Environment
Effects Statement

Attachment VI
Works Approval Application



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Attachment VI

Works Approval Application

Executive summary

Overview

North East Link is a proposed new freeway standard road connection that would complete the missing link in Melbourne's metropolitan ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include upgrades to the Eastern Freeway. The project would also support the provision of a range of complementary and associated works, separate from the project. The project includes twin tunnels with associated tunnel ventilation systems. The tunnel ventilation system would include two ventilation structures located in the vicinity of the northern portal, located at Blamey Road, and the southern tunnel portal, located south of the Veneto club. The emergency smoke exhaust system would consist of exhaust points at the northern and southern portals as well as an emergency smoke discharge structure at the Manningham Road Interchange.

The *Scheduled Premises Regulations* under the *Environment Protection Act 1970* (EP Act) specify that road tunnel ventilation systems are scheduled activities under Schedule 1, L03 of the regulations. Therefore, a Works Approval is required prior to the construction of the North East Link tunnel ventilation system.

It should be noted that this Works Approval Application is limited specifically to the approval of the tunnel ventilation system. A Works Approval from EPA Victoria is not required for the other elements of the reference project.

The Minister for Planning has determined that an Environment Effects Statement (EES) is required for North East Link. The project would be delivered in line with the Environmental Performance Requirements (EPRs) developed and exhibited as part of the EES. A number of these EPRs are relevant to this Works Approval Application as they relate to the tunnel ventilation system. This performance-based approach aims to achieve acceptable outcomes for the community and environment, while providing a delivery model with sufficient flexibility to encourage innovation and address specific challenges and issues.

Project definition

The project definition for North East Link includes the following key concepts:

- Environmental Performance Requirements
- Reference Project
- Variations.

Influenced by the environmental assessments undertaken, EPRs have been developed to satisfy environmental standards and any other requirements for the construction and operation of the project contained in legislation, policy or the scoping requirements.

The Reference Project is a concept design that demonstrates a feasible way for the project to achieve the Victorian Government's objectives and the EPRs. It has been used in this Works Approval Application to demonstrate the project's feasibility and ability to achieve acceptable outcomes. It provides a basis for assessing the expected potential environmental risks and impacts, while recognising that the project could be configured differently.

The Reference Project may not be the design ultimately adopted for the project. Firms tendering to construct and/or operate the project may offer variations to its scope, design or route alignment that deliver better value for money or that incorporate innovative approaches in design, technology operations or financial structuring that are not considered in the Works Approval Application. However, these variations would need to comply with the conditions on any applicable Works Approval decisions and the EPRs set out in the EES.

The final detailed design of the ventilation system, prepared by the successful tender would be subject to EPA's review to assess compliance against the EPRs and the conditions of the specific project approvals.

Relevant environmental considerations

The Works Approval Application considers the following key environmental aspects with regard to the tunnel ventilation system:

- Greenhouse gas emissions
- Air quality
- Noise and vibration
- Climate change.

The Works Approval Application also provides a detailed discussion to demonstrate that the proposed project reflects best practice.

Other environmental aspects such as surface water, groundwater, land and waste would be considered as part of the EES as they are not related to the tunnel ventilation system which is the subject of this Works Approval Application. Similarly, greenhouse gas emissions, air quality, noise and vibration and climate change impacts associated with the project both including and beyond the tunnel ventilation system are considered as part of the EES.

Stakeholder and community engagement

A wide range of engagement activities and communication tools have been used to support engagement on North East Link and to provide the best opportunities for stakeholders and the community to be involved in the consultation process.

The stakeholder and community responses which are specific to the ventilation system include concerns about visual impacts, emissions and air quality and noise impacts in the immediate and surrounding areas which include residences, schools community clubs and facilities, parklands, wetlands and a retirement village.

The feedback received from the community and stakeholders throughout the engagement process directly informed the investigations undertaken by technical specialists for the project and design development for the Reference Project.

Land use planning

The northern ventilation structure is located on Commonwealth Land, which is not subject to the provisions of Victoria planning schemes. The emergency smoke discharge structure and southern ventilation structure are located on land within the municipality of Manningham and are subject to the Manningham Planning Scheme. A range of planning provisions and potential planning permit requirements are associated with the tunnel ventilation structures.

Based on the strategic significance of the project, a planning scheme amendment is considered to be the most appropriate approval mechanism to facilitate the use and development of land for North East Link in an integrated and consistent manner across all affected planning schemes.

Forming part of the suite of documents which comprise the draft planning scheme amendment are an Incorporated Document and associated Specific Controls Overlay (SCO) which introduce project-specific planning controls. An Incorporated Document is a commonly used planning approvals tool in major Victorian transport (and other) infrastructure projects which has the effect of 'switching off' permit triggers subject to the project meeting a range of specified conditions. The planning scheme amendment also proposes the introduction of a Design and Development Overlay (DDO) that would be applied to the tunnel alignment to protect tunnel infrastructure assets from incompatible development.

Application of best practice

Sources of emissions or discharges to the environment must be managed in accordance with 'best practice' as set out in the relevant State Environment Protection Policies (SEPPs).

In determining what constitutes best practice for a certain activity or industry sector, EPA Publication 1517.1 puts forward the defining elements of best practice to be considered when interpreting requirements and provides guidance on how to demonstrate compliance with these elements of best practice.

All of the relevant defining best practice elements from the EPA publication 1517.1 have been addressed for the proposed project. This includes the use of preventative measures for environmental management through an environmental risk assessment and the development of EPRs, undertaking all practicable measures with regard to proportionality and cost-effectiveness, and the consideration of local and international evidence of best practice measures in similar projects.

Climate change

To assess the climate change risks relevant to North East Link, including the potential impact of climate change on tunnel ventilation, and potential adaptation measures for risks considered high and significant, a Climate Risk Workshop (the workshop) was held. The workshop brought together 25 North East Link Project and Technical Adviser personnel working across the project.

The most significant climate risks identified with a potential to impact on tunnel ventilation systems were power failure in the tunnels due to extreme heat or wind, rendering the ventilation system inoperable and potential damage to ventilation structures from extreme rainfall. Adaptation measures have been considered to reduce the impact of both these risks. They include both design considerations and future contingencies. As the project moves through to detailed design there may be an opportunity to also consider adaptation measures for medium and low risks.

Greenhouse gas and energy use

An assessment of greenhouse gas emissions and energy use for the North East Link tunnel ventilation system was conducted. Factors and methods used to estimate emissions were taken from the *National Greenhouse Accounts Factors* 2018 (NGA Factors) and the National Greenhouse and Energy Reporting Measurement Determination (NGER Measurement Determination). These are recognised nationally as guidance documents in the development of greenhouse gas inventories.

For the purpose of the Works Approval Application, the greenhouse gas assessment was required to consider the energy use and greenhouse gas emissions associated with the scheduled activity, the operation of the tunnel ventilation system. Emissions from some other activities associated with the operation of the tunnels such as lighting, dewatering and the operation of signs were also included in the greenhouse gas assessment. Other activities such as maintenance activities and embodied emissions in raw materials were assessed but are not included in the scope of the Works Approval Application as they do not relate to the operation of the ventilation system.

The assessment results indicate that the operation of the ventilation system would generate 74 kt CO_2-e per annum of scope two emissions and 7 kt CO_2-e per annum of scope three emissions. These emissions are generated through the consumption of electricity.

It is noted that this represents the maximum operational emissions associated with the tunnel ventilation system. It is anticipated that actual emissions would be reduced through the application of best practice as outlined in the EPRs.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to greenhouse gas and energy use, Works Approval conditions of the West Gate Tunnel have required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> ...
> *(d) the tunnel ventilation and lighting systems, showing compliance with best practice requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'*
> ..."

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision.

As such, an updated evaluation of best practice would be undertaken during the detailed design phase to confirm that the contractor's design meets the requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'.

Air quality

An air quality assessment for North East Link tunnel ventilation system was conducted. The operational impact of emissions to air was assessed using the approved regulatory model AERMOD for the tunnel ventilation structures. The model inputs were characterised by using traffic modelling data and converting this information to total emissions with reference to vehicle emissions factors developed from the COPERT Australia road transport air pollutant emission inventory model and 2020 future year factors from PIARC. Three uniform Cartesian receptor grids were used with all gridded receptor points input at ground level. An additional 191 sensitive receptors were modelled based on those identified in the EES social impact assessment.

Emissions from the tunnel ventilation structures were shown to comply with relevant air quality criteria for normal operation. While $PM_{2.5}$ and PM_{10} exceeded air quality criteria, this was determined to be a result of high background concentrations, with the tunnel ventilation structures making a small contribution to ground level concentrations.

Sensitivity analysis was conducted based on the following scenarios:

- Maximum lane capacity, 24 hours per day, 365 days per year
- Emissions at in-tunnel air quality limits
- Increased diesel to petrol fuelled car ratios – doubled portion of diesel fuelled cars
- Alternative ventilation structure locations in the immediate vicinity of the reference project location
- 2025 future year adjusted vehicle emission rates.

Sensitivity analyses demonstrated no change in compliance for the scenarios modelled.

The use of conservative assumptions around traffic forecasts and air modelling means that the predicted ground level pollutant concentrations and associated air quality impacts in the report are likely to be overestimated.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to air quality, Works Approval conditions of the West Gate Tunnel have required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> *(a) the tunnel ventilation system and exhaust stacks, showing measures to be taken to ensure compliance with State environment protection policy (Air Quality Management) and ensure impacts are equivalent to or less than the Reference Project assessed for this Works Approval;*
> *…"*

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision.

As such, further air quality assessment is likely to be required during the detailed design phase to confirm that the contractor's design, including the final location of ventilation structures, is compliant with the relevant air quality criteria.

An air quality monitoring plan has been developed for ambient air quality post project completion, continuous emission monitoring from ventilation structures, ventilation structure verification testing, and in-tunnel air quality monitoring.

Noise and vibration

A noise and vibration assessment for the reference project North East Link tunnel ventilation system was conducted. The potential noise and vibration impacts during operation, including operation of the tunnel ventilation system, were assessed. Technical investigations were undertaken to determine the existing environmental conditions and background noise levels by undertaking attended and unattended noise monitoring.

Modelling predicts that the noise from the ventilation system with the proposed silencers would comply with the requirements of *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1* (SEPP N-1). SEPP N-1 provides for the establishment of noise limits based on background noise levels.

It was concluded that tunnel ventilation noise can achieve compliance with SEPP N-1 through conventional means such as selection of suitable equipment and attenuation measures.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to noise, Works Approval conditions of the West Gate Tunnel have required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> ...
> *(d) the tunnel ventilation system, showing measures to be taken to ensure compliance with the State environment protection policy (Control of Noise from Commerce, Industry and Trade) No. N-1"*

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision.

As such, additional noise modelling would be undertaken during the detailed design phase to confirm that the contractor's design is compliant the SEPP N-1 requirements. Noise monitoring would be conducted post commissioning of the ventilation system to demonstrate operational compliance with SEPP N-1 requirements.

Environmental management

North East Link environmental impacts during construction and operation would be managed in accordance with the North East Link Project Environmental Management Framework (EMF), incorporating EPRs. Contractors would be required to develop environmental management documents including a Construction Environmental Management Plan (CEMP), an Operation Environmental Management Plan (OEMP) and Worksite Environmental Management Plans (WEMPs) that address potential environmental impacts and requirements of the EMF, including EPRs.

1 Introduction

1.1 Background

This Works Approval Application, prepared in accordance with Environment Protection Act 1970 (Vic) (EP Act) is for the tunnel ventilation system which would form a component of North East Link.

The tunnel ventilation system is designed to:

- Protect the safety and health of motorists using the tunnels during normal operation, heavy traffic conditions and emergency conditions
- Allow the air quality inside and outside the tunnels to meet the air quality criteria relevant to the project, as determined by EPA Victoria
- Allow the tunnels to be operated in a safe, effectively controlled and managed manner, including during major and minor incidents
- Minimise the consumption of energy and other resources, whilst protecting the safety and health of motorists and meeting applicable air quality criteria inside and outside the tunnels.

The tunnel ventilation system would include two ventilation structures each 40 metres in height and located in the vicinity of the tunnel portals near the Blamey Road interchange and the Bulleen Oval (west of Bulleen Road). Each ventilation structure would include an emissions outlet. The emergency smoke exhaust system would consist of exhaust points at the northern portal, the Manningham Road interchange and at the southern portal. These structures would be designed in accordance with EPA Victoria requirements, and the urban design strategy for the project.

Other components of North East Link are subject to separate regulatory and planning assessment and approval processes.

1.1.1 Applicant details

Applicant details	
Applicant name	North East Link Project, a division of the Major Transport Infrastructure Authority, an administrative office in relation to the Department of Transport.
ABN	69 981 208 782
ACN	-
Registered Address	Level 14, 121 Exhibition Street, Melbourne, VIC 3000
CEO	Duncan Elliott

In the last 10 years, North East Link Project has not been found guilty of one or more relevant offences, as defined in the *EP Act*, and is therefore a fit and proper person for the purposes of Section 20C(3)(b) of the Act.

1.1.2 Project value and application fee

The cost of North East Link is estimated at $15.6 billion with an application fee of $65,025 payable to EPA Victoria.

1.1.3 Requirement for Works Approval

The *Scheduled Premises Regulations* under the *EP Act* specify that road tunnel ventilation systems are scheduled activities under Schedule 1, L03 of the regulations. Therefore, a Works Approval is required prior to the construction of the North East Link tunnel ventilation system.

The *Environment Protection Act 2017* (the 2017 Act) was passed in October 2017 and the *Environment Protection Amendment Act 2018*, which amends the 2017 Act, was passed in August 2018. The amended 2017 Act is intended to commence on 1 July 2020. This Works Approval Application is to be determined under the *EP Act*. However, future licencing of the tunnel ventilation system would be under the amended 2017 Act.

This Works Approval Application is for a Reference Project – the concept design which demonstrates the project's feasibility and ability to achieve acceptable outcomes. The Reference Project may not be the exact design ultimately adopted for the project.

In previous similar projects, EPA Victoria has applied approval conditions to account for possible changes made by the successful tenderer to the design which could impact upon the environment.

In the Works Approval for the West Gate Tunnel ventilation system, the following condition WA_W1 was applied:

> *Before commencing construction of the following components of the works, you must provide to EPA Victoria with a report or reports with the plans and specifications of those components, including details of:*
> *(a) the tunnel ventilation system and exhaust stacks showing measures to be taken to ensure compliance with State environment protection policy (Air Quality Management) and ensure impacts are equivalent to or less than the design assessed for this Works Approval;*
> *(d) the tunnel ventilation and lighting systems, showing compliance with best practice requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'; and*
> *(e) the tunnel ventilation system, showing measures to be taken to ensure compliance with the State environment protection policy (Control of Noise from Commerce, Industry and Trade) No. N-1.*

It is anticipated that for the North East Link tunnel ventilation system, EPA would apply a similar approach of using approval conditions to accommodate for potential changes to the design.

This Works Approval Application is supported by the following technical reports:

- 14 Air quality impact assessment
- Appendix A Air quality monitoring plan
- Appendix B Noise impact assessment.

An environmental discharge licence from EPA Victoria would be required before the tunnel ventilation system could operate. This licence would be applied for at a later stage.

1.2 Approvals context

1.2.1 Overall North East Link approvals

At the same time that this Works Approval Application has been prepared, North East Link has been undergoing environmental assessment under the *Environment Effects Act 1978 (Vic)*. In December 2017, the Minister for Planning determined that an Environment Effects Statement (EES) is required for North East Link. The EES has been prepared in response to the Minister's decision requiring an EES and the Scoping Requirements issued by the Minister to set out specific matters to be investigated and documented in the EES.

Additionally, a Cultural Heritage Management Plan (CHMP) has been prepared in accordance with the requirements of *Aboriginal Heritage Act 2006 (Vic)* in parallel with the preparation of the EES.

North East Link is a 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act) because of the potential for significant impact on matters of national environmental significance and on the environment of Commonwealth Land, requiring assessment and approval under the *EPBC Act*. EPBC approval is being sought through the preparation of a Public Environment Report (PER) that is being exhibited in parallel to the EES and this Works Approval Application.

The principal approvals for North East Link under Victorian legislation are:

- Works Approval and licence under the *EP Act* (this application)
- Amendments to the Banyule, Boroondara, Manningham, Nillumbik, Whitehorse, Whittlesea and Yarra Planning Schemes under the *Planning and Environment Act 1987 (Vic)* (PE Act).

Figure 1.1 shows the relationships between the principal approvals, including this Works Approval Application for the tunnel ventilation system, and other major North East Link approvals.

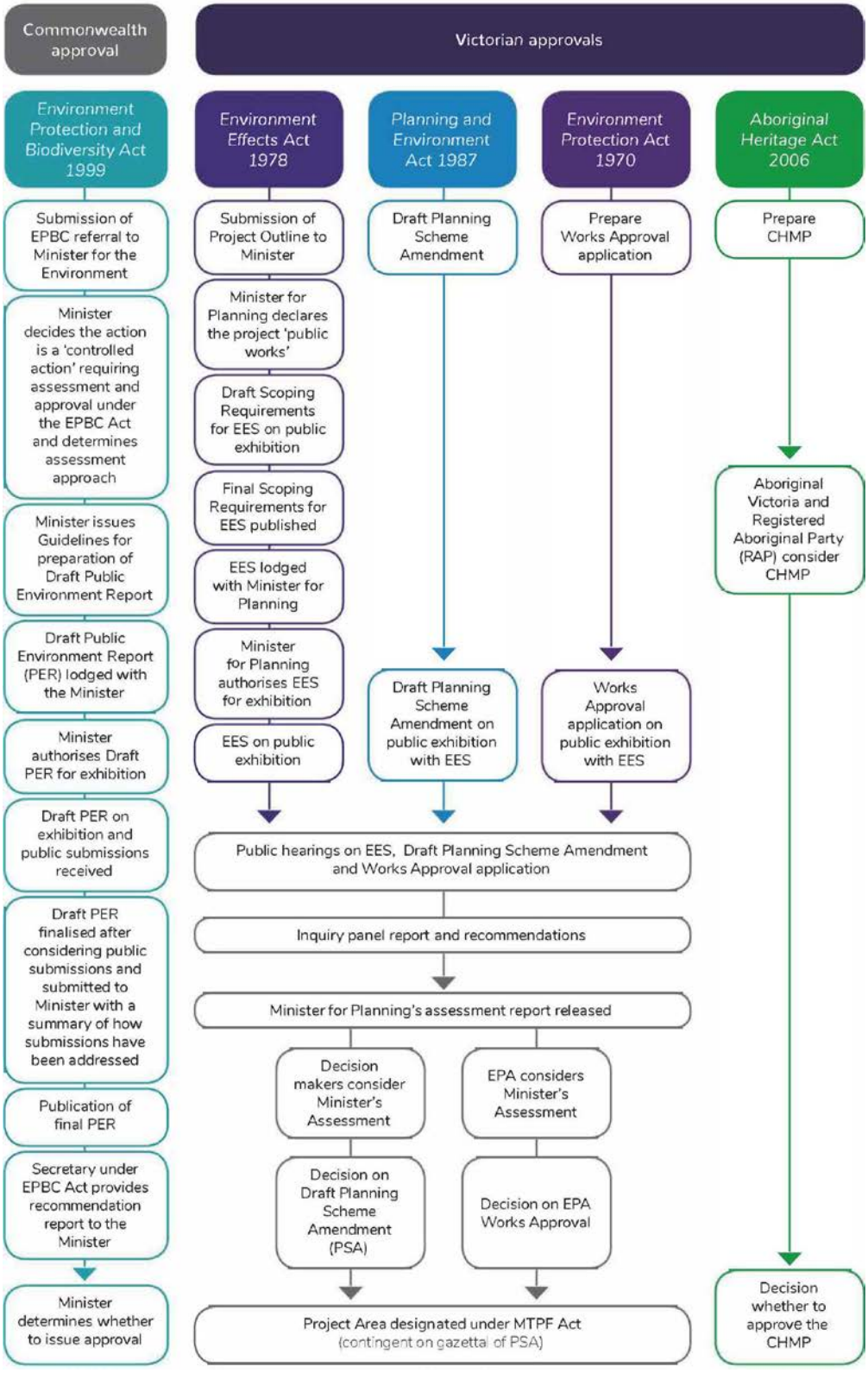


Figure 1.1 North East Link key approvals processes

A number of secondary approvals would be required under Victorian legislation for North East Link, although these are not directly related to the Works Approval Application for the tunnel ventilation system. These secondary approvals are:

- Permits for impacts to places on the Victorian Heritage Register and consents for impacts to places on the Victorian Heritage Inventory under the *Heritage Act 2017 (Vic)*
- Consent for works on freeways and arterial roads declared under the under the *Road Management Act 2004 (Vic)*
- Permits to take protected species from public lands or, in some circumstances, private lands and permits to remove protected or threatened species in the project boundary under the *Flora and Fauna Guarantee Act 1988 (Vic)*
- Authorisation to remove fauna habitat under the *Wildlife Act 1975 (Vic)*
- Various licences for works near waterways, the construction of groundwater bores or the extraction of water under the *Water Act 1989 (Vic)*
- Approval to occupy crown land under the *Crown Land (Reserves) Act 1978 (Vic)* has been achieved following the designation of the project area under the *Major Transport Projects Facilitation Act 2009 (Vic)*.

1.3 Project delivery approach

The project would be delivered in line with the Environmental Performance Requirements (EPRs) developed and exhibited as part of the EES. This performance-based approach aims to achieve acceptable outcomes for the community and environment, while providing a delivery model with sufficient flexibility to encourage innovation and address specific challenges and issues.

Compliance with the EPRs would be required via commercial delivery mechanisms that place clear obligations on contractors and through the Environmental Management Framework (EMF) developed for the project. Compliance with the EPRs would also be mandated by the planning scheme amendment for the project and specifically the Incorporated Document.

The Independent Environmental Auditor would audit of the project proponent's compliance with the EMF, including EPRs.

An ongoing community engagement program allows issues to be identified and managed promptly and appropriately during all phases of the project. A description of this program is provided in Section 4.

2 Project definition

This section describes the overall North East Link alignment and key elements for project context. However, the scheduled premises for which this Works Approval Application seeks approval from EPA Victoria is the road tunnel ventilation system, and not the overall North East Link project.

2.1 Project description

North East Link is a proposed new freeway standard road connection that would complete the missing link in Melbourne's metropolitan ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include upgrades to the Eastern Freeway. The project would also support the provision of a range of complementary and associated works, separate from the project.

The following section describes the North East Link alignment and the project elements:

- **M80 Ring Road to the northern portal** – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at M80 Ring Road and Grimshaw Street.
- **Northern portal to southern portal** – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnels would then continue to the southern portal located south of the Veneto Club.
- **Eastern Freeway** – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and provision of new dedicated bus lanes for the Doncaster Busway. There would also be provision of a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

These areas are illustrated in Figure 2.1 on the following page.

The project would also improve existing bus services from Doncaster Road to Hoddle Street through the Doncaster Busway as well as pedestrian connections and the bicycle network with connected walking and cycling paths from the M80 Ring Road to the Eastern Freeway.

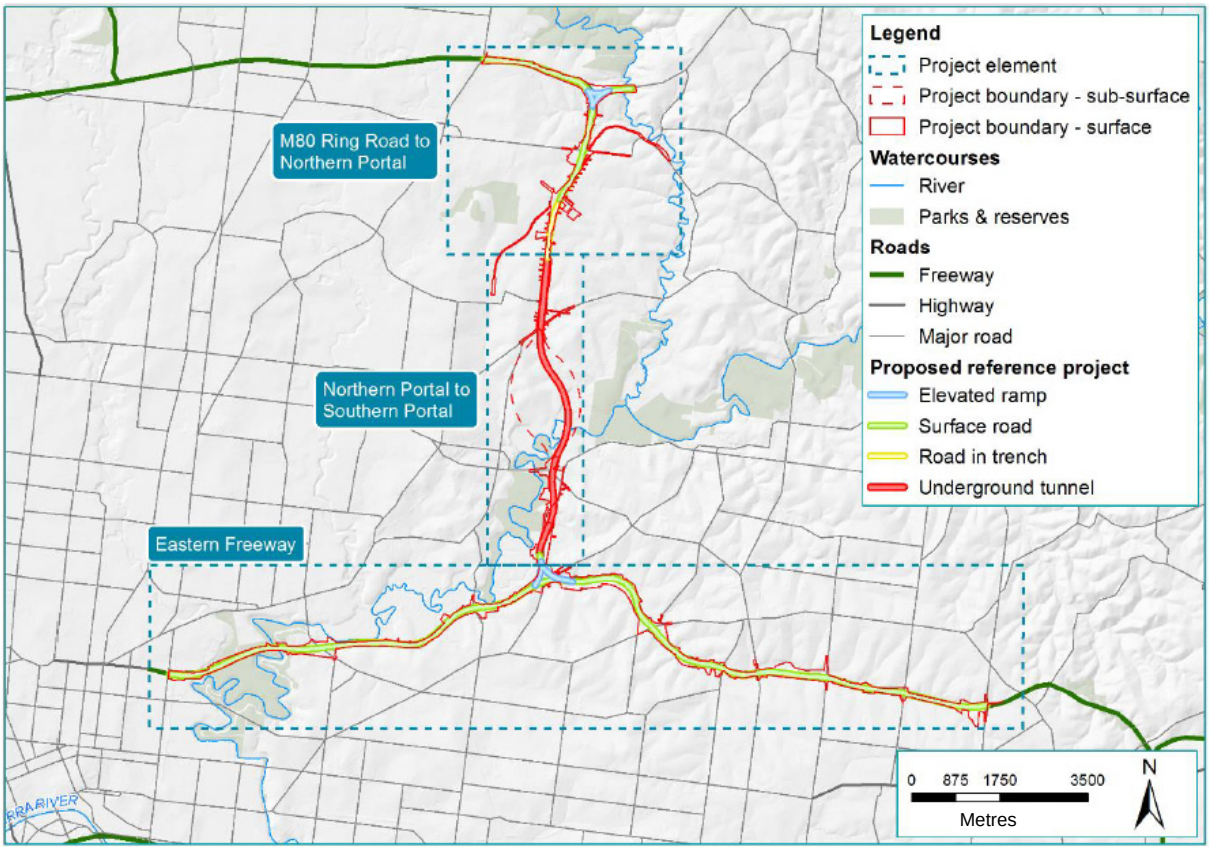


Figure 2.1 Overview of North East Link

The tunnel ventilation system locations are illustrated in Figure 2.2.

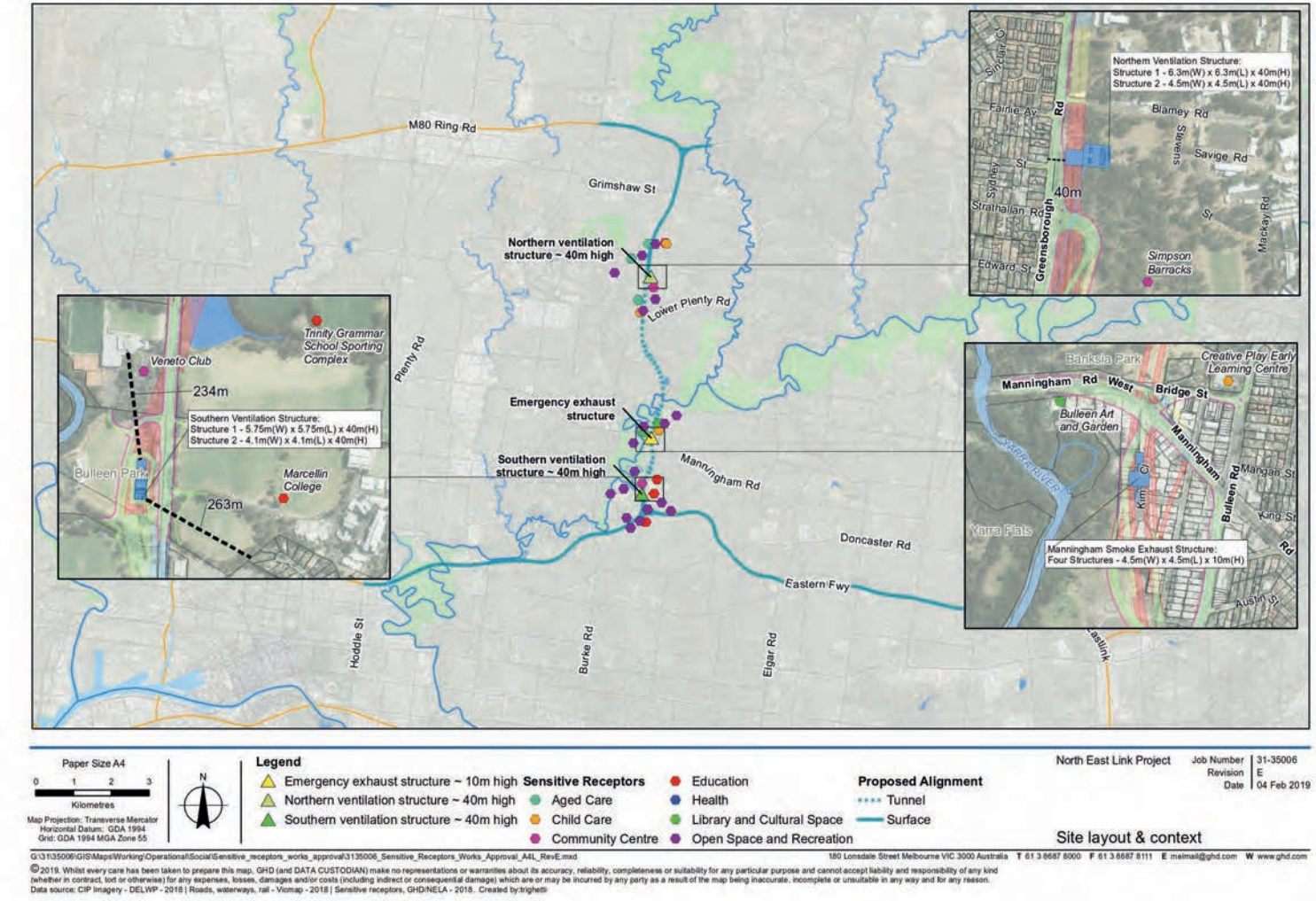


Figure 2.2 Tunnel ventilation structure locations

2.1.1 Project tunnels

This section provides further details on the tunnels which are serviced by the tunnel ventilation system.

North East Link includes approximately six kilometre twin tunnels from Blamey Road through to near the Veneto Club. At their deepest point, the top of the tunnels would be approximately 40 metres underground, in the vicinity of Sevenoaks Avenue in Heidelberg.

The twin tunnels would be designed and operated with three traffic lanes in each direction and have a vertical clearance of 4.9 metres. Over-dimensional vehicles exceeding this height and placarded vehicles would not be permitted to use the tunnels. Lanes would be 3.5 metres wide with a 1.0 metre left shoulder and 0.5 metre right shoulder.

A speed limit would be posted with an overhead lane use management system and signage to manage opening and closing lanes as required, to optimise traffic flows, respond to incidents, or allow tunnel maintenance.

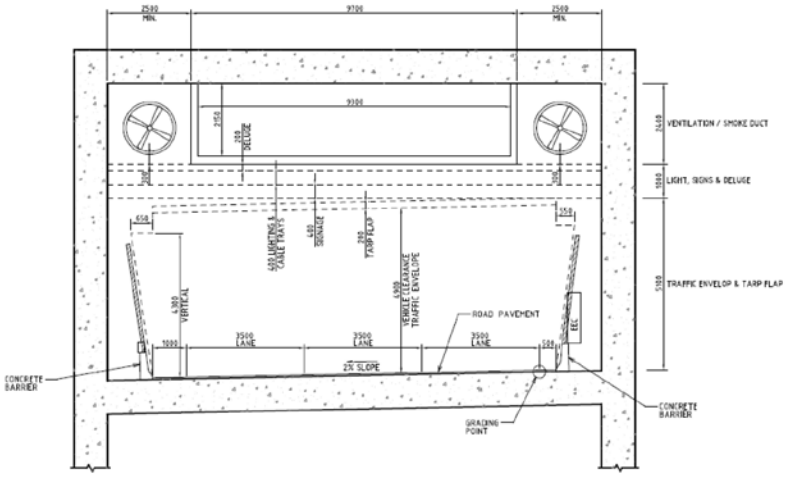
The bored tunnels would have 16 metres between them and cross passages with a vertical clearance of 2.1 metres would connect the two tunnels at a spacing of approximately 120 metre intervals.

Tunnels would have ancillary infrastructure, such as electricity supply, water treatment, and the tunnel ventilation system.

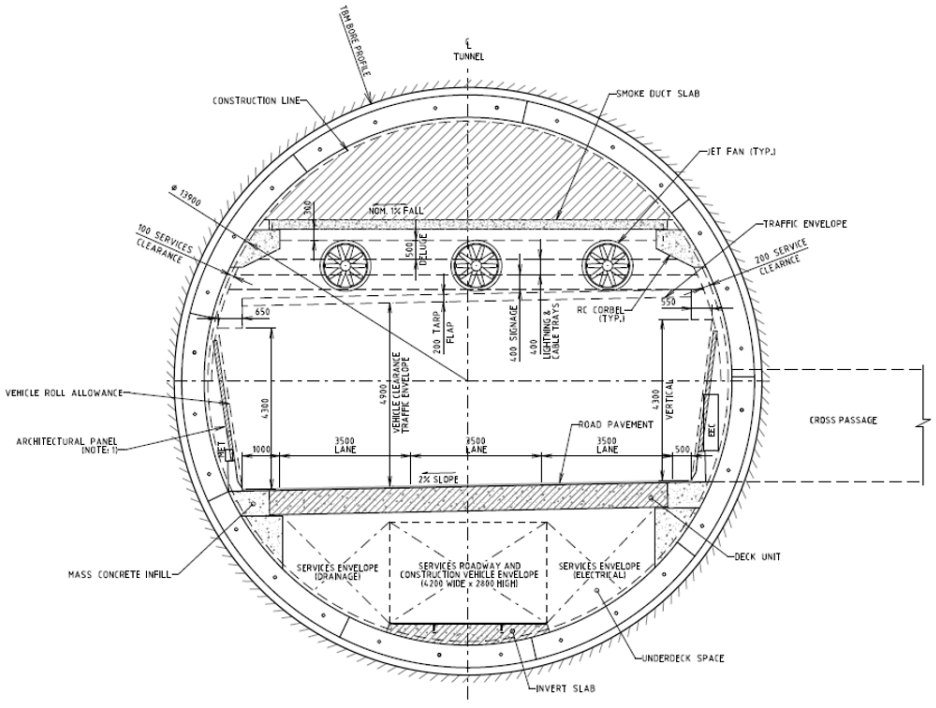
Tunnels for the project would be constructed with three techniques which reflect their shape and dimensions. These types of tunnels are:

- Cut and cover – 2.7 kilometres in length located over in the following areas:
  - Blamey Road to Lower Plenty Road
  - Bridge Street to just north of Golden Way
  - Rocklea Road to Bulleen Oval
- Bored – 3.0 kilometres in length located from Lower Plenty Road to Bridge Street
- Mined – 400 metres in length located from Avon Street to Rocklea Road.

Figure 2.3 on the following page shows typical cross-sections of the cut and cover, bored and mined tunnels.



TYPICAL CUT & COVER TUNNEL CROSS SECTION



TYPICAL BORED TUNNELS CROSS SECTION

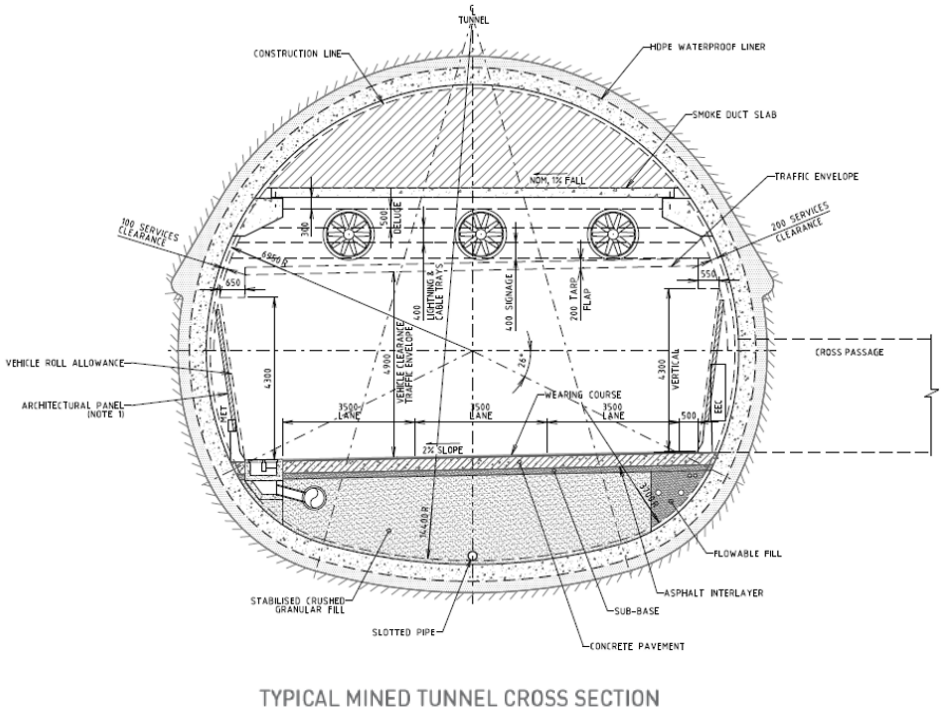


Figure 2.3 Typical cross-section of cut and cover, bored and mined tunnels

2.1.2 Project boundary

The North East Link project boundary encompasses all areas that would be used for permanent structures and temporary construction areas (both above and below ground). It provides the basis for the specialist assessments undertaken for this Works Approval application and has been refined through the EES process.

The project boundary is shown in Figure 2.1.

2.2 Proposed activities

2.2.1 Construction

Key construction activities for North East Link are as follows:

- General earthworks including topsoil removal, clearing and grubbing vegetation
- Relocation, adjustment or installation of new utility services
- Construction of retaining walls and diaphragm walls including piling
- Ground treatment to stabilise soils

- Tunnel portal and dive shaft construction
- Storage and removal of spoil
- Construction of cross passages, ventilation structures and access shafts
- Installation of drainage and water quality treatment facilities
- Installation of a Freeway Management System
- Tunnel construction using TBMs, mining and cut and cover techniques
- Installation of noise barriers
- Restoration of surface areas.

2.2.2 Operation

Following construction of North East Link, the key operation phase activities would include:

- Operation and maintenance of new road infrastructure
- Operation and maintenance of Freeway Management System
- Operation and maintenance of the tolling system
- Operation of North East Link motorway control centre
- Operation and maintenance of the tunnel ventilation system
- Operation and maintenance of water treatment facilities
- Operation and maintenance of the motorways power supply (substations)
- Maintenance of landscaping and Water Sensitive Urban Design (WSUD) features.

2.2.3 Climate change adaptation

A climate change assessment was done as part of the development of the North East Link Reference Project. For the design of North East Link and its tunnel ventilation system, the key climate change adaptation activities identified are:

- Consideration of backup electricity supply or redundancy to maintain critical systems in the event of an outage
- Ensuring that there are two sources of electricity to the tunnel ventilation system, one at either end of the tunnels to provide redundancy
- Key electrical substations being located above the 1 in 2000 AEP flood level
- Consideration of the impacts of climate change (ie increased rainfall intensity and sea-level rise) in flood modelling and drainage design

- Consideration of redundancies such as ‘safe-to-fail’ areas in flood modelling and drainage design
- Location of key equipment inside of the tunnels with the tunnel entrances protected by flood barriers.

During the operation of North East Link, the key climate change adaptation activities identified are:

- Enactment of emergency management procedures and tunnel management systems in collaboration with emergency services.

2.3 Receiving environment

2.3.1 Sensitive receptors

The EES social impact assessment identified a number of community facilities which represent sensitive receptors in proximity to North East Link as a whole. A list of these sensitive receptors is given in Appendix F. These sensitive receptors include, but are not limited to, schools, kindergartens, aged care facilities, hospitals, childcare centres and recreational areas. Figure 2.4 shows the locations of these sensitive receptors in relation to the ventilation structures, which have been marked. It is noted that many of the sensitive receptors marked in Figure 2.4 are not in close proximity to the ventilation structures.

Residential areas are also considered sensitive receptors.

The closest sensitive receptors to the northern ventilation structure are between 130 and 150 metres of the proposed location. These closest receptors include the residential area within Simpson Barracks to the east and the residential area of Macleod to the north and west.

The closest sensitive receptors to the southern ventilation structure are approximately 140 metres from the proposed location. These closest receptors include the Carey Grammar Sports Complex, Veneto Club and Marcellin College.

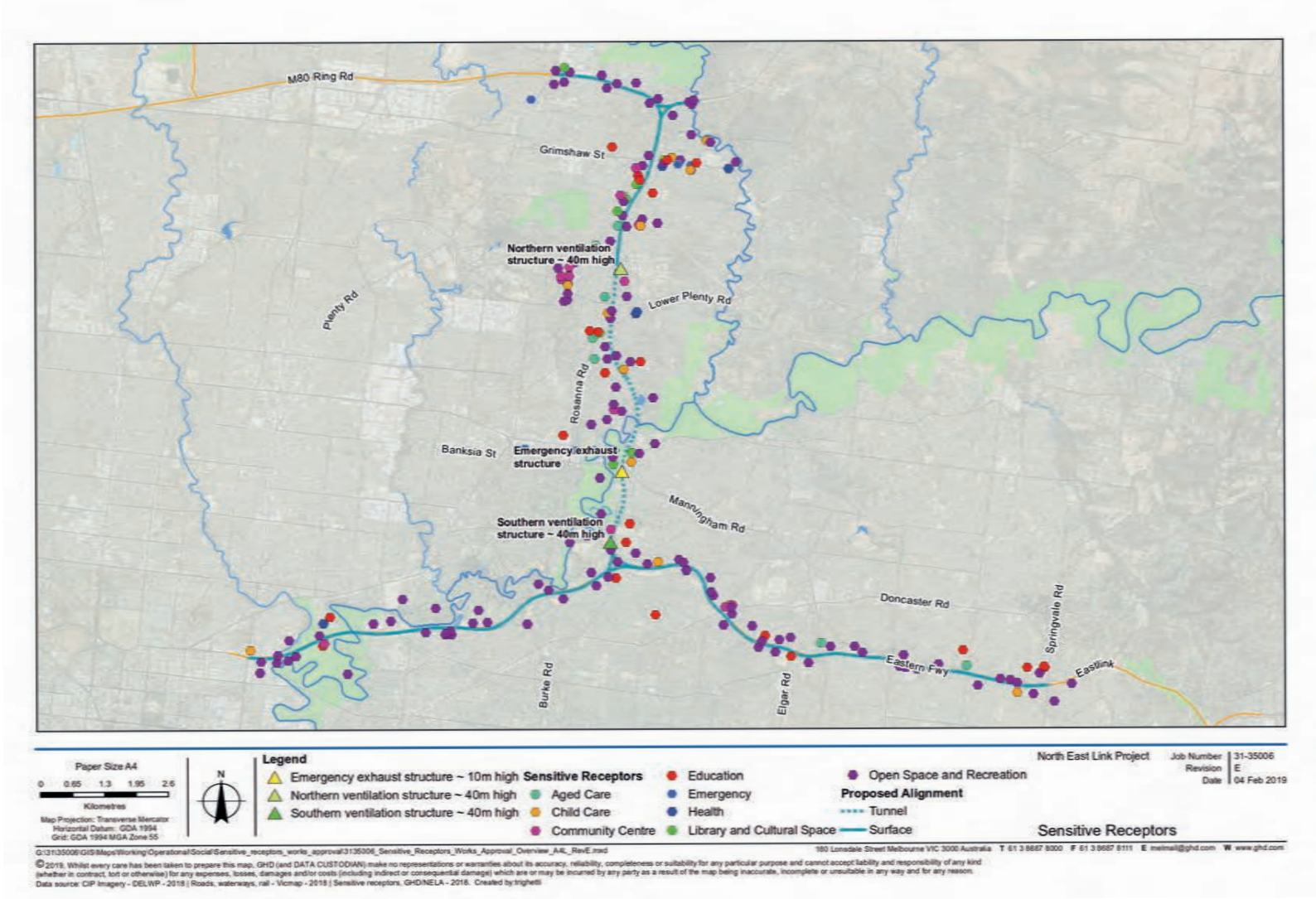


Figure 2.4 Sensitive receptors

2.3.2 Topography

The landform surrounding the M80 Ring Road is relatively undulating with the Plenty Gorge Parklands ranging in elevation between approximately 100 metres and 50 metres above sea level. Similarly, the undulating landscape around the Plenty River and Partington Flats in Greensborough has hills and flats with the lowest elevations occurring along the course of the river. Moving south, Watsonia North, Watsonia and Yallambie are approximately 80 metres above sea level. The land gently slopes towards the Warringal Parklands and Yarra Flats where the elevation can be as low as 10 metres.

