-TP0-416*, (NSW Roads and Traffic Authority, October 2006) shown below.  **Figure 2-1 Environmental risk evaluation matrix (RTA, 2006)**

<table>
<tr><th>Task</th><th>Methodology</th></tr>
<tr><td></td><td>
<table>
<tr><th>Descriptor</th><th>Description</th><th>Example *</th></tr>
<tr><td>Rare</td><td>The event may occur only in extreme circumstances</td><td>Practically impossible</td></tr>
<tr><td>Unlikely</td><td>The event could occur at some time</td><td>"I've heard of it happening…"happens every five years</td></tr>
<tr><td>Moderate</td><td>The event should occur at some time</td><td>"it has happened before…"happens annually</td></tr>
<tr><td>Likely</td><td>The event will probably happen</td><td>Happens monthly</td></tr>
<tr><td>Almost certain</td><td>The event is expected to occur in most circumstances</td><td>"it's a common occurrence…"happens weekly or more often</td></tr>
</table>
Figure 2-2 Method for determining likelihood (probability), (RTA, 2006)
<table>
<tr><th>Descriptor</th><th>Description</th></tr>
<tr><td>Insignificant</td><td>No injuries, no adverse social or environmental impact. No real impact on the community, low financial loss.</td></tr>
<tr><td>Minor</td><td>On-site release immediately contained, medium financial loss, contained in a small area.</td></tr>
<tr><td>Moderate</td><td>Minor reversible impact on environment. On-site release contained with outside assistance, measurable adverse environmental or social impact, will result in annoyance or nuisance to community, high financial loss.</td></tr>
<tr><td>Major</td><td>Major reversible impact on environment. Loss of production capacity, off site release with no detrimental effects, major financial loss</td></tr>
<tr><td>Catastrophic</td><td>Major, widespread irreversible impact on environment</td></tr>
</table>
Figure 2-3 Method for determining consequence (severity), (RTA, 2006)

Factors including the intensity and duration of activities, relative location in relation to surrounding sensitive receivers, existing air quality and prevailing meteorological conditions were considered to develop likelihood and consequence ratings, and resulting initial risk ratings for each phase of construction.
</td></tr>
<tr><td>Develop mitigation measures and recalculate residual risks.</td><td>Following the initial assessment, air quality mitigation measures were recommended, where necessary, to minimise and mitigate phases of construction where 'moderate risks' or higher were estimated. Residual risk ratings were calculated based on the application of recommended management measures and safeguards.</td></tr>
</table>

2.2 Operations

Potential impacts to air quality during the operation of the proposal are generally associated with changes in motor vehicle traffic emissions. Key pollutants associated with exhaust fumes include carbon monoxide (CO), nitrogen dioxide (NO_2) and particulate matter (as PM_{10} and $PM_{2.5}$), as well as volatile organic compounds (VOCs).

To evaluate potential operational air quality impacts, a quantitative assessment approach was applied using the Roads and Maritime *Tool for Roadside Air Quality* (TRAQ) prediction model. TRAQ, which uses the CALINE4 air dispersion model for predicting air pollutant concentrations near roadways, was used to develop models for the following assessment scenarios:

- Scenario 1: Existing road, year of opening (2021)
- Scenario 2: Proposed upgrade, year of opening (2021)

- Scenario 3: Existing road, future year (2031)
- Scenario 4: Proposed upgrade, future year (2031).

Modelling considered concept upgrade arrangements, measured and forecast traffic data (volumes, composition and speeds), worst case meteorological conditions (Wind speed one metre per second (m/s); Atmospheric stability Class F stable night time conditions; 15 degrees Celsius) and 2021 and 2026 vehicle fleet exhaust emissions from the emissions databases built into the TRAQ model from the NSW Office of Environment and Heritage for scenarios 1 and 2, and 3 and 4 respectively.

Predicted roadside concentrations were compared in relative terms (with and without the proposal) and against criterion from relevant policy and guidelines discussed below in Section 4 and Section 5. Mitigation measures were recommended, as required, to manage any identified operational impacts.

3. Existing environment

3.1 Meteorology

The nearest weather station with long-term historical records operated by the Bureau of Meteorology (BoM) is the Penrith Lakes Automatic Weather Station (AWS) (station number 67113). This station is located about eight kilometres northwest of the proposal. Table 3-1 below displays long-term temperature and rainfall averages recorded at this station from its date of commission in 1995 to present (April 2016).

Table 3-1 Long-term temperature and rainfall data from BoM Penrith Lakes AWS

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean rainfall (mm)	Mean number of rain days (> 1 mm)
January	30.7	18.5	100.8	7.6
February	29.4	18.5	121.4	7.8
March	27.5	16.6	69.2	7.5
April	24.4	13.1	53.1	5.8
May	21.0	9.3	40.4	4.7
June	18.1	6.9	52.4	5.7
July	17.7	5.4	29.8	4.2
August	19.9	6.2	30.6	3.6
September	23.3	9.4	31.2	4.7
October	25.9	12.1	53.4	5.3
November	27.3	15.0	85.7	8.0
December	29.2	16.9	62.4	7.0
Annual	**24.5**	**12.3**	**728.1**	**71.9**

The data in Table 3-1 indicates that the study area experiences warm and wet summers with a mean daily maximum temperature of around 29 degrees Celsius. Months through winter and the beginning of spring are the coldest and driest periods of the year with average monthly rainfall from July to September of around 30 millimetres per month.

To determine prevailing wind conditions around the proposal area, annual and seasonal wind roses were generated from data collected in the years 2013, 2014 and 2015. These are displayed below in Figure 3-1, Figure 3-2 and Figure 3-3 for 2013, 2014 and 2015 respectively. Annual and seasonal wind roses are generally consistent from each of the three years, with winds blowing from the southwest most common during all times of the year. Calm conditions (i.e. wind speeds less than 0.5 metres per second) were most common in autumn and spring; occurring around 20 per cent of the time during these seasons.