The Eastern Freeway is also located at low elevations; ranging between 20 metres at the intersection with Bulleen Road and increasing to 40 metres at Doncaster Road and continuing to increase to 80 metres at the intersection with Springvale Road. The land either side of the freeway increases in elevation with the broad landform being that the road is located in low lying lands between the hills of Doncaster and Box Hill.

The Doncaster Busway between Bulleen Road and Hoddle Street would be located on consistent elevations in the order of 20 metres. The land adjoining the freeway increases in elevation on both sides, except for Yarra Bend Park and the area between Chandler Highway and Burke Road where the land to the north of the road consists of golf courses and river flats.

A topographical map of the area surrounding North East Link is shown in Figure 2.5.

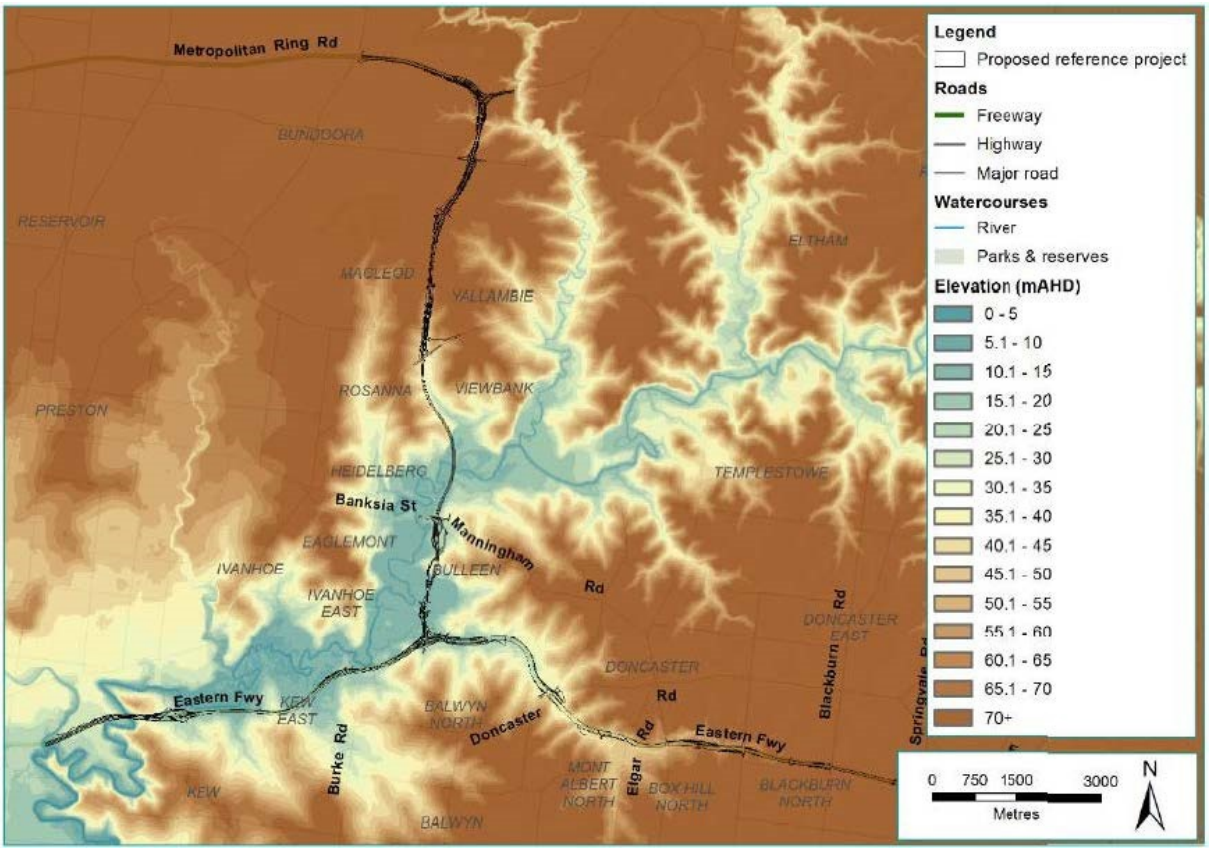


Figure 2.5 North East Link topography

3 Relevant environmental considerations

3.1 Beneficial uses

3.1.1 Air

The *State Environment Protection Policy (Air Quality Management)* (SEPP (AQM)) identifies the following beneficial uses of the air environment relevant to this project:

- Life, health and well-being of humans
- Life, health and well-being of other forms of life, including the protection of ecosystems and biodiversity
- Local amenity and aesthetic enjoyment
- Visibility.

Section 10 of this document addresses the air quality assessment for North East Link.

3.1.2 Noise

The *State Environment Protection Policy (Control of Noise from Industry, Commerce and Trade) No. N-1* (SEPP N-1) identifies normal domestic and recreational activities including, in particular, sleep in the night period as protected beneficial uses.

Section 11 of this document addresses the noise and vibration assessment for North East Link.

3.1.3 Greenhouse gas

The SEPP (AQM) identifies climate systems that are consistent with human development, the life, health and well-being of humans and the protection of ecosystems and biodiversity as a beneficial use.

Section 9 of this document addresses the greenhouse gas assessment for North East Link.

3.1.4 Climate change

Section 17 of the *Climate Change Act 2017* specifies that decision makers must have regard to climate change for a decision made or action taken that is authorised by the provision of an Act specified in Schedule 1. This includes the issue of a Works Approval by EPA Victoria under Section 19B of the EP Act.

Under the *Climate Change Act 2017*, relevant considerations for a person making a decision or taking an action in regard to the potential impacts of climate change are:

- Potential biophysical impacts
- Potential long and short term economic, environmental, health and other social impacts
- Potential beneficial and detrimental impacts
- Potential direct and indirect impacts
- Potential cumulative impacts.

Relevant considerations in regard to the potential contribution to the state's greenhouse gas emissions are:

- Potential short-term and long-term greenhouse gas emissions
- Potential direct and indirect greenhouse gas emissions
- Potential increases and decreases in greenhouse gas emissions
- Potential cumulative impacts of greenhouse gas emissions.

The potential impacts of climate change relevant to the North East Link tunnel ventilation system are summarised in Section 8. The most significant climate risks identified with a potential to impact on tunnel ventilation system were power failure in the tunnels due to extreme heat or wind, rendering the ventilation system inoperable and potential damage to ventilation structures from extreme rainfall. Adaptation measures have been considered to reduce the impact of both of these risks, including both design considerations and future contingencies.

The potential contribution to Victoria's greenhouse gas emissions of the North East Link tunnel ventilation system are summarised in Section 9. The assessment found that the predicted annual operational greenhouse gas emissions from North East Link are equivalent to 0.07 per cent of the current annual emissions from Victoria.

Section 8 of this document addresses the climate change assessment for North East Link.

3.2 Principles of the *Environment Protection Act 1970*

It is considered that the inclusion of the tunnels in North East Link is consistent with the principles of the *EP Act*. While there are acknowledged environmental impacts associated with the construction and operation of the tunnels, these are outweighed by the benefits to the environment and sensitive receptors associated with avoiding a similar length of surface roadway.

The relevant principles of the *EP Act* are reproduced below with a brief discussion (*in italic*) against each of these elements, explaining how the proposed project addresses the principles.

1B Principle of integration of economic, social and environmental considerations

1 Sound environmental practices and procedures should be adopted as a basis for ecologically sustainable development for the benefit of all human beings and the environment.

2 This requires the effective integration of economic, social and environmental considerations in decision making processes with the need to improve community well-being and the benefit of future generations.

3 The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.

The supporting assessments for this Works Approval Application have considered the potential social and environmental impacts of the project. Feedback from the community engagement process has informed the technical assessments and overall design development. In the consideration of environmental matters, all practicable measures have undertaken to achieve best practice. Part (3) of the principle has also been addressed through the evaluation of management practices for proportionality and cost-effectiveness.

1C The precautionary principle

1 If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

2 Decision making should be guided by—

a a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable; and

b an assessment of the risk-weighted consequences of various options.

Throughout the environmental assessment process, a risk-based approach has been adopted. The identification of significant potential environmental impacts of this project has been guided by an environmental risk assessment, which has informed and been informed by the development of EPRs. Moreover, the North East Link tunnel ventilation system implements best practice environmental protection measures in air quality, noise management, and greenhouse gas and energy efficiency (see Section 6).

1D Principle of intergenerational equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

The environmental assessments completed for the North East Link tunnel ventilation system and summarised in this Works Approval Application have identified the measures required to mitigate significant environmental impacts of the development such that environmental health, diversity and productivity are maintained for future generations. The project is considered necessary to meet the transport needs of future generations.

1E Principle of conservation of biological diversity and ecological integrity

The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.

The siting of the ventilation structures is such that they are unlikely to have significant impacts upon local flora, fauna or ecosystems. Furthermore, the air emissions related to the tunnel ventilation structures are expected to be within the SEPP limits and thus not have significant impacts on nearby ecology.

1I Principle of wastes hierarchy

Wastes should be managed in accordance with the following order of preference:

a Avoidance

b Re-use

c Re-cycling

d Recovery of energy

e Treatment

f Containment

g Disposal.

The minimisation and appropriate management of waste during North East Link construction and operation in accordance with the waste management hierarchy is included as a project EPR (SCC4). Compliance with this and other EPRs would be mandated and enforced through the contractual arrangements established between the Victorian Government and contractors appointed for delivery of the project (see Section 12 for further information). The ventilation system does not produce solid waste.

1J Principle of integrated environmental management

If approaches to managing environmental impacts on one segment of the environment have potential impacts on another segment, the best practicable environmental outcome should be sought.

The technical assessments which support this Works Approval Application have sought to balance the potential impacts of the project on various segments of the environment in order to produce the best practicable environmental outcome. For example, while the tunnel ventilation system uses energy, ventilation system operation results in better environmental outcomes when compared to the uncontrolled release of emissions from the tunnels. Moreover, at a project level, the operation of the tunnels and related infrastructure, including the tunnel ventilation system, is considered to result in better environmental outcomes than the operation of an equivalent surface road.

1L Principle of accountability

1 The aspirations of the people of Victoria for environmental quality should drive environmental improvement.

2 Members of the public should therefore be given:

   a access to reliable and relevant information in appropriate forms to facilitate a good understanding of environmental issues

   b opportunities to participate in policy and program development.

Stakeholder consultation completed during environmental assessments for North East Link have provided members of the public with access to information about the tunnel ventilation systems, as well as the project as a whole, in a variety of forms. The general public has also been given the opportunity to comment on North East Link, with the comments informing project design and EPRs. Section 4 summarises the engagement activities, feedback received and responses to feedback.

3.3 Other considerations

A human health impact assessment has been undertaken as part of the EES process.

The scope of the health impact assessment was determined to meet the relevant scoping requirements of the EES and was undertaken in a manner consistent with health impact assessments undertaken for similar major roadway projects in Australia, and discussions with the Victorian Environment Protection Authority (EPA) and the Department of Health and Human Services (DHHS).

The focus of the health impact assessment was to assess both the benefits and/or impacts to the local community and users of the project.

The health impact assessment investigated the following:

- Changes in air quality within the local community associated with emissions from the tunnel ventilation structures
- Changes in air quality associated with changes in emissions from major surface roads
- Exposure of vehicle occupants to emissions present within the tunnels, during operation
- Changes in noise and vibration within the community
- Health implications of social changes related to the project.

The health impact assessment will be scrutinised by an independent panel as part of the EES process. Thus, human health impacts are not separately addressed in this Works Approval Application.

4 Stakeholder and community engagement

4.1 Stakeholders

North East Link, as a large infrastructure project, has the following stakeholder groups:

- Victorian government
- Australian government
- Local government
- Private road operators
- Traditional owners and Indigenous groups
- Residents, land owners and land managers
- Road and public transport users
- Social service and health care providers
- Community and environment interest groups
- Freight industry and transport operators
- Community and education providers and user groups (including young people)
- Vulnerable groups and individuals
- Utilities providers
- Emergency services
- Sporting groups
- Culturally and linguistically diverse communities
- Industry associations and peak bodies
- Cyclists and walkers
- Local and regional business owners.

4.2 Engagement activities

A wide range of engagement activities and communication tools have been used to support engagement on North East Link and to provide opportunities for stakeholders and the community to be involved in the consultation process. These are instrumental to building awareness about the project and to ensuring that information is disseminated regularly and feedback from the community and stakeholders is received and considered.

Key engagement activities and communication tools used for North East Link include:

- Briefings, meetings, and workshops – held as requested and required to discuss and consult on a range of project issues and opportunities with key stakeholders including councils, major land owners (such as Simpson Barracks), business owners, industry and community groups and organisations.
- Print and digital communication –project newsletters, fact sheets and brochures, posters and signage, maps and videos, engagement snapshots and reports, email updates, social media, and advertising through radio, local print media and digital channels.
- Community information sessions – design updates have been held across the project area with project staff and technical specialists available to answer questions and record feedback.
- Community pop-up sessions – presence at local events, markets and festivals.
- Community Liaison Groups – two groups representing a variety of stakeholders from the northern and southern parts of North East Link, chaired by an independent facilitator.
- Community Technical Discussion Groups – members of the community with a deeper interest and level of technical understanding were invited to form two discussion groups, focussing on engineering & design and cycling & walking, which were chaired and supported by North East Link Project staff.
- Small group workshops – a series of two community workshop allowing community participation during the North East Link planning phase.
- Technical Reference Group – established by DELWP with representatives from a number of government agencies who give advice on technical matters associated with the EES studies and statutory approval processes. The TRG reviewed relevant EES technical documents and provided inputs to this Works Approval Application.

In addition, North East Link's dedicated stakeholder and community engagement case managers have conducted one-on-one meetings with many directly affected residents, businesses and other land owners and stakeholders.

North East Link Project engaged with communities with targeted needs, by working with community group leaders, support agencies and local government to reach Culturally and Linguistically Diverse groups and vulnerable and hard to reach communities.

Communication and engagement activities for North East Link were generally in accordance with EPA Publication 1560.1 and are summarised in Table 4.1 and Table 4.2.

Table 4.1 Communication and engagement activities 2018

Aware	Informed	Engaged
797,000+ people reached through social media	111,985+ visits to the project website	1,370+ pieces of feedback provided in person and online
236,000+ homes received 3 newsletters	45,940+ visits to online project maps	135+ people joined 45 workshops and discussion groups
9,440+ e-newsletter subscribers received 7 email updates	6,395 + visitors to 20 information displays	585+ responses to intercept, telephone and doorknock surveys
215+ adverts in local newspapers, on radio stations and on roadside signs	300+ questions answered through the online Q & A tool	20+ Community Liaison Group meetings
	2,175+ conversations with land owners, tenants and businesses	685+ calls to the 1800 hotline
	250+ meetings and briefings with stakeholders	545+ emails to the community@ inbox

Table 4.2 Community information sessions 2018

Location	Date	Time	Venue	Visitors (approx.)
Watsonia	Saturday 21 April	10am-1pm	Gresswell Uniting Church	700
Rosanna	Sunday 22 April	10am-1pm	Rosanna Bowling Club	500
Melbourne CBD	Tuesday 24 April	12pm-2pm	VicRoads Hub	80
Blackburn North	Tuesday 24 April	5pm-8pm	New Hope Baptist Church	180
Bulleen	Thursday 26 April	5pm-8pm	Veneto Club	490
Greensborough	Saturday 28 April	10am-1pm	Melbourne Polytechnic	300
Doncaster	Sunday 29 April	10am-1pm	Manningham City Square	250
Kew	Tuesday 1 May	5pm-8pm	Kew RSL	180

Location	Date	Time	Venue	Visitors (approx.)
Watsonia	Saturday 16 September	10am-4pm	Watsonia RSL	560
	Sunday 17 September			
Doncaster	Thursday 20 September	9am-9pm	Doncaster Shopping Centre	300
Bulleen	Saturday 22 September	10am-4pm	Yarra Junior Football League clubhouse	205
	Sunday 23 September			
Melbourne CBD	Tuesday 2 October	10am-4pm	VicRoads Hub	40
Greensborough	Saturday 6 October	9am-5pm	Greensborough Plaza	385
Richmond	Saturday 13 October	9am-5pm	Victoria Gardens Shopping Centre	105
Ringwood	Sunday 14 October	9am-5pm	Eastland Shopping Centre	140
Box Hill	Thursday 18 October	9am-7pm	Box Hill Central	295
Preston	Saturday 20 October	9am-5pm	Northland Shopping Centre	650
Epping	Sunday 21 October	10am-5pm	Pacific Epping	295
Bulleen	Thursday 25 October	9am-5.30pm	Bulleen Plaza	615
Dandenong	Saturday 27 October	9am-5pm	Dandenong Plaza	125
Total	**20 information displays**			**6,395**

4.3 Feedback received

Given that the consultation activities were not specific to the ventilation structures but rather North East Link as a whole, a variety of feedback was received from stakeholders and community.

Feedback related directly to the ventilation structures and how this has been considered is summarised in Table 4.3.

Table 4.3 Feedback received on ventilation structures and project response

Feedback	Project response
Concerns about visual impacts from ventilation structures on nearby residents and other sensitive receptors such as schools and community facilities.	A Guiding Principle for the project is to minimise impacts on communities, including minimising landscape and visual impacts. In response to feedback from communities, the northern tunnel portal was moved further north to Blamey Road so ventilation structures could be located on what is currently Simpson Barracks land and further away from residential properties. Moving the tunnel portal to Blamey Road also significantly increased the amount of green space next to Greensborough Road and opportunities for new planting. An assessment of the potential landscape, visual impacts and lighting impacts as a result of project infrastructure including ventilation structures has been completed. The overshadowing impacts of the project have also been considered from a landscape and visual impact assessment perspective. The project Urban Design Strategy would guide the contractors to develop a detailed design with consistent, high quality urban design outcomes. The contractors would be required to develop a project design that reflects the Urban Design Strategy and to refer urban design and landscape plans to the Office of the Victorian Government Architect for review. These requirements are to be imposed through project EPRs.
Concerns about emissions from ventilation structures concentrating in the local area and requests for more information about how air quality will be monitored.	The air quality impact assessment considered the potential impact of ventilation structure emissions over a large area, as well as a number of potential future emissions scenarios. The approach to management and monitoring of emissions from the tunnel ventilation structures would be documented in the project Operation Environmental Management Plan (refer to Section 12.1). An ambient air quality monitoring program would be established in consultation with EPA to measure the air quality impacts of North East Link, including monitoring before operation. The contractors would also be required to monitor in-tunnel air quality and ventilation structure emissions following the opening of North East Link, (refer to Section 10.5).
Concerns emissions could disperse and settle in low-lying areas such as Banyule Flats and Koonung Creek and requests for weather and topography to be considered.	The air quality modelling undertaken to inform the air quality impact assessment took into account the effect of the topography of the region on the dispersal of ventilation structure emissions, including consideration of the Banyule Flats and the Koonung Creek valley. In addition, data from the Bureau of Meteorology Automatic Weather Station at Viewbank from 2013-2017 was used to inform the assessment of air quality impacts from tunnel ventilation structure emissions. Details of the air quality assessment can be found in Section 10.

Feedback	Project response
Concerns that air quality monitoring during operation will not be reliable and that EPA guidelines will not be enforced.	An air quality monitoring plan has been established and is summarised in Section 10.5. The approach to management and monitoring of surface road vehicle emissions and emissions from the tunnel ventilation structures would be documented in the project Operation Environmental Management Plan (refer to Section 12.1).
Concerns about noise impacts on nearby residents and other sensitive receptors such as schools and community facilities	The noise impact assessment considered the potential noise impact of the ventilation system and predicts compliance with *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1* (SEPP N-1). Noise monitoring would take place for up to five years after construction is completed, as agreed with EPA Victoria, to verify noise requirements are being met (EPR NV7).

5 Ventilation system description

The ventilation system for the Reference Project has been designed to perform three primary functions:

- Provide acceptable in-tunnel air quality during normal operation
- Provide smoke control in the event of a fire incident
- Provide sufficient dispersion so that ground level pollutant concentrations meet air quality standards in the areas around the ventilation structures.

5.1 Design in-tunnel performance criteria

For normal operation, defined as traffic flowing with an average speed of 20 km/h or greater, the design has considered the following emissions criteria:

- NSW In-tunnel Air Quality (Nitrogen Dioxide) Policy 0.5 ppm as a rolling 15-minute average based on a tunnel/route averaged value (NSW Government Advisory Committee on Tunnel Air Quality 2016)
- In-tunnel visibility criteria are based on PIARC (2012) recommendations.

In addition, the following in-tunnel criteria have been applied for in-tunnel carbon monoxide (CO):

- Maximum of 150 ppm
- 15-minute average of 50 ppm
- Two hour average of 25 ppm.

The ventilation system has been designed to meet the following requirements for normal operation:

- The average longitudinal air velocity in any tunnel section would not exceed 10 m/s
- The system would have no null points, ie no stagnant or zero net velocity air
- Zero portal emissions from all portals
- Road tunnel emissions would be discharged from a vertical structure in accordance with EPA Victoria design requirements and SEPP (AQM) design criteria.

5.2 Tunnel portal emissions

The ventilation system is designed such that each tunnel portal has no net portal emissions. This is achieved through ensuring that there is a net inflow of air into the tunnels at each tunnel portal. The system has been designed such that there is an ingress of air between 0.5 and 1.0 m/s, with an average of 0.75 m/s, at each portal with the vitiated air being exhausted out of the exhaust vents.

Numerous modelling cases were run due to variability in traffic volumes, speeds and composition. Diurnal and congested traffic model cases were run for the years 2026 and 2036 at varying speeds from 0 to 80 km/h. Modelling results demonstrate that for all design cases there are no net portal emissions and that all the vitiated air is removed through the exhaust vents.

It is convention in Australia for long tunnels to have zero portal emission requirements specified by regulatory bodies when they are first operated. However, both the CityLink (Domain tunnel) and EastLink tunnels are permitted portal emissions during night time periods or at other times when there are low traffic volumes. In addition, EPA Victoria have recently approved a trial by EastLink to have 30 per cent of tunnel emissions continually discharged from the portal, day and night, in order to save energy.

The design of the North East Link tunnel ventilation system assumed in the Reference Project aims to achieve safe air quality within policy levels, both within and external to the tunnels, and under normal operating conditions without the need for portal emissions.

However, very low traffic volumes in the early hours of the morning may make it possible, subject to regulatory approval, for the mechanical ventilation system to be minimised in order to conserve energy. Ventilation may occur via the natural piston effect induced by vehicles as they travel through the tunnels. At these times, there could either be minimal or zero discharge via the ventilation structures, although in-tunnel air could be discharged via the portals.

Modelling and assessment of the impact of tunnel portal emissions on air quality has not been undertaken in this study. Regulatory approved dispersion models are unable to accurately assess the impact of portal emissions under any circumstance. This does not mean that portal emissions cannot be undertaken without breaching air quality standards. There have been many studies that have examined portal emissions and found that ambient air quality standards can be maintained. The contractor may wish to undertake such studies to allow portal emissions under some circumstances.

5.3 Location

The reference project includes two ventilation structures at the:

- Northern portal
- Southern portal.

Additionally, an emergency smoke discharge structure would be located at the Manningham Road Interchange – for emergency discharges only.

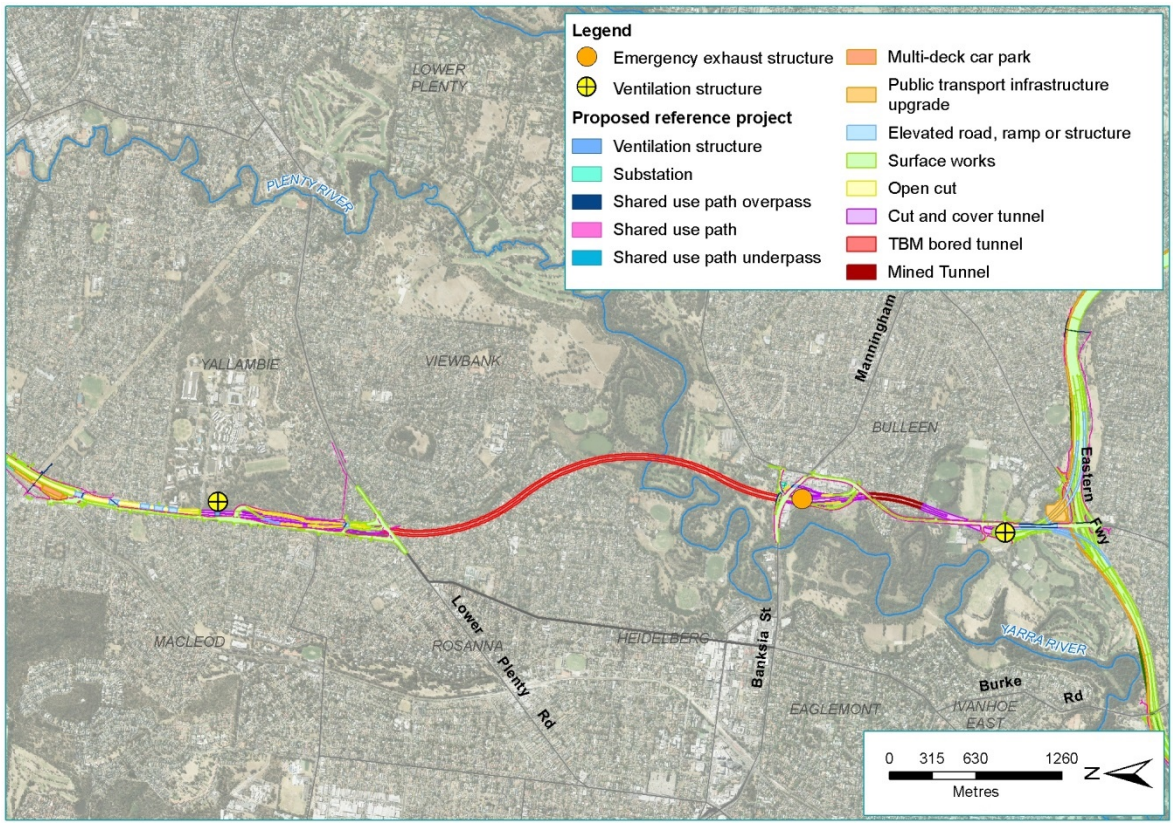


Figure 5.1 Locations of tunnel ventilation structures and emergency smoke discharge structure

The tunnel ventilation structure locations have been selected with consideration of potential visual and other environmental impacts.

Between Lower Plenty Road and Manningham Road there is no location for a ventilation structure which would avoid an impact on private property or the environmentally sensitive areas of Banyule flats and the Yarra River. Placing such equipment in potential flood zones was also avoided in ventilation structure location.

The possibility of a second southern ventilation structure located at the Manningham Road interchange, at the location of the proposed emergency smoke discharge structure, was investigated as part of the ventilation system design. Following this investigation, it was concluded based on visual amenity impacts that the best outcome for the project as a whole would be achieved with a single southern ventilation structure.

5.4 Ventilation system elements

5.4.1 Elements of works

The works to be assessed in this Works Approval Application are a tunnel ventilation system consisting of the following components. The numbers below are indicative, based on the reference project, and are subject to revision in the detailed design. The design consists of the following general items, with more detailed equipment schedules provided below.

- Two ventilation structures, northern portal (Blamey Rd) and southern portal (Bulleen Rd) with expected discharge heights of 40 metres
- One emergency smoke discharge structure at Manningham Road Interchange, with a discharge height of at least 3 metres above local roof level, in compliance with AS 1668.2-2012 (The use of ventilation and air conditioning in buildings – Mechanical ventilation in buildings), clause 3.10.3
- In-tunnel jet fans – likely number and power consumption are subject to change. Indicative number = 209 reversible jet fans (100 in the northbound tunnel and 109 in the southbound tunnel), each with an indicative power consumption of 45 kW
- In-tunnel modular smoke dampers arranged in groups of four or more, spaced at 80 metres centres
- Overhead smoke duct
- Flood walls around the south ventilation structure and Manningham Rd interchange to accommodate a 1 in 200 AEP flooding event.

Table 5.1 Northern (Blamey Road) ventilation structure equipment schedule

Item	Value[1]
Number of fans	8
Fan fire rating	250°C, 2 hours
Fan capacity	200 m³/s @ 900 Pa 55 m³/s @ 2500 Pa
Fan direction	Uni-directional
Fan impeller diameter (nominal)	3600 mm
Fan motor power (rated)	360 kW
VSD control	Yes

Item	Value[1]
Transitions	Inlet: 8 off (1 per fan) Bell mouth. ∅5400 mm to ∅3600 mm. Length: 900 mm. Radius: 900 mm. Outlet: 8 off (1 per fan) ∅3600 mm to (7500 x 7000) mm (W x H) Length: 15,000 mm
Inlet attenuator	1 off, modular (20,000 x 5,000 x 2,400) mm (W x H x L) Fire rating: 250°C, 2 hours
Outlet attenuator	1 off, modular (38,500 x 15,000 x 3,000) mm (W x H x L) Fire rating: 250°C, 2 hours
Fan isolation dampers	Inlet: 8 off (to fit ∅3600 mm fan) Outlet: 8 off (to fit ∅3600 mm fan) Fire rating: 400°C, 2 hours
Inlet plenum control dampers	3 off, modular 1: (18,000 x 20,000) mm (W x L) roadway 2: (10,000 x 3000) mm (W x H) SB smoke duct 3: (10,000 x 3000) mm (W x H) NB smoke duct Fire rating: 400°C, 2 hours
Transition discharge dampers	Outlet: 8 off (7500 x 7000) mm (W x H) Fire rating: 250°C, 2 hours
Outlet plenum control dampers	2 off, modular 1: (6650 x 6650) mm (W x D) 2: (4700 x 4700) mm (W x D) Fire rating: 250°C, 2 hours
Discharge Outlet	2 off, 40 m² and 20 m² 40 m²: (6320 x 6320) mm (W x D) 20 m²: (4700 x 4700) mm (W x D) Height: 40 m above local ground level (TBC) Sampling points, as required by EPA Victoria and appropriate Australian Standard for stack sampling.
Air Quality monitors	CO, NO_x, PM_{10}, $PM_{2.5}$, Temperature, Velocity, Humidity (as required by EPA Victoria)
Filtration	None

Table 5.2 Southern (Bulleen Road) ventilation structure equipment schedule

Item	Value[1]
Number of fans	6
Fan fire rating	250°C, 2 hours
Fan capacity	200 m³/s @ 900 Pa 55 m³/s @ 2500 Pa
Fan direction	Uni-directional
Fan impeller diameter (nominal)	3600 mm
Fan motor power (rated)	360 kW
VSD control	Yes
Transitions	Inlet: 6 off (1 per fan) Bell mouth. ∅5400 mm to ∅3600 mm. Length: 900 mm. Radius: 900 mm. Outlet: 6 off (1 per fan) ∅3600 mm to (7500 x 7000) mm (W x H) Length: 15,000 mm
Inlet attenuator	1 off, modular (10,000 x 10,000 x 2,400) mm (W x D x L) Fire rating: 250°C, 2 hours (optional)
Outlet attenuator	1 off, modular (24,500 x 15,000 x 3,000) mm (W x H x L) Fire rating: 250°C, 2 hours
Fan isolation dampers	Inlet: 6 off (to fit ∅3600 mm fan) Outlet: 6 off (to fit ∅3600 mm fan) Fire rating: 400°C, 2 hours
Inlet plenum control dampers	3 off, modular 1: (10,000 x 10,000) mm (W x H) roadway 2: (9000 x 3500) mm (W x H) SB smoke duct 3: (6000 x 3500) mm (W x H) NB smoke duct Fire rating: 400°C, 2 hours
Outlet plenum control dampers	2 off, modular 1: (5750 x 5750) mm (W x D) 2: (4130 x 4130) mm (W x D) Fire rating: 250°C, 2 hours
Transition discharge dampers	Outlet: 6 off (7500 x 7000) mm (W x H) Fire rating: 250°C, 2 hours

Item	Value[1]
Discharge Outlet	2 off, 33 m² and 17 m² 33 m²: (5750 x 5750) mm (W x D) 17 m²: (4120 x 4120) mm (W x D) Height: 40 m above local ground level (TBC) Sampling points, as required by EPA Victoria and appropriate Australian Standard for stack sampling.
Air Quality monitors	CO, NO_x, PM_{10}, $PM_{2.5}$, Temperature, Velocity, Humidity (as required by EPA Victoria)
Filtration	None

[1] Note: values are indicative only, based on the reference project, and are subject to revision during detailed design.

Table 5.3 Manningham Road emergency ventilation structure equipment schedule

Item	Value[1]
Number of fans	4
Fan fire rating	250°C, 2 hours
Fan capacity	90 m³/s @ 2400 Pa
Fan direction	Uni-directional
Fan impeller diameter (nominal)	3600 mm
Fan motor power (rated)	360 kW
VSD control	No
Transitions	Inlet: 4 off (1 per fan) Bell mouth. ∅5100 mm to ∅3600 mm. Length: 750 mm. Radius: 750 mm. Outlet: 4 off (1 per fan) ∅3600 mm to (4500 x 4500) mm (W x H) Length: 3700 mm
Inlet attenuator	1 off, modular (32,000 x 3000 x 2,400) mm (W x H x L) Fire rating: 250°C, 2 hours (optional)
Outlet attenuator	1 off, modular (4500 x 4500 x 2400) mm (W x D x L) Fire rating: 250°C, 2 hours
Fan isolation dampers	Inlet: 4 off (to fit ∅3600 mm fan) Outlet: 4 off (to fit ∅3600 mm fan) Fire rating: 400°C, 2 hours

Item	Value[1]
Inlet plenum control dampers	2 off, modular (15,000 x 3000) mm (W x H) Fire rating: 400°C, 2 hours
Outlet vent dampers	4 off, modular (4500 x 4500) mm (W x D) Fire rating: 250°C, 2 hours
Discharge Outlet	4 off, (4500 x 4500) mm (W x D) Height: >=3 m above access level (TBC)
Air Quality monitors	None
Filtration	None

[1]Note: values are indicative only, based on the reference project, and are subject to revision during detailed design.

Table 5.4 In-Tunnel Jet Fans equipment schedule

Item	Value[1]
Number of fans	Southbound tunnel: 109 Northbound tunnel: 100
Fan fire rating	250°C, 2 hours
Fan capacity	Discharge velocity: 33.8 m/s Discharge flow rate: 41.5 m^3/s
Fan direction	Fully reversible
Fan impeller diameter (nominal)	1250 mm
Fan motor power (rated)	45 kW
VSD control	~50% of fans VSD, ~50% of fans DOL (soft start) Southbound tunnel: 55 Northbound tunnel: 50
Transitions	Not applicable
Noise attenuator	Yes (TBC) Fire rating: 250°C, 2 hours
Fan isolation dampers	No
Fan mounting	Vibration isolation/dampers Safety chains (TBC)
Filtration	No

[1]Note: values are indicative only, based on the reference project, and are subject to revision during detailed design.

5.4.2 Design life

Design lives for project components are yet to be finalised. However, it is expected that the following design lives would apply to the ventilation system:

- The design life of the ventilation system mechanical and electrical equipment, such as fans and dampers, is 20 years.
- Minor structures, such as jet fan support brackets, are to have a design life of 30 years.
- The vent station building/façade/claddings are to be constructed with a design life of 50 years, however, parts of the vent station that connect directly to the tunnels require a design life of 100 years.
- The smoke duct is to be constructed with a design life of 100 years.

5.4.3 Drainage works and stormwater

It is anticipated that the tunnel ventilation system would have minimal impact on stormwater systems or requirements for stormwater management.

5.5 Ventilation structures

Tunnel ventilation systems are a mature technology, successfully implemented in many locations, including the Citylink and Eastlink tunnels in Victoria, M5 East and Lane Cove tunnels in NSW and the Legacy Way and Clem Jones tunnels in Queensland. The system of exhaust vents and jet fans proposed for North East Link is similar to that of the Westconnex tunnels, which are currently under construction in NSW. A detailed discussion regarding consideration of best practice in relation to technology selection is contained in Section 7.2.

The ventilation structures would each have primary and secondary vents. The primary vent of each structure is designed to operate at all times while the secondary vent is able to be utilised as required, based on vehicle volumes, time of day, in-tunnel air quality, and tunnel maintenance requirements.

Northern and southern portals

The design drawings and site layout plans for the northern portal and southern portal are presented in Appendix C.

The fans would be fire rated for at least two hours at a minimum temperature of 250 °C. All fans would be installed with variable speed drives (VSD).

Two sets of noise attenuators would be installed in each ventilation structure: 1) between the fans and the tunnel roadways and; 2) between the fans and the discharge point. The noise attenuators would be sized to comply with in-tunnel and external ambient noise requirements.

Airflow control dampers would be located in both the northern and southern ventilation structures. These would be fire rated for two hours at 400 °C or better.

The discharge outlets are proposed to be 40 metres high in the Reference Project. There would be a partition to the discharge outlet for the release to atmosphere of vitiated air during normal and emergency operation.

The main fans at both ventilation structures would perform both normal air extraction and smoke duct air extraction. The main axial fans assist in the control of portal emissions. This design decision was made for the following reasons:

- There is a significantly reduced risk that the smoke system fans would not operate
- There is limited space at the southern ventilation structure to incorporate separate smoke and normal ventilation systems, as are being incorporated in the West Gate Tunnel Project
- Visual amenity concerns at the northern portal ventilation structure have meant that an additional smoke system and associated vertical discharge structures have not been incorporated in the Reference Project.

Manningham Road Interchange

The Manningham Road emergency smoke discharge structure would function during fire or smoke extraction incidents only.

The design drawings and site layout plan for the Manningham Road Interchange emergency smoke discharge point are given in Appendix C.

The reference project has assumed the fans would be arranged vertically for improved efficiency. The fans are to be fire rated for two hours at 250 °C or better.

All fans would be uni-directional as they are to act in an air or smoke extraction capacity only.

There would be noise attenuators on the entry to the smoke and after the discharge fans. The noise attenuators are primarily installed to mitigate noise during regular testing of the system. These noise attenuators would be made as small as possible to reduce interference with emergency response performance.

Airflow control dampers would also be utilised in the Manningham Road emergency smoke discharge structure. The airflow control dampers are expected to be similar, if not identical, to those installed on at the northern and southern portal vent stations.

There would be four discharge outlets for the release to atmosphere of vitiated air from emergency operation.

The location and design of the Manningham Road emergency smoke discharge structure would be refined during detailed design.

5.6 In-tunnel air movement

Jet fans would be utilised to control the air movement inside the tunnels, in particular, the prevention of portal emissions. During congested periods when traffic speeds are low, jet fans would also be utilised to induce enough fresh air into the tunnels in order to comply with in-tunnel air quality criteria. Additionally, jet fans would be utilised to induce the critical velocity inside the tunnels for the control of smoke during a fire incident.

5.7 System operation

Operating hours

The ventilation system would be operated on a continuous, 24/7 basis.

Emission controls

While the emissions from vehicles cannot be controlled, the ventilation system has been designed to prevent emissions from tunnel portals, including ramps, and to ensure that emissions are discharged to the atmosphere through the vertical ventilation structures.

Electrostatic precipitators and denitrification technologies are not considered to be required for air quality management to meet air quality standards and as such, it is proposed that such systems not be installed nor provision be made for them to be retrofitted into the ventilation system. This is discussed further in Section 7.2.

5.8 Process controls and monitoring

During tunnel operation, ambient air quality, in-tunnel air quality, and ventilation structure emissions would be monitored.

Ambient air quality

An ambient air quality program would be undertaken in consultation with EPA Victoria. This monitoring would include at least one year of monitoring before operation and five years post opening of North East Link, or such lesser period as agreed with EPA Victoria.

In-tunnel air quality

In-tunnel air quality would be monitored to demonstrate compliance with in-tunnel air quality objectives (refer to Section 5.1). The monitoring results would be reported publicly on a quarterly basis for five years post opening of North East Link, or such lesser period as agreed with EPA Victoria.

Ventilation structure emissions

Ventilation structure emissions would be monitored to demonstrate compliance with the SEPP (AQM), and the EPA Victoria licence. The monitoring results would be reported publicly on a quarterly basis for five years post opening of North East Link, or such lesser period as agreed with EPA Victoria.

Air quality monitoring equipment would be installed inside the discharge outlet chambers for the northern and southern tunnel ventilation structures.

A series of sampling access points to the discharge chamber would be constructed. These sampling points would comply with the requirements of *AS4323.1-1995 Stationary source emissions Selection of sampling positions*.

No discharge point monitoring equipment would be installed at the Manningham Road Interchange emergency smoke discharge structure.

Appendix A details the air quality monitoring plan, including monitoring parameters, instruments, sampling frequencies and calibration and maintenance requirements.

6 Land use planning

A number of planning and environmental approvals are triggered under a range of legislation for North East Link, which are discussed in Section 1.2 of this application.

This section provides an overview of the relevant land use planning considerations pursuant to the *PE Act* and as required for the Works Approval Application (refer EPA Publication 1658 *Works approval application guideline*).

6.1 Planning controls

Project components and activities including ventilation and emergency exhaust structures and vegetation removal to facilitate construction of these structures are associated with the use and development of land for the purpose of a road, as defined under the *PE Act* (ie these are only required to service the road and associated operation).

Victoria Planning Provisions state that the use of land for a 'road' is exempt from requiring a planning permit, except if located in a Public Conservation and Recreation Zone or an Urban Floodway Zone.

Where the project works intersect an overlay, a similar exemption applies to the development of land for roadworks, unless specifically required in the planning scheme.

The northern ventilation structure is located on Commonwealth Land, which is not subject to the Victoria Planning Provisions.

The emergency smoke discharge structure and southern ventilation structure are located on land within Manningham and accordingly are subject to the Manningham Planning Scheme. Relevant planning provisions and planning permit triggers associated with the proposed structures are outlined in the sections below.

6.1.1 Northern ventilation structure

The northern ventilation structure is planned to be located on Commonwealth Land (designated CA on planning scheme mapping), associated with the Simpson Barracks. As mentioned previously, Commonwealth Land is not subject to the provisions of Victoria planning schemes.

Land immediately surrounding the northern ventilation structure also extends (in part) into Commonwealth Land. Further afield, surrounding land is subject to the Banyule Planning Scheme and is generally zoned for residential land use (General Residential Zone 2 (GRZ2) and Neighbourhood Residential Zone (NRZ3)), major roads (Greensborough Road, zoned RD1Z) and land zoned for open space and recreation purposes (eg Public Parks and Recreation Zone (PPRZ), including Winsor Reserve to the east of Greensborough Road.

Surrounding Commonwealth Land, and in addition to zone controls, a number of overlays are also applicable that refer to land to be acquired for road purposes and the protection of significant vegetation (eg Vegetation Protection Overlays and Environmental Significance Overlays), reflecting the vegetated character of the area.

Figure 6.1 and Figure 6.2 show planning controls relevant to the northern ventilation structure. The relevant planning permit triggers associated with the northern ventilation structure are summarised in Table 6.1.

While the northern ventilation structure is currently located on Commonwealth Land, prior to being constructed and operated, the land would be transferred to Victorian jurisdiction.

Table 6.1 Northern ventilation structure planning permit triggers

Planning Scheme Provision	Municipality	Activity	Permit Requirement
Zones			
NA – Commonwealth Land			
Overlays			
NA – Commonwealth Land			

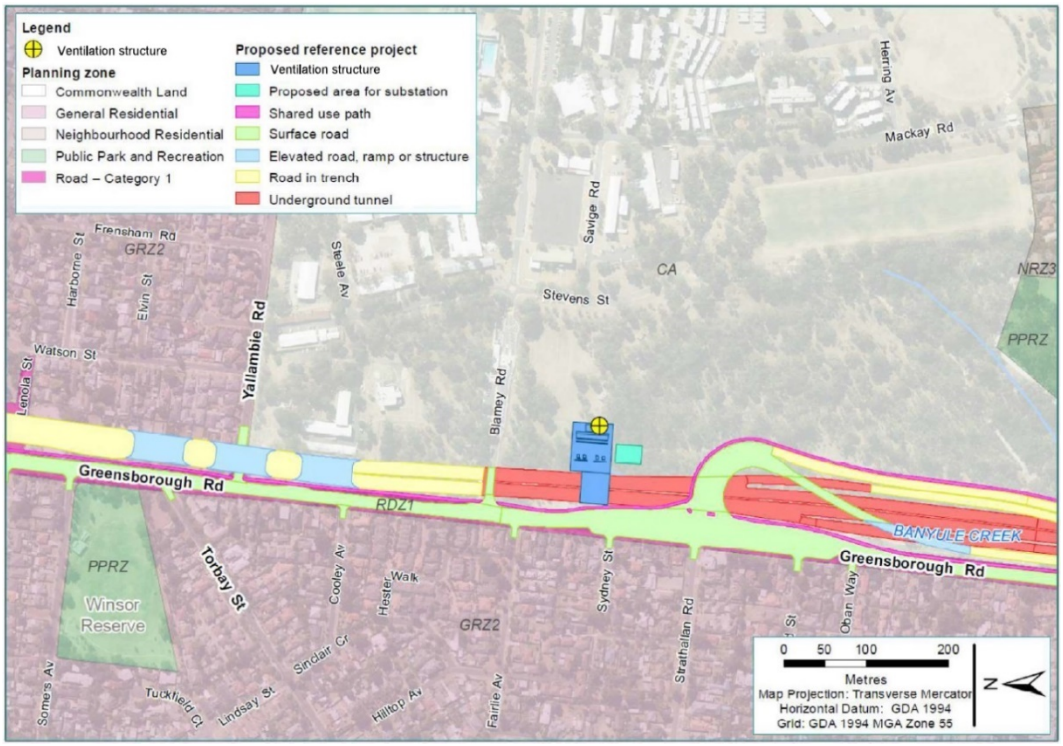


Figure 6.1 Northern ventilation structure zones

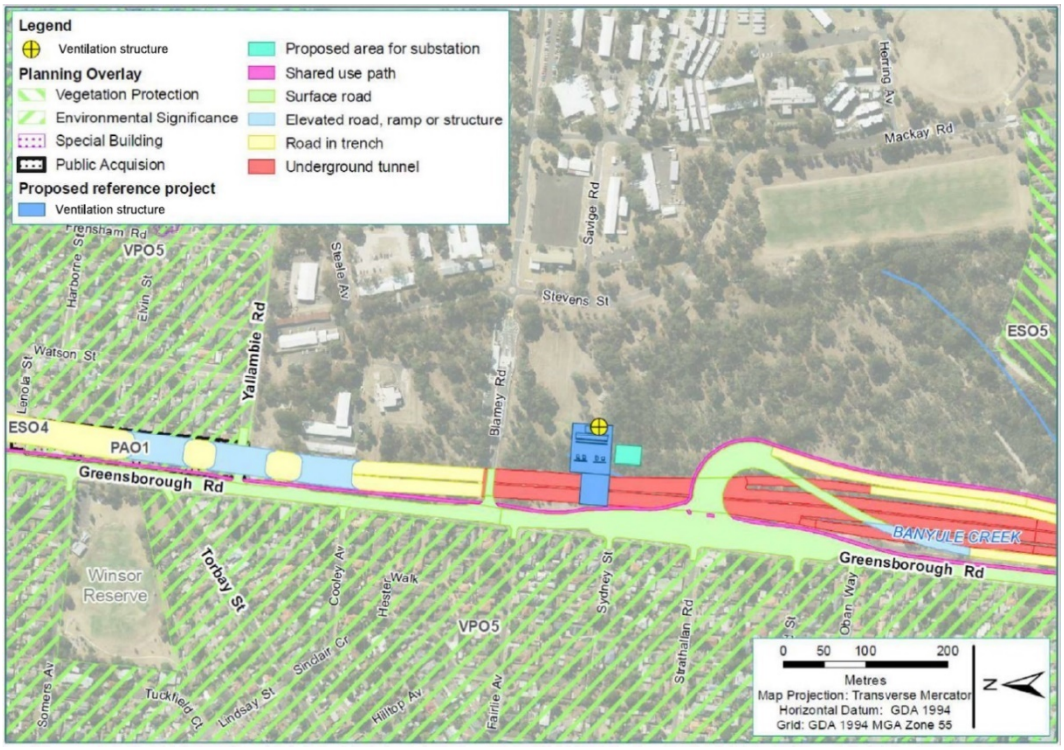


Figure 6.2 Northern ventilation structure overlays

6.1.2 Manningham Interchange emergency exhaust structure

The emergency exhaust structure is planned to be located amongst the proposed Manningham Interchange on land currently comprising the Bulleen Industrial Estate. The land is currently zoned for industrial purposes (Industrial 1 Zone (IN1Z)) under the Manningham Planning Scheme.

Overlays that apply to the subject land include potential inundation risk (Land Subject to Inundation Overlay (LSIO)) and protection of the Yarra River and its environs, including associated design and built form requirements (Design and Development Overlay Schedule 2 (DDO2-B) and Significant Landscape Overlay, Schedule 2 (SLO2)).

Land uses surrounding the subject site and Bulleen Industrial Estate are generally associated with residential (Residential Growth Zone 2 (RGZ2) and GRZ1), major roads (RD1Z) and land for public open space, conservation and recreation purposes (PPRZ and Public Conservation and Recreation Zone (PCRZ)) typically associated with the Yarra River and surrounds.

The SLO2, DDO2 and LSIO, in addition to Environmental Significance Overlays that refer to the inundation, environmental, landscape and ecological significance of the Yarra and its environs also apply to surrounding land. A number of Heritage Overlays are present associated with various structures and trees in the area as are public acquisition overlays for road and open space purposes. Design and design and built form objectives associated with increasing residential densities around activity centres and main roads on the western side of Bulleen Road apply(Design and Development Overlay, Schedule 8 'Residential Areas Surrounding activity Centres and Along Main Roads' (DDO8).

Figure 6.3 and Figure 6.4 show planning controls relevant to the emergency exhaust structure. The relevant planning permit triggers associated with the emergency exhaust structure are summarised in Table 6.2.

Table 6.2 Manningham interchange emergency exhaust planning permit triggers

Planning Scheme Provision	Municipality	Activity	Permit Required[1,2]
Zones			
Industrial 1 Zone (IN1Z)	Manningham	Use	No – a Road is exempt
		Buildings and works	No – Roadworks are exempt
Overlays			
Significant Landscape Overlay, Schedule 2 'Yarra (Birrarung) River Corridor Environs' (SLO2)	Manningham	Buildings and works	No – Roadworks are exempt
		Remove, destroy or lop vegetation	Yes

Planning Scheme Provision	Municipality	Activity	Permit Required[1,2]
Design and Development Overlay Schedule 2 'Yarra (Birrarung) River Corridor Protection' (DDO2-B)	Manningham	Buildings and works	No – Roadworks are exempt
Land Subject to Inundation Overlay (LSIO)	Manningham	Buildings and works	No – Roadworks are exempt

[1]Clause 62.01 identifies uses not requiring a planning permit. '*Any requirement in this scheme relating to the use of land other than a requirement in the Public Conservation and Resource Zone, does not apply to: The use of land for a Road except within the Urban Floodway Zone and a Public Conservation and Resource Zone*'.

[2]Clause 62.02 identifies buildings and works not requiring a permit unless specifically required by the planning scheme. '*Any requirement in this scheme relating to the construction of a building or the construction of carrying out of works, other than a requirement in the Public Conservation and Resource Zone, does not apply to: Roadworks*'.

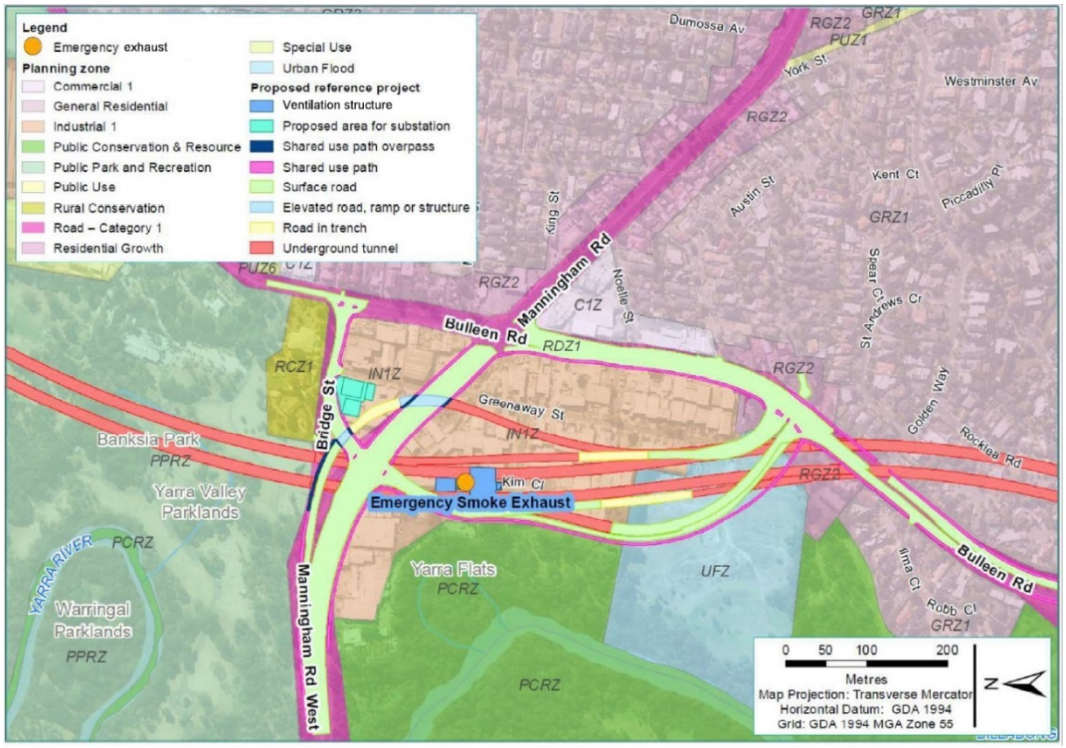


Figure 6.3 Manningham Interchange emergency exhaust structure zones

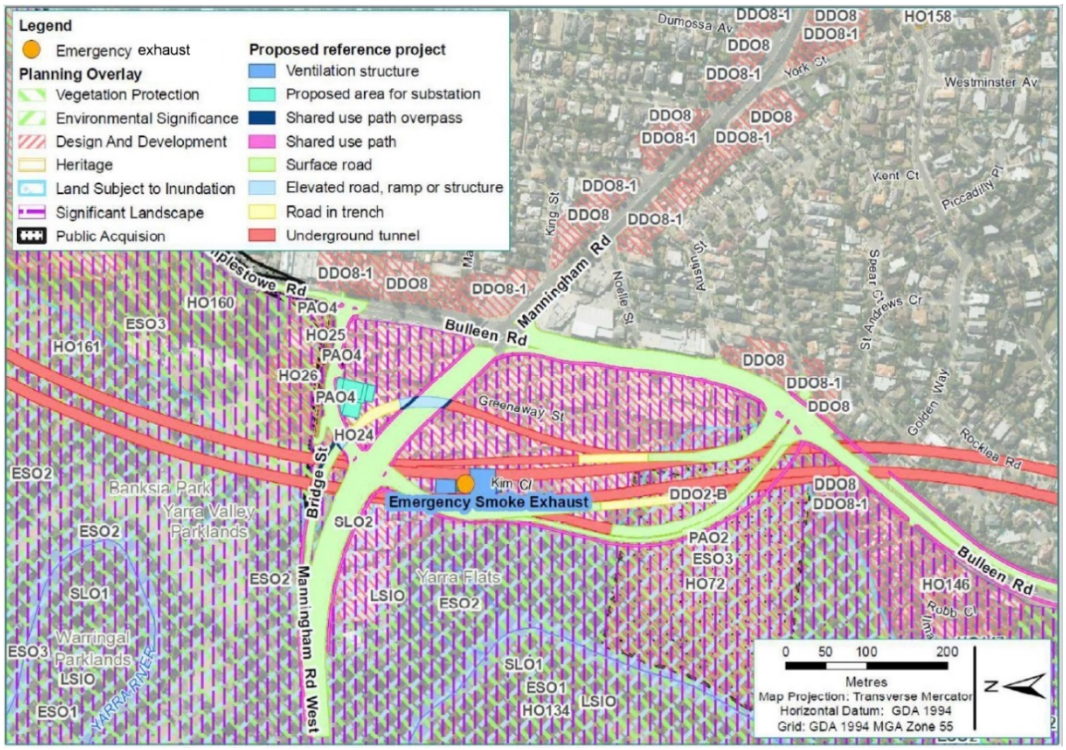


Figure 6.4 Manningham Interchange emergency exhaust structure overlays

6.1.3 Southern ventilation structure

The southern ventilation structure is planned to be located within part of Bulleen Park, and is subject to the Manningham and Boroondara Planning Schemes. The subject land is zoned Public Park and Recreation Zone (PPRZ) for open space and recreation uses. Overlays that apply to the subject land include the LSIO and the SLO2, associated with consideration of flooding impacts and protection of the Yarra River and environs. Overlays that refer to ecologically significant areas also apply to the land (Environmental Significance Overlay, Schedule 2 (ESO2) and Schedule 3 (ESO3)).

Surrounding land uses within Manningham and Boroondara (to the south) include conservation and recreation purposes, typically associated with the Yarra River and surrounds. Overlays that refer to environmental, landscape and ecological significance of the Yarra and its environs, in addition to inundation/flooding risk apply in the area surrounding the southern ventilation structure. Several sporting, education and civic facilities are also in proximity, such as Marcellin College, Trinity College Sporting Complex, Boroondara Tennis Centre and the Veneto Club.

Figure 6.5 and Figure 6.6 show planning controls relevant to the southern ventilation structure. The relevant planning permit triggers associated with the southern ventilation structure are summarised in Table 6.3.

Table 6.3 Southern ventilation structure planning permit triggers

Planning Scheme Provision	Municipality	Activity	Permit Required[1,2]
Zones			
Public Park and Recreation Zone (PPRZ)	Manningham	Use	No – a Road is exempt
		Buildings and works	No – Roadworks are exempt
Overlays			
Significant Landscape Overlay, Schedule 2 'Yarra (Birrarung) River Corridor Environs' (SLO2)	Manningham	Buildings and works	No – Roadworks are exempt
		Remove, destroy or lop vegetation	**Yes**
Land Subject to Inundation Overlay (LSIO)	Manningham	Buildings and works	No – Roadworks are exempt
Environmental Significance Overlay, Schedule 2 'Sites of Biological Significance' (ESO2)	Manningham	Buildings and works	No – Roadworks are exempt
		Remove, destroy or lop vegetation	**Yes**
Environmental Significance Overlay, Schedule 3, 'Buffer Conservation Areas Supporting Site of Biological Significance' (ESO3)	Manningham	Buildings and works	No – Roadworks are exempt
		Remove, destroy or lop vegetation	**Yes**

[1]Clause 62.01 identifies uses not requiring a planning permit. *'Any requirement in this scheme relating to the use of land other than a requirement in the Public Conservation and Resource Zone, does not apply to: The use of land for a Road except within the Urban Floodway Zone and a Public Conservation and Resource Zone'.*

[2]Clause 62.02 identifies buildings and works not requiring a permit unless specifically required by the planning scheme. *'Any requirement in this scheme relating to the construction of a building or the construction of carrying out of works, other than a requirement in the Public Conservation and Resource Zone, does not apply to: Roadworks'.*

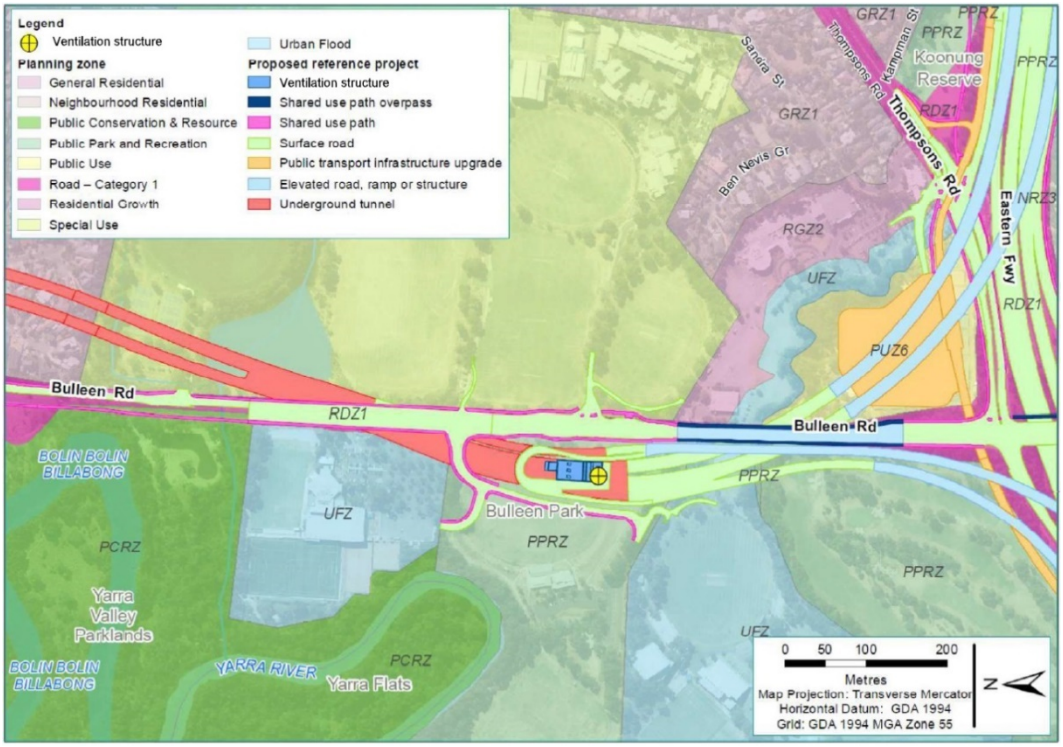


Figure 6.5 Southern ventilation structure zones

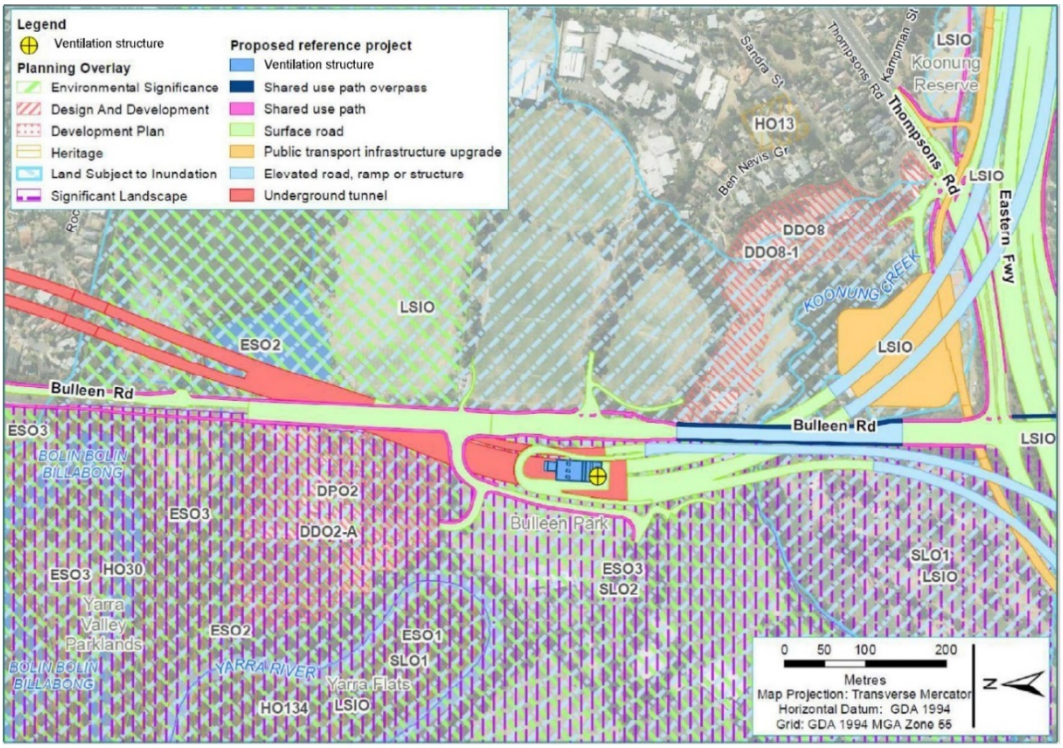


Figure 6.6 Southern ventilation structure overlays

6.2 Planning approval pathway

Analysis of the relevant planning controls confirm that the emergency smoke discharge and southern ventilation structures would trigger the requirement to obtain a planning permit under the Manningham planning scheme. The northern ventilation structure is located on Commonwealth Land, which is not subject to the Victoria Planning Provisions.

The proposed structures form part of the wider North East Link project, which trigger a number of planning permit triggers across the seven affected planning schemes (Banyule, Manningham, Boroondara, Yarra, Whitehorse, Whittlesea and Nillumbik).

The planning permit process is the traditional pathway used to obtain planning approval for the use and development of land (where no planning scheme amendment is required). However, this process becomes more complex where multiple planning schemes and planning permit triggers are involved. Other than a planning permit, the *PE Act* provides other pathways which could be used to facilitate the approval of North East Link, including an Order published in the Government Gazette, a planning scheme amendment or a combination of a planning scheme amendment and planning permits.

Based on the strategic significance of the project, a planning scheme amendment is considered to be the most appropriate approval mechanism to facilitate the use and development of land for North East Link in an integrated and consistent manner across all affected planning schemes.

The preferred form of amendment would be a 'GC' planning scheme amendment (multi planning scheme) to the affected planning schemes outlined above and facilitated by the Minister for Planning. This would be undertaken as part of the wider EES approvals process, which assesses the environmental effects of the project, informed by the various technical assessments (including air quality, noise emissions, surface water, landscape visual and land use planning, amongst others).

Forming part of the suite of documents which comprise the draft planning scheme amendment are an Incorporated Document and associated Specific Controls Overlay (SCO) which introduce project-specific planning controls. An Incorporated Document is a commonly used planning approvals tool in major Victorian transport (and other) infrastructure projects which has the effect of 'switching off' permit triggers subject to the project meeting a range of specified conditions. The planning scheme amendment also proposes the introduction of a Design and Development Overlay (DDO) that would be applied to the tunnel alignment to protect tunnel infrastructure assets from incompatible development.

Preparation of the planning scheme amendment must have regard to the relevant Ministerial Directions, including Ministerial Direction No 11 (Strategic Assessment of Amendments), which provides direction on the strategic evaluation of a planning scheme amendment and the outcomes it produces and Ministerial Direction No 19, which refers to amendments that may significantly impact the environment, amenity and human health.

The appointment of a joint Inquiry and Advisory Committee (IAC) by the Minister for Planning would review the planning scheme amendment and public submissions in its investigation and consideration of the environmental effects of the project.

7 Application of best practice

7.1 Best practice overview

EPA Publication 1517 *Demonstrating Best Practice* outlines the requirements for application of best practice as set out in the relevant State Environment Protection Policies (SEPPs), and provides guidance on how to demonstrate compliance with best practice requirements.

Sources of emissions or discharges to the environment must be managed in accordance with 'best practice'. A risk based approach was applied to identify the environmental segments which have the greatest potential to be impacted by the tunnel ventilation system. This identified that emissions to air, noise and greenhouse gas emissions were the environmental segments where the application of best practice was required to be assessed. This is consistent with the approach taken to other recent tunnel ventilation system works approval applications such as the West Gate Tunnel.

There are various definitions of best practice presented in the relevant SEPPs, the most detailed of these is outlined in the SEPP (AQM) as follows:

'*the best combination of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity*'

where eco-efficient is defined as:

'*producing more goods with less energy and fewer natural resources, resulting in less waste and pollution*'.

The consideration of eco-efficient techniques is supported by the principle of Integrated Environmental Management outlined in Section 1J of the *EP Act*. This principle states that if approaches to managing environmental impacts on one segment of the environment have potential impacts on another segment, the best practicable environmental outcome should be sought.

Principles of the *Environment Protection Act 1970* are outlined in Section 3.2. The requirements for best practice that are relevant to this Works Approval Application are listed in Table 7.1.

Table 7.1 Requirements for best practice

	Clause or section	Emitter/industry requirement
SEPP (AQM)	Cl. 18	Apply best practice to the management of emissions
	Cl. 19	Reduce emissions to maximum extent achievable for new or substantially modified sources of 'Class 3' indicators
	Cl 20	Reduce emissions to maximum extent achievable for 'Class 3' indicators
	Cl. 33	Manage greenhouse gas emissions in accordance with Cl. 18 and 19
SEPP (N-1)	Cl. 16	Design premises so that noise emissions do not exceed the noise limits
	Cl. 19	Use quietest equipment available when replacing or installing new equipment, where a significant reduction in noise in noise sensitive areas can be expected to occur
EPA Publication 864 *Protocol for Environmental Management: Greenhouse gas emissions and energy efficiency in industry* (PEM)	Section 2.1	Where the anticipated level of energy use associated with the application is 500 gigajoules per annum or more (or greater than 100 tonnes of energy-related CO_2 –equivalent emissions per annum), identify and implement best practice with respect to the activities that are the subject of the application

In determining what constitutes best practice for a certain activity or industry sector, EPA Publication 1517.1 puts forward the defining elements of best practice to be considered when interpreting requirements. All of the relevant defining best practice elements from this publication are reproduced below with a brief discussion (*in italic*) against each of these elements, explaining how the proposed project has addressed the best practice requirements.

- **Best practice for site selection and management systems** – An assessment of environmental impact needs to consider the sensitivity of the receiving environment and is therefore site-specific. The best practice assessment may also need to be applied to site selection, site layout, site operation (eg operating hours), and management systems to ensure that human health and amenity, and the environment, are protected.

  The supporting environmental assessments for this Works Approval Application have considered the existing conditions of the surrounding environment. The Reference Project assumes configuration and operation of the ventilation system with reference to relevant and current international standards, tunnel ventilation system technology used in leading projects around the world, and recent similar projects in Australia which have adopted best practice standards. Ultimately, the siting, layout, operation and management of the tunnel ventilation system would be determined by the contractor, in line with the suite of EPRs developed for the project, the need

to achieve compliance with SEPP N1 and SEPP AQM and Works Approval Conditions, which reflect the best practice requirements.

- **Best practice is preventative** – Best practice contributes to ensuring that the proposed environmental impact is prevented, or minimised, as far as practicable. This may mean going beyond the general or overall minimum requirements of quantified standards. For example, where a risk assessment identifies a particular set of high risk air quality indicators, targeted best practice measures are needed, rather than mere compliance with the ground level concentration design criteria specified in SEPP (AQM).

  Works built to best practice now are less likely to need partial retrofits to adapt to future changes in standards and less likely to incur increased business costs associated with this. (Such changes can arise from improved understanding of the impacts of pollutants.)

  An environmental risk assessment has been undertaken for the EES to identify significant potential environmental risks and impacts from the project.

  The identified risks associated with the tunnel ventilation system include:

  – *greenhouse gas emissions resulting from ventilation system operation*
  – *human health impacts due to increased in-car pollutant levels*
  – *health impacts to surrounding community due increased ambient pollutant levels and pollutants levels around tunnel portals*
  – *a reduction in human amenity due to fixed infrastructure noise.*

  This risk assessment informs and has been informed by the EPRs and impact assessments which have been summarised in this report.

- **Best practice means undertaking all practicable measures** – Decisions with regard to practicability, when assessing best practice, should have regard to technical, logistical and financial considerations. This is different from meeting absolute (quantified) limits set out in SEPPs or regulations, where cost is not a consideration in assessing compliance. EPA does not expect best practice to be pursued 'at any cost'. It is important that the proposed approach be cost effective in the context of the relevant industry sector within which the site operates or is planned to operate, as well as within the context of the total project cost. Most important is that the preferred option is proportional to the environmental risk. This element of best practice is also supported by the principle of Integration of economic, social and environmental considerations under Section 1B of the *EP Act*, which clearly outlines that best practice measures need to be cost effective and proportional to the significance of the environmental problem being addressed.

  The supporting environmental assessments for this Works Approval Application (refer to 14, Appendix A, Appendix B) have considered all practicable measures to achieve best practice with reference to the proportionality and cost-effectiveness of the measures considered.

- **Best practice may be internationally demonstrated and locally available** – Identifying best practice means identifying the combination of measures or practices that demonstrably prevent or minimise environmental impact. An assessment of best practice needs to give reasonable consideration to the availability of technology. In many circumstances, the assessment may invite a comparison with practices used elsewhere in the world. This is particularly the case where the relevant practice under examination is novel or has a limited basis for comparison in Australia, and where international best practice is reasonably available and achievable in Australia under local operating conditions. Alternatively, there may be occasions where these circumstances do not prevail and where best practice may need to be assessed at a more local level.

  Case studies are referenced in the following sections of this Works Approval Application to outline how best practice standards have been achieved for recent similar projects in Australia and internationally.

7.2 Best practice in air quality

The SEPP (AQM) requires the application of best practice to the management of new air emission sources.

The aspects relevant to best practice management of air emissions from the North East Link tunnels include:

- Design of the tunnel ventilation system
- The receiving environment into which emissions from the tunnel ventilation structures are discharged
- The potential impact of emissions on the receiving environment
- Air pollution control technology options and efficacy, together with capital and operating costs
- Whether other sources of pollution in the local environment can achieve greater pollutant reduction at a lower cost.

EPA Victoria's '*Demonstrating Best Practice – EPA publication 1517.1, October 2017*' provides a methodology to demonstrate best practice, as well as guidelines on the requirements for a Works Approval Application.

Consistent with the requirements of SEPP (AQM), the North East Link ventilation system requires the application of best practice in managing emissions to air.

For Class 3 indicators (such as benzene, 1,3 butadiene and PAHs), emissions would need to be reduced to the Maximum Extent Achievable (MEA). MEA is defined in the SEPP (AQM) as:

> '*a degree of reduction in the emission of wastes from a particular source that uses the most effective, practicable means to minimise the risk to human health from those emissions and is at least equivalent to or greater than that which can be achieved through the application of best practice*'.

Best practice for management of emissions from the tunnel ventilation system principally relates to ensuring that the most appropriate technology is selected, consistent with the elements of best practice outlined in Section 7.1. As such, the following sections evaluate the appropriateness of emissions control technologies for the tunnel ventilation system.

7.2.1 Assessment of air quality performance without air pollution control technology

The outcomes of the tunnel ventilation structure air dispersion modelling confirm that air pollution control technology is not required. Emissions from the tunnel ventilation structures are modelled to be compliant with applicable SEPP (AQM) criteria. The project only assessment showed emissions from the ventilation system contributing a maximum of 15 per cent of the design criteria for the 2026 scenario and 18 per cent of the design criteria for the 2036 scenario. The highest project contributions to the maximum predicted ground level concentration when both the project and background were considered were less than 6 per cent. Refer to Section 10 for details on air assessment methodology, EPRs, and results.

Tunnel ventilation structure air dispersion modelling has been based on conservative assumptions, including vehicle emission factors remaining at levels predicted for 2020. However, the following improvements in fleet emission performance are expected in Victoria (EPA Victoria 2013):

- Overall reductions in vehicle pollutant emissions through new vehicle standards, namely Euro 5 and 6 for light vehicle and Euro 5 for heavy vehicles
- Reduced particulate emissions from diesel engines
- Reduced NO_x emissions from petrol and diesel engines due to cleaner exhaust.

In addition, sales in electric vehicles have increased by 77 per cent from 2016 to 2017 (NTC 2018) and an increasing number of hybrid and electric vehicles are expected (EPA Victoria 2013), further reducing vehicle emissions of NOx and particulate matter.

The following additional conservative assumptions were made in modelling:

- Background pollutant levels remaining at 2013-2017 levels in 2026 and 2036
- Including exceptional events such as bushfires in background concentrations during modelling
- Assuming conservative ‘high’ traffic volume estimates for the tunnels.

Given that the modelling was based on the conservative assumption, the air quality performance of the tunnel ventilation system is expected to be better than that modelled for this Works Approval Application. Thus pollutant concentrations would be further below the SEPP (AQM) criteria.

7.2.2 Efficacy of air pollution control technology

Efficacy of ESPs

The removal efficiencies of particulate matter (PM) using electrostatic precipitators (ESPs) depends on factors such as air speeds, particle size, particle concentration and the composition of the emissions discharge. PM removal efficiencies for ESPs installed in road tunnels are of the order of 70 per cent (EPA 2006) which is low in comparison with up to 99.9 per cent for ESPs in industrial applications.

There are several reasons for this, including:

- ESPs operate more efficiently when PM concentrations are high. This is not the case for road tunnels where PM concentrations are low due to the high ventilation rates used to maintain in-tunnel air quality for human health and visibility reasons
- ESPs are more efficient at removing larger particles than smaller particles. A large proportion of particulate matter generated from vehicular emissions is small (less than 2.5 microns).

ESP technology is considered most appropriate for situations where particulate matter is high relative to gaseous emissions or where an increased supply of fresh air is unavailable or particularly costly to provide (NHMRC 2008).

An ESP removal efficiency of 70 per cent is not expected to achieve significant health, environmental or cost benefits because emissions from the ventilation structures are predicted to make only a small contribution to background PM_{10} and $PM_{2.5}$ concentrations.

Efficacy of DeNOx systems

De-nitrification (DeNOx) technology is primarily used for the removal of nitrogen dioxide (NO_2), with prior removal of PM needed to enhance removal efficiency. The filter system consists of a framework supporting a number of filter modules and a fan to draw air through the modules. Each module comprises a wire basket containing carbon as the filter medium.

Only limited data on the performance of DeNOx technology is available. The most recent information is for a DeNOx system installed on the M5 East tunnel in Sydney on a trial basis (refer to Section 7.2.3).

7.2.3 Utilisation of air pollution control technology in Australia and abroad

M5 East Sydney trial of air pollution control technology

In 2011, a trial was undertaken of the operational performance of the M5 East air filtration plant which had been installed as part of an air quality improvement plan. This air filtration plant incorporated both ESP and DeNOx technology. The trial evaluated the performance of the ESP and DeNOx systems, the reliability of the complete air filtration plant, the impact of the air filtration plant on in-tunnel air quality, and the cost-effectiveness of the overall air filtration system.

The trial found that:

- The operational efficiencies were lower than expected for both the ESP and DeNOx. Particulate removal from the ESP was approximately 65 per cent for both PM_{10} and $PM_{2.5}$, compared to a claimed efficiency of over 80 per cent. Nitrogen removal from the DeNOx system was 55 per cent, again lower than expected
- The ESP system was creating larger particles (over 20 µm) which were deposited downstream of the ESP
- The DeNOx system did not effectively capture NO_2, instead converting it to NO and releasing it to the atmosphere
- The ESP system was both unreliable and vulnerable to modifications such as decreased airflow
- The operational cost of the ESP was more than 10 times the estimated health benefit from the system, where the health benefit was derived from the damage cost of $PM_{2.5}$ per tonne in Sydney as evaluated in study commissioned by the NSW EPA (PAEHolmes 2013).

The results of the M5 East trial lead to the recommendation that 'the operation of the air filtration plant should cease in its current form' and 'alternative methods for reducing NO_2 and PM be investigated further including consideration of other components of the [air quality improvement plan] for the benefit of both the M5 East and for future tunnel designs' (AMOG 2012, p. 50).

Other examples of pollution control technology in Australia

While provision has been made for the installation of pollution control technology in a number of Australian road tunnels, the systems have not needed to be retrofitted.

In the conditions of Works Approval for the City Link Domain and Burnley tunnel ventilation systems (EPA 1997), EPA Victoria required that works be designed and constructed to allow for the future retrofitting of ESPs within the Burnley tunnel ventilation structure.

Similarly, in the EPA Victoria Works Approval assessment for the West Gate Tunnel Project, EPA Victoria found that 'the installation of pollution control equipment at this time is not feasible as a best practice measure', however included a condition that provision must be made for the retrofitting of pollution control equipment, should it be warranted (EPA Victoria 2017).

The EPA Victoria assessment report for the East West Link Project (EPA Victoria 2014a), EPA Victoria considered that:

- The combination of good tunnel air quality and high exhaust gas volume makes the use of air pollution control technology unnecessary, as demonstrated by the M5 East tunnel experience in Sydney. The relatively small gain in air quality impact is not justified by the cost, which needs to be considered as a part of best practice assessment in accordance with the policy principles set out in SEPP AQM including '*7(1)(c) The measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed*'.
- The need to use air pollution control technology to protect air quality in areas around the tunnel ventilation structures, does not exist for this project.
- Tunnel ventilation system can achieve adequate dispersion of emissions during normal operation ensuring all emissions are discharged from the ventilation structures and not from the tunnel portals.
- For Class 3 indicators, it is not feasible to use emission control technology to remove these from the tunnel ventilation structures.

In its submission on the East West Link Comprehensive Impact Statement, EPA Victoria (2014b), stated that:

> *"as part of its assessment EPA has reviewed the need to filter emissions before leaving the vent stack. In previous tunnel ventilation system approvals (CityLink and East Link) filters were not required as the fans direct air flow through the tunnels to provide a safe in-tunnel air quality and dilute the emissions to a point where filters would not provide a significant benefit to air quality"*

To date, no permanent air pollution control equipment has been installed in Australian road tunnels to control vehicle emissions to air.

International use of ESPs

There are approximately sixty tunnels with ESPs installed worldwide, with the majority of these installed in Japan and Norway. These ESPs tend to be used for a small proportion of tunnel operation time or in circumstances where tunnel ventilation systems are unfeasible.

In Japan, these ESPs are predominantly used to maintain visibility, although ESPs have been used in some Japanese tunnels to achieve ambient air quality objectives. ESPs are generally used on an as-needs-basis, with operational hours varying depending on the tunnel. For example, the Kan-Etsu tunnel ESPs operate for approximately 20 per cent of total hours in the northbound tunnel and 3 per cent of total hours in the southbound tunnel while the Tokyo Aqualine tunnel ESPs operate for only 12 to 13 hours per year (approximately 0.15 per cent of total hours) (Dix 2016).

In Norway, ESPs have been installed in eight tunnels. These ESPs are generally used to maintain in-tunnel visibility and only two of the Norwegian tunnel ESP systems have been installed for the principal purpose of reducing discharges to the environment. In 2008, a study by CETU (2016) found that only the ESPs upstream of the extraction systems were still in use, with the other ESPs turned off due to uncertain performance and energy requirements (CETU 2016).

In Spain, 22 particulate filtration systems have been installed in the 32.5 kilometre M30 Orbital Motorway in Madrid. Despite being initially operated for 20 hours per day at full power, as of 2009 these systems only operated for a few hours per week (CETU 2016).

In South Korea and Vietnam, ESPs have been installed for air quality and visibility purposes in mountainous areas where fresh air inlets ventilation structures would be impractical. (Western Distributor Authority 2017).

ESPs have also been installed in one tunnel in each of Italy and France for the purpose of limiting tunnel portal emissions and improving local air quality (Dix 2006).

International case studies show that ESPs are generally either rarely utilised, utilised upstream of ventilation structures only, or utilised where the installation of fresh air ventilation systems is impractical.

International use of DeNOx

DeNOx systems have been installed in Spain, Norway, Germany, Japan and Australia (CETU 2016).

As with ESPs, DeNOx systems tend to be rarely used or used on an ‘as needs’ basis. In Spain, the DeNOx system in the M30 Orbital Motorway were initially operated for 20 hours per day but as of 2009 were only operated for a few hours per week (CETU 2016). In the Laerdal tunnel in Norway, the DeNOx system has never been switched on due to low traffic and pollutant levels (CETU 2016).

Previous trials of DeNOx systems had mixed results. A Japanese pilot of two road denitrification plants in Tokyo had ‘preferable results’ and led to the establishment of a number of DeNOx systems in road tunnels across Japan (Katatani and Dix 2011). This is in contrast with the results of the Australian M5 East trial of DeNOx which indicated that it was ineffective at capturing NO_2 (refer to Section 6.2.3 for details).

7.2.4 Alternative methods to improve tunnel air quality

The National Health and Medical Research Council has found that vehicle fleet emission reductions represent the most effective means of managing air quality in and around tunnels (NHMRC 2008).

Indeed, in the EPA Victoria assessment report for the East West Link Project (EPA Victoria 2014a), the EPA considered that

> *"The most effective method to remove [Class 3 indicators] is through fuel quality requirements and motor vehicle engine specifications and exhaust gas controls. The improved emission quality associated with the introduction of tighter fuel quality requirements and Euro vehicle emission standards is considered to represent MEA [maximum extent achievable] for Class 3 indicators"*

Fleet emission reductions also represent a more effective means of reducing PM_{10} emissions. Table 7.2, below, compares the results and costs of the M5 East tunnel ESP trial with annual PM_{10} reductions and emission reduction cost ($ per tonne) of a number of fleet emission reduction strategies and Figure 7.1 gives the marginal cost abatement curve for various PM_{10} reduction measures. A comparison of the results of the M5 East ESP trial and the fleet emission reduction measures makes clear that fleet measures can achieve greater PM_{10} emission reductions at a significantly lower cost than ESP systems.

Table 7.2 Annual emission reductions and costs of selected PM_{10} reduction methods (SKM 2010)

PM_{10} reduction measure	PM_{10} reduction (tonnes per annum)	Cost of PM_{10} reduction ($ per tonne)
Truck and bus diesel retrofit program	1	151 000
Diesel locomotive replacement (USEPA Tier 0 to Tier 2)	53	156 000
Diesel locomotive replacement (USEPA Tier 0 to Tier 2 + Retrofit Tier 2 Locomotives with selective catalytic reduction)	72	191 000
Euro 5/6/ emission standards for new passenger vehicles	131	209 000
M5 East ESP (operating costs)	0.2	3 800 000
M5 East ESP (total cost)	0.2	17 400 000

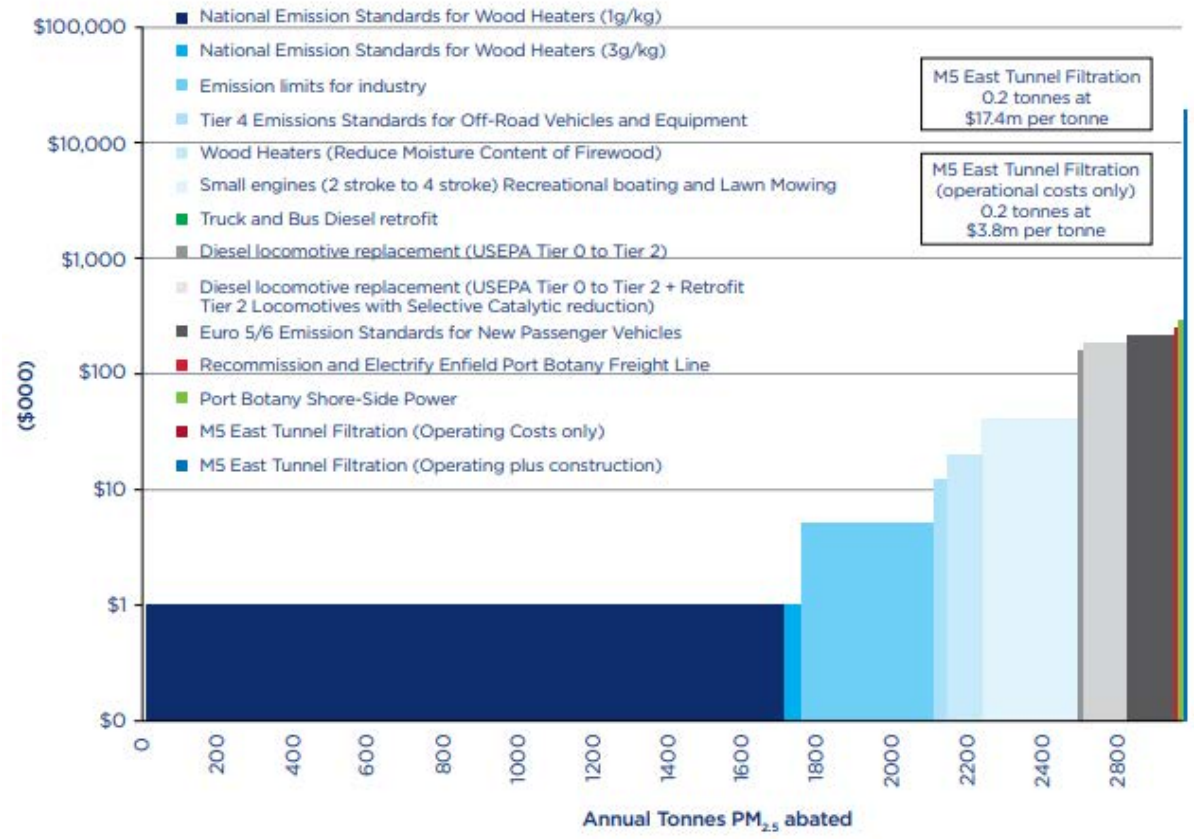


Figure 7.1 Marginal cost abatement curve showing annual tonnes $PM_{2.5}$ able to be abated and cost per tonne of abatement ($'000s) for a variety of measures (RMS 2014)

7.2.5 Conclusions on air pollution control technology

In regards to the use of air pollution control technology in the North East Link tunnel ventilation system, the following has been found:

- Air quality modelling shows that compliance with the SEPP AQM, with emissions from the ventilation system contributing a maximum of 18 per cent of the design criteria for the project only assessment and less than 6 per cent of the design criteria when both project and background are considered, is able to be achieved without air pollution control technology.
- Trials of DeNOx and ESP in the M5 East Sydney tunnel have shown that air pollution control technology is costly and unreliable in terms of environmental outcomes.
- In international locations where air pollution control technology has been installed in road tunnels, it is generally utilised on an as-needs-basis for a few hours and in some cases has been switched off.