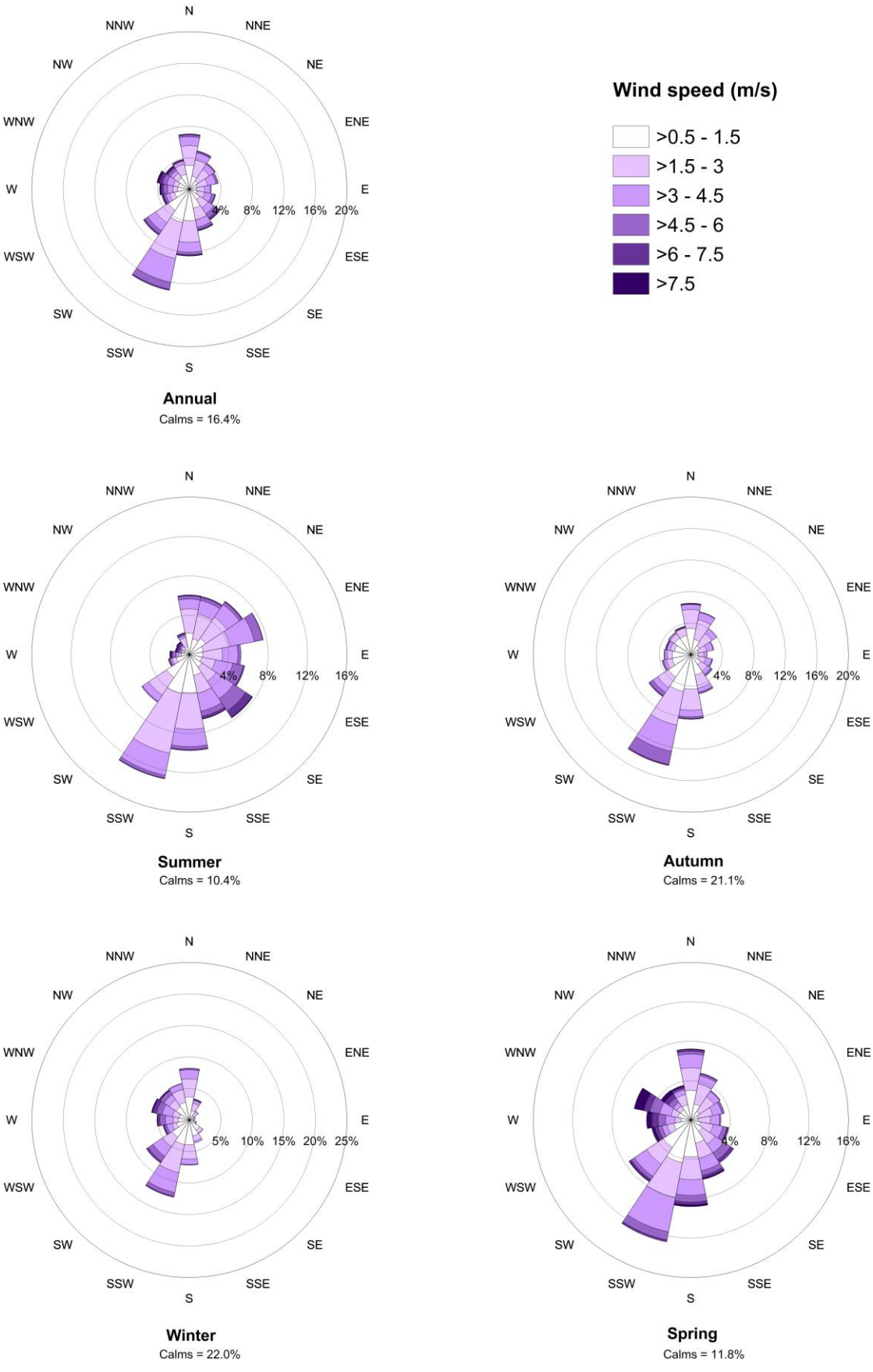


Figure 3-1 2013 Annual and seasonal wind roses for Penrith Lakes AWS

Figure 3-2 2014 Annual and seasonal wind roses for Penrith Lakes AWS

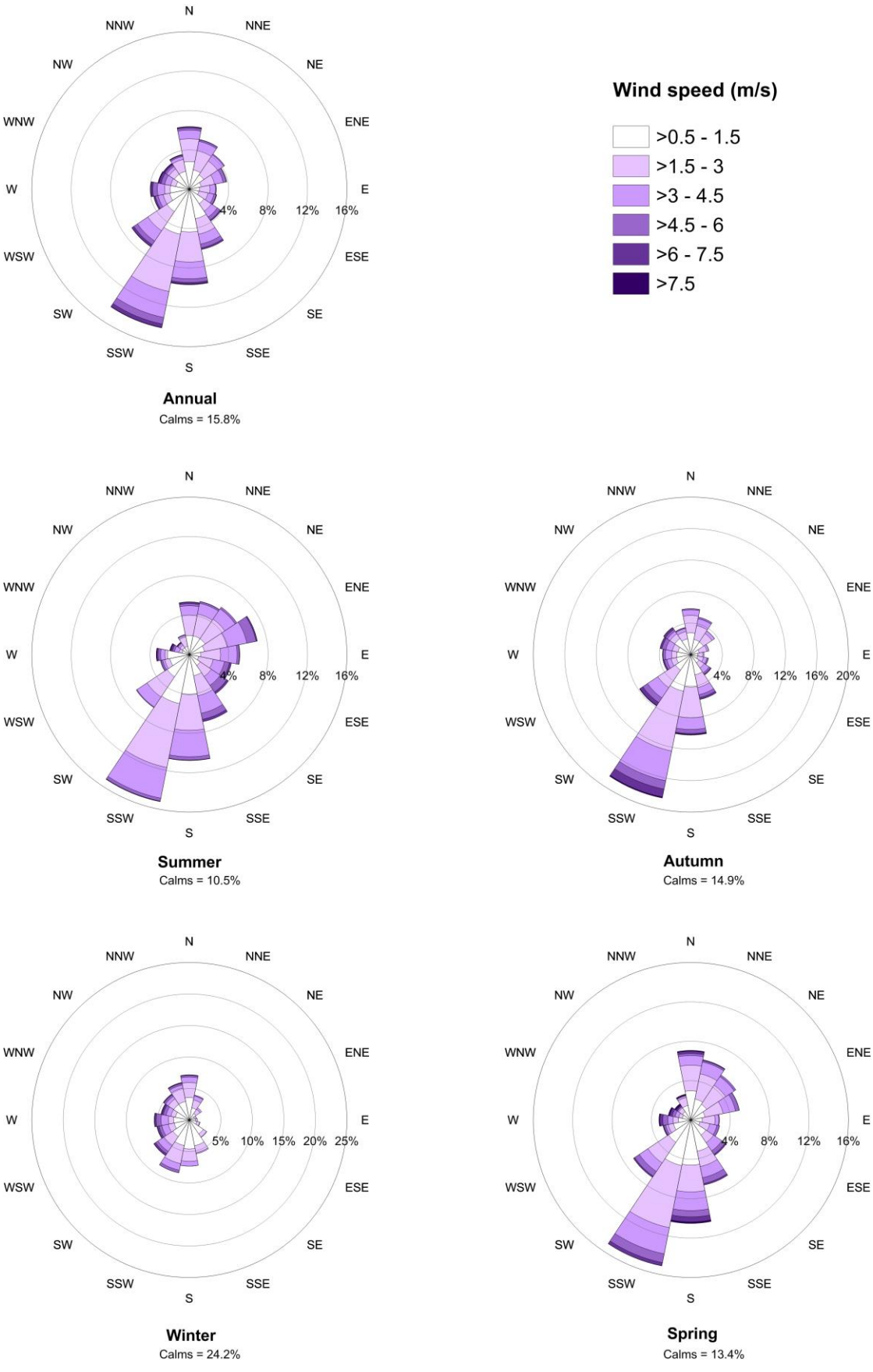


Figure 3-3 2015 Annual and seasonal wind roses for Penrith Lakes AWS

3.2 Ambient air quality

3.2.1 Air quality index

The NSW Office of Environment and Heritage (OEH) have developed a metric known as the 'air quality index' (AQI). The purpose of the AQI is to provide an indication of the overall air quality by considering pollutant data measurements for ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) and PM_{10}, as well as visibility against criteria presented in the *Variation to the National Environment Protection (Ambient Air Quality) Measure* and OEH standard for visibility. These readings are converted to a single overall value, known as the AQI using the formula:

$$AQI\ pollutant = \frac{Pollutant\ data\ reading}{Standard} \times 100$$

Table 3-2 from the OEH provides a scale for relating AQI values to a qualitative indication of individual and relative air quality.

Table 3-2 AQI value classifications, (http://www.environment.nsw.gov.au/aqms/aqi.htm)

AQI value	Resulting classification
0 to 33	Very good
34 to 66	Good
67 to 99	Fair
100 to 149	Poor
150 to 199	Very poor
Greater than 200	Hazardous

Statistics generated from daily AQI values calculated at the nearest OEH air quality monitoring station located about six kilometres to the east of the proposal at St Marys are presented below in Table 3-3. These statistics indicate that daily AQI values are generally 'good' with occasional days of 'poor' air quality or worse, usually driven by particulate matter concentrations.