- Vehicle fleet emission reduction measures, such as tightened emission standards or the retrofitting of emission control technology to emissions, would provide a greater improvement in air quality both within and outside of the tunnels.

With consideration to these findings alongside the principles of the *EP Act* and EPA Publication 1517 *Demonstrating Best Practice*, air pollution control technology is not considered best practice for the North East Link ventilation system.

Moreover, it is suggested that provision need not be made for future retrofitting of air pollution control technology. This is for the following reasons:

- Air quality modelling shows that compliance with the SEPP AQM, with emissions from the ventilation system contributing a maximum of 18 per cent of the design criteria, is able to be achieved without air pollution control technology.
- Future changes in fleet emission performance and electric vehicle uptake will likely further improve air quality, reducing the likelihood of any future need for air pollution control technology.
- While provision has been made for the installation of pollution control technology in a number of Australian road tunnels, the systems have not needed to be retrofitted.

7.3 Best practice in noise management

In order to meet the best practice requirements, noise impacts have been reduced within the design through:

- The use of VSD fans and selected VSD jet fans such that fan noise can be reduced during periods of low traffic volumes.
- Acoustic attenuators/silencers on the intake and discharge of the fans included to control the breakout of noise from the in-tunnel jet fans into the tunnel space.
- Noise attenuators installed in each portal vent station between the fans and the tunnel roadway and between fans and discharge point to achieve compliance with SEPP N-1 requirements.
- Ongoing monitoring of noise levels to confirm compliance with the relevant standards.

Section 11.5 sets out contractor responsibilities and audit requirements in the implementation of EPRs and best practice in the construction and operation of the North East Link.

7.4 Best practice in greenhouse gas and energy efficiency

The greenhouse gas assessment indicates that the energy-related greenhouse gas emissions associated with operation of the tunnel ventilation system are 81 tonnes CO_2-e per annum.

In order to meet the best practice requirements for greenhouse gas and energy efficiency specified in the SEPP (AQM) and the PEM, energy efficiency has been optimised in the design of ventilation fans and tunnel lighting.

7.4.1 Energy efficiency provisions for ventilation fans

Energy efficiency in ventilation fans would be achieved through:

- The use of VSD fans and selected VSD jet fans for main ventilation fan control to ensure acceptable in-tunnel air quality is maintained.
- Tailoring ventilation levels to traffic flows.

The operation of the ventilation fans for energy efficiency is described below.

Normal operation

While the system is designed to function with only five fans operational, when available, all six would be run at a reduced speed using VSDs. With all six fan operating to meet the requirements of five fans, a nominal 17 per cent reduction in fan speed is required. This speed reduction should result in an approximate 43 per cent reduction in power consumption per fan and an approximate 30 per cent power consumption for the combined ventilation structure main fans[1].

[1] The power reduction per fan difference to the whole station power reduction is due to adjusting for 6 fans operating instead of 5 to deliver the same air flow rate.

Consideration of alternative ventilation technologies

The use of low static pressure fans was considered during equipment selection for the reference design. However, their use was discounted for the following reasons:

- Low pressure fans are larger in size than a high pressure fan (with at least twice the diameter) and are required to be arranged vertically resulting in an increased ventilation structure footprint, leading to increased visual impacts and an increased loss of parklands area
- Low pressure fans are unable to power the smoke extraction system, leading to a requirement for a separate smoke extraction system, further increasing the ventilation structure size and associated visual and land use impacts
- Little change to the energy usage, which is dominated by the use of jet fans to meet requirements for zero portal emissions
- For substantial energy savings to be achieved through the use of low static pressure fans, a large ventilation structure would need to be placed at each of the exit portals (at least six exit portals) which would further increase impacts on community, visual amenity, land use as well as generating additional costs
- The technology is not new, however a road or rail tunnel using low pressure fans has not yet been constructed and applied in the Australian setting.

In accordance with Principle 1B of the EP Act, the evaluation of low static pressure fans has integrated social considerations alongside environmental considerations. In balancing the energy savings which could be achieved through the use of low static pressure fans against the large increase in community impacts which would result from an increase in the number and size of ventilation structures, it is considered that the use of low static pressure fans is not justified.

Portal emissions

EPA Victoria has in the past required that tunnels be designed and operated to have zero portal emissions. However, through undertaking air quality monitoring and air impact modelling it has been possible for some tunnel operators to demonstrate that achieving zero portal emissions is not required at all times of the day. Consequently, EPA Victoria has amended some tunnel operator's licence conditions to allow portal emissions over night and on weekends (ie non-peak periods).

The North East Link tunnel ventilation system has been designed to be able to achieve zero portal emissions. To prevent portal emissions from the main tunnels and ramp portals for the North East Link tunnels dictates that the main fans and a significant number of jet fans must always be operational. Modelling has estimated that the ventilation structures must be discharging at least 600 m^3/s for all hours of the day. Energy demand calculations have been based on the requirement for zero portal emissions at all times of day.

The tunnel ventilation system has been designed to be adaptable so that if, following further monitoring and modelling, EPA Victoria were to grant approval for some portal emissions, energy savings could be achieved.

7.4.2 Energy efficiency in lighting

In order to minimise energy consumption related to tunnel lighting, light emitting diode (LED) lighting would be used in both the vehicle tunnels and access tunnels for North East Link.

In service tunnels, proximity LED lighting would be used, with a minimum lighting level maintained for safety purposes with enhanced lighting activated when service tunnels are occupied.

An intelligent tunnel lighting control system which enables the control of tunnel luminaires during the daytime would be implemented.

7.4.3 Renewable energy

Sustainability targets would be developed for North East Link. It is anticipated that a target for a minimum percentage of renewable energy consumption would be included. Greater use of renewable energy would reduce the tunnel ventilation system's electricity-related greenhouse gas emissions.

To inform the setting of targets an assessment of the types and amounts of renewable energy that can be self-generated during the construction and operation phases of the project, options for the purchase of renewable energy for the construction and operation phase of the project, and the relative costs of each option considered has been performed. Based on this assessment, a decision will be made on the best approach to incorporating renewable energy into North East Link.

8 Climate Change

This section assesses the potential impact of climate change on the tunnel ventilation system. Legislative context for this is given in Section 3.1.4. The assessment against the criteria of the *Climate Change Act 2017* is provided in Section 9.2.1.

8.1 Assessment methodology

8.1.1 Climate change resilience & adaptation

Climate change has the potential to put infrastructure at risk due to degradation, failure and increased maintenance and replacement costs. The long life span associated with infrastructure assets highlights the importance of assessing climate change risks and integrating adaptation strategies early to allow due consideration of risks and incorporation of appropriate adaptation measures.

To assess the climate change risks relevant to North East Link, including the potential impact of climate change on tunnel ventilation, and potential adaptation measures for risks considered high and significant, a Climate Risk Workshop (the workshop) was held on Thursday the 8th of February 2018. The workshop brought together 25 North East Link Project and Technical Adviser personnel working across the project. The objectives of the workshop were to:

- Engage the North East Link project team early on climate risk management across all disciplines to further their understanding and knowledge of climate impacts and gain buy-in and support for addressing potential climate impacts.
- Discuss how these impacts should be considered in the reference project, or in future stages of the project.
- Enable climate risks to be managed by incorporating adaptation measures early into the project.

8.1.2 Identification of relevant climate change projections and future altered climate and environmental conditions

Historical climate data for the study area was obtained from the Viewbank Bureau of Meteorology (BoM) weather station (station number 86068) which is located in the project corridor. Data recording for the site commenced in 1999. Climate projections for the study area are drawn from the CSIRO and BoM *Climate Change in Australia Technical Report* and *Climate Change in Australia Southern Slopes Cluster Report* (Grose et al. 2015). These reports reflect the information from the IPCC's latest report, the *Fifth Assessment Report* (AR5). These projections are consistent with those in the Victorian Government's *Climate Ready Factsheets* and *Regional Data Sheets* and with projections used in recent Victorian transport infrastructure projects including by the Level Crossings Removal Project.

Research conducted by the CSIRO and BoM indicate that the Greater Melbourne region has already become warmer and drier; with this climate trend likely to continue into the future (DELWP 2015). Anticipated changes to the climate include:

- Temperatures to continue to increase year round
- Fewer frosts
- More frequent and more intense downpours
- More hot days and warm spells
- Less rainfall in winter and spring
- Harsher fire weather and longer fire seasons (DELWP 2015).

Additionally, climate projections published in the Climate Change in Australia Southern Slopes Cluster Report (Grose et al. 2015) indicate:

- Increases in evapotranspiration and decrease in soil moisture
- Decreases in humidity
- Increases in solar radiation.

Detail of the historic and climate projection data for the study area is provided in Appendix E.

8.1.3 Identification of potential impacts under a changed climate

To identify potential impacts to the project under climate change, the workshop followed the climate risk assessment method as outlined in the *Australian Standard 5334 – Climate Change Adaptation for Settlements and Infrastructure – A Risk Based Approach (AS 5334-2013)*. The workshop:

- Provided an overview of the climate change projections used to inform the risk assessment
- Discussed risks associated with a range of climate variables
- Discussed potential adaptation options to manage risks.

Attendees were divided into three groups comprising of both environment specialists and engineering disciplines including hydrology, roads and civil, structures, tunnels and asset management. Each group was facilitated by a climate change risk specialist. Each group completed three group activities:

- **Identifying climate risks**: Participants identified hazards and risks that may impact the project as a result of the following climate variables average temperature, days over 35 °C, fire weather, extreme wind solar radiation, evaporation and average and extreme rainfall and identified hazards and risks that may impact the project. Risk identification included the consideration of biophysical risks, long and short term economic, environmental, health and other social impacts.
- **Rating risks**: Participants used the NEL Risk Assessment Framework to rate the likelihood and consequence of the identified risks, resulting in an overall risk rating for each risk.

- **Identifying adaptation actions for significant and high risks**: For significant and high risks, participants identified potential adaptation measures to be considered as part of the project.

A further follow-up meeting was also held with relevant technical specialists to specifically explore the impact of climate change on tunnel ventilation and to discuss adaptation measures. Climate risks were assessed using the North East Link Risk Assessment Framework, which requires the consideration of potential biophysical impacts and long and short term economic, environmental, health and other social impacts.

8.2 Assessment outcomes

8.2.1 Potential impacts under a changed climate

With regard to the impact of climate change on the tunnel ventilation system the following preliminary risks were identified (see Table 8.1).

Table 8.1 Potential climate risks relating to tunnel ventilation

Risk	Climate hazard	Description
Power failure in the tunnels rendering ventilation system inoperable	Extreme heat	Extreme heat could result in unexpected demands for electricity with more people using air conditioning and other appliances resulting in increased stress on transmission lines, possible short circuiting or shut down. This could result in brownouts or blackouts causing a loss of power to the tunnel ventilation system, reducing its capacity or rendering it inoperable.
	Extreme wind	Extreme wind could damage transmission lines which could result in a loss of power to the tunnel ventilation system, reducing its capacity or rendering it inoperable.
Damage to ventilation structures	Extreme rainfall	Extreme rainfall could damage the ventilation structures reducing their capacity or rendering them inoperable.
	Extreme wind	Extreme wind could damage the ventilation structures reducing their capacity or rendering them inoperable.
	Bushfire	Bushfire could damage the ventilation structures reducing their capacity or rendering them inoperable.
	Solar radiation	Solar radiation could cause degradation to materials from which the ventilation structures are constructed.
	Decreased soil moisture and increased evaporation	Decreased soil moisture and increased evaporation could impact settlement of soils and affect the footing of structures and underground infrastructure.

Risk	Climate hazard	Description
Unforeseen disbursement of emission affecting sensitive receptors	Change in wind conditions	Changes in wind conditions could cause the disbursement of emission from tunnel ventilation systems to be different from that previously modelled. This includes changes in wind speed and potential changes in prevailing wind patterns.
Failure of ventilation system	Increase in average annual temperature	Increase in average temperature could cause increase stress to the ventilation system.

8.3 Climate change adaptation and mitigation

8.3.1 Resilience of the project to climate change

The following adaptation measures were identified for the more significant risks. Incorporating the adaptation measures outlined in Table 8.2 into project design and future contingencies would increase the resilience of the tunnel ventilation system to the impact of climate change.

Table 8.2 Adaptation measures

Risk	Climate hazard	Adaptation measures (design changes and future contingencies)
Power failure in the tunnels rendering ventilation system inoperable	Extreme heat Extreme wind	Consideration has been given during design to: • The requirement for backup power or redundancy to maintain critical systems in the event of an outage. • Ensuring that there are two sources of electricity to the tunnel ventilation system, one at either end of the tunnels to provide a level of redundancy • Key electrical substations being located above the 1 in 2000 AEP flood level or alternative mitigation measures, such as flood gates. • Location of key equipment inside of the tunnels with the tunnel entrances protected by flood barriers. During operation, emergency management procedures and tunnel management systems to be enacted in collaboration with emergency services.

Risk	Climate hazard	Adaptation measures (design changes and future contingencies)
Damage to ventilation structures	Extreme rainfall	The tunnel ventilation system is co-located with the tunnel portals. Tunnel portals are protected from 1 in 200 AEP flood events by flood protection structures. Consideration has been given to the impacts of climate change (ie increased rainfall intensity and sea-level rise) in all flood modelling and drainage design and redundancies such as 'safe-to-fail' areas have also been considered. During operation, emergency management procedures and tunnel management systems to be enacted in collaboration with emergency services.

8.4 Conclusions

The most significant climate risks identified with a potential to impact on the tunnel ventilation system were power failure in the tunnels due to extreme heat or wind, rendering the ventilation system inoperable and potential damage to ventilation structures from extreme rainfall. Adaptation measures have been considered to reduce the impact of both these risks. They include both design considerations and future contingencies. As the project moves through to detailed design there may be an opportunity to also consider adaptation measures for medium and low risks.

9 Greenhouse gas and energy use

A greenhouse gas and energy assessment for North East Link has been prepared as part of the EES. A summary is provided below as recommended by EPA Guideline 1568.

9.1 Assessment methodology

9.1.1 Assessment boundary

For the purpose of the Works Approval Application, the greenhouse gas assessment was required to consider the energy use and greenhouse gas emissions associated with the scheduled activity, which is the operation of the tunnel ventilation system.

Emissions from some other activities associated with the operation of the tunnels such as lighting, dewatering and the operation of signs were also included in the greenhouse gas assessment. Other activities such as maintenance activities and embodied emissions in raw materials were assessed but are not included in the scope of the Works Approval Application as they do not relate to the operation of the ventilation system.

The definitions of emissions scope are described within the *National Greenhouse and Energy Reporting Act 2007* and National Greenhouse and Energy Reporting Regulations 2018 as follows:

- Scope 1: The release of greenhouse gas into the atmosphere as a direct result of North East Link Project activities. The operation of the tunnel ventilation system does not result in direct greenhouse gas emissions and therefore no Scope 1 emissions were assessed for the Works Approval Application.
- Scope 2: The release of greenhouse gas into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by North East Link through purchases. For instance, the consumption of electricity by the tunnel ventilation system.
- Scope 3: Other indirect release of greenhouse emissions. For instance, emissions associated with the extraction and refining of fuels consumed. While the *Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry)* (the PEM) does not require Scope 3 emissions to be assessed, for completeness, Scope 3 emissions have been assessed.

9.1.2 Emission sources

Scope 2 emission sources were considered for the operation of the tunnel ventilation system.

Emissions from traffic using the North East Link road network were excluded from the greenhouse gas assessment for the Works Approval as they are not related to the scheduled activity, being the operation of the tunnel ventilation system.

The Scope 3 emission sources considered for the Works Approval Application were limited to those associated with the extraction, production and transport of electricity consumed in relation to the operation of the tunnel ventilation system.

9.1.3 Calculations

Scope 2 and Scope 3 emissions from electricity use were estimated using the following formula:

$$Y = Q \times EF$$

Where:

Y is the emissions of the relevant scope (tonnes CO_2-e)

Q is the quantity of electricity purchased (MWh)

EF is the emission factor for Victoria for the relevant emissions scope, taken from the National Greenhouse Account Factors July 2018 (tonnes CO_2-e per MWh).

9.2 Assessment outcomes

The PEM requires applicants for a Works Approval that trigger the thresholds for annual energy use and greenhouse gas emission to estimate annual energy consumption in gigajoules, by energy type and associated greenhouse gas emissions. This includes the use of fuels on site and consumption of electricity. The thresholds are 500 GJ/year of energy use and 100 t CO_2-e/year greenhouse gas emissions. The estimated greenhouse gas emissions from the tunnel ventilation system are above these criteria.

The greenhouse gas emissions related to the operation of the North East Link tunnel ventilation system have been calculated. Predicted emissions from operational electricity use are presented in Table 9.1.

Table 9.1 Greenhouse gas emissions from electricity use

Operation	Electricity consumption (MWh/year)	Energy consumption (GJ/year)	Scope 2 (kt CO_2-e/year)	Scope 3 (kt CO_2-e/year)
Tunnel ventilation system (including pumps, signs and tunnel lighting)	69,500	250,100	74	7

Energy consumption figures assume 24 hour a day, seven days a week, 52 weeks per year operation. It is likely that equipment would draw less than this amount of power (ie ventilation fans may be shut down over night), however the conservative assumption of maximum power usage has been made.

The assessment results indicate that the operation of the ventilation system would generate 74 kt CO_2-e per annum of Scope 2 emissions and 7 kt CO_2-e per annum of Scope 3 emissions.

9.2.1 Assessment against criteria of *Climate Change Act 2017*

Section 17(4) of the *Climate Change Act 2017* states that in having regard to the potential contribution to the state's greenhouse gas emissions, decision makers must consider climate change.

The relevant considerations are reproduced below with a brief discussion (*in italic*) against each of these elements, explaining the results of the greenhouse gas assessment in relation to the principles.

- Potential short-term and long-term greenhouse gas emissions.

  The annual greenhouse gas emissions resulting from the operation of the tunnel ventilation system are predicted to be 81 kt CO_2-e per annum (Scope 2 and 3).

- Potential direct and indirect impacts greenhouse gas emissions.

  The operation of the tunnel ventilation system is predicted to result in no direct (Scope 1) greenhouse gas emissions. The indirect (Scope 2 and Scope 3) greenhouse gas emissions resulting from the operation of the tunnel ventilation system are predicted to be 81 kt CO_2-e per annum.

- Potential increases and decreases in greenhouse gas emissions.

  The operation of the tunnel ventilation system is predicted to contribute an additional 81 kt CO_2-e annually to Victorian greenhouse gas emissions.

- Potential cumulative impacts of greenhouse gas emissions.

  Tunnel operation is predicted to contribute 96 per cent of the annual greenhouse gas emissions from the operation of North East Link. This represents 0.07 per cent of emissions from all Victorian sectors in 2016, which were 115,103 kt CO_2-e (AGEIS, 2018).

9.3 Environmental performance requirements

The EPRs relevant to greenhouse gas emissions for the North East Link tunnel ventilation system are presented in Table 9.2.

Table 9.2 EPRs relevant to greenhouse gas emissions

EPR Code	Environmental Performance Requirement
SCC1	**Implement a Sustainability Management Plan** North East Link Project must set sustainability targets and specify ratings to be achieved under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool. Contractors must develop and implement a Sustainability Management Plan that contains measures to meet, as a minimum, the sustainability targets and specified ratings.
SCC2	**Minimise greenhouse gas emissions** Integrate sustainable design practices into the design process and implement these to minimise, to the extent practicable, greenhouse gas emissions arising from construction, operation and maintenance of North East Link.
SCC3	**Apply best practice measures for energy usage for tunnel ventilation and lighting systems** Best practice measures for energy usage are to be applied for the tunnel ventilation and lighting systems in accordance with the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry).

In regard to EPR SCC1, it is intended that the sustainability targets would include objectives for energy and carbon, both of which have the potential to reduce the greenhouse gas impact of the tunnel ventilation system. Practical measures that can be implemented to reduce greenhouse gas emissions include investigating and implementing:

- Energy efficiency measures
- The use of renewable energy
- The purchase of carbon offsets.

9.4 Application of best practice

In order to meet the best practice requirements for greenhouse gas and energy efficiency specified in the SEPP (AQM) and the PEM, energy efficiency has been optimised in the design of ventilation fans and tunnel lighting.

The provisions for best practice in greenhouse gas and energy use are discussed in Section 7.4.

9.5 Conclusions

The predicted operational greenhouse gas emissions from North East Link are equivalent to 0.07 per cent of current annual emissions from Victoria and 0.02 per cent of current annual emissions from Australia. Given these percentages, North East Link's predicted operational emissions are not considered to be significant.

The results of this assessment are conservative as they are based on calculations using current greenhouse gas emissions from the Victorian electricity grid. As more renewable energy becomes available, it is expected that the project's electricity-related emissions would decrease over time in line with the decreasing greenhouse gas intensity and the use of more fuel-efficient vehicles.

Overall, greenhouse gas emissions could be reduced through the application of best practice as outlined in the EPRs in Section 9.3.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to greenhouse gas and energy use, Works Approval conditions of the West Gate Tunnel have required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> ...
> *(d) the tunnel ventilation and lighting systems, showing compliance with best practice requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'*
> ..."

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision.

As such, an updated evaluation of best practice would be undertaken during the detailed design phase to confirm that the contractor's design meets the requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'.

10 Air quality

An air quality assessment for the North East Link tunnel ventilation system has been prepared. A full copy of the tunnel ventilation system air quality assessment is provided in 14. A summary is provided below.

10.1 Assessment methodology

The following methodology was applied to the air quality assessment:

- Obtain background concentrations of ambient air quality and prevailing meteorology to understand the existing conditions
- Model traffic emissions associated with the operation of the tunnels
- Undertake dispersion modelling to predict air quality impacts associated with the discharges from the tunnel ventilation system
- Establish EPRs to manage air emissions and comply with the SEPP (AQM)

10.1.1 Model inputs

Background concentrations of CO, NO_2, PM_{10} and $PM_{2.5}$ were sourced from the EPA Victoria ambient air quality monitoring station located in Alphington. While CO, NO_2, PM_{10} concentrations for 2013 to 2017 were used, $PM_{2.5}$ concentrations for 2014 to 2017 were used as the $PM_{2.5}$ monitoring equipment was installed at the Alphington AAQMS in 2014. Background air quality values for PAHs and VOCs recommended by EPA Victoria were used.

Meteorological data from the Bureau of Meteorology (BoM) meteorological monitoring station at Viewbank (AWS 086068) were used as inputs to the dispersion modelling. Cloud cover from Essendon Airport and sonde data from Melbourne Airport were utilised. Data from the years 2013 to 2017 were analysed.

Traffic data for 2026 and 2036 were sourced from traffic modelling, with the conservative 'high' traffic volume estimate used. For the purposes of emissions modelling, it was assumed that passenger car traffic for North East Link is 15 per cent diesel-fuelled and 85 per cent petrol-fuelled.

The traffic emissions assessment was based on vehicle emission factors developed using the COPERT Australia road transport air pollutant emission inventory model configured using vehicle fleet mix and mean fleet mileage statistics for Victoria in 2010 based on NPI Australian Motor Vehicle Emissions Inventory. These factors were adjusted based on future year factors for the year 2020 for PM_{10}, $PM_{2.5}$, CO and NO_2 described by PIARC.

$$2020\ future\ year\ adjusted\ emissions\ factors = (2010\ assessment\ emission\ factors) \times (2020\ future\ year\ factor)$$

The adjusted 2020 emission factors were used with the predicted project diurnal traffic data to generate diurnal emission rates for the ventilation structures.

10.1.2 Assessment approach

For the northern and southern ventilation structures, the operational impact of emissions to air was assessed using the approved regulatory model AERMOD (version 15181). The model was prepared in accordance with the EPA Victoria *Guidance Notes for Using the Regulatory Air Pollution Model* the exception being the AERMOD urban option, which was utilised based on consultation with EPA Victoria and AERMOD specialists. The operational impact of emissions to air was not assessed for the emergency smoke discharge structure as this discharge point is for emergency use only.

It was determined that the highest one-hour average ground level concentration (GLC) of $PM_{2.5}$ was predicted using data from 2017. As such, all subsequent modelling was conducted using the 2017 meteorological and background concentration datasets.

Three uniform Cartesian receptor grids were used to model sensitive receptors, one outer grid with a 100 metre resolution centred on the project and two inner grids with 25 metre resolutions centred on the northern and southern ventilation structure. In addition, discrete receptors were input at the location of 191 selected sensitive receptors within the domain of the model. The locations of the receptor grids and discrete receptors are given in Figure 10.1. All receptor points were input at ground level.

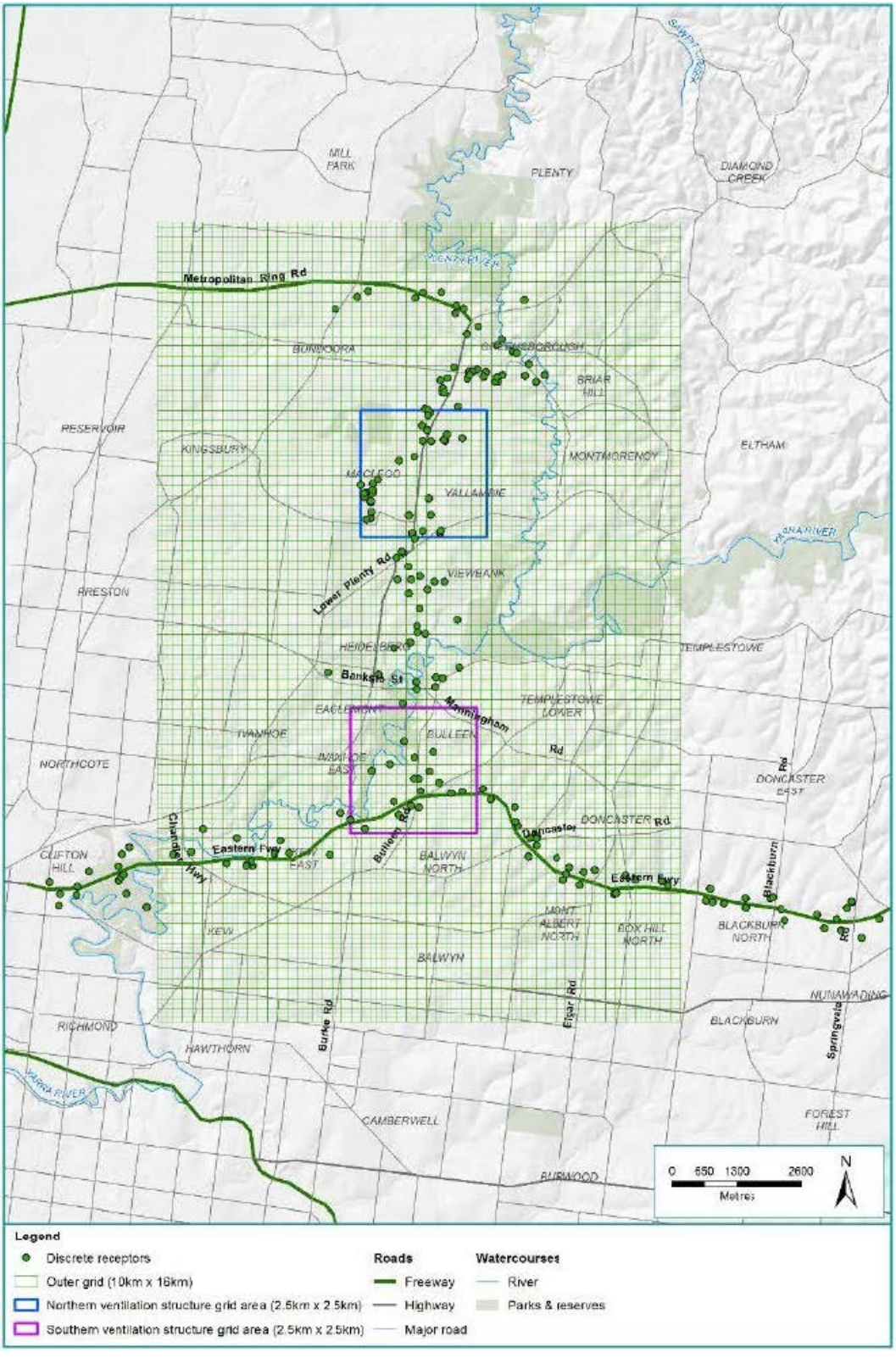


Figure 10.1 Model domain gridded and discrete receptors

10.1.3 Emissions criteria

Pollutant impacts from the ventilation structures have been assessed against the SEPP (AQM) Schedule A design criteria (Table 10.1). Assessment criteria are based on the 99.9th percentile as determined by modelling, in accordance with Schedule C of the SEPP (AQM).

Table 10.1 Ventilation structure emissions criteria

Pollutant	Criterion (mg/m^3)	Averaging period
PM_{10}	0.08	1 hour
$PM_{2.5}$	0.05	1 hour
NO_2	0.19	1 hour
CO	29	1 hour
Benzene	0.053	3 minute
Toluene	0.65 (odour)	3 minute
Ethylbenzene	14.5	3 minute
Xylene isomers	0.35 (odour)	3 minute
Formaldehyde	0.04	3 minute
1,3 Butadiene	0.073	3 minute
PAH [as B(a)P toxic equivalent]	0.00073	3 minute

10.1.4 Modelling scenario and sensitivity analysis

Air dispersion modelling was conducted for the Reference Project for normal operation predicted traffic volumes and fleet mixes for 2026 (Scenario A) and 2036 (Scenario B). The model inputs were characterised utilising vehicle emissions factors developed with the COPERT Australia road transport air pollutant emission inventory model.

In addition, the following sensitivity analyses were conducted:

- Maximum lane capacity, 24 hours per day, 365 days per year
- Emissions at in-tunnel air quality limits
- Increased diesel to petrol fuelled car ratios – doubled portion of diesel fuelled cars
- Alternative ventilation structure locations (discussed further in Section 10.1.5)
- 2025 future year adjusted vehicle emission rates (discussed further in Section 10.1.6).

10.1.5 Alternative ventilation structure locations

For the purposes only of sensitivity analysis, the impact of alternative ventilation structure locations was assessed through modelling of a $PM_{2.5}$ under Scenario B (2036) conditions. The northern and southern ventilation structures were each assessed separately. Four alternative locations for each of the northern and southern ventilation structures were modelled at the extremities of identified regions of assessment (Figure 10.2 and Figure 10.3).



Figure 10.2 Northern ventilation structure – reference project and sensitivity testing locations



Figure 10.3 Southern ventilation structure – reference project and sensitivity testing locations

10.1.6 2025 future year adjusted vehicle emission rates

As described in Section 10.1.1, vehicle emission factors were developed from the COPERT Australia inventory model configured using vehicle fleet mix and mean fleet mileage statistics for Victoria in 2010 scaled using PIARC 2020 future year factors.

In the absence of future year Victorian vehicle fleet mix and mean fleet mileage statistics with which to configure COPERT Australia, or PIARC future year factors beyond 2020, composite vehicle emissions factors for Brisbane for the years 2010 and 2025 (City of Brisbane, 2016) developed using COPERT Australia were used to estimate future year factors with which to adjust the PM_{10}, $PM_{2.5}$ and NO_2 assessment emission factors out to 2025.

$$2025\ future\ year\ adjusted\ emissions\ factors = (2010\ assessment\ emission\ factors) \times (2025\ future\ year\ factor)$$

10.2 Assessment outcomes

10.2.1 Dispersion modelling results

Project only

In order to assess the impact of the project alone, the maximum predicted project contribution to ground level concentrations of pollutants were calculated for Scenario A (2026) and Scenario B (2036).

Table 10.2 and Table 10.3 present the maximum (99.9th percentile) results for PM_{10}, $PM_{2.5}$, CO and NO_2 for Scenario A and Scenario B for gridded receptor points without consideration of the background concentration.

Table 10.2 Dispersion modelling results for receptor grid points – Scenario A (2026), project only

	Units	SEPP (AQM) design criterion	Maximum at a receptor grid point	
			Predicted GLC	Project contribution relative to design criterion (%)
PM_{10}	µg/m^3	80	4.2	5.3
$PM_{2.5}$	µg/m^3	50	3.6	7.2
CO	mg/m^3	29	0.15	0.52
NO_2	µg/m^3	190	29	15

Table 10.3 Dispersion modelling results for receptor grid points – Scenario B (2036), project only

	Units	SEPP (AQM) design criterion	Maximum at a receptor grid point	
			Predicted GLC	Project contribution relative to design criterion (%)
PM_{10}	µg/m^3	80	4.8	6.0
$PM_{2.5}$	µg/m^3	50	4.1	8.2
CO	mg/m^3	29	0.15	0.52
NO_2	µg/m^3	190	35	18

Table 10.4 and Table 10.5 present the maximum (99.9th percentile) project only PM_{10}, $PM_{2.5}$, CO, and benzene results for discrete receptors for Scenario A and Scenario B without consideration of the background concentration.

Table 10.4 Dispersion modelling results for discrete receptors – Scenario A (2026), project only

	Units	SEPP (AQM) design criterion	Maximum at a discrete receptor	
			Predicted GLC	Project contribution relative to design criterion (%)
PM_{10}	µg/m^3	80	2.9	3.6
$PM_{2.5}$	µg/m^3	50	2.5	5.0
NO_2	µg/m^3	190	20	10
Benzene	µg/m^3	53	2.7	5.0

Table 10.5 Dispersion modelling results for discrete receptors – Scenario B (2036), project only

	Units	SEPP (AQM) design criterion	Maximum at a discrete receptor	
			Predicted GLC	Project contribution relative to design criterion (%)
PM_{10}	µg/m^3	80	3.3	4.1
$PM_{2.5}$	µg/m^3	50	2.9	5.7
NO_2	µg/m^3	190	22	12
Benzene	µg/m^3	53	2.7	5.0

For Scenario A, the maximum assessed project contributions to the PM_{10}, $PM_{2.5}$, CO, NO_2 and benzene ground level concentrations are up to 15 per cent of the design criteria (NO_2) at the most affected gridded receptor points and up to 10 per cent of the design criteria (NO_2) at the most affected discrete receptor.

For Scenario B, the maximum predicted project contributions to the PM_{10}, $PM_{2.5}$, CO, NO_2 and benzene ground level concentrations are up to 18 per cent of the design criteria (NO_2) at the most affected gridded receptor points and up to 12 per cent of the design criteria (NO_2) at the most affected discrete receptor.

Project and background

In order to assess the impact of the project in conjunction with background concentrations, a second assessment was completed. This second assessment included time-varying background concentrations for PM_{10}, $PM_{2.5}$, CO and NO_2 and constant background concentrations for benzene, toluene, ethylbenzene, xylene isomers, 1,3-butadene, formaldehyde, and PAHs.

The results of dispersion modelling including the project and background for Scenario A (2026) and Scenario B (2036) are summarised in Table 10.6 and Table 10.7. It should be noted that the time-varying background concentrations (PM_{10}, $PM_{2.5}$, CO and NO_2) strongly influenced the assessment outcomes, and in particular the hour at which the assessed maximum (99.9th percentile) occurs. As such, the project contributions relative to design criteria listed in Table 10.6 and Table 10.7 may differ from those listed in Table 10.2 and Table 10.3.

Table 10.6 Dispersion modelling results – Scenario A (2026), project and background

	Units	SEPP (AQM) design criterion	Maximum predicted GLC			Project contribution relative to design criterion (%)
			Total	Project	Background	
PM_{10}	**µg/m^3**	**80**	**200**	**0.17**	**200**	**0.22**
$PM_{2.5}$	**µg/m^3**	**50**	**74**	**0.063**	**74**	**0.13**
CO	mg/m^3	29	2.5	0.032	2.5	0.11
NO_2	µg/m^3	190	130	11	120	5.6
Benzene	µg/m^3	53	14	5.6	8.0	11
Toluene	µg/m^3	650	59	11	47	1.7
Ethylbenzene	µg/m^3	14,500	9.4	4.2	5.2	0.029
Xylene isomers	µg/m^3	350	33	11	22	3.1
1,2-Butadiene	µg/m^3	73	1.7	1.2	0.48	1.6
Formaldehyde	µg/m^3	40	8.7	2.3	6.4	5.8
PAHs	µg/m^3	0.73	0.0011	0.00056	0.00055	0.077

Note: **Bold text** indicates exceedances of the design criterion when background values included.

Table 10.7 Dispersion modelling results – Scenario B (2036), project and background

	Units	SEPP (AQM) design criterion	Maximum predicted GLC			Project contribution relative to design criterion (%)
			Total	Project	Background	
PM_{10}	**µg/m³**	**80**	**200**	**0.21**	**200**	**0.27**
$PM_{2.5}$	**µg/m³**	**50**	**74**	**0.083**	**74**	**0.17**
CO	mg/m³	29	2.5	0.037	2.5	0.13
NO_2	µg/m³	190	130	11	120	5.7
Benzene	µg/m³	53	14	5.6	8.0	11
Toluene	µg/m³	650	59	11	47	1.7
Ethylbenzene	µg/m³	14,500	9.4	4.2	5.2	0.029
Xylene isomers	µg/m³	350	33	11	22	3.1
1,2-Butadiene	µg/m³	73	1.7	1.2	0.48	1.6
Formaldehyde	µg/m³	40	8.8	2.3	6.4	5.8
PAHs	µg/m³	0.73	0.0011	0.00058	0.00055	0.079

Note: **Bold text** indicates exceedances of the design criterion when background values included.

PM_{10} and $PM_{2.5}$ exceedances were primarily due to background concentrations, which have a strong influence on ground level concentrations of pollutants.

Summary of dispersion results

With the inclusion of background values, all modelled pollutants except PM_{10} and $PM_{2.5}$ are compliant with the SEPP (AQM). The non-compliance of PM_{10} and $PM_{2.5}$ is considered to be due to high background levels, not actual tunnel emissions.

For the non-compliant values in Table 10.6 and Table 10.7, the contribution from the ventilation structures was found to be negligible, less than one per cent, for both Scenario A and Scenario B.

In its assessment report for the West Gate Tunnel Project, EPA Victoria noted that as the contribution of ventilation structures to predicted concentrations is small, the exceedances of the SEPP (AQM) were not considered to conflict with the intent of the Policy. Consistent with the results of the West Gate Tunnel air quality assessment, in the case of the North East Link tunnel ventilation system, the exceedances of PM_{10} and $PM_{2.5}$ are associated with background concentrations, not the contribution of the tunnel ventilation system. Thus, the exceedances of PM_{10} and $PM_{2.5}$ are not considered to conflict with the intent of the SEPP (AQM).

Sensitivity analysis results

Maximum lane capacity

With the assumption of maximum lane capacity, 24 hours per day, 7 days per week, all modelled pollutants except PM_{10} and $PM_{2.5}$ are compliant with the SEPP (AQM).

The PM_{10} and $PM_{2.5}$ background concentrations exceeded the design criteria without accounting for project contributions. Project ventilation structure emissions result in no additional PM_{10} exceedances. Project ventilation structure emissions result in an additional 16 $PM_{2.5}$ exceedances.

Tunnel ventilation structure PM_{10} emissions contributed 0.12 per cent of the predicted 99.9th percentile ground level concentration, equivalent to 0.31 per cent of the design criterion. Tunnel ventilation structure $PM_{2.5}$ emissions contributed 1.5 per cent of the predicted 99th percentile ground level concentration, equivalent to 2.3 per cent of the design criterion.

The maximum predicted project contribution to PM_{10} ground level concentrations, without including background concentrations, is 12 per cent of the design criterion. The maximum predicted project contribution to $PM_{2.5}$ ground level concentrations, without including background concentrations, is 17 per cent of the design criterion.

Emissions at in-tunnel air quality limits

With the assumption of emissions at in-tunnel air quality limits, modelling indicated compliance with both CO and NO_2 design criteria.

Tunnel ventilation structure CO emissions contributed 6.7 per cent of the design criterion. Tunnel ventilation structure NO_2 emissions contributed 6.9 per cent of the design criterion.

The maximum predicted project contribution to CO ground level concentrations, without including background concentrations, is 7.6 per cent of the design criterion. The maximum predicted project contribution to NO_2 ground level concentrations, without including background concentrations, is 19 per cent of the design criterion.

Although maximum ventilation rates were assumed, the low contributions from the project in relation to the design criteria indicate that a lower ventilation rate may also achieve compliance.

Increased diesel to petrol fuelled cars ratio

With the assumption of a doubling of the proportion of diesel cars, project contributions to the 99.9th percentile ground level concentrations increased by 15 per cent for PM_{10} and 8.5 per cent for $PM_{2.5}$ to 0.31 per cent and 0.18 per cent of the design criteria, respectively.

NO_2 project contribution to ground level concentrations increased by approximately 32 per cent to 7.5 per cent of the design criteria.

Alternative ventilation structure locations

As previously discussed, the $PM_{2.5}$ background concentrations exceeded the design criteria without accounting for project contributions. Each of the alternative northern ventilation structure locations results in one additional exceedance of the $PM_{2.5}$ design criterion. Each of the alternative southern ventilation structure locations also results in one additional exceedance of the $PM_{2.5}$ design criterion.

At the northern ventilation structure, the maximum project contributions to ground level concentrations, without including background concentrations, differ by less than 1.0 per cent, at approximately 8.1 per cent of the design criterion. At the southern ventilation structure, the maximum project contributions to ground level concentrations, without including background concentrations, differ by less than 3.0 per cent, at between 6.3 per cent and 6.5 per cent of the design criterion.

Maximum predicted project contributions to ground level concentrations occur at similar distances from each of the ventilation structures, however, the direction from ventilation structures varies.

2025 future year adjusted vehicle emission rates

The project contributions of PM_{10}, $PM_{2.5}$ and NO_2 to the 99.9th percentile ground level concentration were found to decrease by approximately 25 per cent, 56 per cent, and 68 per cent, respectively, compared with the Scenario B predictions.

The maximum predicted project contribution to PM_{10} ground level concentrations, without including background concentrations, is 4.2 per cent of the design criterion. The maximum predicted project contribution to $PM_{2.5}$ ground level concentrations, without including background concentrations, is 4.4 per cent of the design criterion. The maximum predicted project contribution to NO_2 ground level concentrations, without including background concentrations, is 5.8 per cent of the design criterion.

10.3 Environmental performance requirements

The EPRs relevant to air quality for the North East Link tunnel ventilation system are presented in Table 10.8.

Table 10.8 EPRs relevant to air quality

EPR Code	Environmental Performance Requirement
AQ2	**Design tunnel ventilation system to meet EPA requirements for air quality** Design, construct and operate the permanent tunnel ventilation system to meet the requirements of the State Environmental Protection Policy (Air Quality Management) and in accordance with the requirements of the EPA Victoria Works Approval.
AQ3	**Achieve in-tunnel air quality performance standards** Design, construct and operate a tunnel ventilation system to introduce and remove air from the tunnels to meet the in tunnel air quality requirements for carbon monoxide (CO) and for NO_2 listed below. In tunnel air quality must meet the following CO standards: Maximum peak CO value of 150ppm 15 minute average CO value of 50ppm 2-hour average CO value of 25ppm. The tunnel ventilation system must also be designed and operated so that the tunnel average nitrogen dioxide (NO_2) concentration is less than 0.5 ppm as a rolling 15 minute average. Develop and implement contingency measures to manage in-tunnel air quality in the event of incidents or emergencies. Apply best practice Australian management techniques to minimise impacts on health from in-tunnel exposure to $PM_{2.5}$ and PM_{10}.
AQ4	**Monitor ambient air quality** Develop and undertake an ambient air quality monitoring program in consultation with EPA Victoria to measure the air quality impacts of North East Link during operation. The ambient air quality monitoring program must include at least one year of monitoring before operation and, for the ventilation structures, be in accordance with the EPA Victoria licence.
AQ5	**Monitor compliance of in-tunnel air quality and ventilation structure emissions** Monitor the in-tunnel air quality and ventilation structure emissions during operation of the ventilation system to demonstrate compliance with EPR AQ2, EPR AQ3 and the EPA Victoria licence to the satisfaction of EPA Victoria. Report the monitoring results publicly in accordance with the EPA Victoria licence. Take remedial action to the satisfaction of EPA Victoria if standards outlined in EPR AQ2, EPR AQ3 and the EPA Victoria licence are not met.