Table 3-3 St Marys AQI value statistics

Period	St Marys AQI value statistics		
	Annual daily average	95th percentile of daily values	Annual daily maximum
2013	57	105	670
2014	50	88	272
2015	45	79	220

3.2.2 Background concentrations

The OEH operates a state wide air quality monitoring network which provides information on current and historical air quality. The network includes 15 air quality stations around the greater Sydney region. The nearest stations in relation to the proposal are located at St Marys (about six kilometres to the east), Bringelly (about 17 kilometres to the south) and Prospect (20 kilometres to the east). Noting its relative proximity, measurements at St Marys are considered to be most representative of background air quality conditions around the proposal area. The primary pollutants of concern during construction and operations, as identified in Section 2, are NO_2, CO and particulate matter. Concentrations of CO and $PM_{2.5}$ are not measured at this station. Both CO and $PM_{2.5}$ are measured at Prospect, although measurement of $PM_{2.5}$ only began in December 2014.

$PM_{2.5}$ data from 2013 and 2014 are available at Liverpool (about 26 kilometres to the southeast). As such, ambient concentrations for CO and $PM_{2.5}$ have been considered for this assessment from the stations at Prospect and Liverpool, with NO_2 and PM_{10} concentrations adopted from St Marys.

It is noted that VOCs are not measured at any OEH air quality monitoring stations.

Table 3-4 Summary of pollutants measured at nearby OEH monitoring stations

OEH air quality monitoring station	Address	nitrogen dioxide (NO_2)	carbon monoxide (CO)	Particulate matter PM_{10}	Particulate matter $PM_{2.5}$
St Marys	Mamre Road	✓		✓	
Bringelly	Ramsay Road	✓		✓	
Prospect	William Lawson Park	✓	✓	✓	✓ #
Liverpool	Rose St	✓	✓	✓	✓

$PM_{2.5}$ data only available at Prospect for 2015.

A summary of the ambient concentrations of PM_{10}, $PM_{2.5}$, NO_2 and CO measured at these four stations from 2013 to 2015 is shown below in Table 3-5.

Table 3-5 Summary of ambient pollutant concentrations measured from 2013 to 2015 at St Marys, Bringelly, Prospect and Liverpool

Station	Year	PM_{10} µg/m^3			$PM_{2.5}$ µg/m^3			NO_2 µg/m^3		CO mg/m^3
		100th %ile 24 hour	95th %ile 24 hour	Annual	100th %ile 24 hour	95th %ile 24 hour	Annual	100th %ile 1 hour	Annual	100th %ile 8 hour
St Marys	2013	93	32.7	16	-	-	-	75.9	10.7	-
	2014	45	28.3	16.7	-	-	-	63.6	7.9	-
	2015	53	27.3	15	-	-	-	65.6	8.3	-
Bringelly	2013	97.2	30.4	17	-	-	-	75.9	9.3	-
	2014	42.6	28.9	16.6	-	-	-	51.3	8.6	-
	2015	57	27.7	15.8	-	-	-	55.4	8.1	-
Prospect	2013	81.8	33.3	19.2	-	-	-	100.5	21.7	1.8
	2014	44.3	30.2	17.6	-	-	-	96.4	21	1.5
	2015	68.7	29.7	17.6	29.6	15.5	8.2	108.7	21.7	1.7
Liverpool	2013	98.5	36.7	21	73.8	18.6	9.4	114.8	22.7	2.4
	2014	40.8	32.9	19.1	24.3	16.1	8.6	90.2	21.4	2.5
	2015	68.6	31	18.5	32.2	16.9	8.5	123	20.1	2.1

VOCs are not presently measured at any OEH air quality monitoring stations. As outlined in the *Western Sydney Airport Draft Environmental Impact Statement Volume 4 Appendix F1 Local air quality and greenhouse gas,* (Pacific Environment Limited, October 2015); two historical studies have previously been completed by the NSW EPA to investigate baseline concentrations of air toxics:

- Air Toxics Monitoring Program (ATMP) involving the collection of 24 hour-averaged measurements at the Sydney CBD, Rozelle, St Marys and Blacktown from 1996 to 2001
- Ambient Air Quality Monitoring and Fuel Quality Testing Project (AAQMFQTP) where 24 hour-averaged measurements were collected from October 2008 to October 2009 at Turrella and Rozelle.

During the ATMP study, annual and 24 hour-averaged benzene concentrations of 1.4 µg/m^3 and 4.2 µg/m^3 were measured at St Marys respectively. Annual benzene concentrations of 1.4 µg/m^3 were measured at Turrella during the AAQMFQTP study.

Considering these data, the following background concentrations were adopted for the purpose of this assessment. It is noted that the one hour averaged CO background concentration has been approximated using the formula provided in the *AUSPLUME User Manual,* (Victorian Environment Protection Authority) for estimating sub-hourly concentrations from hourly data. The formula was modified to estimate the one hour concentration from the available eight hour averaged data.

Table 3-6 Adopted pollutant background concentrations

Pollutant	Averaging time	Adopted background concentration (100th percentile)
PM_{10}	24 hour	29.4 µg/m^3
	Annual	15.9 µg/m^3
$PM_{2.5}$	24 hour	16.8 µg/m^3
	Annual	8.7 µg/m^3
NO_2	1 hour	68.4 µg/m^3
	Annual	9.0 µg/m^3
CO	1 hour	2.5 mg/m^3
	8 hour	1.7 mg/m^3
VOCs as benzene	1 hour	2.6 µg/m^3

3.3 Nearby receivers

Sensitive receivers surrounding the proposal mostly comprise low-density residential properties. Some commercial premises are also located nearby, particularly around The Northern Road's intersection with Maxwell Street/Bringelly Road. Nearby Schools include Kingswood South Public School, Kingswood High School and Penrith Christian School.

Receivers are closest to the proposal along the northern section of the upgrade between the intersections with Maxwell Street/Bringelly Road and Jamison Road, as well as further south along the western side of the proposal area between the intersection with Aspen Street and around Powys Close. In its present configuration, typical distances from The Northern Road to the first row of receivers along each segment as considered in the operational assessment (Section 6.2) are summarised in Table 3-7.

Table 3-7 Summary of surrounding receivers

Segment	Description	Nearest and typical distances to surrounding receivers (m)
Segment 1	The Northern Road north of Jamison Road	Nearest: Approx. 10 m to the east of the alignment Typical: Approx. 15 m either side (east and west) of the alignment
Segment 2	The Northern Road between Jamison road and Smith Street	Nearest: Approx. 15 m to the west of the alignment Typical: Approx. 20 m either side (east and west) of the alignment
Segment 3	The Northern Road between Smith Street and Maxwell Street	Nearest: Approx. 15 m to the southwest of the alignment Typical: Approx. 20 m either side (northeast and southwest) of the alignment with the Kingswood South Public School around 50 m to the east
Segment 4	The Northern Road between Maxwell Street and Tukara	Nearest: Approx. 15 m to the west of the alignment

Segment	Description	Nearest and typical distances to surrounding receivers (m)
	Road	Typical: Approx. 20 m generally set to the west of the alignment
Segment 5	The Northern Road between Tukara Road and the M4 Motorway	Nearest: Approx. 10m to the west of the alignment Typical: Approx. 40 m to the west of the alignment with the Penrith Christian College around 150 m to the east
Segment 6	The Northern Road between the M4 Motorway and Glenmore Parkway	Nearest: Approx. 40 m to the west Typical: Approx. 70 m either side (east and west) of the alignment
Segment 7	The Northern Road south of Glenmore Parkway	Nearest: Approx. 30 m to the west Typical: Approx. 50 m to the west and more than 100 m to the east

The offset distance from The Northern Road to the surrounding receivers are expected to decrease by up to a distance equivalent to the addition of two new lanes of traffic, or around four to eight metres as a result of the proposal, though it is noted that the alignment would occupy areas of median and/or shift in one direction at different locations along the upgrade route. It is noted that the final design would not result in lanes set at a distance of less than five metres from surrounding receivers, as per the relevant recommended safeguards to be implemented (refer to Section 7).