10.4 Application of best practice

In order to meet the requirements of the SEPP (AQM) air quality has been considered in the design of the tunnel ventilation system. In addition, the tunnel ventilation system has been designed such that in-tunnel concentrations would comply with the requirements of PIARC.

The use of air pollution control technology, namely ESP and DeNOx systems, is not considered to be required for the North East Link ventilation system.

Further discussion of best practice in air quality is given in Section 7.2.

10.5 Air quality monitoring plan

An air quality monitoring plan has been prepared and is available in Appendix A. The key monitoring activities are summarised below.

10.5.1 In-tunnel air quality monitoring

In-tunnel air quality monitoring would be conducted to:

- Demonstrate compliance with the proposed in-tunnel air quality limits for CO and NO_2 (refer to EPR AQ3, Table 10.8)
- Ensure appropriate visibility for vehicle drivers under various tunnel operating conditions
- Prevent tunnel portal emissions and resultant environmental impacts by monitoring air speed and direction.

Monitoring equipment would be installed at specific locations within each tunnel to monitor air speed and direction, visibility, CO and NO_2. Equipment performance specifications would comply with the limits specified in Australian Standard AS/NZS 3580.18:2017 '*Measurement of road tunnel air quality*', with equipment calibration and maintenance also conducted in accordance with AS/NZS 3580.18 and NATA requirements. AS/NZS 3580.18 represents worldwide best practice and is currently in the process of being adopted as an ISO Standard.

In-tunnel CO, NO_2 and visibility data would be used to control operation of the tunnel exhaust ventilation system variable speed drive fans.

Final data validation would occur on a monthly basis, including review of equipment calibration records and long term data trends. Data that does not meet the validation process would be marked as invalid and not included in any further data processing.

10.5.2 Continuous emissions monitoring

Continuous emission monitoring systems (CEMS) would be installed on each ventilation structure to monitor the emission of the following pollutants, together with exhaust gas velocity, temperature and relative humidity:

- PM_{10}
- $PM_{2.5}$
- NOx
- CO.

Installed equipment would include sample pumps, sample lines, gas conditioning equipment and automatic calibration systems.

Equipment calibration and maintenance would be conducted in accordance with EPA Victoria Publication No. 440.1, NATA requirements and relevant test method requirements.

CEMS data would be remotely accessed and downloaded on a daily (weekday) basis and preliminary validation conducted. Data failing the validation process would be marked as invalid and not included in any further data processing.

Final data validation would occur on a monthly basis, including a review of monthly equipment calibration records and long term data trends. Data that does not meet the validation process would be marked as invalid and not included in any further data processing.

10.6 Conclusions

Emissions from the tunnel ventilation structures have been modelled. With the inclusion of background values, all modelled pollutants except PM_{10} and $PM_{2.5}$ are compliant with the requirements of the SEPP (AQM).

The contribution of the tunnel ventilation system to ground level concentrations of PM_{10} and $PM_{2.5}$ are small in comparison to background levels, with the non-compliance of PM_{10} and $PM_{2.5}$ considered to be due to high background levels, not tunnel emissions.

Multiple sensitivity analyses, including the analysis of alternative ventilation structure locations, showed relatively little change in the maximum predicted ground level pollutant concentrations. This was largely due to the low project contribution to ground level pollutant concentrations relative to background levels.

Tunnel ventilation structure air dispersion modelling has been based on the following conservative assumptions:

- Vehicle emission factors remaining at levels predicted for 2020
- Background pollutant levels remaining at 2013-2017 levels in 2026 and 2036
- Including exceptional events such as bushfires in background concentrations during modelling
- Assuming conservative 'high' traffic volume estimates for the tunnels.

The use of these conservative assumptions means that the predicted ground level pollutant concentrations and associated air quality impacts in the report are likely to be overestimated.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to air quality, Works Approval conditions of the West Gate Tunnel required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> *(a) the tunnel ventilation system and exhaust stacks showing measures to be taken to ensure compliance with State environment protection policy (Air Quality Management) and ensure impacts are equivalent to or less than the design assessed for this Works Approval;*
> *…"*

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision.

As such, further air quality assessment would be completed during the detailed design phase to confirm that the contractor's design, including the final location of ventilation structures, is compliant with PIARC and SEPP (AQM) requirements.

11 Noise and vibration

A noise and vibration assessment for the North East Link tunnel ventilation system has been prepared. A full copy of the noise and vibration assessment is provided in Appendix B. A summary is provided below.

11.1 Assessment methodology

A noise assessment was undertaken by SLR Consulting Australia as part of the project EES. The purpose of the assessment, among others, was to assess the potential noise impacts from the operation of the tunnel ventilation during operation of North East Link, against the requirements of SEPP N-1. Based on a preliminary selection of plant items, the need for any additional in-principle noise control measures was identified that need to supplement the existing design to achieve compliance.

Sensitive receptors were identified for the noise and vibration assessment using aerial photography. Sensitive receptors were selected for assessment based on areas of highest predicted noise emissions, assessed using noise contour maps, the nature of the receiver and the nature of surrounding land uses. It was generally considered that background noise would not significantly change with increased separation distance from the ventilation structures.

Attended and unattended measurements of existing noise environment were undertaken as part of the Existing Conditions assessment for North East Link. The monitoring at the nearest locations to the assessment sites were used to determine the relevant noise limits. For the purposes of this assessment, the background noise levels at assessment locations positioned further away from a main road are assumed to be 5 dBA lower than the nearest monitoring position.

SEPP N-1 Effective Noise Levels due to the proposed operation were predicted using 'SoundPLAN' environmental noise modelling software, version 8.0. The modelling was undertaken using the ISO 9613-2:1996 prediction method.

The assessment conservatively assumes that the ventilation fans (not including emergency smoke exhaust fans) would be operating at full capacity during the day, evening and night time; noting that this is unlikely to occur given the use of variable speed fans.

Two sets of noise attenuators have been assumed between the ventilation fans and the tunnel roadways and between the fans and the discharge point at the northern and southern ventilation structures. For the purposes of the noise assessment, noise attenuators for the ventilation fans have been assumed to be of the rectangular duct straight splitter type with 43 per cent open-area, and 3 metres long. Tunnel jet fans are assumed to have noise attenuation consisting of in-line circular 1250, 1D silencers installed on the intake and discharge side of the fan unit.

There are multiple substations along the tunnelled section of the project. All, excepting for two will be below ground, and consequently would have negligible acoustical influence on the prevailing noise environment, given it has appropriate space for acoustically treated ventilation systems incorporated into the scheme (which will be refined during the detailed design phase of the project). The two substations located on the surface at the Northern Portal and Manningham Interchange, will be housed in new buildings with provisional space for ventilation and noise mitigation and have been included in the noise model. The locations of the substations are shown in Appendix C.

The noise model was created adopting the assumptions listed in Section 6.4.1 of the noise assessment report (Appendix B).

11.2 Assessment outcomes

The tunnel ventilation system has been designed and operated to comply with the *State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1* (SEPP N-1). SEPP N-1 provides for the establishment of noise limits based on background noise levels.

The reference design includes a number of potential uncertainties associated with the noise assessment. These may include the dynamic attenuation of the silencer (compared to the static test results), the potential for regenerated noise across the face of the silencer and the degradation of the silencer due to dust build-up (assuming yearly cleaning and appropriate maintenance). The modelling, however, contains some conservatism; the fans are positioned at the base of the discharge within a fan room whereas they were modelled near the top of the ventilation structure, the acoustical losses at bends of ductwork, acoustic losses up the structure, end reflection loss at the point of discharge, or specific directionality of the noise are not included in the modelling and will act to lower the predicted emissions. Having considered the balance of uncertainties and the conservatism within the modelling, and the degree to which the predictions are below the criteria; it is considered that the conservatism within the noise model is sufficient to offset the possible uncertainty.

Noise contours showing the predicted dispersion of noise from ventilation fans and substations are shown in Figure 11.1, Figure 11.2 and Figure 11.3.

Sensitive receptors were selected based on these noise contours as well as the following considerations:

- Northern portal: selected receptors were considered to be in the optimum locations given that ambient noise levels are unlikely to significantly change with increased distance from Greensborough Road, whereas noise from the fan decreases as a point source.
- Manningham Interchange: the selected receptors were considered to be the most sensitive, based on topography and land use. One receptor was selected nearest to the substation building (40-42 Bridge Street), and two receivers to the east in Bulleen Road and Elizabeth Street.
- Southern portal: the selected receptor represents the receptor in the quietest area, where impacts would be the highest. At other locations, higher ambient noise from traffic would result in higher, less stringent criteria.

The selected sensitive receptors and zoning are shown in Figure 11.4, Figure 11.5 and Figure 11.6. Noise limits and zoning levels have been determined in accordance with SEPP N-1 for the selected sensitive receptors.

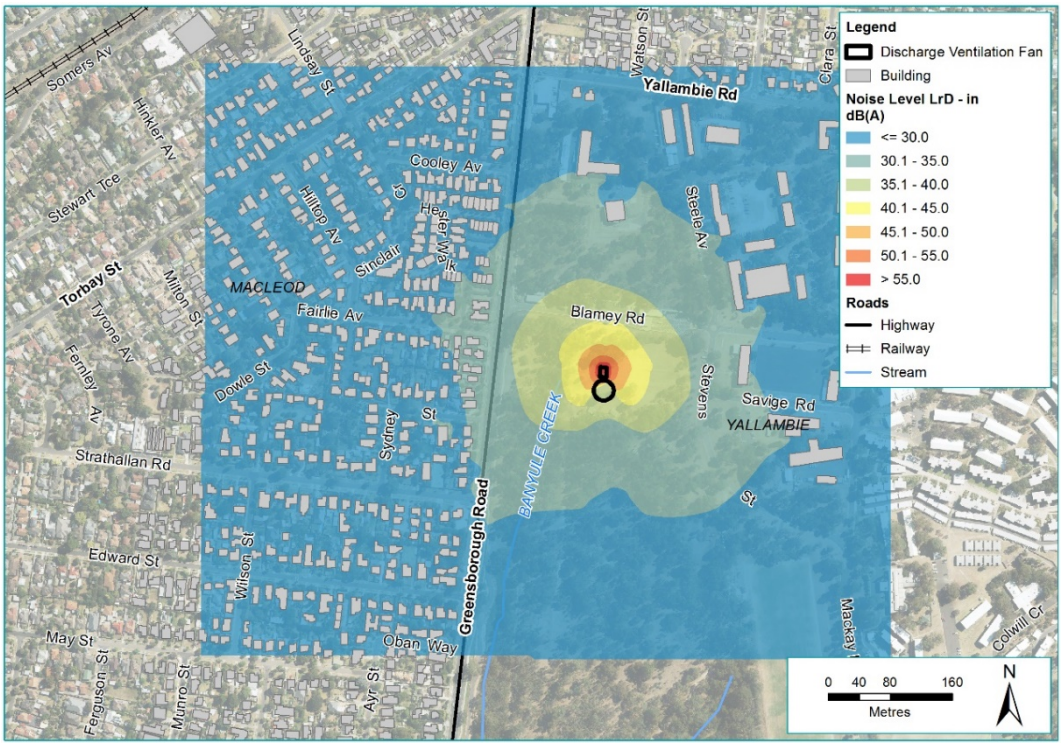


Figure 11.1 Noise contours – Northern portal

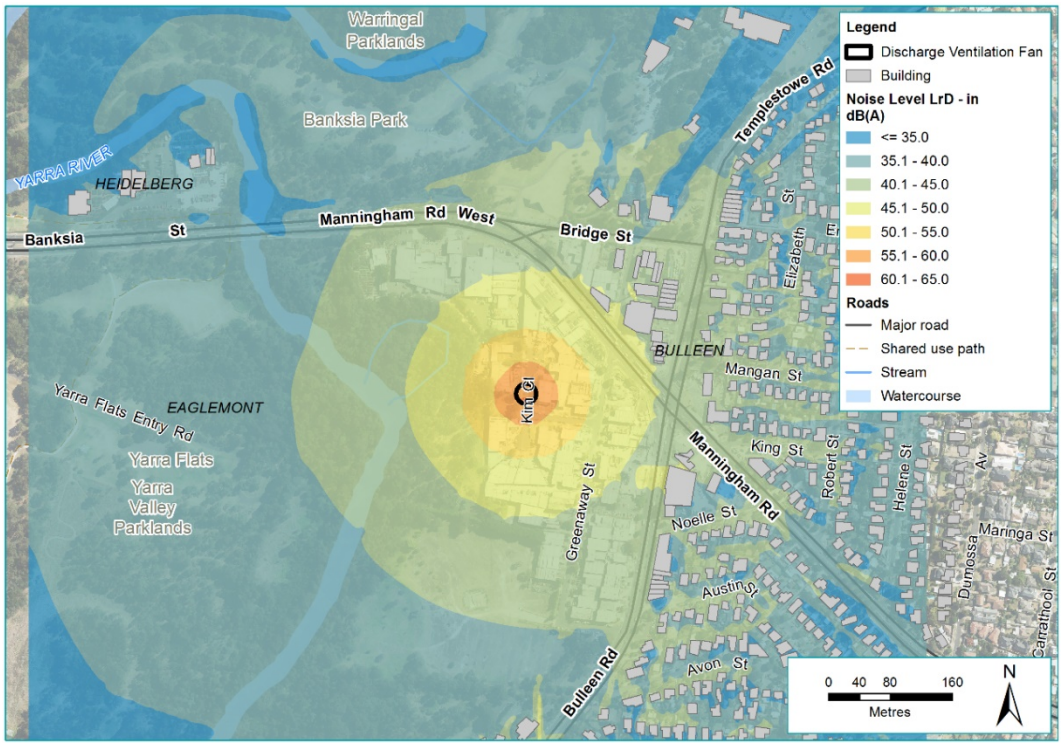


Figure 11.2 Noise contours – Manningham Interchange

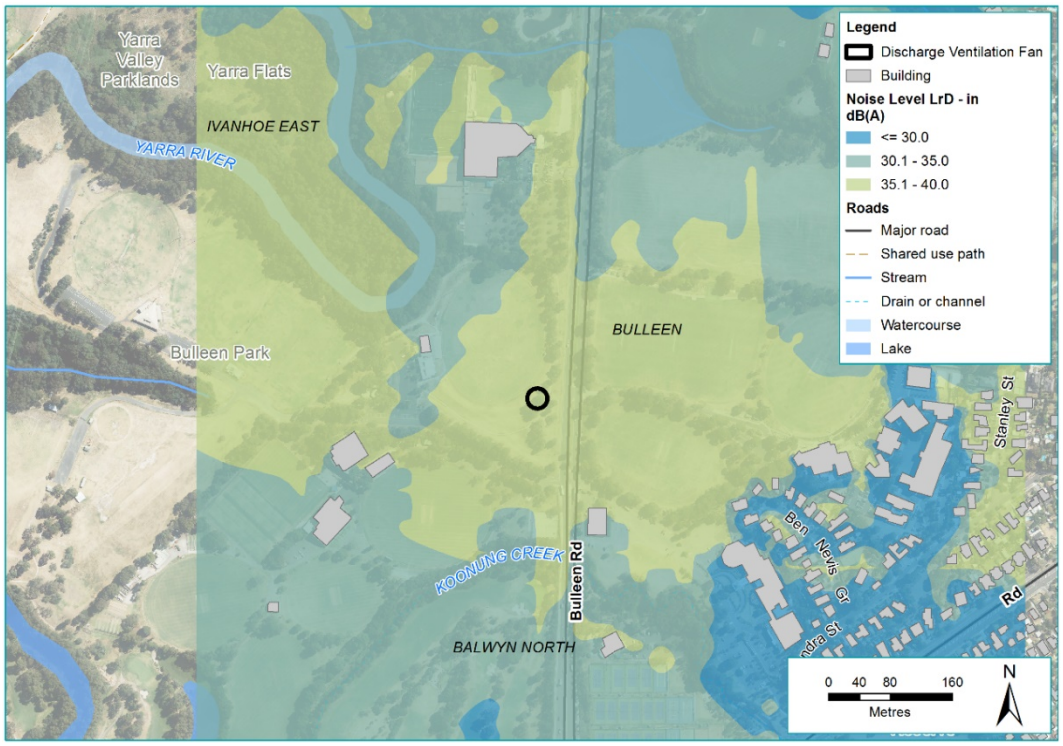


Figure 11.3 Noise contours – Southern portal

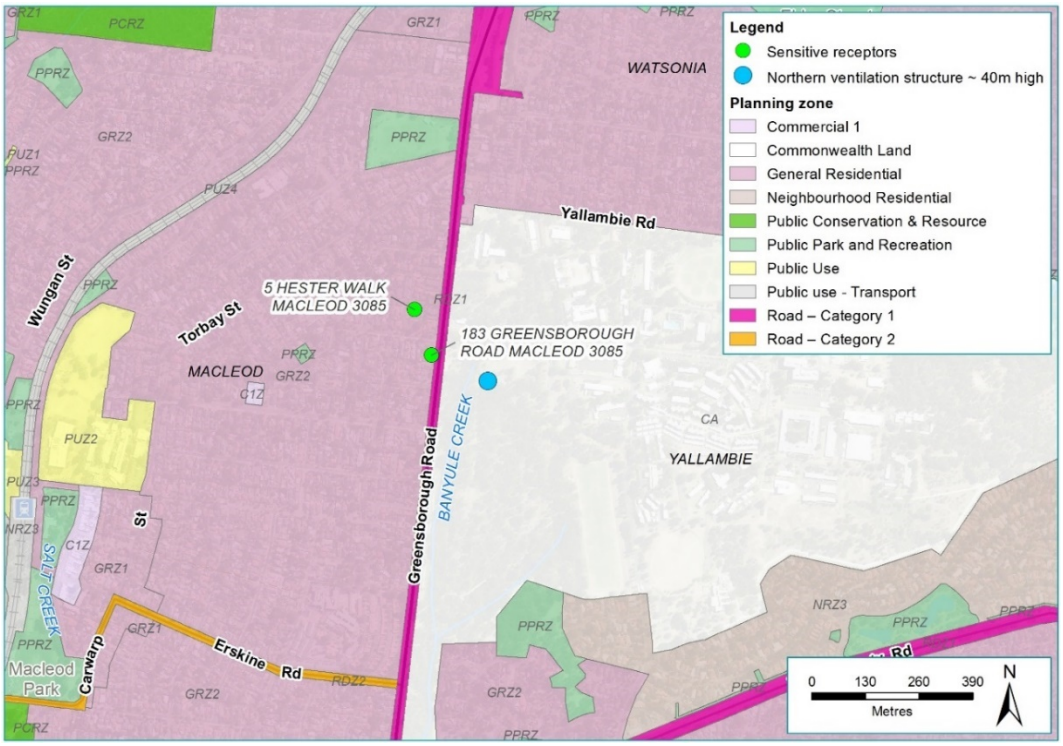


Figure 11.4 Sensitive receptors – Northern Portal

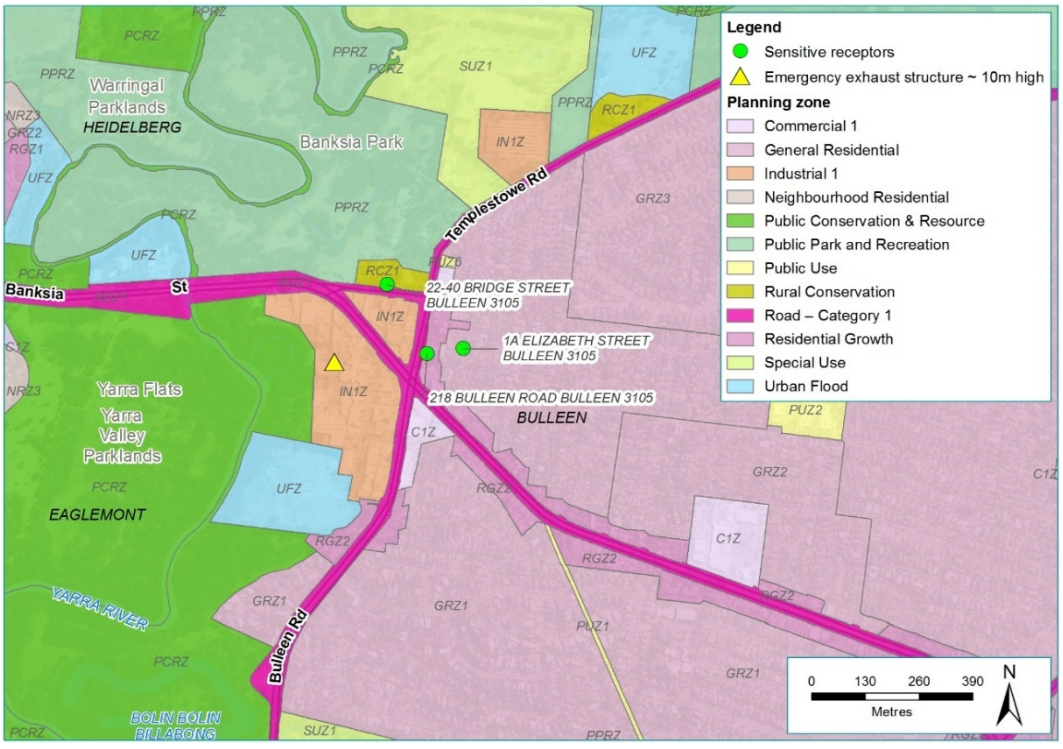


Figure 11.5 Sensitive receptors – Manningham Interchange

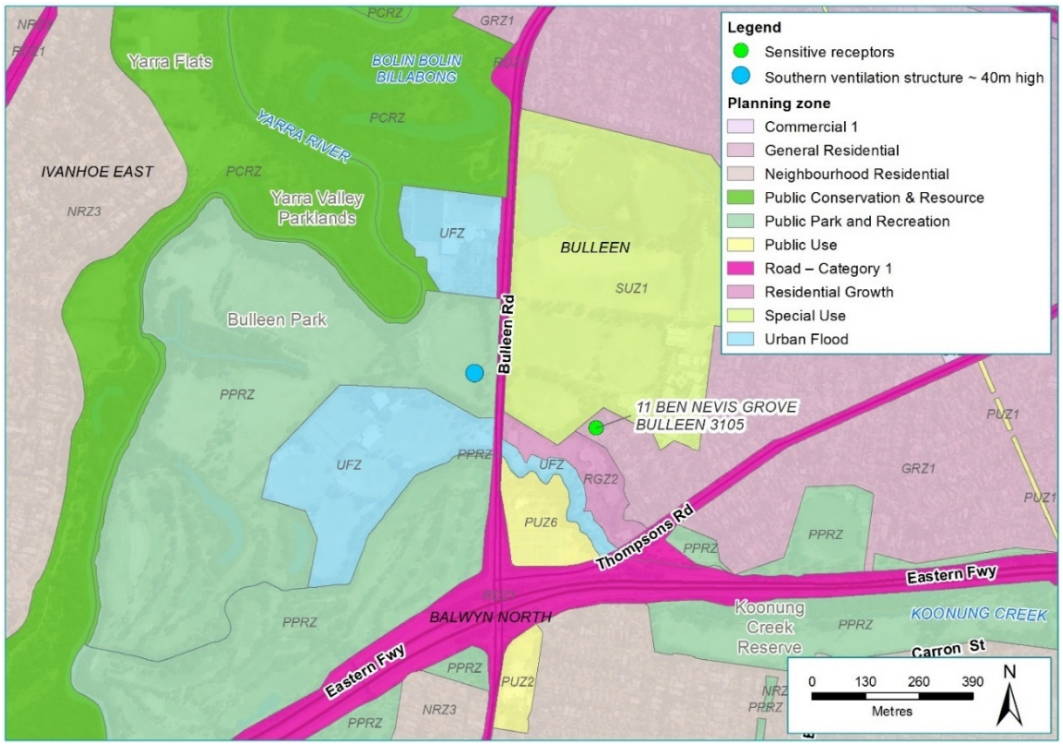


Figure 11.6 Sensitive receptors – Southern portal

Table 11.1 presents an assessment of the predicted tunnel ventilation system noise levels at the sensitive receptors against the established noise limits and zoning levels, based on SEPP N-1.

For Manningham Interchange, the assessment was completed against the daytime noise limits only. The fans at Manningham Interchange would not be used as part of normal tunnel ventilation, and would only be active when removing smoke from the tunnel. Consequently, the unit requires testing every quarter which is anticipated to last for approximately 5 minutes. Testing is to be limited to the daytime period only.

Table 11.1 Noise limits and compliance

		Background level, (dBA L_{90})	Zoning level (dBA)	Noise limit (dBA L_{eq})	Adjusted noise limit[1] (dBA L_{eq})	Predicted emissions, (dBA)	Compliance with SEPP N-1
Northern ventilation structure							
183 Greensborough Road, Watsonia	Daytime	59	53	53	-	33	Yes
	Evening	56	46	47	-	33	Yes
	Night-time	44	41	41	-	33	Yes
	Daytime	55	51	51	-	28	Yes

		Background level, (dBA L_{90})	Zoning level (dBA)	Noise limit (dBA L_{eq})	Adjusted noise limit[1] (dBA L_{eq})	Predicted emissions, (dBA)	Compliance with SEPP N-1
5 Hester Walk, Watsonia	Evening	52	45	47	-	28	Yes
	Night-time	40	40	40	-	28	Yes
Manningham Interchange (testing of emergency smoke exhaust fans only)							
218 Bulleen Road	Daytime	53	57	55	52	49	Yes
1A Elizabeth Street	Daytime	48	53	53	50	46	Yes
40-42 Bridge St	Daytime	48	53	53	50	48	Yes
Southern ventilation structure							
11 Ben Nevis Grove	Daytime	46	50	50	-	36	Yes
	Evening	48	44	48	-	36	Yes
	Night-time	43	39	43	-	36	Yes

[1]Daytime noise limits at Manningham Interchange adjusted by 3dBA to account for possible noise contributions of future development.

This assessment predicted that the noise from the ventilation system (with the proposed silencers) would comply with the requirements of SEPP N-1 during the day, evening and night-time at all noise sensitive buildings around the northern and southern ventilation structures; and during the proposed daytime testing of the smoke exhaust fans at residences near the Manningham Interchange.

11.3 Environmental performance requirements

The EPRs relevant to noise and vibration for the North East Link tunnel ventilation system are presented in Table 11.2.

Table 11.2 EPRs relevant to noise emissions

EPR Code	Environmental Performance Requirement
NV6	**Design permanent tunnel ventilation system to meet EPA requirements for noise** Design and implement the permanent tunnel ventilation system to achieve compliance with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 and in accordance with the Works Approval. Provide detailed design to the satisfaction of EPA Victoria prior to commencement of the works permitted by the Works Approval.
NV7	**Monitor noise from tunnel ventilation system** Measure noise from the permanent tunnel ventilation system on commencing road operation and monitor noise from the tunnel ventilation system post opening of the North East Link, as agreed with EPA Victoria, to verify compliance with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1. Identify and implement contingency measures to be implemented if noise level targets are not met.

11.4 Application of best practice

In order to meet the best practice requirements, noise impacts have been reduced within the design through the use of VSD fans, the use of noise attenuators or silencers, and ongoing monitoring to confirm compliance.

The provisions for best practice in noise management are discussed in Section 7.3.

11.5 Conclusions

Tunnel ventilation noise can achieve compliance with the SEPP N-1 through conventional means such as the selection of suitable equipment and attenuation measures.

The contractor chosen to build the tunnel ventilation system would also be responsible for its ongoing operation. This responsibility would be implemented through contractual documents and the North East Link Environmental Performance Requirements (EPRs). EPR NV6 gives the contractor responsibility for ensuring the tunnel ventilation system's compliance with all aspects of SEPP N-1, which includes the principle of the application of best practice, at the point of initial operation and on an ongoing basis. EPR NV7 gives the contractor responsibility to monitor noise emissions from the tunnel ventilation system on commencing road operation and post opening to verify compliance with the SEPP N-1. Compliance with these EPRs would be achieved through a potential combination of appropriate initial design choices to be specified during the detailed design process, ongoing noise monitoring and appropriate maintenance, replacement of parts or the addition of extra attenuation as required. As set out in the Project's Environmental Management Framework, an independent auditor will undertake audits during construction and operation to confirm compliance with and implementation of the EPRs.

In previous similar projects, EPA has applied approval conditions to account for possible changes made by the successful tenderer to the design. For example, in relation to noise, Works Approval conditions of the West Gate Tunnel have required that:

> *"Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of:*
> ...
> *(e) the tunnel ventilation system, showing measures to be taken to ensure compliance with the State environment protection policy (Control of Noise from Commerce, Industry and Trade) No. N-1"*

It is anticipated that the conditions of approval for the North East Link tunnel ventilation system would include a similar provision requiring the contractor to submit detailed design documentation and updated noise modelling to EPA Victoria, that demonstrates that the tunnel ventilation system to be built can achieve compliance with SEPP N-1 at the time of construction completion and during future operation.

As such, it is envisaged that an acoustic consultant would be engaged by the contractor to demonstrate that further updates to the proposed ventilation system would achieve compliance with the SEPP N-1 noise limits. This includes an assessment of the fans and silencers ultimately selected for installation and consideration of the layout of the facility (including the noise path between the fan and the point of discharge). The assessment would take into account silencer insertion-loss data based on dynamic testing of the product under similar conditions to the operation conditions and address flow noise across the face of the silencer.

When selecting silencers or other forms of noise mitigation, consideration would be given to the acoustic performance throughout the life of the product. The report would detail how the potential for acoustic degradation in the performance equipment (such as silencers) through wear and dust build-up would be addressed.

The detailed design would also consider and justify the need for adjustments to the predicted levels, having consideration of the character of the noise (tonal, impulsive or low frequency).

The contractor would review current best practices relating to the tunnel ventilation system and justify the design with respect to best practice, as part of the detailed design. Noise monitoring would be conducted post commissioning of the ventilation system to demonstrate operational compliance with SEPP N-1 requirements.

12 Environmental management

As required by EPA Publication 1658, this section describes the Project's Environmental Management Framework, how potential construction impacts are being managed and mitigated, and provides an environmental risk assessment of non-routine operation as related to the tunnel ventilation system.

12.1 Overview

North East Link would be delivered in accordance with an Environmental Management Framework (EMF), incorporating Environmental Performance Requirements (EPRs), which would be approved by the Minister for Planning. Contractors would be required to develop and implement an Environmental Management Strategy, a Construction Environmental Management Plan (CEMP), an Operation Environmental Management Plan (OEMP) and Worksite Environmental Management Plans (WEMPs) that address the requirements of the EMF, including EPRs.

Specific monitoring programs would be developed and implemented as part of the CEMP and OEMP. In addition, compliance with the EMF, including EPRs, would be monitored by each of the contractors, North East Link Project and an Independent Environmental Auditor.

Audits would be carried out at regular intervals to evaluate compliance with the EMF, including EPRs. These audits would be carried out in accordance with *AS/NZS ISO 19011 Guidelines for auditing management systems*.

12.1.1 Environmental management framework

An EMF has been developed for North East Link to provide a transparent and integrated governance framework to manage the environmental effects of the project.

In setting out the proposed governance framework for managing the environmental effects of the project, the EMF provides clear accountabilities for the implementation of EPRs in the development and delivery of the project.

Compliance with the EMF, including EPRs, would be mandated and enforced by North East Link Project on behalf of the Victorian Government through the contractual arrangements established between the Victorian Government and contractors appointed for delivery of the project.

12.1.2 Environmental performance requirements

North East Link would be developed and operated in accordance with EPRs which would be approved by the Minister for Planning in approving the EMF. The EPRs define the minimum environmental outcomes that must be achieved during design, construction and operation of the Project.

The performance-based approach of the EPRs enables different design alternatives or construction methodologies to be considered to achieve the required outcomes. This provides a delivery model that is flexible and encourages innovation through the procurement process by allowing tenderers to determine how EPRs would be achieved while developing and optimising the project design.

The EPRs have been informed by relevant environmental legislation and policy requirements and project specific measures recommended by specialists to minimise risk and avoid, reduce or offset environmental impacts identified through the EES risk and impact assessment process.

A set of recommended EPRs has been established, covering a range of topics, including topics of relevance to the ventilation system such as air quality, greenhouse gas, noise and vibration, and social and community. The recommended EPRs of relevance to the tunnel ventilation system greenhouse gas, air quality, and noise and vibration impacts are included in Sections 9.3, 10.3 and 11.3, respectively.

The EMF and the final EPRs would be approved by the Minister for Planning and implemented through the project contracts between the Victorian Government and Contractors and the environmental management documentation.

The project contracts would specify for each EPR whether the Victorian Government or contractor is responsible for implementation.

12.1.3 Environmental management documentation

The EMF requires the preparation of environmental management systems and other project specific documentation by North East Link Project and contractors to monitor and control environmental impacts during design, construction and operation. The environmental management documentation must comply with the EMF, including the EPRs, and address relevant legislation, approval conditions, and contractual requirements.

Figure 12.1 presents an overview of the key environmental management documentation and the relationship to other EMF components.

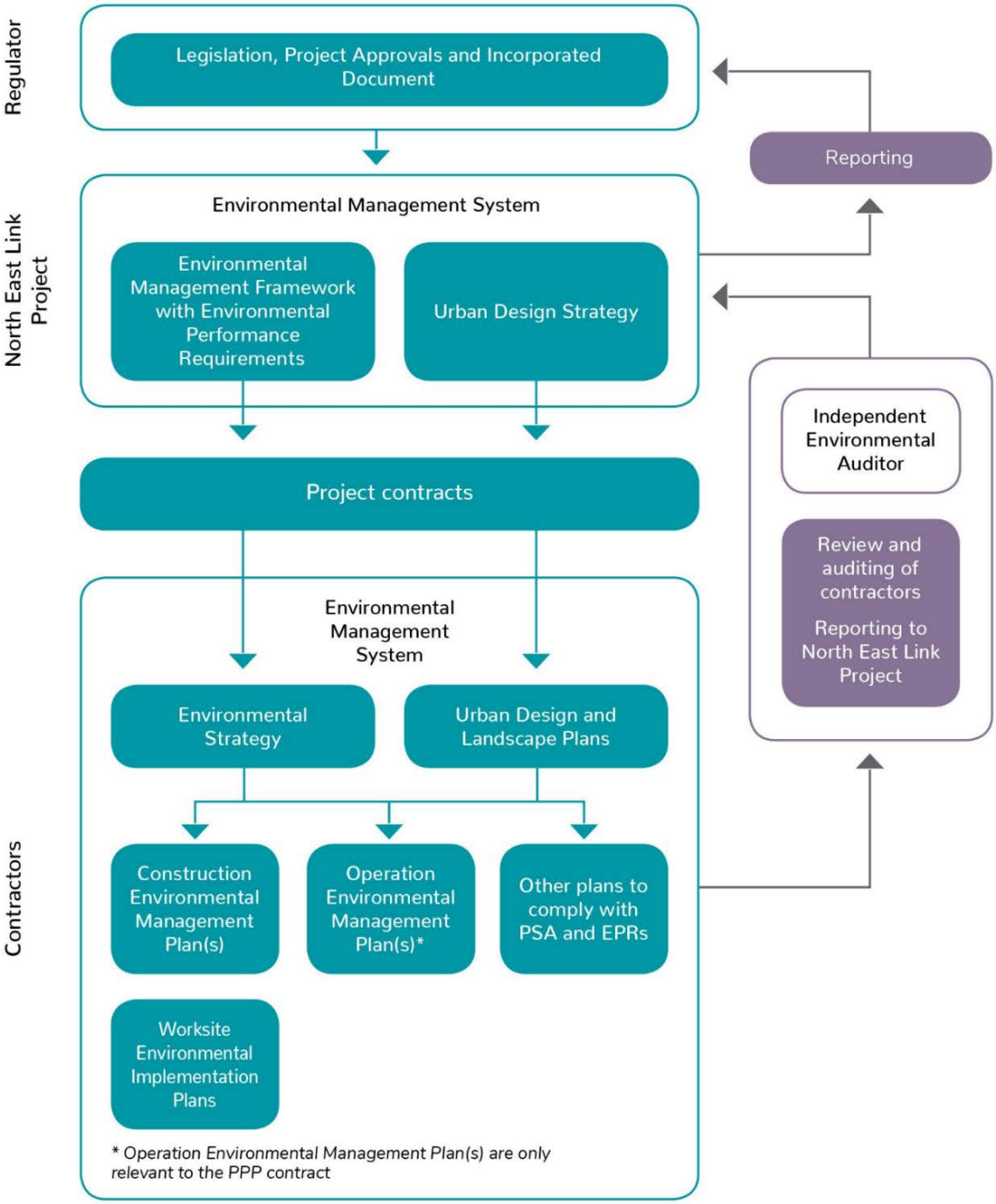


Figure 12.1 Key environmental management documentation

The construction and operation of North East Link would be carried out in accordance with environmental management systems that are consistent with AS/NZS ISO 14001. Environmental management systems provide organisations with a framework and systematic approach to achieving their organisation level objectives for environmental management and sustainability and driving continuous improvement.

In addition to environmental management systems, environmental management documents would be prepared to describe the specific processes, procedures, management and mitigation measures that would be implemented to manage the environmental effects of North East Link. There are three levels of environmental management documents required for North East Link as presented in Table 12.1.

Table 12.1 Key environmental management documents

Level	Purpose	Plans
1 Strategic Framework	Set the strategic direction and overarching requirements for project delivery	• Environmental Management Framework and Environmental Performance Requirements • Urban Design Strategy
2 Management of project-wide impacts	Guide specific programs or works in order to consistently manage potential impacts on the community or environment	• Environmental Strategy • Urban Design and Landscape Plans • Construction Environmental Management Plan (CEMP) • Operation Environmental Management Plan (OEMP)
3 Technical plans	Plans would reflect the contractors' methods of implementing the EMF and other regulatory requirements for specific impacts or locations. These plans may be amended at any stage to reflect the variation of conditions/activities throughout the life of the project	• All other plans required by EPRs such as the Worksite Environment Implementation Plans, CEMP and OEMP sub plans.

12.2 Construction impact management

The potential impacts due to the construction of the North East Link tunnel ventilation system and proposed controls have been identified.

12.2.1 Dust

Dust may be generated during earthworks, such as excavating and stockpiling at construction laydown areas, and may impact upon human health, amenity and environmentally sensitive sites.

The impacts of dust would be managed through the following measures:

- Implementation of a Dust and Air Quality Management and Monitoring Plan to minimise air quality impacts during construction, including dust
- Implementation of a Communications and Community Engagement Plan, including an approach to mitigating community impacts including dust.

12.2.2 Odour

There is a potential for odour impacts from the excavation of soil and possible excavation of contaminated soil.

The potential for impacts of odour would be managed through the following measures:

- Implementation of a Dust and Air Quality Management and Monitoring Plan to minimise air quality impacts during construction, including odour
- Implementation of a spoil management plan which includes requirements and methods for odour management during excavation, stockpiling and transportation of any contaminated materials.

12.2.3 Noise and vibration

There is a potential for noise and vibration impacts from the operation of plant and machinery, heavy vehicle deliveries and spoil removal during construction works.

Potential noise and vibration impacts from construction would be managed through:

- Preparation, implementation and maintenance of a Construction Noise and Vibration Management Plan
- Management of construction noise and vibration impacts to sensitive receptors in accordance with EPA Publication 1254 *Noise Control Guidelines*
- Implementation of daytime management noise levels during the standard hours recommended in the NSW Interim Construction Noise Guidelines (ICNG)

- Establishment of construction vibration limits for utilities either in agreement with asset owners or by following the DIN 4150 Guideline targets specified in the EPRs
- Implementation of a Communications and Community Engagement Plan, including an approach to mitigating community impacts including noise.

12.2.4 Vehicle and plant emissions

The use of construction vehicles on the road network and plant and equipment at construction compounds would result in the emission of air pollutants which may have a negative impact upon human health.

The impacts of vehicle and plant emissions would be managed through the following measure:

- Implementation of a Dust and Air Quality Management and Monitoring Plan to minimise air quality impacts during construction, including vehicle and plant emissions.

12.2.5 Spills of fuels and hazardous substances

There is the potential for spills and leaks from construction equipment or from the handling of hazardous substances.

The potential for spills would be managed through the following measures:

- The minimisation of chemical and fuel storage on site
- Compliance with the Victorian WorkCover Authority and Australian Standard AS1940 Storage Handling of Flammable and Combustible Liquids and EPA Victoria publications 480 Environmental Guidelines for Major Construction Sites and 347 Bunding Guidelines
- The implementation of requirements for the installation of bunds and precautions to reduce the risk of spills
- The development of contingency and emergency response plans to handle fuel and chemical spills, including availability of on-site hydrocarbon spill kits
- A Spoil Management Plan which includes remediation management for contaminated land and groundwater to remediate contamination caused or exacerbated during the course of the project.

12.2.6 Contaminated soil and materials

There is the potential for earthworks to require the excavation, stockpiling, transport and treatment/disposal of contaminated soil which may result in impacts to human health and the environment. There is also the potential for hazardous waste materials to be encountered during construction.

The potential impacts from contaminated soil and materials would be managed through a Spoil Management Plan which would include:

- A requirement for detailed site investigation (in accordance with AS 4482.1-2005) prior to any excavation of potentially contaminated areas to identify location, types and extent of impacts
- A health, safety and environmental plan for the management of hazardous substances including:
  - Risks associated with exposure to hazardous substances for employees, visitors and general public
  - Measures to control exposure in accordance with relevant regulations, standards and best practice guidance and to the satisfaction of WorkSafe and the EPA
  - Method statements detailing monitoring and reporting requirements.

12.2.7 Acid sulfate soil

There is the potential for earthworks to require the excavation, stockpiling, transport and treatment/disposal of acid sulfate soil which may result in impacts to human health and the environment.

The potential impacts from acid sulfate soil would be managed through the following measures:

- Measures to characterise acid sulfate soil and rock prior to excavation
- Measures to prevent oxidation
- Identification of suitable sites for re-use management or disposal of acid sulfate soil and rock.

These measures would be in accordance with the Industrial Waste Management Policy (Waste Acid Sulfate Soils) 1999, EPA Victoria Publication 655.1 Acid Sulfate Soil and Rock 2009, and the Department of Sustainability and Environment's Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soil.

12.2.8 Asbestos fibres

There is the potential for earthworks to require the excavation, stockpiling, transport and treatment/disposal of soil with asbestos fibres.

The potential impacts from asbestos fibres in soil would be managed through the following measures:

- Requirements within the CEMP and OEMP for the development and implementation of management measures for dangerous substances, including asbestos, in accordance with Industrial Waste Management Policies, regulation and relevant guidelines
- A Spoil Management Plan which would include a health, safety and environmental plan for the management of hazardous substances.

12.2.9 Greenhouse gas emissions

Land clearing and consumption of materials and electricity generated from fossil fuels, operation of plant and equipment, and transportation of materials and equipment during construction would result in the release of greenhouse gas emissions which could contribute to global climate change.

Greenhouse gas emissions would be reduced through the following measures:

- Development and implementation of a Sustainability Management Plan to meet sustainability targets, including provisions for renewable energy use and materials efficiency
- Integration of sustainable design practices into the design process to minimise, to the extent practicable, greenhouse gas emissions arising from construction.

12.3 Risk assessment of non-routine operation

As a part of the risk assessment for project operation, the risks related to the non-routine operation of the tunnel ventilation system and proposed controls have been identified.

Additional risks related to the potential impacts of climate change on the tunnel ventilation system and adaptations are described in Section 8.

12.3.1 Fire events

Video based automatic incident detection systems would notify the operator in a timely manner of a collision that may initiate a fire.

A water-based fire suppression system compliant with AS 2118.3-2010 (Automatic fire sprinkler systems), or an alternative equivalent performance system, would operate in the tunnels and intersection caverns and ramps to minimise fire size and spread. Initial response firefighting equipment would be available in emergency equipment cabinets.