4. Policy setting

In NSW, emissions to air are controlled by the *Protection of the Environment Operations Act 1997* (POEO Act) and the following regulations:

- Protection of the Environment Operations (Clean Air) Regulation 2010
- Protection of the Environment Operations (General) Regulation 2009, Part 5.4 Air pollution.

The *Approved Methods for Modelling and Assessment of Air pollutants in NSW (Approved methods),* (Department of Environment and Conservation, 2005) provides methods for modelling and assessing emissions to air in NSW. *Technical framework – Assessment and management of odour from stationary sources in NSW (Odour from stationary sources),* (DEC, 2006) provides additional guidance for the assessment and management of odours.

On 25 February 2016 the *Variation to the National Environment Protection (Ambient Air Quality) Measure* entered into force and introduced the new national air quality standards for PM_{10} and $PM_{2.5}$. While all jurisdictions have agreed to this action, no States (including the NSW Environment Protection Authority or Department of Planning & Environment) have prescribed a change to their air quality criteria to be used for the assessment of specific projects. As such, relevant criteria for PM_{10} and $PM_{2.5}$ from both the *Approved Methods* and the variation to the NEPM have been considered as part of this assessment.

5. Criteria

Relevant assessment criteria for the proposal from the *Approved methods* and the recent variation to the NEPM for the primary pollutants associated with the construction and operational of the proposal identified above are presented below in Table 5-1.

Table 5-1 Air quality impact assessment criteria (DEC, 2005)

Pollutant	Averaging time	Criteria	Source
Particulate matter (PM_{10})	24 hours	50 µg/m^3	DEC, 2005
	Annual	30 µg/m^3	DEC, 2005
Particulate matter ($PM_{2.5}$)	24 hours	25 µg/m^3	NEPM
	Annual	8 µg/m^3	NEPM
Total suspended solids (TSP)	Annual	90 µg/m^3	DEC, 2005
Deposited dust	Annual (maximum increase)	2 g/m^2/month	DEC, 2005
	Annual (maximum total)	4 g/m^2/month	DEC, 2005
Carbon monoxide (CO)	15 minutes	100 mg/m^3	DEC, 2005
	1 hour	30 mg/m^3	DEC, 2005
	8 hours	10 mg/m^3	DEC, 2005
Nitrogen dioxide (NO_2)	1 hour	246 µg/m^3	DEC, 2005
	Annual	62 µg/m^3	DEC, 2005
Volatile organic compounds (VOCs) as benzene	1 hour	29 µg/m^3	DEC, 2005

These criteria relate to the 100th percentile (99.9th percentile for benzene), total cumulative concentration of pollutants in the air and not just contributions from project-specific sources. As such, ambient pollutant concentrations determined in Table 3-6 must also be considered when evaluating against these criteria.

From the data presented in Section 3.2.2 it is noted that annual background $PM_{2.5}$ concentrations already exceed the NEPM criteria (8.7 µg/m^3 against 8 µg/m^3).

6. Potential impacts

6.1 Construction

Potential air quality impacts during construction were evaluated using the risk-based approach outlined in Section 2.1. Mitigation measures were recommended based on the estimated initial, unmitigated risk level, with residual risk levels calculated for each phase of construction as outlined in the construction methodology section of the REF. The phases of construction were considered as follows:

- Site establishment including installation of temporary fencing, erosion and sedimentation controls and signage
- Establishment and operation of construction compound sites and storage facilities
- Vegetation clearing, grubbing and removal
- Stripping, stockpiling and management of topsoil and unsuitable materials
- Preparation of subgrade
- Bulk earthworks including placement and compaction of sub-base course and base course
- Construction of pavement and median
- Drainage and utilities work
- Bridge demolition and preparation and installation activities for new bridge structure
- Installation of permanent traffic control signals and road furnishings; line marking and street lights
- Landscaping and demobilisation from the site.

The assessment is presented below in Table 6-1.

As expected, phases involving the handling, disturbance and management of materials were determined to have the highest potential to generate impacts during construction.

Receivers in the direction of prevailing wind conditions from the site (typically blowing from the south to western quadrant, therefore located from the north to east of the proposal) and set close to the site and associated compounds would be most susceptible to dust-related impacts during construction. Measures to protect receivers in the direction of prevailing winds and close to the site is identified as being the most critical air quality-related matter during construction.

Table 6-1 Construction air quality risk assessment

Phase of construction	Potential impacts	Initial risk rating			Recommended mitigation measures	Residual risk rating		
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Site establishment including installation of temporary fencing, erosion and sedimentation controls and signage	• Emissions to air including dust and products of combustion (from equipment operations).	Minor	Unlikely	Low	• Inspecting the plant/equipment prior to start of work. • Conduct routine servicing and maintenance, and subsequent inspections to ensure that equipment continues to operate efficiently.	Insignificant	Unlikely	Low
Establishment and operation of construction compound sites and storage facilities	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces.	Moderate	Likely	High	• Installation of perimeter screening around long-term compound sites. • Impose low speeds limits around compound sites to limit the generation of dust from vehicle movements. • Apply wheel-wash or rumble grid facilities at access points to limit the tracking of materials beyond the site boundary. • Ensure that compound area surfaces are well compacted or sealed to limit the potential for dust generation.	Moderate	Moderate	Moderate
Vegetation clearing, grubbing and removal	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces.	Moderate	Likely	High	• Inspecting the plant/equipment prior to the start of work. • Conduct routine servicing and maintenance, and subsequent inspections to ensure that equipment continues to operate efficiently. • Avoid dry conditions where winds are blowing in the direction from the vegetation clearance area towards nearby receivers. • Install dust monitoring devices to quantify dust levels and determine whether control measures are adequate or whether further actions are required.	Moderate	Moderate	Moderate

Phase of construction	Potential impacts	Initial risk rating			Recommended mitigation measures	Residual risk rating		
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Stripping, stockpiling and management of topsoil and unsuitable materials	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces and stockpiled materials.	Moderate	Likely	High	• Installation of perimeter screening around long-term stockpiling locations. • Regularly water stockpiles. • Wherever possible and practical, limit the amount of materials stockpiled around the site. • Ensure that all loads are covered when materials are being hauled to and from site. • Clean loose materials and debris from the tailgate of vehicles unloading materials to stockpiles prior to departure from site. • Position stockpiling areas as far as possible from surrounding receivers. • Limit stockpiling activities during conditions where winds are blowing strongly in the direction(s) from the stockpiling location to nearby receivers. • Install dust monitoring devices to quantify dust levels and determine whether control measures are adequate or whether further actions are required.	Moderate	Moderate	Moderate

Phase of construction	Potential impacts	Initial risk rating			Recommended mitigation measures	Residual risk rating		
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Excavation and preparation of subgrade	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces. • Dust and debris arising from haulage of materials. • Odours arising from uncovered contaminated and/or hazardous materials. • Mobilisation of uncovered asbestos containing materials (ACM).	Moderate	Moderate	Moderate	• Regular water exposed and disturbed areas especially during inclement weather conditions. • Wherever possible, minimise the extent of disturbed and exposed surfaces, and restore as soon as possible. • Ensure that all loads are covered and any loose materials/debris is removed before departure from site. • Apply wheel-wash or rumble grid facilities as appropriate to removal loose material and prevent the tracking of spoil debris onto local roads. • Apply odour supressing agents to materials as necessary to minimise related impacts should any contaminated or hazardous materials be uncovered during the work. • Wherever possible, stage subgrade preparation activities to limit the overall level of impact during this phase or work. • Install dust monitoring devices to quantify dust levels and determine whether control measures are adequate or whether further actions are required. • Adjust the intensity of activities based on measured dust levels, weather forecasts and the proximity of and direction of the work in relation to the nearest surrounding receivers. • Conduct sampling and testing to identify potentially hazardous materials. Ensure that all asbestos-related activities are conducted by an appropriately licenced person and that all asbestos containing materials are lawfully disposed of.	Moderate	Moderate	Moderate

Phase of construction	Potential impacts	Initial risk rating			Recommended mitigation measures	Residual risk rating		
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Bulk earthworks including placement and compaction of sub-base course and base course	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces. • Dust and debris arising from haulage of materials.	Moderate	Likely	High	• Regular watering of exposed and disturbed areas especially during inclement weather conditions. • Wherever possible, stage subgrade preparation activities to limit the overall level of impact during this phase or work. • Install dust monitoring devices to quantify dust levels and determine whether control measures are adequate or whether further actions are required. • Adjust the intensity of activities based on measured dust levels, weather forecasts and the proximity of and direction of the work in relation to the nearest surrounding receivers. • Ensure that all loads are covered and any loose materials/debris is removed before departure from site. • Impose low speeds limits around compound sites to limit the generation of dust from vehicle movements. • Apply wheel-wash or rumble grid facilities as appropriate to removal loose material and prevent the tracking of spoil debris onto local roads.	Moderate	Moderate	Moderate
Construction of pavement and median	• Emissions to air including dust and products of combustion (from equipment operations). • Windborne dust emanating from disturbed/exposed surfaces. • Dust and debris arising from haulage of materials.	Moderate	Moderate	Moderate	• Adjust the intensity of activities based on measured dust levels, weather forecasts and the proximity of and direction of the work in relation to the nearest surrounding receivers. • Ensure that all loads are covered and any loose materials/debris is removed before departure from site. • Impose low speeds limits around compound sites to limit the generation of dust from vehicle movements.	Minor	Unlikely	Low

Phase of construction	Potential impacts	Initial risk rating			Recommended mitigation measures	Residual risk rating		
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Drainage and utilities work	• Emissions to air including dust and products of combustion (from equipment operations). • Odours arising from uncovered contaminated and/or hazardous materials. • Mobilisation of uncovered asbestos containing materials (ACM).	Minor	Unlikely	Low	• Regular watering of exposed and disturbed areas especially during inclement weather conditions. • Application of odour supressing agents to materials as necessary to minimise related impacts should any contaminated or hazardous materials be uncovered during the work. • Conduct sampling and testing to identify potentially hazardous materials. Ensure that all asbestos-related activities are conducted by an appropriately licenced person and that all asbestos containing materials are lawfully disposed of.	Minor	Unlikely	Low
Demolition of the existing bridge structure and preparation and installation activities for new bridge	• Emissions to air including dust and products of combustion (from equipment operations).	Minor	Unlikely	Low	• Ensure that any material areas associated with this work is secured during project shutdown periods to prevent any dust emanating over the M4 Motorway. • Wet down existing bridge structure during demolition to minimise the generation of dust.	Minor	Rare	Low
Installation of permanent traffic control signals and road furnishings; line marking and street lights	• Emissions to air including dust and products of combustion (from equipment operations). • Fumes associated with painting products and welding activities.	Insignificant	Rare	Low	• Avoid the completion of line marking during inclement weather conditions. • Where possible and practical, install temporary screens around welding activities.	Insignificant	Rare	Low
Landscaping and demobilisation from the site	• Windborne dust emanating from disturbed/exposed surfaces.	Minor	Moderate	Moderate	• Stage work to ensure that finished areas are revegetated as soon as possible. • Regularly maintain and water revegetation areas to aid the establishment of adequate vegetation cover.	Minor	Unlikely	Low

6.2 Operations

Operational air quality impacts were predicted for the following four assessment scenarios using the TRAQ dispersion model, as described in Section 2.2.

- Scenario 1: Existing road, year of opening (2021)
- Scenario 2: Proposed upgrade, year of opening (2021)
- Scenario 3: Existing road, future year (2031)
- Scenario 4: Proposed upgrade, future year (2031).

Predictions for each scenario where made along the seven segments listed below, where traffic conditions change as a result of intersections with other arterial roadways, major street or motorways.

- Segment 1 – The Northern Road north of Jamison Road
- Segment 2 – The Northern Road between Jamison road and Smith Street
- Segment 3 – The Northern Road between Smith Street and Maxwell Street
- Segment 4 – The Northern Road between Maxwell Street and Tukara Road
- Segment 5 – The Northern Road between Tukara Road and the M4 Motorway
- Segment 6 – The Northern Road between the M4 Motorway and Glenmore Parkway
- Segment 7 – The Northern Road south of Glenmore Parkway.

Predicted concentrations for each pollutant of potential concern and each relevant averaging period are displayed below for each segment of scenarios one to four. Results are presented at distances representing the nearest and typical receivers from the project for each segment as presented above in Table 3-7. The first distance in column two relates to distances for the existing road scenarios (i.e. one and three) and the second distance relates to the proposed upgrade scenarios (i.e. two and four).

Tables 6-2 to 6-10 provide results for each pollutant and averaging time as summarised in the following bullets:

- Table 6-2 – Incremental and cumulative results for 24 hour-averaged PM_{10}
- Table 6-3 – Incremental and cumulative results for annually-averaged PM_{10}
- Table 6-4 – Incremental and cumulative results for 24 hour-averaged $PM_{2.5}$
- Table 6-5 – Incremental and cumulative results for annually-averaged $PM_{2.5}$
- Table 6-6 – Incremental and cumulative results for 1 hour-averaged NO_2
- Table 6-7 – Incremental and cumulative results for annually-averaged NO_2
- Table 6-8 – Incremental and cumulative results for 1 hour-averaged CO
- Table 6-9 – Incremental and cumulative results for 8 hour-averaged CO
- Table 6-10 – Incremental and cumulative results for 1 hour-averaged VOC.

For ease of understanding, levels predicted in excess of criteria for the proposal established in Section 5 have been provided in **bold** font.

It is noted that operational air quality changes arising from the proposal along adjoining streets were not deemed as necessary to be assessed owing to the comparatively low volumes of traffic along these streets which would result in roadside air quality levels significantly below the criteria established for the proposal. Regarding changes to traffic along the M4 Motorway resulting from the proposal, these changes in traffic conditions are considered to be minimal and given the distance from the M4 Motorway to the nearest surrounding receivers where extended occupation would reasonably take place, operational air quality-related impacts are not expected

Table 6-2 Background, incremental and cumulative 24 hour-averaged PM_{10} results vs 50 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	29.4	3.4	32.8	29.4	3.6	33	29.4	2.6	32	29.4	4.3	33.7
	Typical: 15/15m		2.9	32.3		3.1	32.5		2.3	31.7		3.7	33.1
2	Nearest:15/10m		2.8	32.2		3.5	32.9		2.1	31.5		4.2	33.6
	Typical: 20/15m		2.3	31.7		3.1	32.5		1.7	31.1		3.6	33
3	Nearest:15/10m		2.9	32.3		3.6	33		2.2	31.6		4.3	33.7
	Typical: 20/15m		2.4	31.8		3.1	32.5		1.8	31.2		3.8	33.2
4	Nearest:15/10m		3.6	33		4.7	34.1		3	32.4		5.5	34.9
	Typical: 20/15m		2.9	32.3		4.1	33.5		2.5	31.9		4.8	34.2
5	Nearest:10/10m		4.8	34.2		5.3	34.7		4	33.4		6	35.4
	Typical: 40/40m		2.4	31.8		2.7	32.1		2	31.4		3.1	32.5
6	Nearest: 40/40m		2.2	31.6		2.8	32.2		2.2	31.6		3.1	32.5
	Typical: 70/70m		1.6	31		2	31.4		1.6	31		2.3	31.7
7	Nearest: 30/25m		2.1	31.5		3	32.4		2.8	32.2		3.8	33.2
	Typical: 50/50m		1.6	31		2.1	31.5		0.6	30		1	30.4