In the event of a fire, the tunnels would be closed. Evacuation from the tunnels would be supported through a public announcement system, radio re-broadcasting, variable message signage, exit signage and emergency lighting. In the main tunnels, vehicles would be evacuated to the non-incident tunnel through cross passages joining the north and south bound tunnels and moved out of the tunnels to an open space. People may also use tunnel portals to exit from the tunnels.

The ventilation system has been designed to prevent smoke 'back layering' in the event of a fire up to 50 MW and allow for emergency responders to approach an incident in a contra tunnel direction. Smoke is to be controlled inside the tunnels by configuring jet fans to induce an air velocity inside the tunnels in the vicinity of the fire to push smoke away, where appropriate, from stationary vehicles. When the fire occurs within approximately 100 metres of a tunnel portal, smoke would be ventilated through the portal. When a fire occurs more than 100 metres from a tunnel portal, airflow would be induced such that smoke can be collected either by the smoke duct or the main tunnel air extraction point, or both.

The extent and makeup of the discharge would be dependent on the nature of the fire within the tunnels. However, the scope of materials likely to be present in a fire is limited by the fact that vehicles carrying dangerous goods as defined by the Victorian *Dangerous Goods Act 1995* would not be allowed within the tunnels.

The emergency smoke discharge structure at Manningham Interchange has been located as far from residential populations as feasible in order to reduce the exposure of the general public to smoke. The discharge height is at least 3 metres above local roof level, in compliance with AS 1668.2-2012 (The use of ventilation and air conditioning in buildings – Mechanical ventilation in buildings), clause 3.10.3.

All aspects of emergency measures, including the discharge of smoke from the tunnels, would be assessed and approved by the fire brigade (MFB) as part of the requirements under AS 4825-2011 (Tunnel Fire Safety).

12.3.2 Power failure

In order to reduce the likelihood of power supply failure to the ventilation fans, North East Link is proposed to be connected to two zone substations. There is a very low likelihood of a zone substation failing. However, in the event of one zone substation failing, all tunnel systems are able to be operated from the power supply of the remaining zone substation.

In the unlikely event of both zone substations failing, immediate closure of the tunnels would commence. Any vehicles inside the tunnels at the time of the power failure would be allowed to exit the tunnels as normal.

Secured no-break back up power would provide sufficient emergency power for operation of the following:

- Signs, communications, CCTV, emergency power outlets and ancillary areas for at least one hour
- Emergency lighting, exit and directional signs in the tunnels and egress routes for at least 1.5 hours
- Variable message signs and incident detection systems that are required for ongoing safe operation of the tunnels for at least one hour
- Vehicle over-height detection devices for at least one hour
- The tunnel management control system and plant management control system for at least four hours
- The tunnel drainage system for at least four hours.

Uninterruptible power supply (UPS) would provide emergency power for operation of the following:

- Necessary parts of the critical safety systems and essential equipment for tunnel evacuation for at least one hour
- The automatic water based suppression system
- Specified freeway control centre systems and equipment for a minimum of one hour.

In the event of both zone substations failing, there would be insufficient power supply to operate the tunnel ventilation system. However, following the initial period of tunnel evacuation, there would be few vehicles inside the tunnels, aside from required emergency and maintenance vehicles. Vehicle emissions and resultant in-tunnel air pollutant levels are thus predicted to be very low during a period of unscheduled power outage and unlikely to result in non-compliances to air quality requirements.

Resumption of normal traffic operations would not commence until all power systems had been restored, and/or approval had been obtained from the appropriate authorities.

12.3.3 Flooding

The northern portal substation is located high in the catchment and is anticipated to be protected by local landscaping, drainage and/or bunding. The Manningham Interchange substation is proposed to be protected through location to the east of the tunnel alignment and being raised above the 1 in 2000 AEP flood level.

The southern portal substation is proposed to be constructed within the portal structure and protected by portal flood gates.

The redundancies in tunnel power supply described in Section 12.3.2 would also apply.

During a flood event which causes power failure to the ventilation system, the emergency response procedures described in Section 12.3.2 would apply.

In the event of a flood leading to failure of both substations, the tunnel roadway would also be affected by flooding, leading to the implementation of flood control measures and tunnel closure.

As in the case of a power outage, following an initial period of tunnel evacuation, there would be few vehicles inside the tunnels, aside from required emergency and maintenance vehicles. Vehicle emissions and resultant in-tunnel air pollutant levels are thus predicted to be very low during tunnel flooding event and unlikely to result in non-compliances to air quality requirements.

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Appendix A Air quality impact assessment

REPORT

North East Link

Tunnel Ventilation System Air Quality Impact Assessment

Prepared for:

North East Link Project

Submitted by:

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Australia

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Executive Summary

This technical report was prepared in support of the application for Works Approval to construct the tunnel ventilation structures associated with North East Link.

Overview

North East Link is a proposed new freeway standard road connection that would complete the missing link in Melbourne's ring road, connecting the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, including works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The tunnels are a key feature of North East Link. The reference project includes twin tunnels of approximately six kilometres in length with tunnel ventilation structures of approximately 40 metres in height located near the exits of each tunnel. The tunnel ventilation structures are intended to disperse emissions captured by the tunnel ventilation system.

The *Environment Protection (Scheduled Premises and Exemptions) Regulations 2017* lists premises that are subject to the works approval and licensing provisions of the *Environment Protection Act 1970*. Under Schedule 1 and L03, an application for works approval is required for construction of the North East Link tunnel ventilation structures, and an Environment Protection Authority (EPA) Victoria licence for their operation.

Impact assessment

Impacts of emissions from the tunnel ventilation structures were assessed through the use of air dispersion modelling. Air dispersion modelling was conducted using the Victorian regulatory model, AERMOD, in accordance with the requirements of State Environment Protection Policy (Air Quality Management) [SEPP(AQM)], to predict ground level concentrations of the following pollutants:

- particulate matter with equivalent aerodynamic diameters less than 10 microns and 2.5 microns (PM_{10} and $PM_{2.5}$ respectively)
- nitrogen dioxide (NO_2)
- carbon monoxide (CO), benzene, toluene, ethylbenzene, xylene (BTEX), 1,3 butadiene, formaldehyde and polycyclic aromatic hydrocarbons (PAH).

For each pollutant, the following scenarios were modelled:

- Scenarios A1 and A2 – projected traffic volumes and fleet mix for 2026 (year of opening, normal operation)
- Scenarios B1 and B2 – projected traffic volumes and fleet mix for 2036 (10 years after opening, normal operation).

Meteorological data files for 2013 to 2017 were developed in accordance with EPA Victoria requirements using data collected at the Alphington ambient air quality monitoring station (AAQMS) and the Bureau of Meteorology Viewbank, Essendon and Melbourne Airport automatic weather stations. Ambient air quality data (PM_{10}, $PM_{2.5}$, NO_2 and CO) collected at the EPA Victoria Alphington AAQMS for the years 2013 to 2017 were adopted as time-varying background concentrations. Appropriate air toxics (BTEX, 1,3 butadiene, formaldehyde and PAH) constant background concentrations were provided by EPA Victoria.

The assessment used a range of conservative assumptions, including:

- Background pollutant concentrations for the modelled years of 2026 and 2036 were assumed to remain at levels recorded for the period 2013 to 2017.

  EPA Victoria predicts a significant reduction in CO and NO_2 concentrations over the next 20 years through cleaner exhaust emissions from petrol, diesel and LPG engines and improvements in national motor vehicle emission standards. Similarly, a significant reduction in particle emissions ($PM_{2.5}$) from diesel vehicle engines is expected by 2030.

  Concentrations of these pollutants in 2026 and, in particular, 2036, will therefore be lower than those used as background levels in the air quality impact assessment.

- The adopted background concentrations for PM_{10}, $PM_{2.5}$, CO and NO_2 include exceptional events (as defined by EPA Victoria) such as bushfires, controlled burns and dust storms. During these periods, concentrations of particulate matter (PM_{10} and $PM_{2.5}$) can reach extremely high levels. Inclusion of data during these periods as representative background concentrations for the project is highly conservative contributing a significant proportion of the overall impact (background plus predicted).

- Vehicle emission factors used in the air quality impact assessment are considered conservatively high because there is a general trend towards lower emission vehicles (older technology vehicles being replaced over time with newer, improved technology vehicles), with expected improvements in vehicle technology beyond 2020 (Scenarios A1 and B1) and 2025 (Scenarios A2 and B2) not accounted for.

- Hybrid and electric vehicles were not considered in the fleet mix. The percentages of these lower emission and zero emission vehicles in the Victorian vehicle fleet are expected to increase significantly in future years.

- The upper limit of the predicted traffic volume range provided for all roads was selected for use in the modelling.

- Acoustic barriers were not considered to have any effect on pollutant concentrations downwind. There is a significant body of evidence to suggest that acoustic barriers reduce pollutant concentrations immediately downwind of roadways at the most impacted sensitive receptors.

Emissions from the North East Link tunnel ventilation system were calculated using adjusted COPERT Australia vehicle emission factors for the 2010 Victorian fleet and projected diurnal weekday traffic conditions. Scenarios A1 and B1 were modelled based on the 2010 COPERT factors adjusted by World Road Association (PIARC) factors that account for the future year 2020 and road gradient. Scenarios A2 and B2 were modelled based on the 2010 COPERT factors adjusted by the relative factors for the Brisbane vehicle fleet in 2010 and 2025 and PIARC road gradient factors.

SEPP(AQM) requires modelling to be conducted based on the worst case scenario during normal operation, which is considered to be reflected in the modelled scenarios for 2026 and 2036. Preliminary modelling established that meteorological data for 2017 gave the highest ground level concentration (GLC) predictions for the period 2013 to 2017. Consequently, 2017 meteorological and background datasets were used for all subsequent modelling of tunnel ventilation system emissions to air..

A. Scenario A1 (2026; 2020 emission factors)

Hourly PM_{10} and $PM_{2.5}$ background concentrations at the Alphington AAQMS exceeded the one hour average SEPP(AQM) design criteria on multiple occasions in 2017. This effectively imposes exceedances before the additional impact of the tunnel ventilation system is considered.

Analysis of the hourly PM_{10} background concentrations showed that exceedances of the 80 micrograms per cubic metre design criterion occurred on 8 occasions during 2017 without any contribution from the project. Project tunnel ventilation system emissions result in no additional exceedances.

The air quality impact assessment indicated that while the one hour average PM_{10} design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.087 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.22 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

The hourly background concentrations for $PM_{2.5}$ at the Alphington AAQMS exceeded the one hour average 50 micrograms per cubic metre design criterion on 20 occasions during 2017. Project tunnel ventilation system emissions result in one additional exceedance with a project contribution of less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that while the one hour average $PM_{2.5}$ design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.08 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.13 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Predicted CO, NO_2, BTEX, 1,3-butadiene, formaldehyde and PAH [as B(a)P TEQ] concentrations comply with the applicable design criteria in 2026.

B. Scenario A2 (2026; 2025 emission factors)

Project tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion.

The air quality impact assessment indicated that while the one hour average PM_{10} design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.065 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.16 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Project tunnel ventilation system emissions result in one additional exceedance of the $PM_{2.5}$ design criterion with a project contribution of less than 0.3 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that while the one hour average $PM_{2.5}$ design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.037 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.055 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Predicted NO_2 concentrations comply with the applicable design criteria in 2026.

The 2025 emission factors sensitivity analysis demonstrated that, while the project contribution to the maximum predicted GLC could decrease significantly, there was relatively little change in the maximum predicted GLCs (project plus background) due to the relatively low project contribution.

C. Scenario B1 (2036; 2020 emission factors)

Project tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion.

The assessment indicated that while the one hour average PM_{10} design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.11 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.27 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Project tunnel ventilation system emissions result in one additional exceedance of the $PM_{2.5}$ design criterion with a project contribution of less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that while the one hour average $PM_{2.5}$ design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.11 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.17 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Predicted CO, NO_2, BTEX, 1,3-butadiene, formaldehyde and PAH [as B(a)P TEQ] concentrations comply with the applicable design criteria in 2036.

D. Scenario B2 (2036; 2025 emission factors)

Project tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion.

The assessment indicated that while the one hour average PM_{10} design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.081 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.20 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Project tunnel ventilation system emissions result in one additional exceedance of the $PM_{2.5}$ design criterion with a project contribution of less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that while the one hour average $PM_{2.5}$ design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.049 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.073 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration.

Predicted NO_2 concentrations comply with the applicable design criteria in 2036.

The 2025 future year adjusted vehicle emission rate analysis demonstrated that, while the project contribution to the maximum predicted GLC could decrease significantly, there was relatively little change in the maximum predicted GLCs (project plus background) due to the relatively low project contribution.

E. Sensitivity analyses

Additional sensitivity analyses were undertaken to evaluate the impact of:

- the North East Link tunnels operating at maximum capacity (24 hours a day, 365 days a year)
- emissions occurring at in-tunnel air quality limits (24 hours a day, 365 days a year)
- increased diesel to petrol fuelled passenger car ratios
- alternative tunnel ventilation structure locations within potential construction footprints.

The maximum capacity, in-tunnel air quality limits and increased diesel passenger car ratio sensitivity analyses demonstrated that, while the project contribution to the maximum predicted GLC could increase significantly, there was relatively little change in the maximum predicted GLCs (project plus background) due to the relatively low project contribution.

Modelling of alternative tunnel ventilation structure locations indicated that there was minimal change in the maximum predicted contributions to the $PM_{2.5}$ GLC (no background), with the northern and southern tunnel ventilation structure options differing by less than 1.0 per cent and 3.0 per cent respectively.

Conclusion

With the exception of PM_{10} and $PM_{2.5}$, compliance with all applicable SEPP(AQM) design criteria was demonstrated for the proposed North East Link tunnel ventilation system under normal operating conditions. The PM_{10} and $PM_{2.5}$ exceedances were due to existing high background concentrations.

SEPP(AQM) does, however, note that in circumstances where design criteria are not met, the proponent may carry out a health risk assessment to demonstrate that there will be no adverse impact from the proposal. A Health Impact Assessment (HIA) has been conducted by enRiskS as part of the Project EES.

Abbreviations

AAQMS	Ambient air quality monitoring station
Air NEPM	National Environment Protection Measure (Ambient Air Quality)
Air Toxics NEPM	National Environment Protection Measure (Air Toxics)
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
AWS	Automatic weather station
BAM	Beta attenuation monitor
BaP (TEQ)	Benzo(a)pyrene (toxic equivalent)
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethyl benzene and xylene isomers
CO	Carbon monoxide
EPA Victoria	Environment Protection Authority Victoria
EQO	Environmental quality objective
ESL	Effects screening levels
EV	Electric vehicle
GLC	Ground level concentration
LGA	Local government areas
MILs	Monitoring investigation levels
NA	Not applicable
ND	Not detected
NEPC	National Environment Protection Council
NM	Not monitored
NO	Nitric oxide
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
NPI	National Pollutant Inventory
NSW EPA	New South Wales Environment Protection Authority
PAH	Polycyclic aromatic hydrocarbons
PM_{10}	Particulate matter with an equivalent aerodynamic diameter less than 10 microns
$PM_{2.5}$	Particulate matter with an equivalent aerodynamic diameter less than 2.5 microns

TCEQ	Texas Commission on Environmental Quality
TEOM	Tapered element oscillating microbalance
SEPP(AAQ)	State Environment Protection Policy (Ambient Air Quality)
SEPP(AQM)	State Environment Protection Policy (Air Quality Management)
VOCs	Volatile organic compounds

Units

%	Per cent
˚C	Degrees Celsius
km/h	Kilometres per hour
m	Metres
mg/m^3	Milligrams per cubic metre
$\mu g/m^3$	Micrograms per cubic metre
mm	Millimetres
MJ/m^2	Megajoules per square metre
m/s	Metres per second
ng/m^3	Nanograms per cubic metre
ppb	Parts per billion
ppm	Parts per million

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1.0 INTRODUCTION

1.1 Background

North East Link ('the project') is a proposed new freeway standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018 the Minister declared the works proposed for North East Link as Public Works and issued a decision confirming that an Environment Effects Statement (EES) is required for the project due to the potential for significant environmental effects.

Similarly, the project was referred to the Australian Government's Department of the Environment and Energy on 17 January 2018. On 13 April 2018 the project was declared a 'controlled action', requiring assessment and approval under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Separate to this EES, a Public Environment Report (PER) is required to be prepared to satisfy the EPBC Act requirements, and assess the impacts of the project on Commonwealth land and matters of national environmental significance (MNES).

Golder Associates Pty. Ltd. (Golder) was commissioned to undertake an air quality impact assessment in support of an application for Works Approval (WA) to construct the North East Link tunnel ventilation system.

1.2 Project description

The North East Link alignment and its key elements include:

- M80 Ring Road to the northern portal – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at M80 Ring Road and Grimshaw Street.
- Northern portal to southern portal – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnel would then continue to the southern portal located south of the Veneto Club.
- Eastern Freeway – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and provision of new dedicated bus lanes for the Doncaster Busway. There would also be provision of a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

These areas are illustrated in Figure 1.

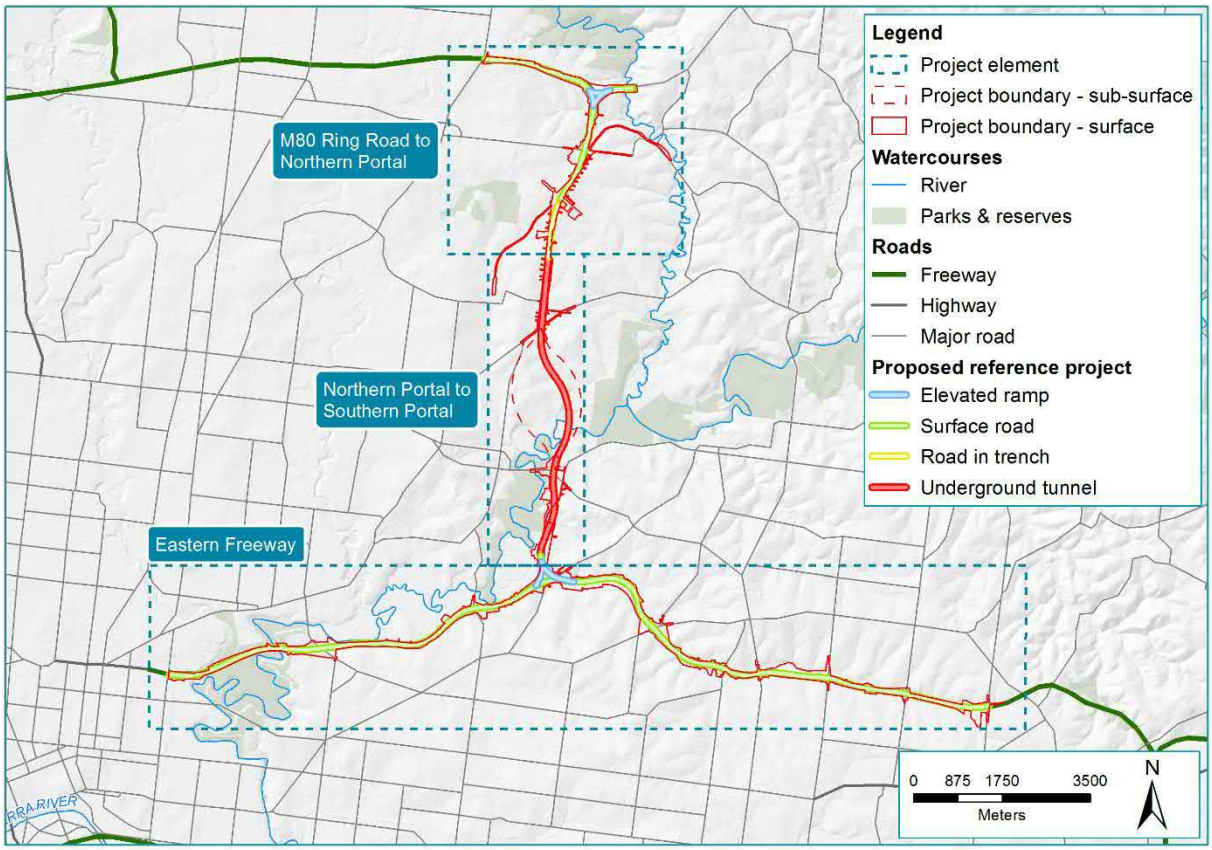


Figure 1: Overview of North East Link

The project would also include improvements to existing bus services from Doncaster Road to Hoddle Street through the Doncaster Busway and pedestrian connections and the bicycle network through connected cycling and walking paths from the M80 to the Eastern Freeway.

2.0 LEGISLATION, POLICY, GUIDELINES AND CRITERIA

The legislative context for the North East Link air quality impact assessment is described below, including details of air quality criteria used to assess the impact of pollutant emissions resulting from project operation.

2.1 Commonwealth Legislation

2.1.1 National Environment Protection Measures

The National Environment Protection Council (NEPC) was established under the *National Environment Protection Council Act 1994* with the primary function of:

- developing National Environment Protection Measures (NEPMs)
- assessing and reporting on the implementation and effectiveness of the NEPMs in each State and Territory.

2.1.2 National Environment Protection (Ambient Air Quality) Measure

The *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) contains standards and goals for key pollutants that are required to be achieved nationwide, with due regard to population exposure. Table 1 presents the standards for pollutants relevant to North East Link: particulate matter with equivalent aerodynamic diameters less than 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$), and nitrogen dioxide (NO_2).

Air NEPM standards apply at performance monitoring locations, with each station located in such a manner that it obtains a representative measure of air quality likely to be experienced by the general population in a region or sub-region of 25,000 people or more. The Alphington ambient air quality monitoring station (AAQMS) is a performance monitoring station in accordance with Environment Protection Authority (EPA) Victoria's Ambient Air Quality NEPM Monitoring Plan for Victoria (EPA Victoria, 2001).

The standards are not applied as modelling criteria for assessing air emissions from individual sources, specific industries or roadside locations.

Table 1: Ambient air quality standards and goals

Pollutant	Averaging period	Air quality standard[1,2]	Maximum allowable exceedances
Particles as PM_{10}	1 day 1 year	50 µg/m^3 25 µg/m^3	None
Particles as $PM_{2.5}$ (2025)	1 day 1 year	20 µg/m^3 7 µg/m^3	None
NO_2	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year None

Notes:
1 Defined as a standard that consists of quantifiable characteristics of the environment against which environmental quality can be assessed.
2 100th percentile

2.1.3 National Environment Protection (Air Toxics) Measure

The aim of the Air Toxics NEPM is to gain a greater understanding of the levels of air toxics at specific locations where elevated concentrations are likely to occur and where the potential for significant human exposure exists.

The Air Toxics NEPM established monitoring investigation levels (MILs) for benzene, toluene, xylene isomers, formaldehyde and benzo(a)pyrene (BaP) as a marker for polycyclic aromatic hydrocarbons (PAH). The MILs

presented in Table 2 were established to assess the significance of monitored air toxics levels on human health.

Table 2: Monitoring investigation levels

Pollutant	Averaging period	Monitoring investigation level[1, 2]	Goal[3]
Benzene	Annual	0.003 ppm	Eight year goal was to gather sufficient data nationally to facilitate development of a standard
Toluene	24 hour Annual	1 ppm 0.1 ppm	
Xylene isomers (as total of ortho, meta and para isomers)	24 hour Annual	0.25 ppm 0.2 ppm	
Formaldehyde	24 hour	0.04 ppm	
B(a)P as a marker for PAH	Annual	0.3 ng/m^3	

Notes:
1 The concentration of an air toxic which if exceeded requires an appropriate form of further investigation and evaluation
2 100th percentile
3 The Air Toxics NEPM was passed into legislation in 2004, consequently the goal date has passed

2.2 Victorian legislation

The *Environment Protection Act 1970* (EP Act) is the primary legislative instrument that governs protection of the environment in Victoria. It sets environmental objectives for air, water and land and regulates the discharge of emissions of these elements to the environment. Pursuant to the EP Act, beneficial uses of the air quality environment are principally protected by the following subordinate regulations and policies:

- *Environment Protection (Scheduled Premises and Exemptions) Regulations 2017*
- *State Environment Protection Policy (Ambient Air Quality)* [SEPP(AAQ)] as amended in July 2016 to incorporate changes to the Air NEPM particle standards (February 2016)
- *State Environment Protection Policy (Air Quality Management)* December 2001 [SEPP(AQM)].

2.2.1 Environment Protection (Scheduled Premises and Exemptions) Regulations

Facilities with the potential to significantly impact on the environment are subject to an EPA Victoria WA for construction as well as an EPA Victoria licence to operate, which may include conditions relating to discharge limits, monitoring and reporting requirements.

Schedule 1 of the *Environment Protection (Scheduled Premises and Exemptions) Regulations 2017* prescribe the premises that are subject to these requirements. Under Schedule 1 and L03, an application for WA will be required for construction of the North East Link tunnel ventilation system, and an EPA Victoria licence for the tunnel ventilation system to operate.

2.2.2 State Environment Protection Policy (Ambient Air Quality)

In general, the *State Environment Protection Policy (Ambient Air Quality)* [SEPP(AAQ)] adopts the requirements of the Air NEPM, with environmental quality objectives (EQOs) for carbon monoxide (CO), NO_2, photochemical oxidants (as ozone), sulphur dioxide (SO_2), lead, PM_{10} and $PM_{2.5}$, together with an additional objective for visibility reducing particles. The SEPP(AAQ) EQOs apply to air quality within a region or sub-region considered to be representative of exposure of the general population in Victoria.

In accordance with the amended Air NEPM (February 2016), the SEPP(AAQ) includes $PM_{2.5}$ objectives of 7 micrograms per cubic metre (annual average) and 20 micrograms per cubic metre (24 hour average) to be implemented by 2025. A factor in this change is the expected improvement in background air quality resulting from improved vehicle emission control technologies.

2.2.3 State Environment Protection Policy (Air Quality Management)

The *State Environment Protection Policy (Air Quality Management)* (SEPP(AQM)) sets out legislative requirements for managing and assessing air emissions in Victoria. The aim of the SEPP(AQM) is to:

- ensure that prescribed air quality objectives are met
- drive continual improvement in air quality, whist having regard to the social and economic development of Victoria
- support the Victorian Government's other environmental goals.

The SEPP AQM identifies the following beneficial uses of the air environment:

- life, health and well-being of humans
- life, health and well-being of other forms of life, including the protection of ecosystems and biodiversity
- local amenity and aesthetic enjoyment
- visibility
- the useful life and aesthetic appearance of buildings, structures, property and materials
- climate systems that are consistent with human development, the life, health and well-being of humans and the protection of ecosystems and biodiversity.

Part II of the SEPP (AQM) classifies air pollutants as Class 1, 2 or 3 air quality indicators according to their potential to adversely affect the beneficial uses of the air environment:

- Class 1 air quality indicators are common or widely distributed air pollutants that may threaten the beneficial uses of local and regional air environments
- Class 2 air quality indicators are hazardous substance that may threaten the beneficial uses of the air environment by virtue of their toxicity, bio-accumulation or odorous characteristics
- Class 3 air quality indicators are extremely hazardous substances that are carcinogenic, mutagenic, teratogenic, highly toxic or highly persistent, which may threaten the beneficial uses of the air environment
- unclassified air quality indicators have the potential to affect the beneficial uses of local amenity and aesthetic enjoyment, namely odour and total suspended particulate matter (nuisance dust).

Schedule A of the SEPP(AQM) lists Class 1, 2 and 3 air quality indicators and their design criteria '*to be used in the assessment of the design of new or expanded sources of emissions*'. These criteria apply to the modelling of emissions from the proposed North East Link tunnel ventilation systems.

Schedule C describes the requirements for conducting air dispersion modelling assessments for new or modified sources of emissions to air in Victoria.

SEPP(AQM) Clause 19 states that a generator of new air emissions '*must apply best practice to the management of those emissions*'.

Best practice is defined as '*the best combination of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a*

generator of emissions in that industry sector or activity'. Eco-efficient is defined as '*producing more goods with less energy and fewer natural resources, resulting in less waste and pollution*'.

Additionally, SEPP(AQM) Policy Principles under 7(1)(c) states that '*the measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed*'.

2.3 Other guidance documents

Other guidelines referenced during preparation of the air quality impact assessment include:

- Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, [World Road Association (PIARC) 2012]
- Future Air Quality in Victoria – Final Report (EPA Victoria 2013a)
- 'Demonstrating Best Practice' (EPA Victoria 2013c).

2.4 Assessment criteria

Pollutant impacts from the North East Link tunnel ventilation system have been assessed against SEPP(AQM) Schedule A design criteria, as presented in Table 3.

Table 3: SEPP(AQM) design criteria

Pollutant	Criterion (mg/m^3)[1, 2]	Averaging period
PM_{10}	0.08	1 hour
$PM_{2.5}$	0.05	1 hour
NO_2	0.19	1 hour
CO	29	1 hour
Benzene	0.053	3 minute
Toluene	0.65 (odour)	3 minute
Ethylbenzene	14.5	3 minute
Xylene isomers	0.35 (odour)	3 minute
Formaldehyde	0.04	3 minute
1,3 Butadiene	0.073	3 minute
PAH [as B(a)P toxic equivalent]	0.00073	3 minute

Notes:
1 Design criteria are to be used in assessing the design of new or expanded sources of emissions such as industrial premises.
2 Assessment criteria based on 99.9th percentile as determined by modelling in accordance with Schedule C of SEPP(AQM)

3.0 METHODOLOGY

The following sections describe the basis for the methodology adopted for the North East Link tunnel ventilation system air quality impact assessment.

3.1 Rationale

The underlying rationale for the methodology is to undertake an assessment of the impacts consistent with the objectives, requirements and guidance provided by the statutory framework as described in Section 2.0 of this report.

Victoria has an established framework for assessing air quality impacts associated with the project which forms the basis of the rationale for the assessment in this report that includes:

- modelling design criteria
- regulatory approved air dispersion models for predicting the impacts of emissions
- data on existing air quality.

Pollutants for which no regulatory objectives are established or proposed to be established in Victoria, or for which no Victorian air quality data is available, have therefore not been considered.

North East Link tunnel ventilation system modelling predictions were assessed against SEPP(AQM) Schedule A modelling design criteria.

3.2 Study area

For the purposes of the air quality impact assessment the study area includes the road tunnel ventilation systems and adjacent areas potentially impacted by emissions from these sources.

The assessment of emissions from the tunnel ventilation systems considers receptors in both close proximity and remote from the sources to ensure that maximum impacts are included.

3.3 Characterisation of existing environment

The receiving environment for North East Link was described, including topography, meteorology and existing air quality. The receiving environment was characterised by:

- identifying relevant sources of existing information (e.g. Bureau of Meteorology and EPA Victoria monitoring station locations)
- extracting data relevant to the project area and presenting it over a representative time period
- collating relevant data into a form to support the impact assessment (e.g. in dispersion modelling).

3.4 Pollutants considered

Air pollutants of relevance to operation of North East Link are:

- particulate matter
- NO_2
- CO
- benzene, toluene, ethylbenzene and xylene isomers (BTEX), formaldehyde and 1,3-butadiene
- PAHs as BaP toxic equivalents (BaP TEQ).

These air pollutants are considered the principal emissions from vehicle traffic.

The following section describes the evaluation of which particulate matter size fractions should be considered, in particular whether it is appropriate to consider ultrafine particles in addition to PM_{10} and $PM_{2.5}$.

3.4.1 Particulate matter size fractions

Public submissions on impact assessments undertaken for other major road projects (e.g. West Gate Tunnel) have raised concerns regarding the impact of ultrafine particles. The following provides the rationale for the particulate matter pollutants considered in this assessment.

Particulate matter (solid and liquid) suspended in ambient air can range in size from nanometres to typically 100 micrometres (microns). PM_{10} and $PM_{2.5}$ are defined as the particle size fractions with equivalent aerodynamic diameters less than 10 microns and 2.5 microns respectively.

Figure 2 shows a typical particle size distribution for ambient air on both a volume and number basis (Solomon, 2012). The majority of the particle volume and consequently mass is in the 0.1 to 10 microns size range, however the majority of particles by number are less than 0.1 microns in size.

Ultrafine particles (UFPs) have been defined in a number of ways, but typically as particles less than 0.1 microns (based on physical size, diffusivity or electrical mobility). They are formed by nucleation-condensation of low vapour pressure compounds formed by high temperature vaporisation or by chemical reactions in the atmosphere to form very small particles. Therefore, in addition to being emitted as primary particles, UFPs are produced by the nucleation of sulphuric acid and water vapour and possibly ammonia and certain organic compounds.

Particulate matter contained in diesel exhaust is almost pure carbon in the form of ultrafine carbon spheroid aggregates with aerodynamic diameters of approximately 0.1 microns. Particles in the nucleation mode subsequently grow by condensation or coagulation mechanisms up to approximately 1 micron.

UFP formation has been observed in environments ranging from relatively unpolluted marine and continental environments to polluted urban areas as an ongoing background process and during nucleation events. However, a large percentage of UFPs come from combustion-related sources such as motor vehicles.

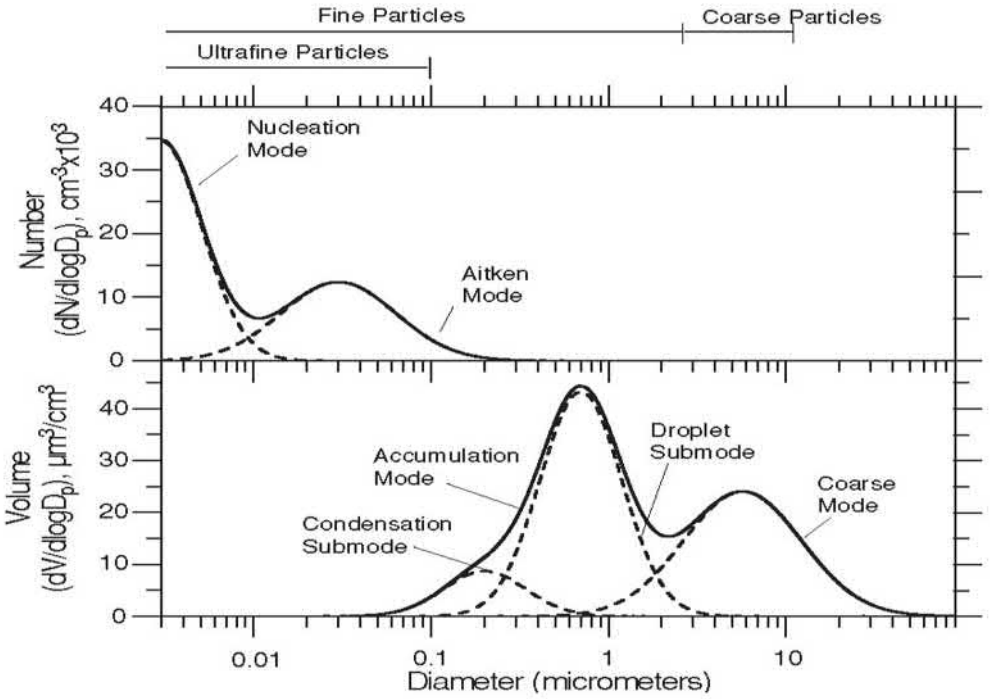


Figure 2: Particle size distribution in ambient air

The World Health Organization (WHO, 2006) suggest that particle number concentrations in urban background environments range from a few thousand to approximately 2 x 10^4 particles per cubic centimetre, whereas concentrations close to roads or in tunnels can reach or exceed 10^5 particles per cubic centimetre.

UFP chemical composition varies by location, with organic carbon, sulphate, elemental carbon and sometimes ammonium and nitrate comprising the bulk of material (Solomon, 2012).

Several studies indicate that UFP mass and number concentrations correlate poorly and that both UFP metrics correlate poorly with $PM_{2.5}$ or PM_{10} mass concentration (Solomon, 2012). WHO also concluded that $PM_{2.5}$ mass concentration and UFP number concentrations are only moderately correlated. WHO and USEPA (USEPA, 2009) do however note that UFP concentrations decrease rapidly at increasing distances from roadways in comparison with accumulation mode particle numbers.

Standardized methods for instrumentation or techniques for measuring UFPs in ambient air are not available, with neither Standards Australia, International Organization for Standardization (ISO), USEPA or the European Union publishing methodology. Consequently, UFP monitoring has been principally restricted to research studies, with most countries not conducting routine monitoring. The problems associated with the lack of a standardised method is supported by Morawska (Morawska, L. et al, 2004), which notes the difficulty in comparing the results reported by different studies as a consequence.

Condensation particle counters have however been used in the majority of studies that evaluate UFP particle number concentrations, detecting particle sizes down to 0.01 or 0.003 microns, depending on the instrument. UFPs can be separated by their electrical mobility, consequently electrical mobility diameter is often used to describe the UFP size distribution, requiring the development of a number of techniques to enable conversion to aerodynamic diameters.

The European Union has incorporated particle number emission limits and measurement methods into current vehicle emission standards (for particles above 0.023 microns), however there are no ambient air quality criteria for UFPs in Europe or elsewhere. In addition, there are no readily available UFP emission factors for

various classes and ages of vehicles, with COPERT, COPERT Australia, PIARC and USEPA MOVES focussed on the $PM_{2.5}$ and PM_{10} size fractions.

WHO (WHO, 2006) refers to there only being a limited number of studies on the association of UFPs with risk of adverse health effect. In this publication WHO conclude that "*while there is considerable toxicological evidence of potential detrimental effects of ultrafine particles on human health, the existing body of epidemiological evidence is insufficient to reach a conclusion on the exposure–response relationship to ultrafine particles. Therefore no recommendations can be provided at present as to guideline concentrations of ultrafine particles*".

Subsequently, WHO (WHO, 2013) concluded that "*although there is considerable evidence that ultrafine particles can contribute to the health effects of PM, for ultrafine particles (measured by the number of particles) the data on concentration–effect functions are too scarce to evaluate and recommend an air quality guideline*". Critical data gaps were identified as:

- lack of epidemiological evidence on the effect of UFPs on health, with only a handful of studies published on this topic
- insufficient understanding of whether the effects of UFPs are independent of those of $PM_{2.5}$ and PM_{10}
- evidence of which UFP physical or chemical characteristics are most significant to health. There is a lack of data on the effects of short-term exposures to UFPs, and there are no epidemiological studies of long-term exposure to UFPs.

These conclusions are similar to those reached by the United States Environmental Protection Agency (USEPA) in the Integrated Science Assessment (ISA) for particulate matter (USEPA, 2009). When examining causality, USEPA concluded that the available evidence for UFPs is suggestive of short term cardiovascular and respiratory effects and inadequate evidence for all remaining short and long term outcomes examined. In contrast, the available evidence for $PM_{2.5}$ exposure suggests a causal relationship for short and long term cardiovascular effects and mortality, with short and long term respiratory effects also likely to be causal. The evidence for $PM_{2.5}$ is also suggestive of long term reproductive and developmental effects, cancer, mutagenicity and genotoxicity.

In December 2012 USEPA published a provisional assessment of studies on health effects of particulate matter published since the 2009 ISA, however this was principally focussed on the $PM_{2.5}$ and $PM_{10\text{-}2.5}$ size fractions.

In 2013 the Health Effects Institute (HEI) conducted a review of the scientific literature on ambient UFPs and their role in adverse health effects associated with ambient air pollution. The report concluded that, despite concerns raised about the potential toxicity of UFPs and the considerable body of research conducted, "*toxicologic studies in animals, controlled human exposure studies, and epidemiologic studies to date have not provided consistent findings on the effects of exposures to ambient levels of UFPs, particularly in human populations. The current evidence does not support a conclusion that exposures to UFPs alone can account in substantial ways for the adverse effects that have been associated with other ambient pollutants such as $PM_{2.5}$*".

At a subsequent USEPA workshop (USEPA, 2015) the HEI Principal Scientist cited a number of limitations in the experimental and epidemiological literature that make inferences about the specific role of UFPs difficult:

- differing definitions and measurements of UFP exposures, including use of near-road or traffic as proxies
- limited consideration of confounding by co-pollutants

- limited statistical power of small study designs; studies primarily examining only short-term UFP exposures
- limited coherence in the choice of and findings on various biological markers of health outcomes.

In its submission to the West Gate Tunnel Project Environment Effects Statement Inquiry and Advisory Committee, EPA Victoria (EPA Victoria, 2017) noted that "*there is clear evidence of health impacts from exposure to elevated concentrations of PM_{10} and $PM_{2.5}$. The science on the health impacts and interactions in air of ultrafine particles continues to evolve. Given the limitation of the science at present, there is no air quality standard for ultrafine particles and no regulatory air monitoring of ultrafine particles in Australia. Any air monitoring undertaken is for research purposes*".

Given the lack of UFP emission factors, standardised measurement methods and ambient air quality criteria, the North East Link tunnel ventilation system air quality impact assessment focuses on the particulate matter size fractions where this information is available, namely $PM_{2.5}$ and PM_{10}.

3.5 Impact assessment

The assessment of potential air quality impacts resulting from North East Link operation involved the use of air dispersion modelling techniques to assess the impacts of air emissions from tunnel ventilation systems.

The dispersal of pollutant emissions to air from the North East Link tunnel ventilation systems were modelled using AERMOD, the Victorian regulatory model under the SEPP(AQM). The AERMOD urban option was used, in accordance with USEPA guidance and approval received from EPA Victoria.

AERMOD requires a range of inputs to describe the project environment:

- topographical data
- meteorological data
- background pollutant concentrations.

The sources of the required data are summarised in Table 4.

Table 4: Air quality model input data

Item	Source	Description
Topographical data	Department of Environment, Land, Water and Planning	2015 Vicmap elevation data (metro 1 to 5 metre contours)
Meteorological data	Viewbank (Bureau of Meteorology) Essendon Airport Melbourne Airport	Wind speed, wind direction, temperature and sigma theta (2013 to 2017) Cloud cover (2013 to 2017) Twice daily weather balloon radiosonde data (2013 to 2017)
Background pollutant concentrations	Alphington (EPA Victoria) Various sites (EPA Victoria)	PM_{10}, $PM_{2.5}$, CO and NO_2 (2013 to 2017; $PM_{2.5}$ 2014 to 2017 only) PAH [benzo(a)pyrene], benzene, toluene, ethyl benzene, xylene isomers, formaldehyde and 1,3 butadiene

Impacts were assessed based on the Victorian legislative framework for the protection of air quality.

4.0 CHARACTERISATION OF EXISTING ENVIRONMENT

The receiving environment describes the physical features, meteorology and existing air quality of the project location. The following sections discuss the receiving environment and identify selected discrete sensitive receptors located within the study area. Air quality impacts from the tunnel ventilation systems are not considered significant beyond this distance.

4.1 Local setting

North East Link will extend from Greensborough through to Bulleen, with the Eastern Freeway upgrade extending the project to Nunawading and Donvale. Works associated with the Doncaster Busway extend west of Doncaster through to the Eastern Freeway terminus in Collingwood.

The section of the Metropolitan Ring Road (M80 Ring Road) to be upgraded is in the suburb of Greensborough, adjoining Bundoora and Watsonia North. North of the M80 Ring Road are special use and residential zones with the area consisting of commercial activities and housing. South of the M80 Ring Road, housing abuts the road reserve within the suburbs of Bundoora and Watsonia North. This area also has several parks and recreation facilities including Plenty Gorge Parklands and Maroondah Aqueduct Reserve to the north and Garvey Oval, Edmund Rice Parade Reserve and Plenty River Trail to the south.

Moving south from Greensborough, North East Link will pass through Watsonia, Macleod, Rosanna and Yallambie to the intersection with Lower Plenty Road. The land alongside the project alignment in these suburbs is mostly residential interspersed with public park and recreation zones, with the exception of Simpson Barracks, located on Commonwealth land in Yallambie.

South of Lower Plenty Road, North East Link will pass through and under Rosanna, Viewbank, Heidelberg and Bulleen. Lower Templestowe in the west and Eaglemont and East Ivanhoe on the eastern side are within one kilometre of North East Link. This section has extensive parks surrounding the Yarra River including the Warringal Parklands, Banksia Park, Yarra Flats Park, Bulleen Park and various bike/walking tracks including the Main Yarra Trail. The parks are a mixture of public recreation and conservation zones as well as land designated as Urban Floodway. The Trinity Grammar School Sporting Complex and Marcellin College sporting grounds in Bulleen are zoned special use. Additionally, there are residential areas and a small industrial centre near Banksia Street.

The project connects with the Eastern Freeway at Bulleen Road, with the upgraded Freeway works extending to Springvale Road and transecting with the suburbs of Bulleen, Balwyn North, Doncaster, Mont Albert North, Box Hill North, Blackburn North, Doncaster East, Donvale and Nunawading. The study area also includes sections of Mont Albert, Box Hill, Blackburn and Mitcham. The land within one kilometre of the upgraded freeway is predominantly residential with public park and recreational reserves including the Koonung Creek Linear Park and Koonung Creek Trail which follow the freeway alignment to Springvale Road.