Table 6-3 Background, incremental and cumulative annually-averaged PM_{10} results vs 30 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	15.9	1.4	17.3	15.9	1.4	17.3	15.9	1	16.9	15.9	1.7	17.6
	Typical: 15/15m		1.2	17.1		1.2	17.1		0.9	16.8		1.5	17.4
2	Nearest:15/10m		1.2	17.1		1.4	17.3		0.9	16.8		1.6	17.5
	Typical: 20/15m		1	16.9		1.2	17.1		0.7	16.6		1.4	17.3
3	Nearest:15/10m		1.2	17.1		1.4	17.3		0.9	16.8		1.8	17.7
	Typical: 20/15m		1	16.9		1.2	17.1		0.8	16.7		1.5	17.4
4	Nearest: 15/10m		1.5	17.4		1.9	17.8		1.2	17.1		2.2	18.1
	Typical: 20/15m		1.2	17.1		1.7	17.6		1	16.9		1.9	17.8
5	Nearest:10/10m		1.9	17.8		2.1	18		1.6	17.5		2.4	18.3
	Typical: 40/40m		0.9	16.8		1.1	17		0.7	16.6		1.3	17.2
6	Nearest:40/40m		0.9	16.8		1	16.9		0.8	16.7		1.3	17.2
	Typical: 70/70m		0.6	16.5		0.8	16.7		0.6	16.5		0.9	16.8
7	Nearest:30/25m		0.9	16.8		1.3	17.2		0.8	16.7		1.6	17.5
	Typical: 50/50m		0.7	16.6		0.8	16.7		0.6	16.5		1	16.9

Table 6-4 Background, incremental and cumulative 24 hour-averaged $PM_{2.5}$ results vs 25 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	16.8	3.4	20.2	16.8	3.6	20.4	16.8	2.6	19.4	16.8	4.3	21.1
	Typical: 15/15m		2.9	19.7		3.1	19.9		2.3	19.1		3.7	20.5
2	Nearest:15/10m		2.8	19.6		3.5	20.3		2.1	18.9		4.2	21
	Typical: 20/15m		2.3	19.1		3.1	19.9		1.7	18.5		3.6	20.4
3	Nearest:15/10m		2.9	19.7		3.6	20.4		2.2	19		4.3	21.1
	Typical: 20/15m		2.4	19.2		3.1	19.9		1.8	18.6		3.8	20.6
4	Nearest: 15/10m		3.6	20.4		4.7	21.5		3.4	20.2		5.5	22.3
	Typical: 20/15m		2.9	19.7		4.1	20.9		3	19.8		4.8	21.6
5	Nearest:10/10m		4.8	21.6		5.3	22.1		4	20.8		6	22.8
	Typical: 40/40m		2.4	19.2		2.7	19.5		2	18.8		3.1	19.9
6	Nearest:40/40m		2.2	19		2.8	19.6		2.2	19		3.1	19.9
	Typical: 70/70m		1.5	18.3		2	18.8		1.6	18.4		2.3	19.1
7	Nearest:30/25m		2.1	18.9		3	19.8		2.8	19.6		3.8	20.6
	Typical: 50/50m		1.6	18.4		2.1	18.9		1.6	18.4		2.7	19.5

Table 6-5 Background, incremental and cumulative annually-averaged $PM_{2.5}$ results vs 8 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	8.7	1.4	**10.1**	8.7	1.4	**10.1**	8.7	1	**9.7**	8.7	1.7	**10.4**
	Typical: 15/15m		1.2	**9.9**		1.2	**9.9**		0.9	**9.6**		1.5	**10.2**
2	Nearest:15/10m		1.2	**9.9**		1.4	**10.1**		0.9	**9.6**		1.6	**10.3**
	Typical: 20/15m		1	**9.7**		1.2	**9.9**		0.7	**9.4**		1.4	**10.1**
3	Nearest:15/10m		1.2	**9.9**		1.4	**10.1**		0.9	**9.6**		1.8	**10.5**
	Typical: 20/15m		1	**9.7**		1.2	**9.9**		0.8	**9.5**		1.5	**10.2**
4	Nearest: 15/10m		1.5	**10.2**		1.9	**10.6**		1.2	**9.9**		2.2	**10.9**
	Typical: 20/15m		1.2	**9.9**		1.7	**10.4**		1	**9.7**		1.9	**10.6**
5	Nearest:10/10m		1.9	**10.6**		2.1	**10.8**		1.6	**10.3**		2.4	**11.1**
	Typical: 40/40m		0.9	**9.6**		1.1	**9.8**		0.7	**9.4**		1.3	**10**
6	Nearest:40/40m		0.9	**9.6**		1	**9.7**		0.8	**9.5**		1.3	**10**
	Typical: 70/70m		0.6	**9.3**		0.8	**9.5**		0.6	**9.3**		0.9	**9.6**
7	Nearest:30/25m		0.9	**9.6**		1.3	**10**		0.8	**9.5**		1.6	**10.3**
	Typical: 50/50m		0.7	**9.4**		0.8	**9.5**		0.6	**9.3**		1	**9.7**

Table 6-6 Background, incremental and cumulative 1 hour-averaged NO_2 results vs 246 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	68.4	10.1	78.5	68.4	11	79.4	68.4	6.2	74.6	68.4	9.7	78.1
	Typical: 15/15m		9.8	78.2		10.7	79.1		6	74.4		9.4	77.8
2	Nearest:15/10m		7.8	76.2		8.6	77		4.4	72.8		7.4	75.8
	Typical: 20/15m		7.5	75.9		8.5	76.9		4.3	72.7		7.3	75.7
3	Nearest:15/10m		8.7	77.1		9.8	78.2		5.3	73.7		8.3	76.7
	Typical: 20/15m		8.4	76.8		9.7	78.1		5.1	73.5		8.2	76.6
4	Nearest: 15/10m		10.4	78.8		11.9	80.3		6.6	75		10.6	79
	Typical: 20/15m		10	78.4		11.8	80.2		6.3	74.7		10.4	78.8
5	Nearest:10/10m		11.8	80.2		12.8	81.2		7.4	75.8		11	79.4
	Typical: 40/40m		7.7	76.1		8.9	77.3		4.9	73.3		7.6	76
6	Nearest:40/40m		8.4	76.8		10.6	79		5.9	74.3		9.1	77.5
	Typical: 70/70m		6	74.4		7	75.4		4.2	72.6		6.5	74.9
7	Nearest:30/25m		7.8	76.2		10.8	79.2		7.1	75.5		10.2	78.6
	Typical: 50/50m		5.8	74.2		7.4	75.8		4.4	72.8		7.2	75.6

Table 6-7 Background, incremental and cumulative annually-averaged NO_2 results vs 62 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	9	2	11	9	2.2	11.2	9	1.2	10.2	9	2	11
	Typical: 15/15m		1.9	10.9		2.1	11.1		1.2	10.2		1.9	10.9
2	Nearest:15/10m		1.6	10.6		1.7	10.7		0.9	9.9		1.4	10.4
	Typical: 20/15m		1.5	10.5		1.6	10.6		0.8	9.8		1.4	10.4
3	Nearest:15/10m		1.7	10.7		2	11		1.1	10.1		1.6	10.6
	Typical: 20/15m		1.6	10.6		1.9	10.9		1	10		1.6	10.6
4	Nearest: 15/10m		2.1	11.1		2.4	11.4		1.4	10.4		2.1	11.1
	Typical: 20/15m		2	11		2.3	11.3		1.3	10.3		2.1	11.1
5	Nearest:10/10m		2.4	11.4		2.6	11.6		1.5	10.5		2.2	11.2
	Typical: 40/40m		1.5	10.5		1.7	10.7		0.9	9.9		1.5	10.5
6	Nearest:40/40m		1.7	10.7		2.2	11.2		1.2	10.2		1.8	10.8
	Typical: 70/70m		1.2	10.2		1.6	10.6		0.8	9.8		1.3	10.3
7	Nearest:30/25m		1.6	10.6		2.1	11.1		1.2	10.2		2	11
	Typical: 50/50m		1.2	10.2		1.5	10.5		0.8	9.8		1.4	10.4

Table 6-8 Background, incremental and cumulative 1 hour-averaged CO results vs 30 mg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	2.5	0.4	2.9	2.5	0.4	2.9	2.5	0.2	2.7	2.5	0.4	2.9
	Typical: 15/15m		0.3	2.8		0.3	2.8		0.2	2.7		0.4	2.9
2	Nearest:15/10m		0.2	2.7		0.2	2.7		0.2	2.7		0.2	2.7
	Typical: 20/15m		0.2	2.7		0.2	2.7		0.2	2.7		0.2	2.7
3	Nearest:15/10m		0.3	2.8		0.4	2.9		0.2	2.7		0.4	2.9
	Typical: 20/15m		0.2	2.7		0.3	2.8		0.2	2.7		0.3	2.8
4	Nearest: 15/10m		0.3	2.8		0.4	2.9		0.2	2.7		0.4	2.9
	Typical: 20/15m		0.2	2.7		0.3	2.8		0.2	2.7		0.3	2.8
5	Nearest:10/10m		0.4	2.9		0.4	2.9		0.2	2.7		0.4	2.9
	Typical: 40/40m		0.2	2.7		0.2	2.7		0.2	2.7		0.2	2.7
6	Nearest:40/40m		0.4	2.9		0.4	2.9		0.4	2.9		0.4	2.9
	Typical: 70/70m		0.2	2.7		0.2	2.7		0.2	2.7		0.4	2.9
7	Nearest:30/25m		0.2	2.7		0.4	2.9		0.2	2.7		0.4	2.9
	Typical: 50/50m		0.2	2.7		0.2	2.7		0.2	2.7		0.3	2.8

Table 6-9 Background, incremental and cumulative 8 hour-averaged CO results vs 10 mg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	1.7	0.2	1.9	1.7	0.2	1.9	1.7	0.2	1.9	1.7	0.4	2.1
	Typical: 15/15m		0.2	1.9		0.2	1.9		0.2	1.9		0.3	2
2	Nearest:15/10m		0.2	1.9		0.2	1.9		0.1	1.8		0.2	1.9
	Typical: 20/15m		0.2	1.9		0.2	1.9		0	1.7		0.2	1.9
3	Nearest:15/10m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
	Typical: 20/15m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
4	Nearest: 15/10m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
	Typical: 20/15m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
5	Nearest:10/10m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
	Typical: 40/40m		0.2	1.9		0.2	1.9		0	1.7		0.2	1.9
6	Nearest:40/40m		0.2	1.9		0.2	1.9		0.2	1.9		0.4	2.1
	Typical: 70/70m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9
7	Nearest:30/25m		0.2	1.9		0.2	1.9		0.2	1.9		0.3	2
	Typical: 50/50m		0.2	1.9		0.2	1.9		0.2	1.9		0.2	1.9

Table 6-10 Background, incremental and cumulative 1 hour-averaged VOC results vs 29 µg/m³ criterion

Segment	Receiver	Scenario 1 – Existing road (2021)			Scenario 2 – Proposed upgrade (2021)			Scenario 3 – Existing road (2031)			Scenario 4 – Proposed upgrade (2031)		
		Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative	Background	Road contribution	Cumulative
1	Nearest:10/10m	2.6	0.4	3	2.6	0.4	3	2.6	0.2	2.8	2.6	0.4	3
	Typical: 15/15m		0.3	2.9		0.3	2.9		0.2	2.8		0.4	3
2	Nearest:15/10m		0.3	2.9		0.4	3		0.2	2.8		0.4	3
	Typical: 20/15m		0.2	2.8		0.3	2.9		0.2	2.8		0.4	3
3	Nearest:15/10m		0.3	2.9		0.4	3		0.2	2.8		0.4	3
	Typical: 20/15m		0.2	2.8		0.3	2.9		0.2	2.8		0.4	3
4	Nearest: 15/10m		0.3	2.9		0.4	3		0.3	2.9		0.6	3.2
	Typical: 20/15m		0.3	2.9		0.4	3		0.2	2.8		0.5	3.1
5	Nearest:10/10m		0.5	3.1		0.5	3.1		0.4	3		0.6	3.2
	Typical: 40/40m		0.2	2.8		0.2	2.8		0.2	2.8		0.3	2.9
6	Nearest:40/40m		0.2	2.8		0.2	2.8		0.2	2.8		0.4	3
	Typical: 70/70m		0.2	2.8		0.2	2.8		0.2	2.8		0.2	2.8
7	Nearest:30/25m		0.2	2.8		0.2	2.8		0.2	2.8		0.4	3
	Typical: 50/50m		0.2	2.8		0.2	2.8		0.2	2.8		0.2	2.8

A summary of the maximum results for each scenario, including the contribution to these cumulative concentrations from vehicle emissions is displayed below.

Table 6-11 Summary of maximum cumulative pollutant concentrations and road contributions for each assessment scenario

Pollutant	Averaging time	Criteria	Scenario 1 – Existing road (2021)		Scenario 2 – Proposed upgrade (2021)		Scenario 3 – Existing road (2031)		Scenario 4 – Proposed upgrade (2031)	
			Cumulative	Road cont. (%)	Cumulative	Road cont. (%)	Cumulative	Road cont. (%)	Cumulative	Road cont. (%)
PM_{10}	24 hour	50 µg/m^3	34.2 µg/m^3	14 %	34.7 µg/m^3	15 %	33.4 µg/m^3	12 %	35.4 µg/m^3	17 %
	Annual	30 µg/m^3	17.8 µg/m^3	11 %	18.0 µg/m^3	12 %	17.5 µg/m^3	9 %	18.3 µg/m^3	13 %
$PM_{2.5}$	24 hour	25 µg/m^3	21.6 µg/m^3	22 %	22.1 µg/m^3	24 %	20.8 µg/m^3	19 %	22.8 µg/m^3	26 %
	Annual	8 µg/m^3	10.6 µg/m^3	18 %	10.8 µg/m^3	19 %	10.3 µg/m^3	16 %	11.1 µg/m^3	22 %
NO_2	1 hour	246 µg/m^3	80.2 µg/m^3	15 %	81.2 µg/m^3	16 %	75.8 µg/m^3	10 %	79.4 µg/m^3	14 %
	Annual	62 µg/m^3	11.4 µg/m^3	21 %	11.6 µg/m^3	22 %	10.5 µg/m^3	14 %	11.2 µg/m^3	20 %
CO	1 hour	30 mg/m^3	2.9 mg/m^3	14 %	2.9 mg/m^3	14 %	2.9 mg/m^3	14 %	2.9 mg/m^3	14 %
	8 hour	10 mg/m^3	1.9 mg/m^3	11 %	1.9 mg/m^3	11 %	1.9 mg/m^3	11 %	2.1 mg/m^3	11 %
VOC	1 hour	29 µg/m^3	3.1 µg/m^3	16 %	3.1 µg/m^3	16 %	3 µg/m^3	13 %	3.2 µg/m^3	19 %

The predicted near-roadside concentrations due to vehicle emissions indicate the following:

- Criteria for PM_{10}, NO_2, CO and VOCs are expected to be met at surrounding nearby receivers for all four assessment scenarios
- $PM_{2.5}$ 24 hour averaged criterion was also predicted to be met at the nearest receivers for each of the four assessment scenarios.
- $PM_{2.5}$ annual criterion was predicted to be exceeded along each segment for each assessment scenario. This is a result of the adopted annual $PM_{2.5}$ background concentration (8.7 µg/m^3) already exceeding the eight µg/m^3 criterion. However, comparisons between the predicted concentrations for the upgrade and no upgrade options were very similar, indicating that the upgrade would not change annually averaged roadside $PM_{2.5}$ concentrations from current conditions.
- Changes between predicted roadside pollutant concentrations for existing road and upgrade scenarios for the same point in time (i.e. 2021 year of opening and 2031 design year) are minimal.
- Contributions to overall cumulative concentrations for both existing road and upgrade scenarios comprise of around 11 to 26 % with overall concentrations dominated by background concentrations.