Works associated with the Doncaster Busway will extend between Doncaster and the Eastern Freeway terminus. The freeway is adjacent to parks and recreation and special use zones which covers golf courses and park lands between Bulleen Road and Chandler Highway. Housing and commercial activities characterise the area to the south of the proposed busway, whilst the Main Yarra Trail interweaves with the road through this section. At the city end, the land is mixed use including residential, parks and recreation, commercial and special use. In particular, the freeway passes alongside Yarra Bend Park and associated amenities including the Collingwood Children's Farm, bike tracks and Dight's Falls. Suburbs within one kilometre of the project between Bulleen Road and Hoddle Street are Bulleen, Ivanhoe East, Ivanhoe, Balwyn North, Kew, Kew East, Alphington, Abbotsford, Fairfield, Fitzroy North, Clifton Hill, Collingwood, Fitzroy and Northcote.

4.2 Discrete receptors

Schedule C, Part B, 5(c) of SEPP(AQM) describes a sensitive location as '*hospitals, schools or residences'*.

EPA Victoria Publication No. 1518 (EPA Victoria, 2013) defines a sensitive land use as '*any land uses which require a particular focus on protecting the beneficial uses of the air environment relating to human health and wellbeing, local amenity and aesthetic enjoyment, for example residential premises, childcare centres, pre-schools, primary schools, education centres or informal outdoor recreation sites*'.

A list of discrete receptor locations, selected from those used for the EES social impact assessment is provided in APPENDIX B. This list includes, but is not limited to, schools, kindergartens, aged care facilities, hospitals, childcare centres and recreational areas.

4.3 Topography

The landform surrounding the M80 Ring Road is relatively undulating with the Plenty Gorge Parklands ranging in elevation between approximately 100 metres and 50 metres above sea level. Similarly, the undulating landscape around the Plenty River and Partington Flats in Greensborough has hills and flats with the lowest elevations occurring along the course of the river. Moving south, Watsonia North, Watsonia and Yallambie are approximately 80 metres above sea level. The land gently slopes towards the Warringal Parklands and Yarra Flats where the elevation can be as low as 10 metres.

The Eastern Freeway is also located at low elevations; ranging from 20 metres at the intersection with Bulleen Road to 40 metres at Doncaster Road, continuing to increase to 80 metres at the intersection with Springvale Road. The land either side of the freeway increases in elevation with the road located in low lying lands between the hills of Doncaster and Box Hill.

The Doncaster Busway between Bulleen Road and Hoddle Street will be located on consistent elevations in the order of 20 metres. The land adjoining the Eastern Freeway increases in elevation on either side, except for Yarra Bend Park and the area between Chandler Highway and Burke Road where the land to the north of the road is golf courses and river flats.

A topographical map of the area surrounding North East Link is shown in Figure 3.

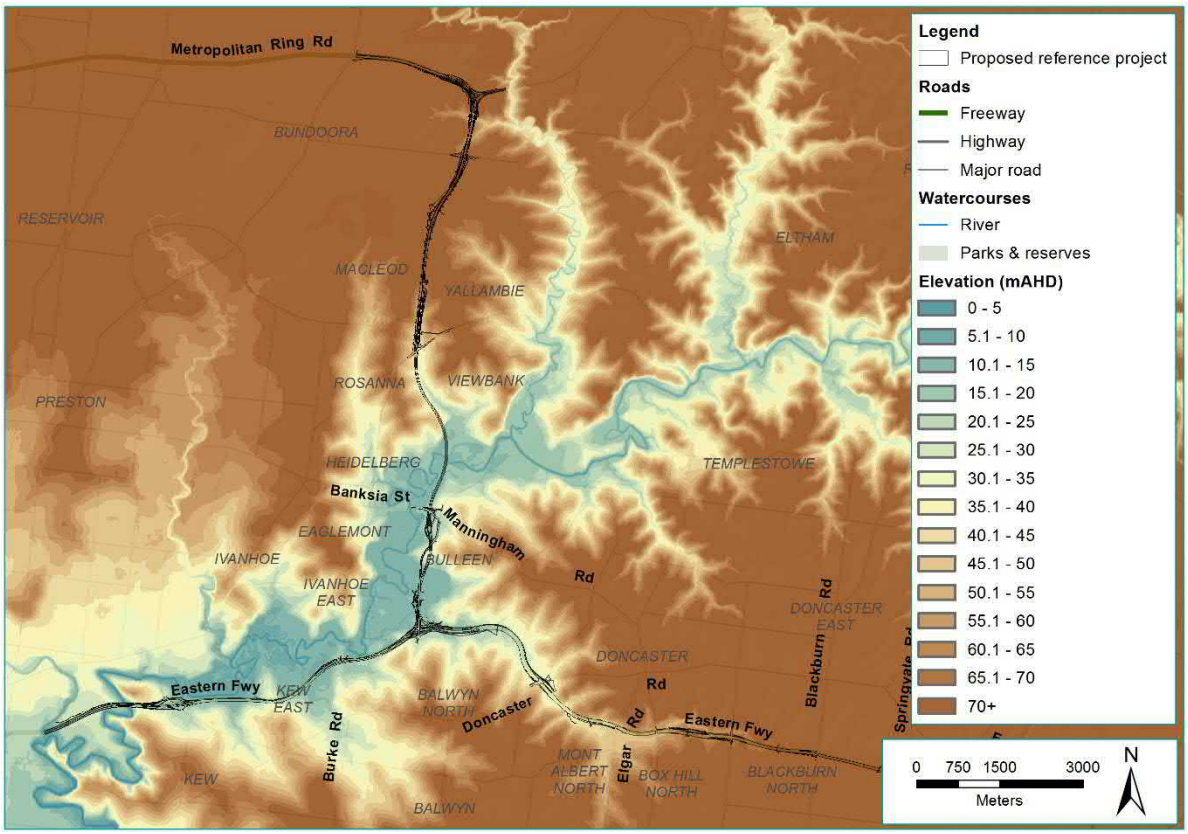


Figure 3: North East Link topography

4.4 Meteorology

Air quality impacts are influenced by regional meteorological conditions, primarily in the form of wind flow regimes, and by local conditions generally driven by topographical features in the form of drainage flows. Topography, wind speed and wind direction affect the dispersal and transport of pollutants.

The Bureau of Meteorology (BoM) collects meteorological data at Automatic Weather Stations (AWS) across Australia. The closest meteorological monitoring station to the North East Link tunnel ventilation structures is operated by BoM within the Banyule Flats Reserve at Viewbank. The station is located approximately 1.6 kilometres west of North East Link, near Banyule Road.

The station details are summarised in Table 5. The station location is displayed in Figure 4

Table 5: BoM Viewbank AWS

Station name	Viewbank
Type	AWS
Number	086068
Year opened	1999
Location (Latitude, Longitude)	-37.74˚, 145.100˚
Height above sea level	66.1 m
Parameters recorded	Temperature, humidity, wind, pressure and rainfall
Data completeness (wind speed and direction)	2013: 8754 hours (99.9%)

Station name	Viewbank
	2014: 8748 hours (99.9%) 2015: 8753 hours (99.9%) 2016: 8751 hours (99.6%) 2017: 8694 hours (99.2%)

Source: (Bureau of Meteorology, 2017) (Bureau of Meteorology, 2017

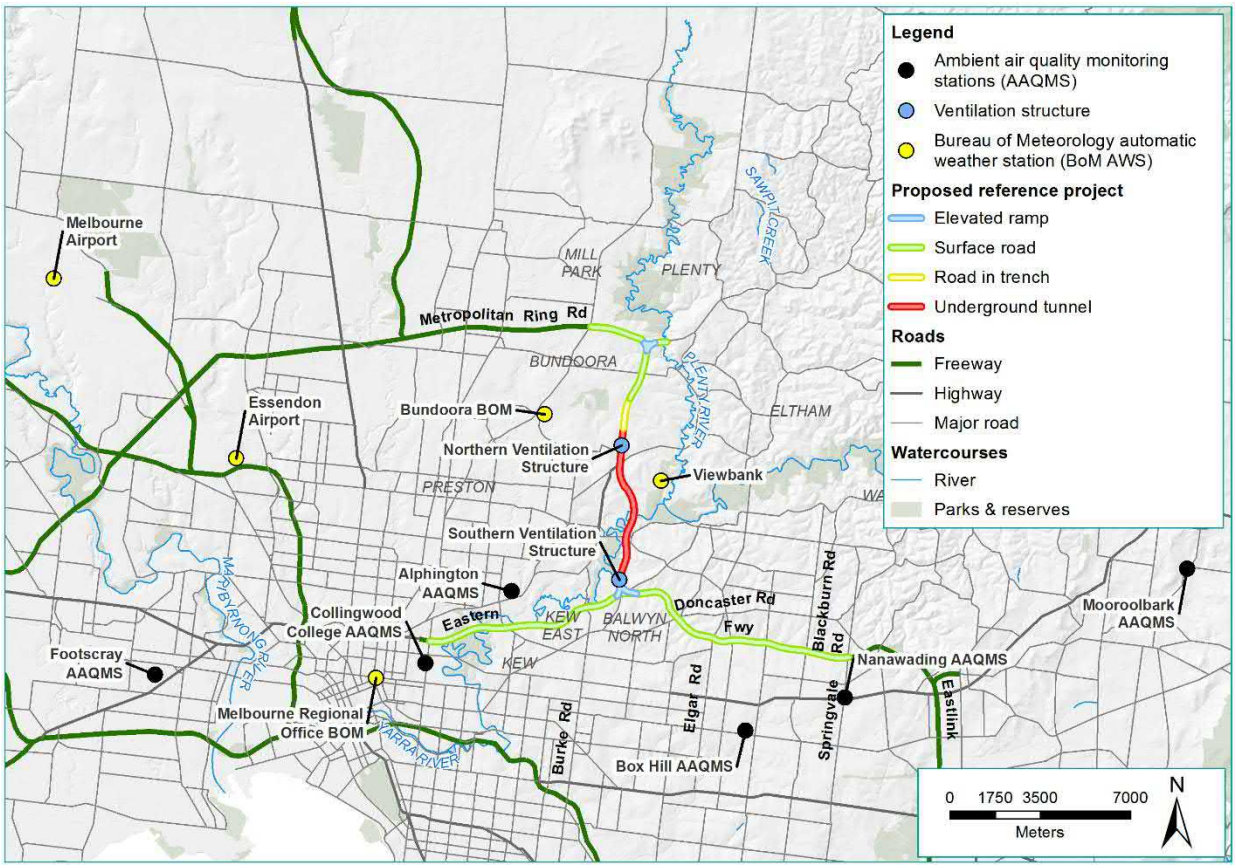


Figure 4: North East Link proximity to BoM AWS and EPA Victoria AAQMS

Other meteorological datasets are available for the EPA Victoria Alphington AAQMS, BoM Bundoora (Latrobe University) AWS, BoM Melbourne AWS and BoM Scoresby Research Institute AWS. However, the Viewbank AWS best reflects meteorology nearest the tunnel ventilation structures due to its proximity to the proposed road alignment and is considered broadly representative of the larger project area. Consequently, the Viewbank AWS data has been used to characterise existing meteorology in the receiving environment and to generate meteorological data files for air dispersion modelling.

Data from the five most recent calendar years (2013 to 2017) was analysed, with the results displayed in wind rose plots in Figure 5 and Figure 6 and a graph demonstrating the monthly temperature profile in Figure 7.

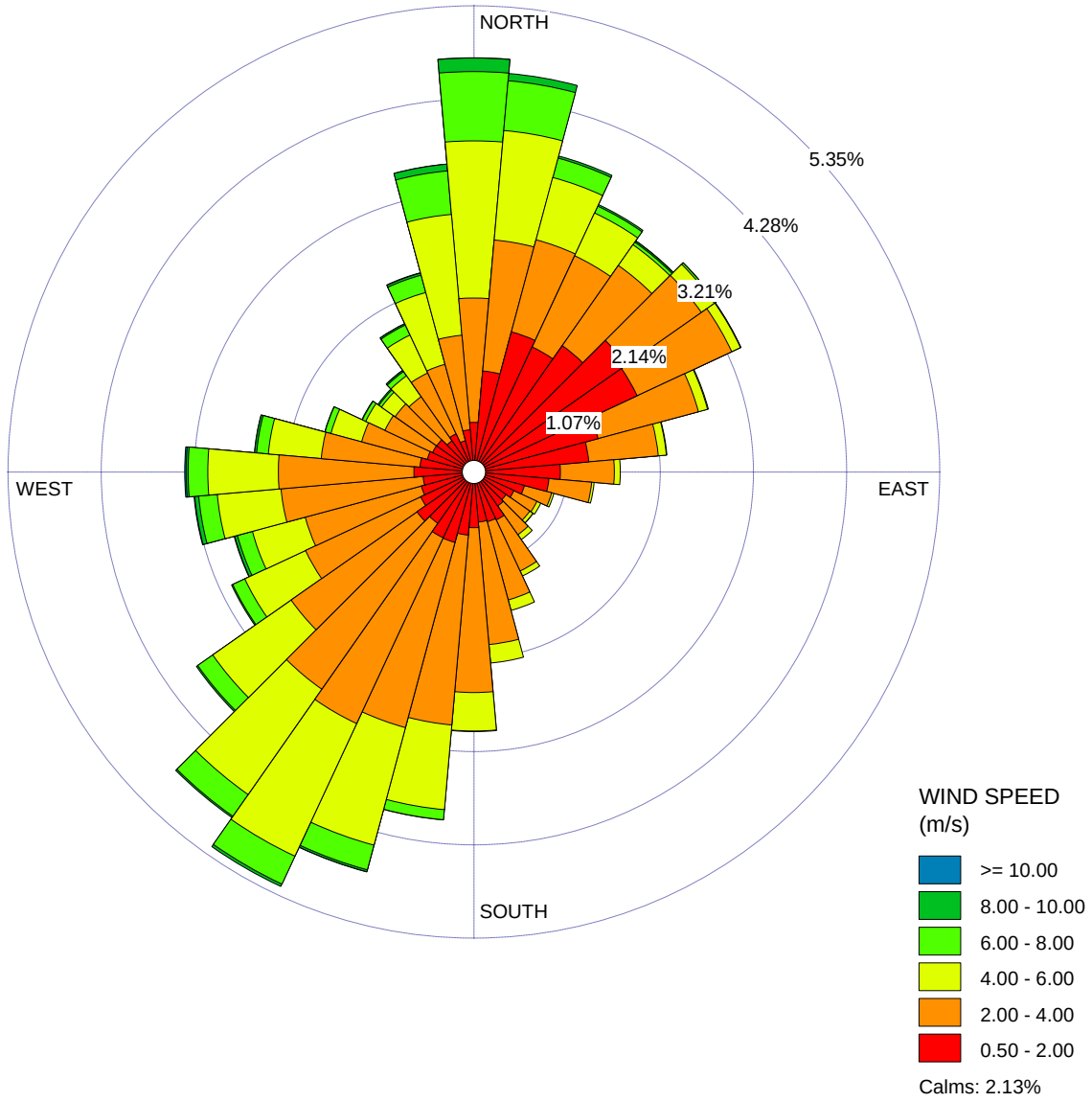


Figure 5: Viewbank AWS wind rose (2013 – 2017)

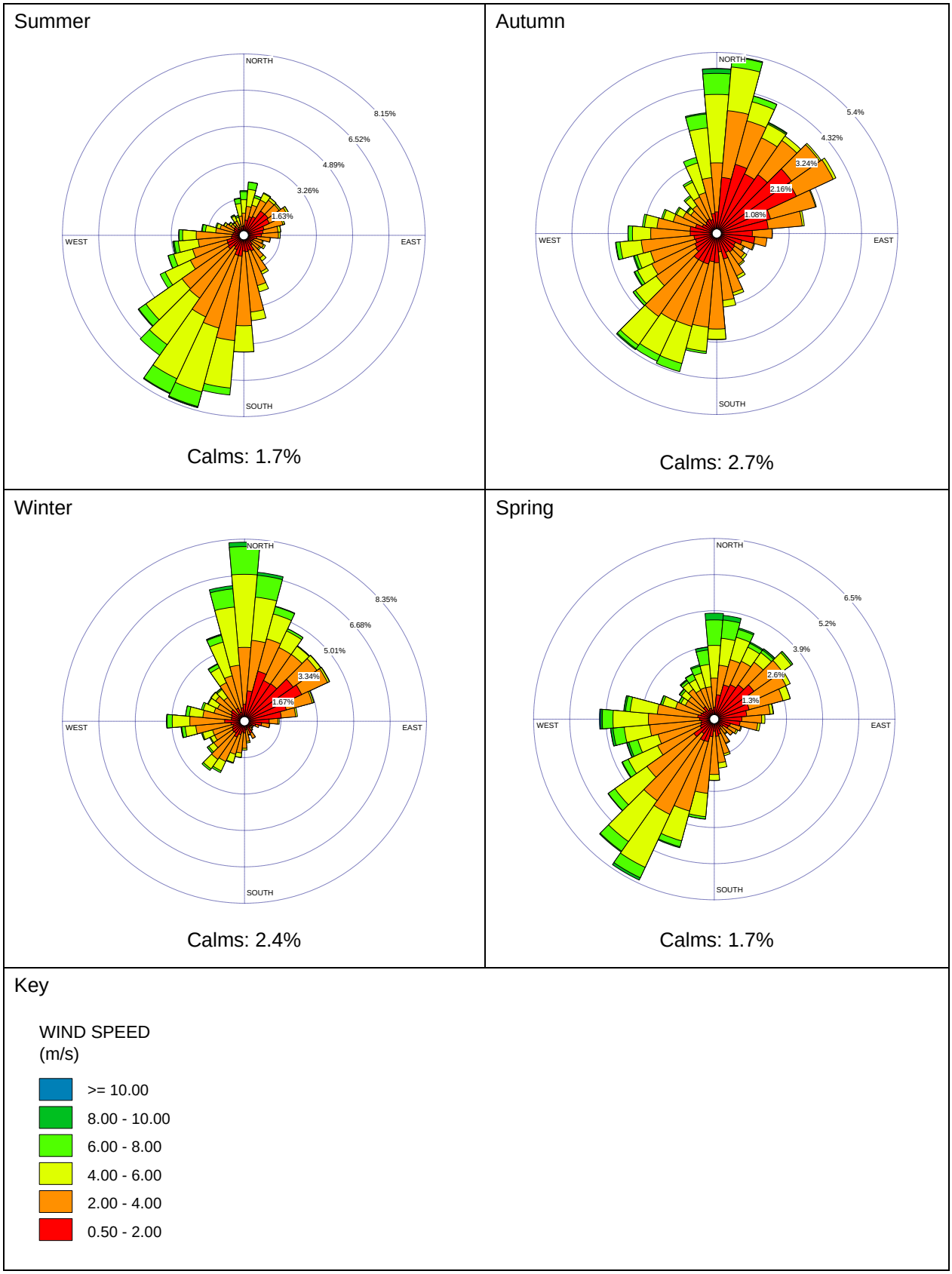


Figure 6: Viewbank AWS seasonal wind roses (2013 – 2017)

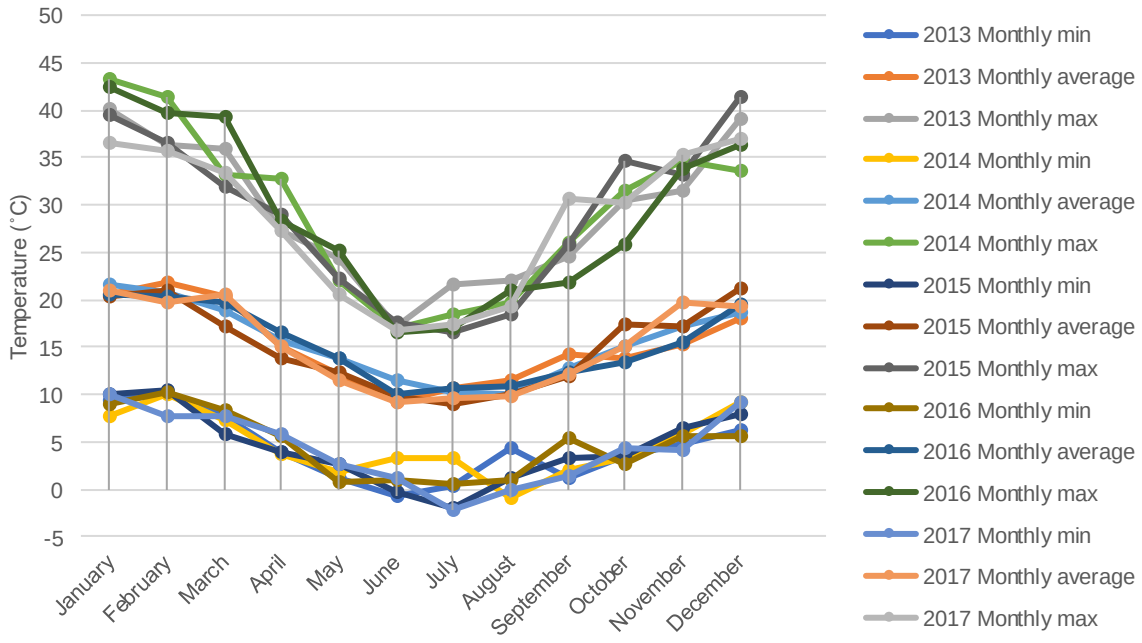


Figure 7: Viewbank AWS monthly temperature profile (2013-2017)

The wind rose plots illustrate that the wind is most commonly blowing from either the south-south-west or north-north-east quadrants, with the summer months particularly dominated by winds from the south-south-west. Autumn had the highest frequency of calm conditions, defined as wind speed less than 0.5 metres per second. Overall the 2013 to 2017 wind observation dataset can be summarised as follows:

- the most frequent wind class is two to four metres per second
- less than 6 per cent of winds exceed six metres per second
- the average wind speed is 3.1 metres per second
- low wind speeds (less than two metres per second) occurred most frequently in autumn and winter
- south-south-west winds predominate in summer and are uncommon in winter
- north and north-north-east winds predominate in winter and are uncommon in summer
- spring and autumn conditions are similar to the annual average.

The temperature trends displayed in Figure 7 show the monthly averages ranging between 22 degrees Celsius in January to 9 degrees Celsius in June/July/August dependent on the year. The highest maximum was 43 degrees Celsius in January 2014 whilst the lowest minimum was -2 degrees Celsius in July 2015.

4.4.1 Data comparison

Data from the Alphington AAQMS for 2013 to 2017 has been compiled for comparison with the Viewbank dataset.

Wind rose plots are presented in Figure 8 and Figure 9 and the monthly temperature profile in Figure 10.

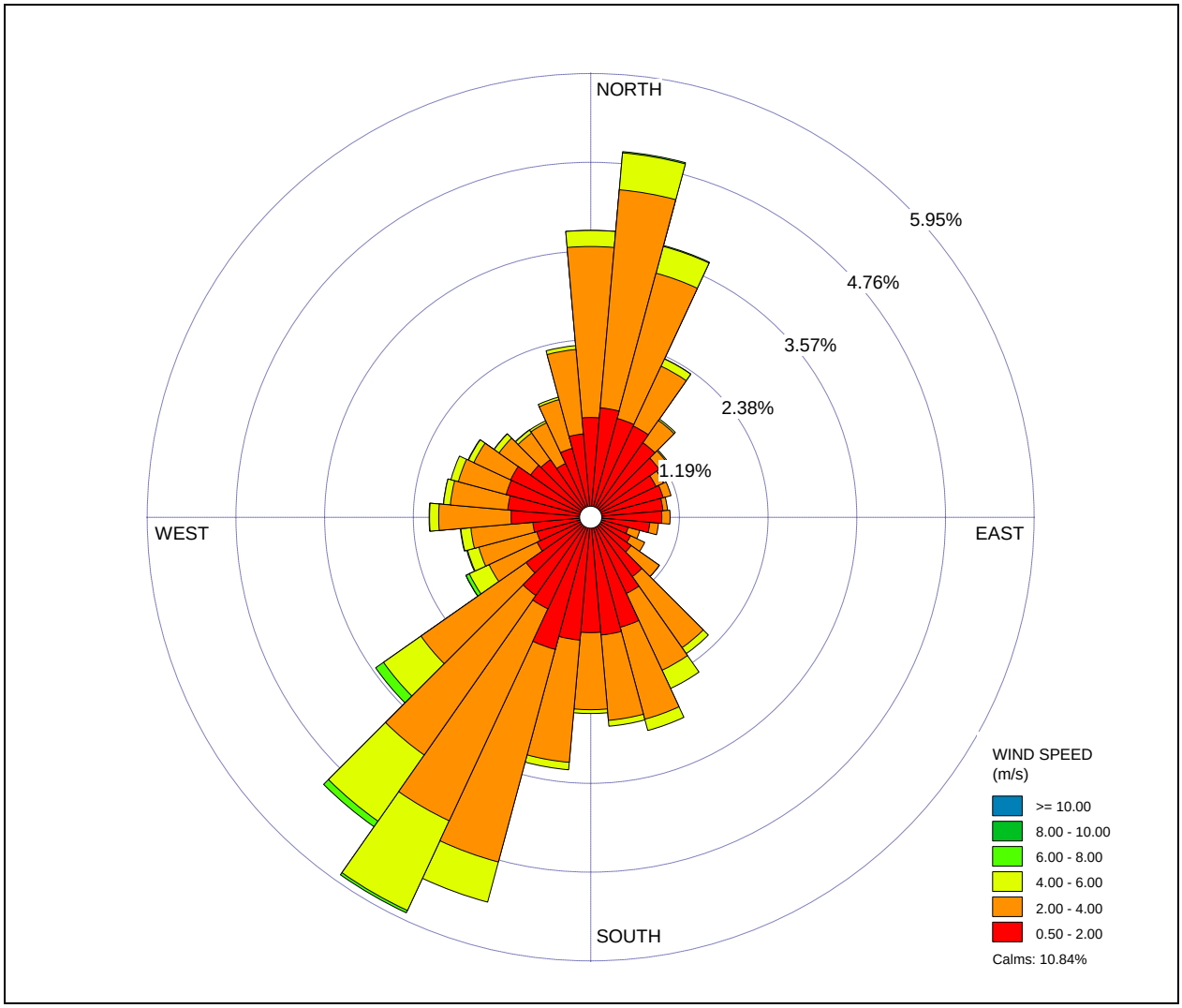


Figure 8: Alphington AAQMS wind rose (2013 – 2017)

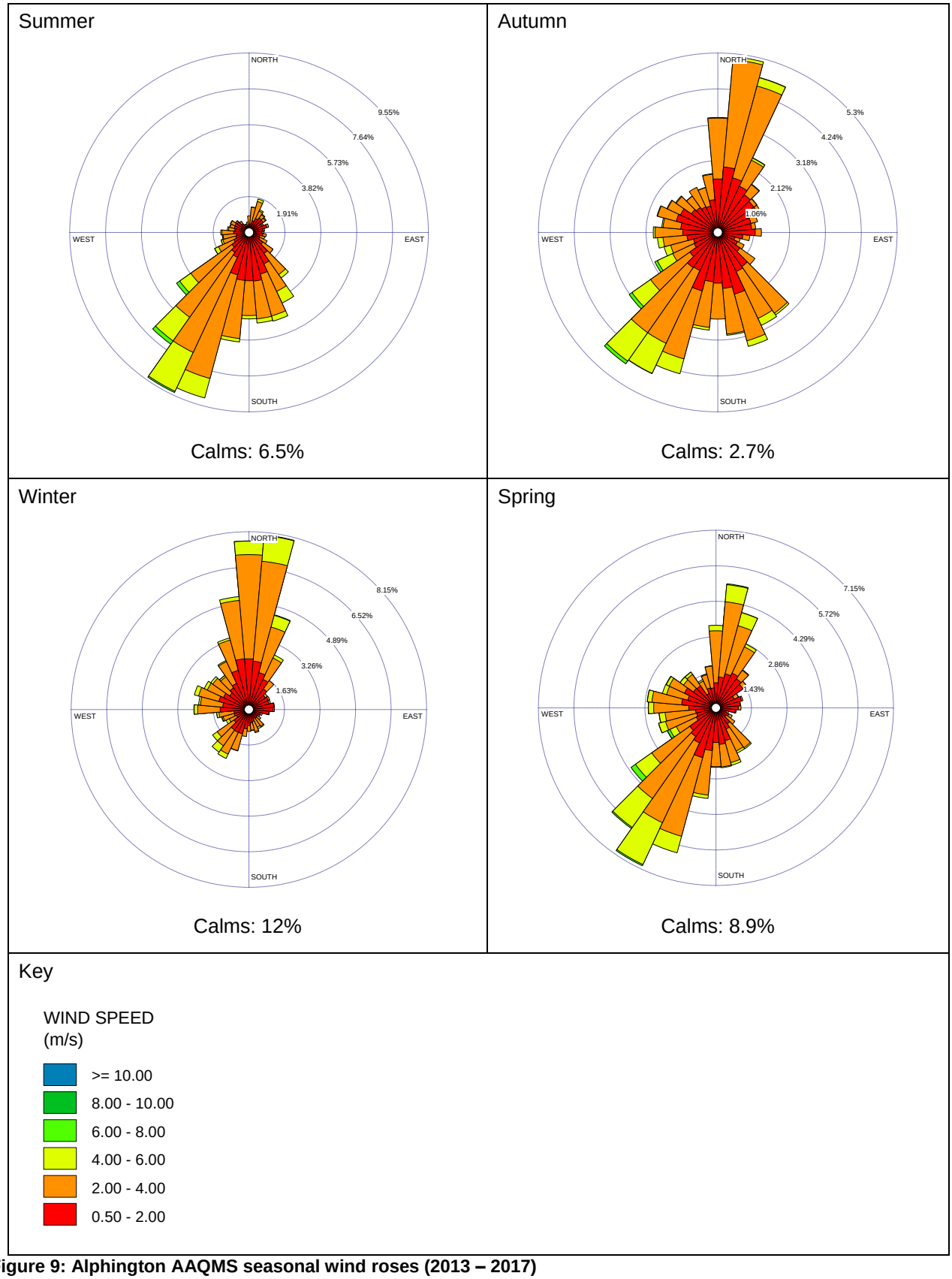


Figure 9: Alphington AAQMS seasonal wind roses (2013 – 2017)

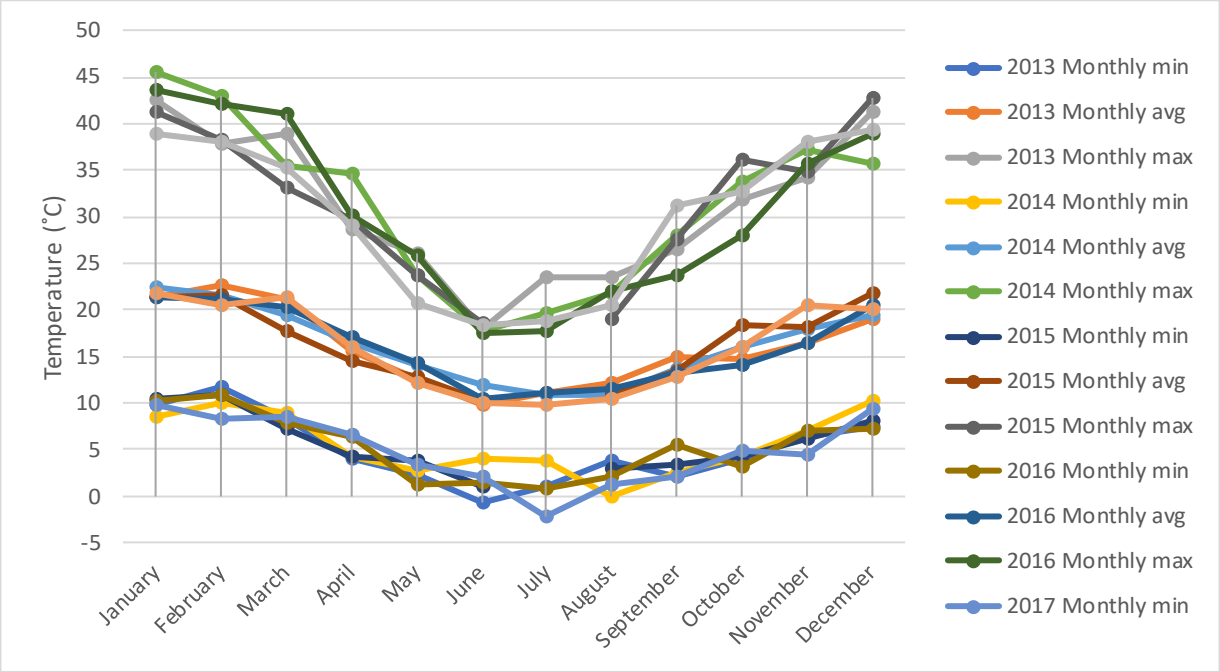


Figure 10: Alphington AAQMS monthly temperature profile (2013 – 2017)

The Alphington AAQMS wind data shows a similar pattern of seasonal distribution to the Viewbank AWS, with southerly winds most common in summer, northerly winds most common in winter, and the spring and autumn distributions similar to the annual wind rose. The wind speed profile is different, with a higher proportion of calms and low winds measured at Alphington compared to Viewbank. This may be due to the trees and shrubs within the immediate vicinity of the Alphington AAQMS, with EPA Victoria previously noting non-compliance with Australian Standard AS 3580.1.1 siting guidelines (EPA Victoria, 2001).

The surface temperature profile at Alphington is very similar to that measured at Viewbank, with both datasets exhibiting the same trends and comparable summary statistics.

Table 6 provides a summary of the wind profiles for both sites, together with temperatures recorded at each station for the investigation period.

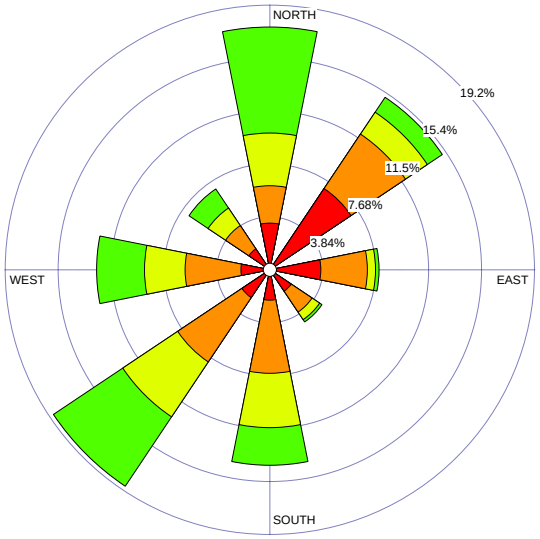
Table 6: Meteorological data comparison 2013-2017

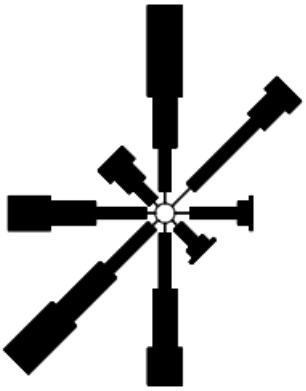
Parameter	Description	Viewbank AWS	Alphington AAQMS
Wind speed	Calms (<0.5 m/s)	2.1%	11%
	Proportion of low wind speeds (0.5 – 2.0 m/s)	31%	40%
	Proportion of medium wind speeds (2.0 – 6.0 m/s)	61%	43%
	Proportion of high wind speeds (>6 m/s)	5.8%	0.4%
	Average wind speed	3.0 m/s	1.9 m/s
Wind direction	Most common wind direction	South-south-westerly	South-south-westerly
	Least common wind direction	South easterly	East-south easterly

Parameter	Description	Viewbank AWS	Alphington AAQMS
Temperature	Highest monthly average	22˚C (February 2013, January 2014)	23˚C (February 2013)
	Lowest monthly average	9˚C (June 2013, July 2015, July 2017)	10˚C (June 2013, June 2015, June 2017)
	Highest annual average	16˚C (2014)	17˚C (2015)
	Lowest annual average	15˚C (2013, 2015, 2016, 2017)	16˚C (2013, 2014, 2016, 2017)

The meteorology comparison indicates that the Viewbank AWS (2013 – 2017) dataset is similar to the Alphington AAQMS data for wind direction and surface temperature profile. Measured wind speeds are typically lower at Alphington AAQMS.

The Viewbank AWS project dataset was also compared with the larger historical record. Figure 11 presents a BoM wind rose for all available three-hourly observations together with the Viewbank 2013 – 2017 annual wind rose. The wind rose comparison shows agreement between the five year dataset and all available observations, with the same pattern of wind distribution and a similar wind speed profile.

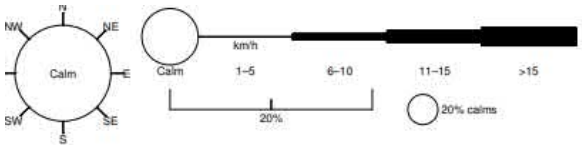




WIND SPEED

(km/h)

- >=15
- 11 - 15
- 6 - 11
- 1 – 6



Wind rose 2013 - 2017

Wind rose 1999 – 2018

This material is sourced from the Bureau of Meteorology

Figure 11: Viewbank AWS time period comparison

4.5 Air emission sources

The main industrial and non-industrial air emission sources contributing to the local airshed include:

- traffic using the road network, including the M80 Ring Road and Eastern Freeway
- industrial and food manufacturing industries
- domestic fuel burning (gas, liquid and solid)
- residential activities (e.g. lawn mowers and barbecues)
- railway operations.

These sources give rise to emissions of key pollutants relevant to North East Link, including CO, oxides of nitrogen [NO_x comprising NO_2 and nitric oxide (NO)], PM_{10}, $PM_{2.5}$, BTEX, formaldehyde, 1,3 butadiene and PAH.

4.6 Ambient air quality

EPA Victoria conducts long term ambient air quality monitoring at performance monitoring stations to meet its obligations under the Air NEPM. The results are compared with SEPP(AAQ) EQOs.

The closest EPA Victoria performance monitoring station to North East Link is the Alphington AAQMS, located approximately 1.5 kilometres from the Eastern Freeway. Performance monitoring stations are also located in Footscray, approximately 11 kilometres from the city end of the Eastern Freeway and Mooroolbark, located approximately 14 kilometres from the Donvale end of the Eastern Freeway. A new station has recently been established in the Melbourne CBD, replacing the historical Richmond and RMIT University performance monitoring stations. The new station was commissioned in 2017 and hence cannot provide sufficient data to establish a historical ambient air quality record.

EPA Victoria also monitors air quality for the AirWatch program, an online map showing hourly data. AirWatch reports data from both performance monitoring stations and other stations, including Box Hill, approximately 3.5 kilometres from the Eastern Freeway.

EPA Victoria also conducts air quality monitoring to investigate local air quality issues or during major pollution events. Of relevance to North East Link, monitoring was undertaken in 2003/2004 in Nunawading to "*assess the level of motor derived air pollutants at a heavily trafficked intersection that might represent worst-case exposure for people working or living in a similar location*" (EPA Victoria, 2004). The monitoring site was approximately 1.6 kilometres south of the Eastern Freeway intersection with Springvale Road. The study concluded that, like other roadside monitoring, the EQOs were met for the parameters measured.

Neighbourhood air quality monitoring was also conducted in 2001 in the playground of Collingwood College less than one kilometre from the city end of the Eastern Freeway. The monitoring program consisted of PM_{10}, NO_2, CO and SO_2 measurement in the College playground adjacent to Hoddle Street. This monitoring campaign also concluded that the contaminants measured were below the objectives of the SEPP(AAQ) (EPA Victoria, 2002).

A summary of relevant monitoring stations is presented in Table 7 . Monitoring locations are displayed in Figure 4.

Table 7: Ambient air quality monitoring near North East Link

Station Name	Description	Location in relation to North East Link	Key pollutants monitored	
Alphington	Performance monitoring station classified as “residential/light industrial”	Approximately 1.5 km north of the Eastern Freeway and 4 km east of North East Link tunnel alignment	CO	✓
			NO_2	✓
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	✓
			VOCs	×
Collingwood College	Campaign monitoring during August to October 2001	Collingwood College playground, adjacent to Hoddle Street, less than 1 km from the Eastern Freeway terminus	CO	✓
			NO_2	✓
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	×
			VOCs	×
Box Hill	AirWatch station located in a residential area near to parks and industrial activity	Approximately 3.5 km south of the Eastern Freeway	CO	×
			NO_2	×
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	×
			VOCs	×
Footscray	Performance monitoring station classified as “industrial/residential”	Approximately 11 km from the city end of the Eastern Freeway	CO	✓
			NO_2	✓
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	✓
			VOCs	×
Mooroolbark	Performance monitoring station classified as “residential”	Approximately 14 km from the Donvale end of the Eastern Freeway	CO	×
			NO_2	×
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	×
			VOCs	×

Station Name	Description	Location in relation to North East Link	Key pollutants monitored	
Nunawading	Campaign monitoring in October 2003 to February 2004	Intersection of Whitehorse Road and Springvale Road, approximately 1.6 km from the Donvale end of the Eastern Freeway.	CO	✓
			NO_2	✓
			PAH	×
			PM_{10}	✓
			$PM_{2.5}$	✓
			VOCs	✓

Note: Indicative $PM_{2.5}$ monitoring has not been included

Review of Table 7 indicates that Alphington and Footscray cover the largest number of key pollutants with Alphington being the closest AAQMS to the project boundary. The Alphington station setting also mirrors the North East Link receiving environment. The station is located in Wingrove Street, Fairfield, adjacent to the Hurstbridge rail line and Alphington train station. The surrounding area is a mix of residential houses, commercial properties and parklands. As discussed in 4.1, the North East Link receiving environment consists of large tracts of residential land, parklands and commercial activities. Industrial facilities comprise a small portion of the receiving environment.

Therefore, data from the Alphington AAQMS is considered to best represent air quality for North East Link. Data for the key pollutants CO, NO_2, PM_{10} and $PM_{2.5}$ form the background air quality for the tunnel ventilation system air quality impact assessment. An analysis of the most recent five calendar years for this site is presented in the following subsections. Long term data (2005 to 2017) for Alphington AAQMS is presented in Section 4.6.5 for comparison.

Air toxics monitoring for PAH and VOCs does not form part of the Alphington AAQMS dataset. Instead, historical air toxics monitoring has been campaign based, conducted at hot spots and also to assess compliance with the Air Toxics NEPM MILs. A summary of PAH and VOC monitoring conducted across metropolitan Melbourne is presented in Section 4.6.6.

Five temporary ambient air quality monitoring stations have been established in the vicinity of North East Link to support project development. Air quality data collected at these stations will be presented at the EES Panel Hearing to enable comparison with EPA Victoria Alphington AAQMS data.

Note: The reported CO, NO_2, PM_{10} and $PM_{2.5}$ results are based on data provided by EPA Victoria for characterising existing air quality and resolving background concentrations for North East Link. The results may differ from historical EPA Victoria reported exceedance concentrations or summary statistics due to new data validation techniques being applied to the Victorian air quality monitoring database.

4.6.1 Carbon monoxide

Monitoring for CO at Alphington AAQMS is conducted in accordance with Australian Standard AS 3580.7.1 (Standards Australia, 2011). Results from this continuous method are compared with the SEPP(AAQ) environmental quality objective (EQO) of 9.0 parts per million, over an eight hour averaging period, with the maximum daily eight hour average reported. Averages were only calculated if a minimum of 75 per cent data capture for the averaging period was attained.

Daily maximum eight hour average carbon monoxide concentrations for 2013 to 2017 are presented in Figure 12 and summarised in Table 8.