As such, for the year of opening (2021) and design year (2031) time frames assessed and based on the presently available data, any changes in local air quality at surrounding receivers from the proposed upgrade will be small and within the existing range of air quality variations within the area provided that final design does not result in lanes set at a distance of less than five metres from surrounding receivers.

7. Safeguards and management measures

The following safeguards and management measures have been developed to specifically manage potential impacts which have been predicted as a result of the proposed work. These measures should be incorporated into relevant Environmental Management Plans (EMPs) during construction and operations.

Table 7-1 Recommended safeguards and management measures

Impact	Environmental safeguard	Responsibility	Timing
Excessive exhaust emissions arising from plant and equipment	Ensure that plant and equipment operates in a proper and efficient manner by: • Inspecting the plant/equipment prior to the start of work. • Conduct routine servicing and maintenance, and subsequent inspections to ensure that equipment continues to operate efficiently.	Construction Contractor	Prior to and routinely during construction.
Dust emissions arising from compound and stockpiling locations	• Installation of perimeter screening around long-term compound sites. • Impose low speed limits around compound sites to limit the generation of dust from vehicle movements. • Apply wheel-wash or rumble grid facilities at access points to limit the tracking of materials beyond the site boundary. • Ensure that compound area surfaces are well compacted or sealed to limit the potential for dust generation. • Regularly water stockpiles. • Wherever possible and practical, limit the amount of materials stockpiled around the site. • Position stockpiling areas as far as possible from surrounding receivers. • Limit stockpiling activities during conditions where winds are blowing strongly in the direction(s) from the stockpiling location to nearby receivers.	Construction Contractor	During construction
Dust emissions arising from materials haulage	• Impose low speed limits across all site haulage routes and abide by road speed limits along public roads. • Ensure that all loads are covered when materials are being hauled to and from site. • Clean loose materials and debris from the tailgate of vehicles prior to departure from site. • Wherever possible, position internal haulage routes away from surrounding receivers.	Construction Contractor	During construction
Dust emissions arising from earthwork, vegetation clearance, bridge and pavement construction activities.	• Regular watering of exposed and disturbed areas especially during inclement weather conditions. • Wherever possible, minimise the extent of disturbed and exposed surfaces, and restore as soon as possible. • Adjust the intensity of activities based on measured dust levels, weather forecasts and the proximity of and direction of the work in relation to the nearest surrounding receivers. • Ensure that any material exposed areas are secured during project shutdown periods to prevent any dust emanating over the M4 Motorway.	Construction Contractor	During construction
Odours arising from uncovered contaminated and/or hazardous materials.	• Application of odour supressing agents to materials as necessary to minimise related impacts should any contaminated or hazardous materials be uncovered during the work.	Construction Contractor	During construction

Impact	Environmental safeguard	Responsibility	Timing
Mobilisation of uncovered asbestos containing materials (ACM).	Conduct sampling and testing to identify potentially hazardous materials. Ensure that all asbestos-related activities are conducted by an appropriately licenced person and that all asbestos containing materials are lawfully disposed of.	Construction Contractor	During construction
Windborne dust emanating from non-vegetated surfaces	• Stage work to ensure that finished areas are revegetated as soon as possible. • Regularly maintain and water revegetation areas to aid the establishment of adequate vegetation cover.	Construction Contractor	During construction
Dust emissions emanating beyond the proposal area	• Install depositional dust gauges to quantify dust levels and determine whether control measures are adequate or whether further actions are required. • These gauges should be installed at regular intervals along the project alignment at representative receiver locations. Gauges should also be installed around major construction compound and stockpiling locations.	Construction Contractor	During construction
Fumes associated with line marking and other activities	• Avoid line marking during inclement weather conditions. • Where possible and practical, install temporary screens around welding areas.	Construction Contractor	During construction
Roadside air quality during operations	• Post-construction traffic measurements should be collected to verify that traffic volumes and characteristics are not materially different from the forecast numbers considered in this assessment. • Where material differences are identified, further assessment should be completed to confirm that the level of impacts remain consistent with the predictions of this study.	Roads and Maritime Services	Post-construction
Roadside air quality during operations	• Ensure that the alignment in the final design of the proposal does not result in lanes less than 5 metres from surrounding receivers.	Roads and Maritime Services	Detailed design

8. Conclusion

An assessment was completed to evaluate potential air quality impacts associated with the construction and operational phases of a proposed upgrade of The Northern Road between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith.

To identify and assess potential impacts during construction a qualitative, risk-based assessment was carried out. Considering the risk matrix tool presented in *Environmental risk management procedure ILC-ES-TP0-416*, (NSW Roads and Traffic Authority, October 2006), initial unmanaged risk ratings of 'high' were determined for several phases of construction including:

- Establishment and operation of construction compound sites and storage facilities
- Vegetation clearing, grubbing and removal
- Stripping, stockpiling and management of topsoil and unsuitable materials
- Bulk earthworks including placement and compaction of sub-base course and base course.

Receivers close to the proposal and in the direction of prevailing wind conditions from the site (were identified as being most susceptible to dust-related impacts during construction.

A variety of different mitigation and management measures were recommended including appropriate work practices and scheduling, equipment selection, monitoring and preventative controls; and residual ratings were calculated. 'Moderate' risk ratings remained for several phases of construction including those above, indicating that careful management of emissions to air will be required during these particular periods of construction.

Impacts to air quality at surrounding receivers as a result of the operation of the proposed upgrade were evaluated by quantitative modelling, using the TRAQ CALINE-based dispersion model. Predictions from this assessment indicated that for the time frames assessed, any changes in local air quality at surrounding receivers from the proposed upgrade will be small and within the existing range of air quality variations within the area. The proposed upgrade is not expected to result in unacceptable pollutant concentration levels at surrounding receivers, provided that final design does not result in lanes set at a distance of less than five metres from surrounding receivers. Post-construction traffic monitoring to verify that traffic volumes and characteristics are not materially different from the forecast numbers assessed was proposed to confirm that levels and resulting outcomes remain consistent with the predictions of this study.

9. References

NSW Roads and Traffic Authority 2006, Environmental risk management procedure ILC-ES-TP0-416.

Pacific Environment Limited 2015, Western Sydney Airport Draft Environmental Impact Statement Volume 4 Appendix F1 Local air quality and greenhouse gas.

NSW EPA 2005, Approved methods for the modelling and assessment of air pollutants in New South Wales.

National Environment Protection Council 2016, Variation to the National Environment Protection (Ambient Air Quality) Measure.

Victorian Environment Protection Authority 2000, AUSPLUME Gaussian Plume Dispersion Model Technical User Manual.