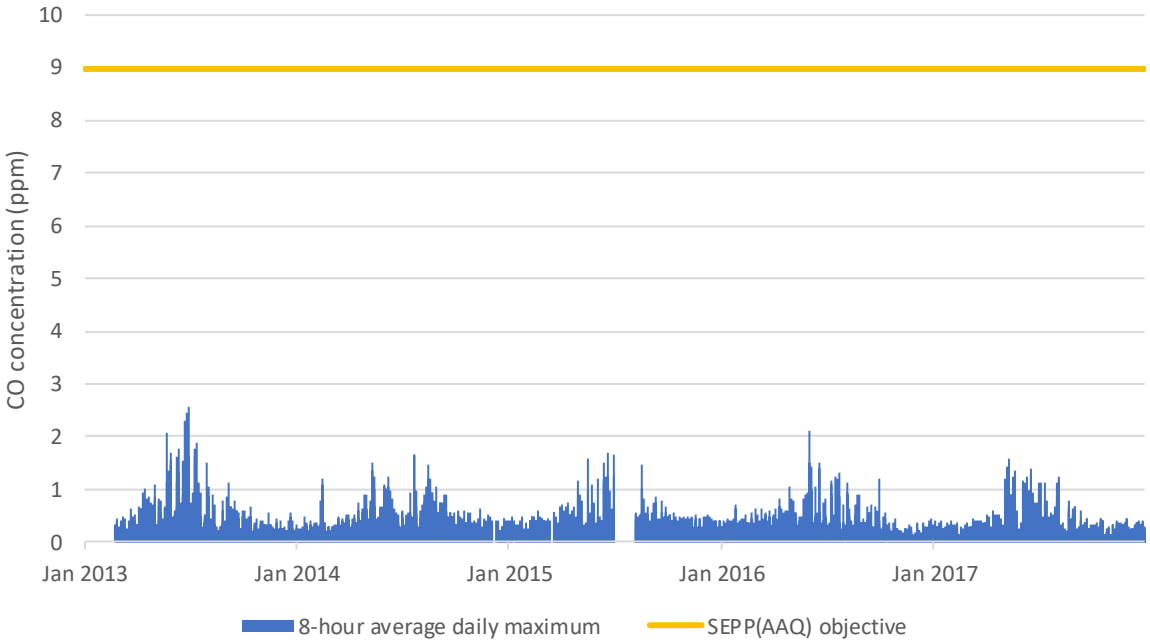


Figure 12: Alphington AAQMS CO: 2013 – 2017 (8 hour average daily maximum)

Table 8: Alphington AAQMS CO results summary (2013 – 2017)

Period	Daily maximum (8 hour average) (ppm)			
	Minimum	Average	Maximum	Standard deviation
2013	0.10	0.50	2.6	0.42
2014	0.060	0.44	1.7	0.26
2015	0.12	0.47	1.7	0.30
2016	0.043	0.41	2.1	0.28
2017	0.017	0.38	1.6	0.28
2013 - 2017	0.017	0.43	2.6	0.30

Alphington CO data indicates compliance with the SEPP(AAQ) EQO of 9.0 parts per million for the period 2013 to 2017. The daily maximum results are consistently less than 3 parts per million (eight hour average) with a standard deviation less than 0.5 parts per million.

4.6.2 Nitrogen dioxide

Monitoring for NO_2 at Alphington AAQMS is conducted in accordance with Australian Standard AS 3580.5.1 (Standards Australia, 2011). The results are compared to the following SEPP(AAQ) EQOs:

- one hour averaging period: 0.12 parts per million
- annual averaging period: 0.03 parts per million.

The NO_2 concentration results for 2013 to 2017 are presented in Figure 13 and Figure 14 and Table 9.

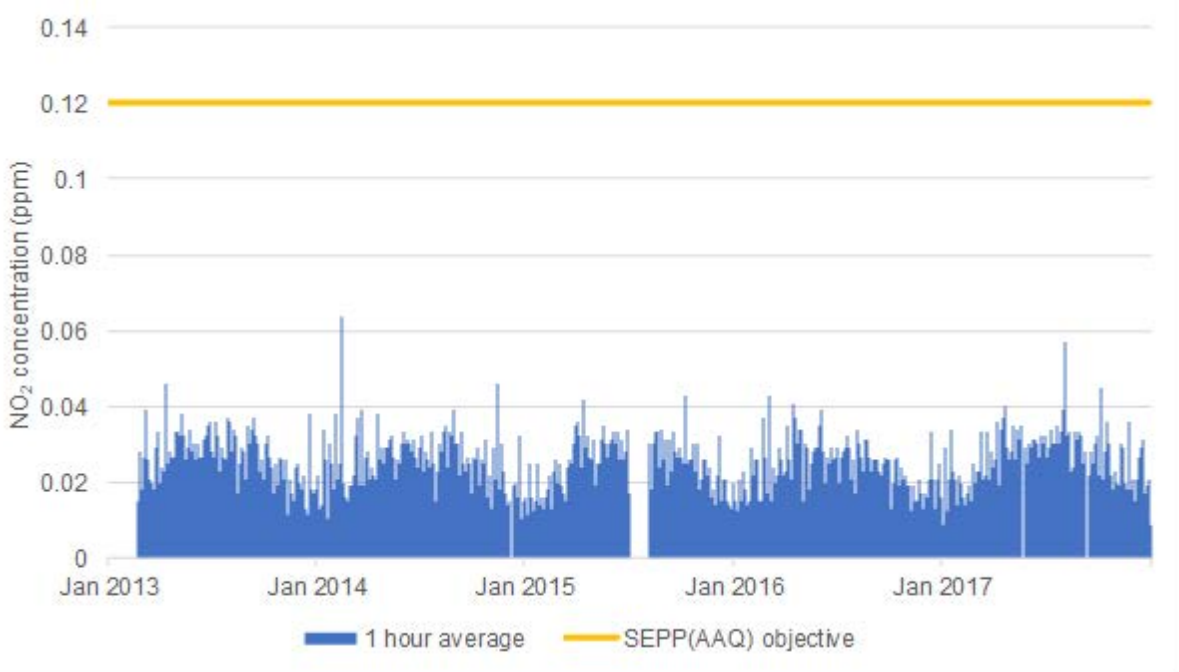


Figure 13: Alphington AAQMS NO_2: 2013 – 2017 (1 hour average)

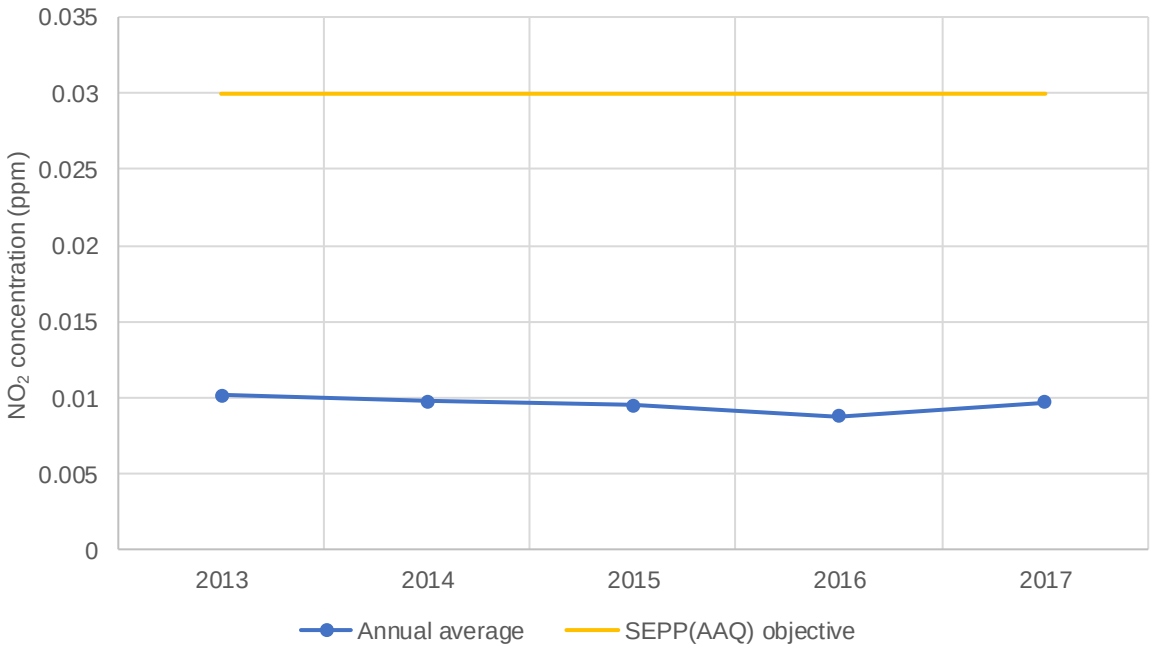


Figure 14: Alphington AAQMS NO_2: 2013 – 2017 (annual average)

Table 9: Alphington NO_2 results summary (1 hour average)

Period	Minimum (ppm)	Average (ppm)	Maximum (ppm)	Standard deviation (ppm)
2013	0.001	0.01	0.05	0.007
2014	0.001	0.01	0.06	0.007
2015	0.001	0.009	0.04	0.007
2016	0.001	0.009	0.04	0.007
2017	0.001	0.01	0.06	0.007
2013 - 2017	0.001	0.01	0.06	0.007

The Alphington NO_2 results for 2013 to 2017 demonstrate compliance with the SEPP(AAQ) one hour and annual average criteria. The maximum measured one hour average concentration was 0.06 parts per million on 13 February 2014. This value is approximately 50 per cent of the criterion. Average results for the period were less than 10 per cent of the short term criterion.

4.6.3 PM_{10}

PM_{10} sampling at Alphington AAQMS is conducted using a tapered element oscillating microbalance (TEOM) in accordance with Australian Standard AS3580.9.8 (Standards Australia, 2008). TEOM data has been adjusted in accordance with National Environment Protection Council (NEPC) requirements (NEPC 2001).

PM_{10} results are compared with the following SEPP(AAQ) EQOs:

- 24 hour averaging period: 50 µg/m^3
- Annual averaging period: 20 µg/m^3

The 24 hour average results for the period 2013 to 2017 are presented in Figure 15 and Table 10. Results with less than 75 per cent data capture were not included in the graph or summary statistics. Annual average results are displayed in Figure 16.

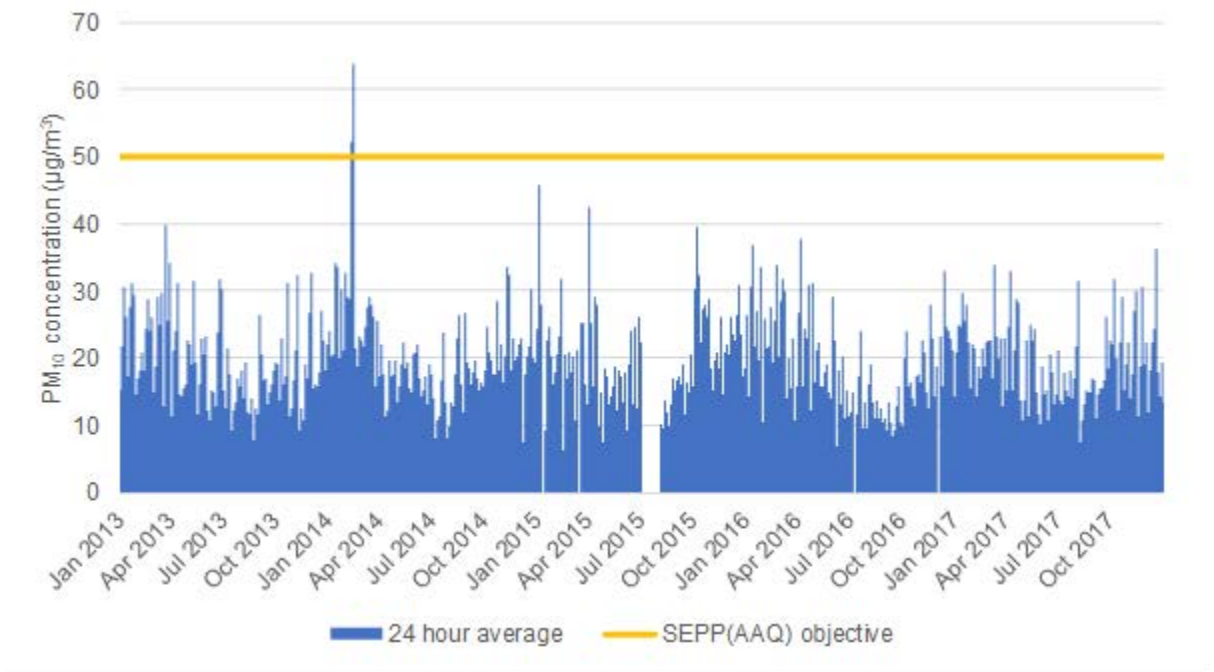


Figure 15: Alphington AAQMS PM_{10}: 2013 – 2017 (24 hour average)

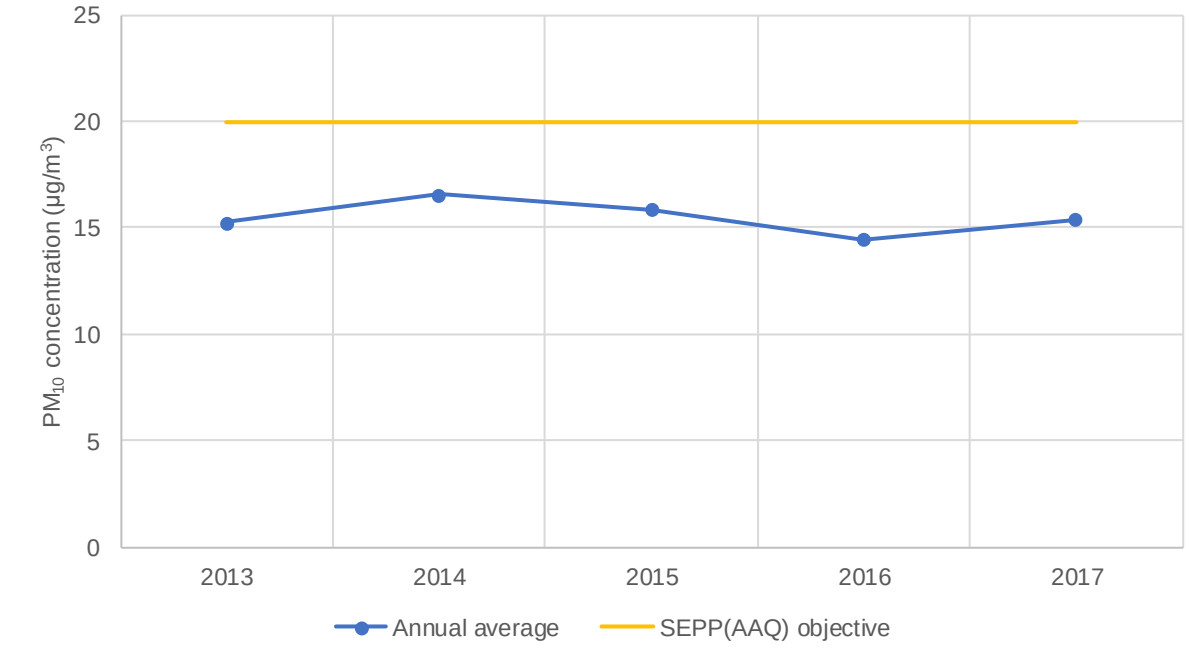


Figure 16: Alphington AAQMS PM_{10}: 2013 – 2017 (annual average)

Table 10: Alphington PM_{10} results summary (24 hour average)

Period	Minimum (µg/m³)	Average (µg/m³)	Maximum (µg/m³)	Standard deviation (µg/m³)
2013	2.1	16	44	6.8
2014	4.1	17	64	7.6
2015	4.1	16	46	6.4

Period	Minimum ($\mu g/m^3$)	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	Standard deviation ($\mu g/m^3$)
2016	2.2	15	38	6.5
2017	4.1	16	44	6.1
2013 - 2017	2.1	16	64	6.7

The PM_{10} results for Alphington show four instances where the 24 hour average was greater than the SEPP(AAQ) EQO:

- 11 February 2014: 52 $\mu g/m^3$
- 12 February 2014: 62 $\mu g/m^3$
- 13 February 2014: 63 $\mu g/m^3$
- 14 February 2014: 64 $\mu g/m^3$

EPA Victoria attribute the February 2014 results to bushfires which occurred in many parts of Victoria. Smoke from these events is visible on images captured on the moderate resolution imaging spectroradiometer (MODIS) on NASA's Aqua satellite (NASA, 2014).

Annual average PM_{10} concentrations demonstrate compliance with the SEPP(AAQ) EQO for 2013 to 2017.

PM_{10} data is also available for EPA Victoria AAQMSs at Box Hill and Mooroolbark. EPA Victoria provides spreadsheet summaries with monthly averaged results for these stations and Alphington for 2013, 2014 and 2015 (EPA Victoria, 2017). The results are reproduced in Figure 17. This figure indicates that results for Alphington are similar to Box Hill and Mooroolbark and follow the same trends. The results also show that where data is available for multiple stations within the vicinity of North East Link, the results are comparable and thus the use of the Alphington dataset to represent existing background air quality across the project modelling domain is reasonable.

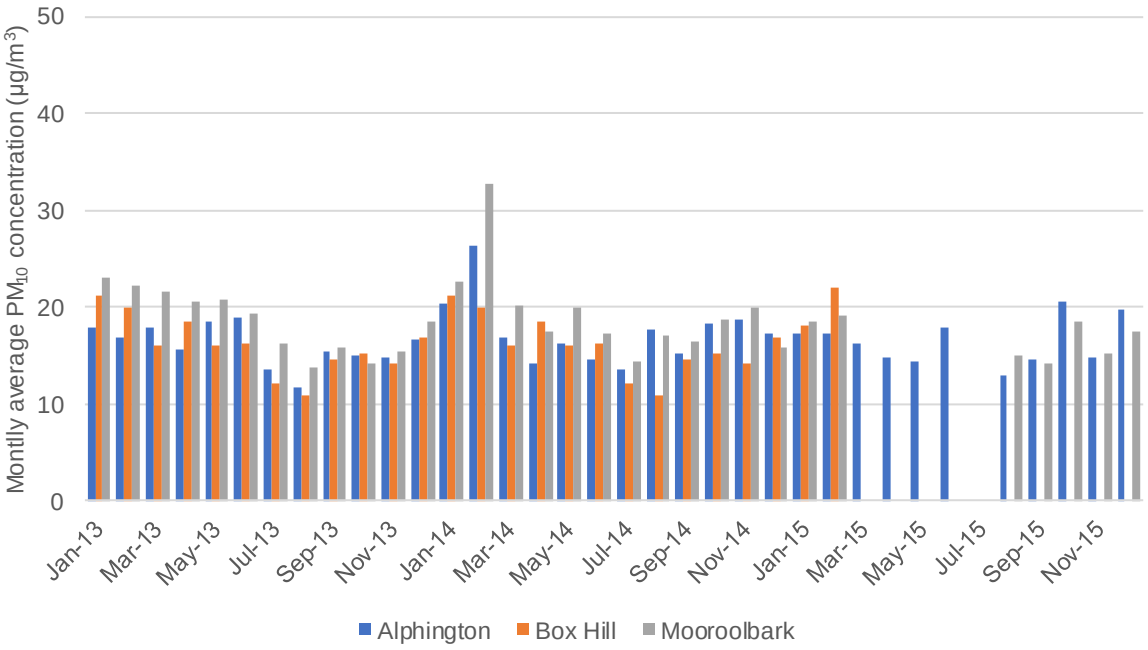


Figure 17: Comparison of PM_{10} results from three monitoring stations 2013 - 2015

4.6.4 $PM_{2.5}$

Monitoring of $PM_{2.5}$ at Alphington AAQMS is conducted using a gravimetric method [a low volume sampler (LVS)] and a continuous monitoring method [a beta attenuation monitor (BAM)]. The BAM was installed in January 2014. The applicable methods are as follows:

- LVS: Australian Standard AS3580.9.10 (Standards Australia, 2017)
- BAM: Australian Standard AS 3580.9.12 (Standards Australia, 2013)

$PM_{2.5}$ determination by LVS provides discrete 24 hour average results every three days. BAM sampling is a continuous technique enabling calculation of multiple averaging periods with data collected every hour of every day. The results from the continuous BAM method have been selected for presentation and analysis for North East Link due to the greater data coverage; with results available for most days of the period 2014 to 2017.

The SEPP(AAQ) $PM_{2.5}$ EQOs are:

- 24 hour averaging period: 25 µg/m^3
- Annual averaging period: 8 µg/m^3

The SEPP(AAQ) contains additional $PM_{2.5}$ objectives for the year 2025 and beyond. The future SEPP(AAQ) EQOs are:

- 24 hour averaging period: 20 µg/m^3
- Annual averaging period: 7 µg/m^3

The 24 hour average $PM_{2.5}$ concentrations for 2014 to 2017 are presented in Figure 18 and summarised in Table 11. Results with less than 75 per cent data capture were not included in the graph or summary statistics. Annual average results are displayed in Figure 19.

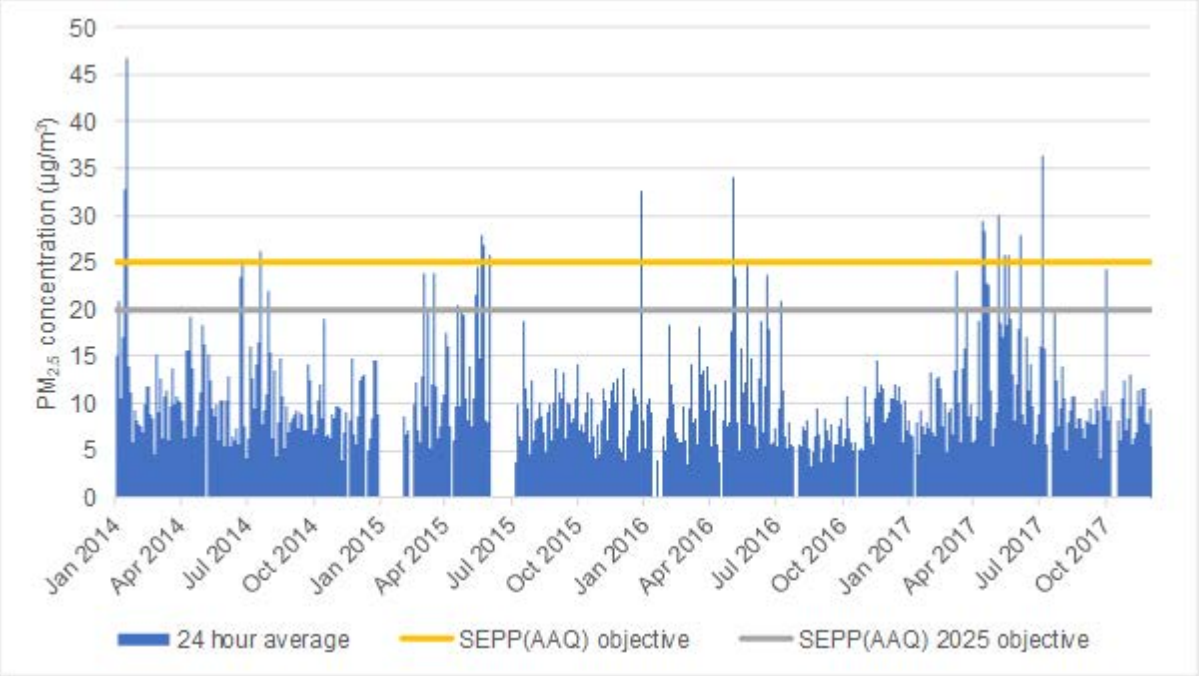


Figure 18: Alphington AAQMS $PM_{2.5}$: 2013 – 2017 (24 hour average)

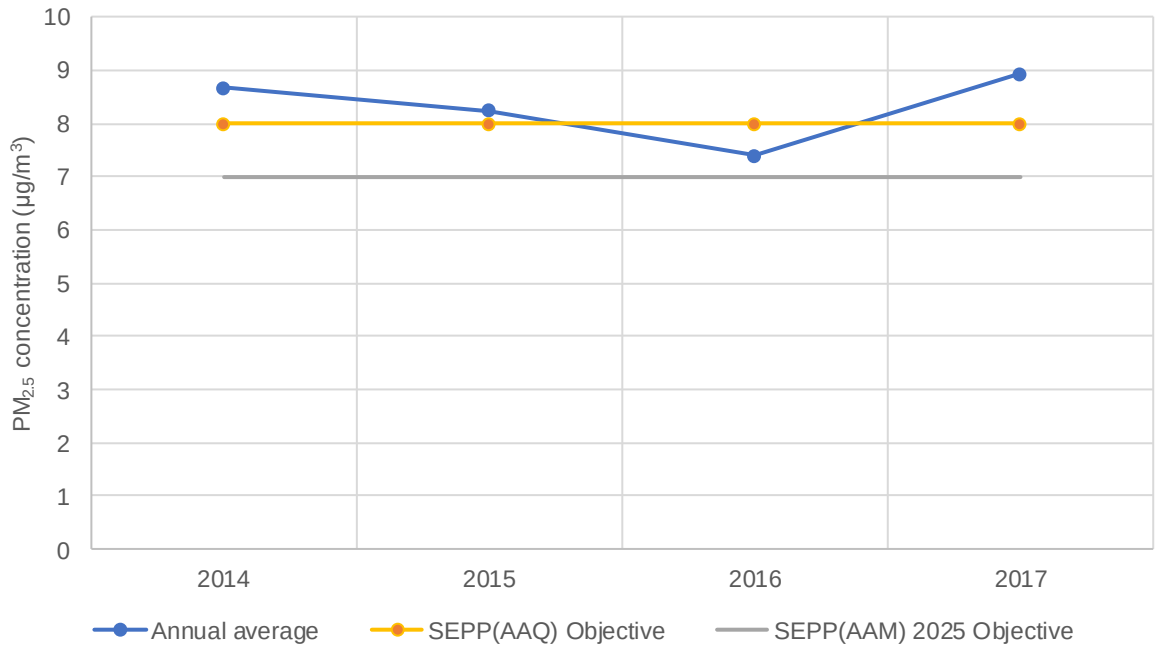


Figure 19: Alphington AAQMS $PM_{2.5}$: 2013 – 2017 (annual average)

Table 11: Alphington AAQMS: PM_{25} results summary (24 hour average)

Period	Minimum ($\mu g/m^3$)	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	Standard deviation ($\mu g/m^3$)
2014	0.71	8.7	47	5.4
2015	2.0	8.3	28	4.5
2016	1.5	7.4	34	4.4
2017	1.8	8.9	36	5.3
2014 - 2017	0.71	8.3	47	5.0

There were 19 days in the period 2013 to 2017 where the $PM_{2.5}$ 24 hour average concentration exceeded the SEPP(AAQ) EQO. These are displayed in Table 12.

Table 12: Alphington AAQMS: $PM_{2.5}$ exceedances 2013-2017

Year	Date	$PM_{2.5}$ concentration 24 hour average ($\mu g/m^3$)
2014	11 February	33
	12 February	41
	13 February	45
	14 February	47
	16 August	26
2015	20 June	28
	21 June	27
	30 June	26
2016	26 January	33
	2 June	34
2017	11 May	28
	12 May	29
	14 May	26
	15 May	28
	4 June	30
	11 June	26
	17 June	26
	2 July	28
	3 August	36

The 2014 February exceedances were due to Victorian bushfires which also caused PM_{10} exceedances for the same period. The August 2014 exceedance is attributed to "*urban sources, likely including the wood heater contribution, due to the calm cold conditions*" (EPA Victoria, 2015). The exceedances in 2015 and 2016 follow a similar pattern, either occurring in summer and attributable to bushfires and planned burns or during cold months and attributed to urban sources such as domestic wood heaters. 2017 has the largest proportion of exceedances, with nine days exceeding the SEPP(AAQ) EQO. The May 2017 results align with an EPA Victoria statement released to news outlets in Melbourne indicating that "*the poor air quality is caused by stable weather conditions resulting in a build-up of $PM_{2.5}$ and smoke from activities such as domestic wood heater usage, motor vehicles and other urban sources*" (Smith & Meehan, 2017).

A significant proportion of the annual average $PM_{2.5}$ results also exceed the SEPP(AAQ) EQO, with 2016 the only year in the dataset below the criterion.

The representativeness of the continuous BAM measured dataset was assessed through comparison with Partisol measured $PM_{2.5}$ concentrations. The comparison was conducted for 2014 and 2015 as this is the only period reported by EPA Victoria for both measurement techniques. The monthly average results for 2014 and 2015 were compiled into a statistical box and whisker plot, with the results displayed in Figure 20. The results indicate that there is general agreement between the two measurement techniques, with BAM results generally higher. The BAM measured $PM_{2.5}$ concentrations are therefore a conservative assessment of existing air quality for North East Link.

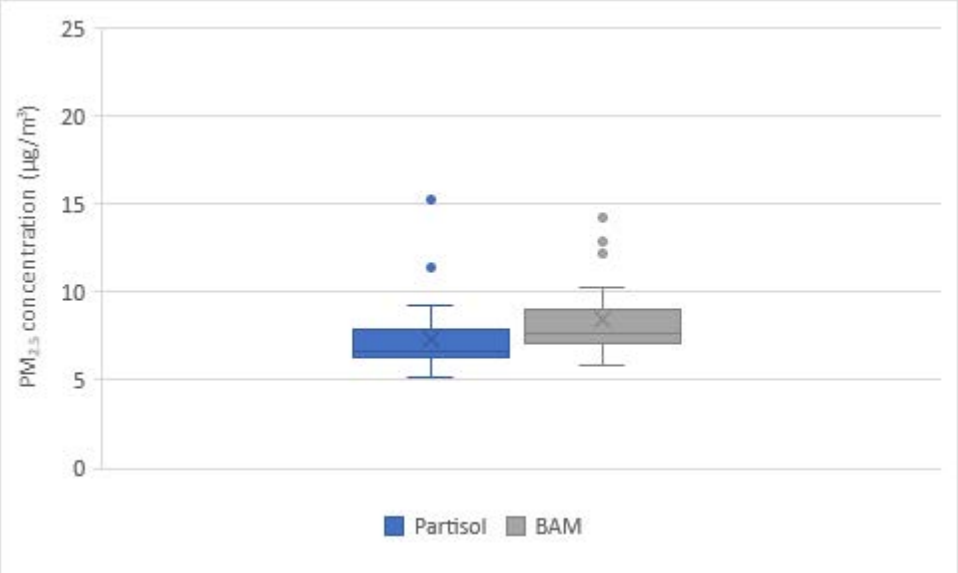


Figure 20: $PM_{2.5}$ Measurement technique comparison (2014 and 2015)

4.6.5 Long term Alphington data

A summary of Alphington AAQMS data from 2005 to 2017 against SEPP(AAQ) objectives is provided in Table 13, with data presented in Figure 21 to Figure 27.

CO and NO_2 concentrations measured from 2005 to 2017 were below SEPP(AAQ) EQOs. PM_{10} concentrations exceeded the SEPP(AAQ) 24 hour average EQO on several occasions during this period, with the PM_{10} annual average EQO exceeded in 2006 and 2009. $PM_{2.5}$ concentrations also exceeded the SEPP(AAQ) 24 hour average objective on several occasions, with the $PM_{2.5}$ annual average EQO exceeded in 2005, 2006, 2007, 2009, 2014, 2015 and 2017.

Annual average PM_{10} concentrations would appear to be declining. For $PM_{2.5}$ EPA has stated (EPA 2018) that "*the data indicates that there has been little change in $PM_{2.5}$ concentrations in recent years, although the increase in $PM_{2.5}$ events in 2017 could signal an increase in the future".*

A summary of Alphington AAQMS data from 2005 to 2017 against SEPP(AAQ) objectives is provided inTable 13. The pattern of PM_{10} and $PM_{2.5}$ exceedances is similar to the 2013/14 to 2017 datasets in that they were caused by exceptional events such as bushfires, planned burns and dust storms in rural Victoria.

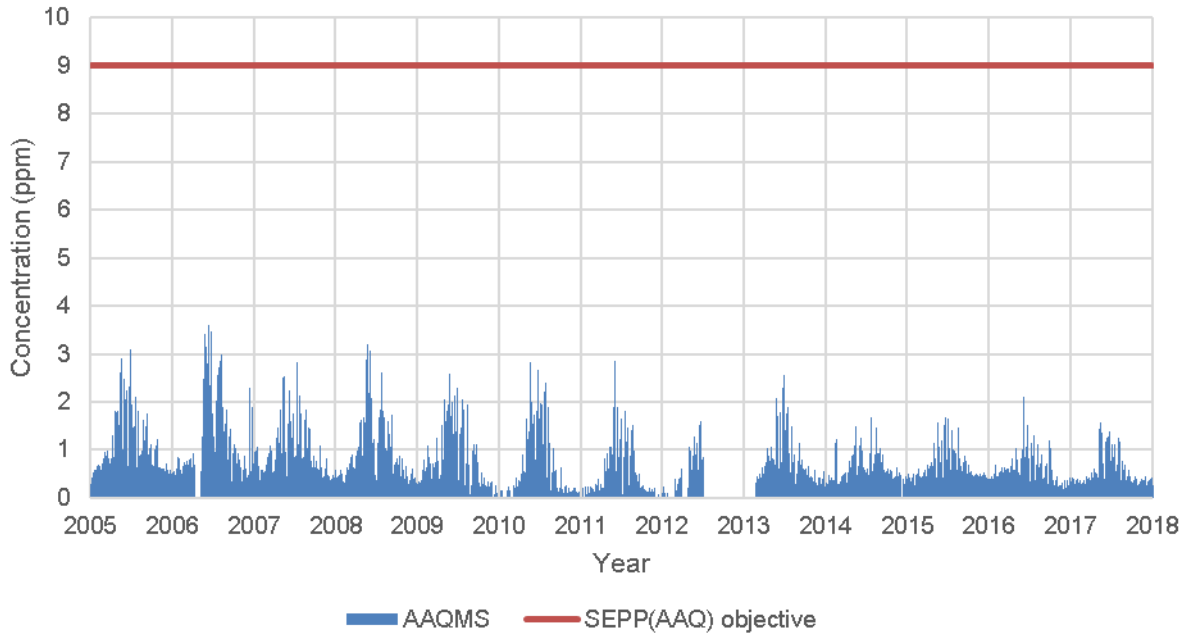
The 2013/14 to 2017 datasets compare well with the long term trends and are considered an appropriate representation of ambient air quality in the existing environment.

Table 13: Alphington AAQMS exceedances, 2005 – 2017

	CO	NO_2	PM_{10} [1]	$PM_{2.5}$ [1]
Year	8 hour	1 hour	24 hour	24 hour
2005	0	0	0	3 (3)
2006	0	0	8 (0)	6 (3)
2007	0	0	2 (0)	3 (1)
2008	0	0	3 (0)	4 (0)
2009	0	0	6 (0)	2 (0)
2010	0	0	0	3 (0)
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	1 (0)
2014	0	0	4 (4)	3 (3)
2015	0	0	0	0
2016	0	0	0	2 (2)
2017	0	0	0	8 (7)

Note:

1 Values in parenthesis exclude exceptional events as reported in EPA Victoria Air Monitoring Reports *Compliance with the National Environment Protection (Ambient Air Quality) Measure,* Publications 1140 (2006), 1231 (2007), 1282 (2008), 1331 (2009), 1390 (2010), 1483 (2011), 1536 (2012), 1569 (2013), 1604 (2014), 1632 (2015), 1663 (2016) and 1703 (2017).



.

Figure 21: Alphington AAQMS CO - 2005 to 2017 (8 hour average)

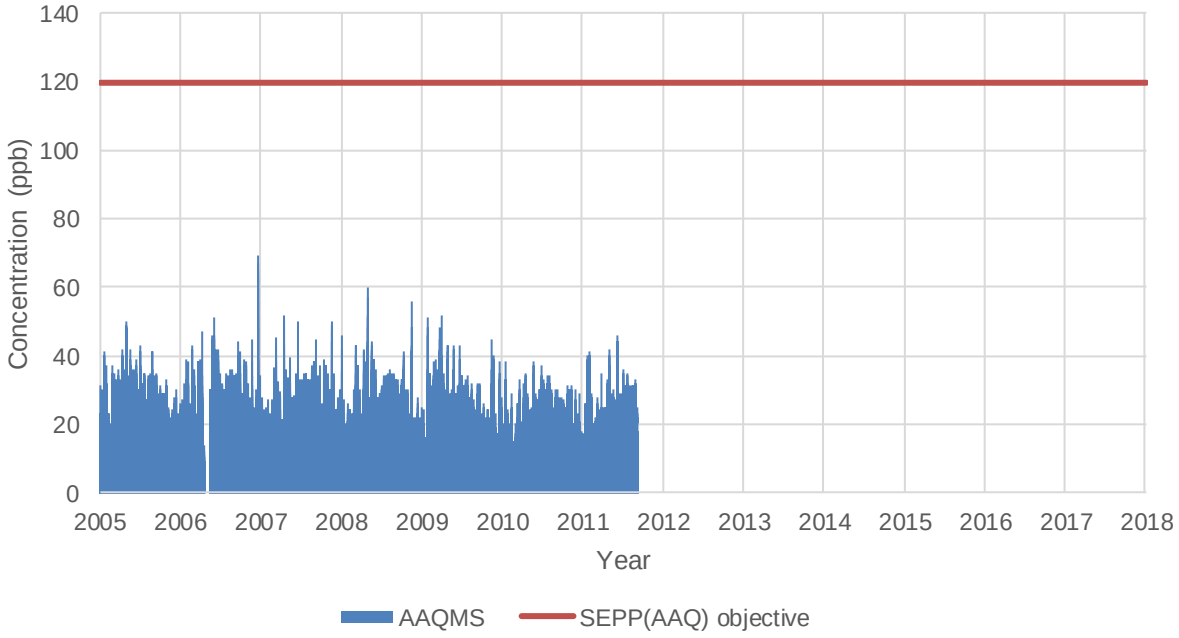


Figure 22: Alphington AAQMS NO_2 - 2005 to 2017 (1 hour average)

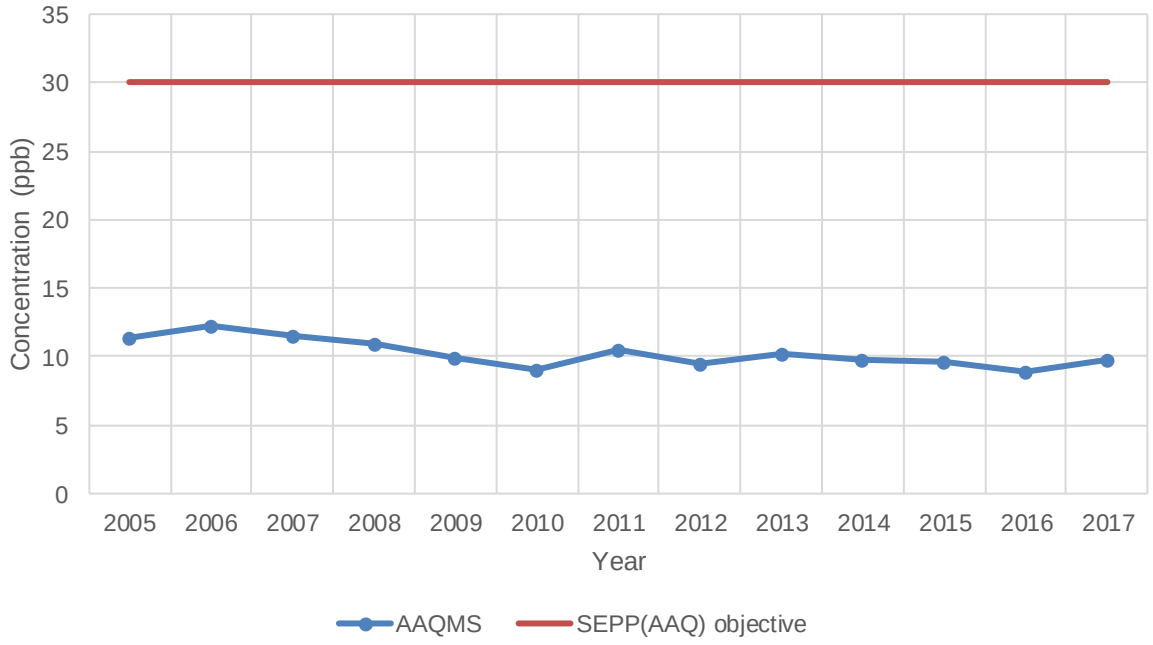


Figure 23: Alphington AAQMS NO_2 - 2005 to 2017 (annual average)

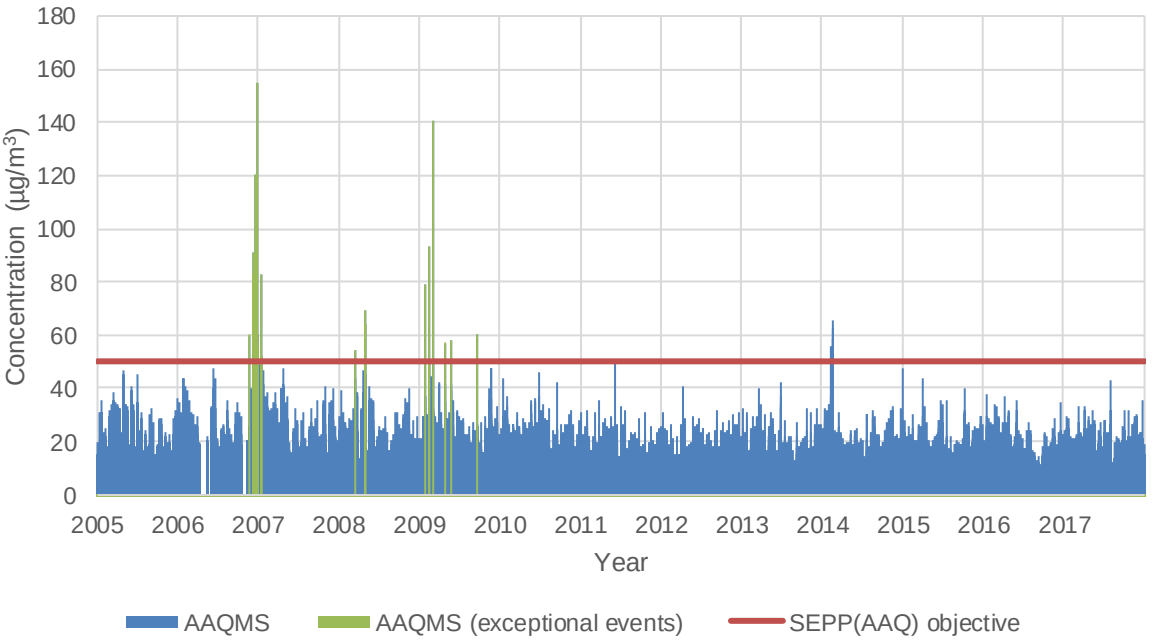


Figure 24: Alphington AAQMS PM_{10} - 2005 to 2017 (24 hour average)

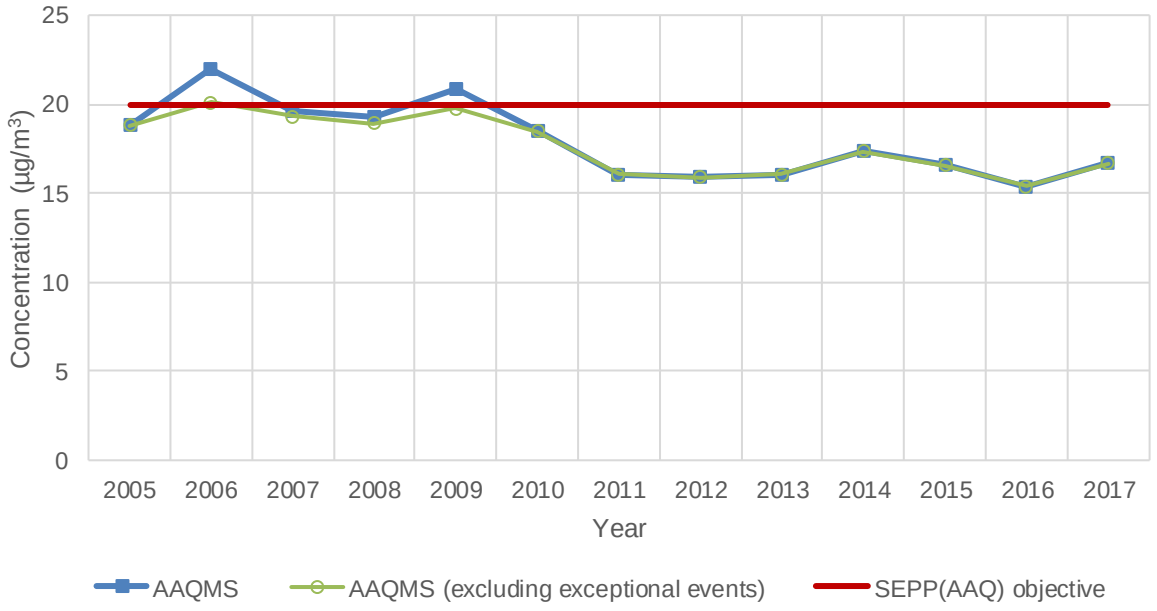


Figure 25: Alphington AAQMS PM_{10} to 2005 to 2017 (annual average)

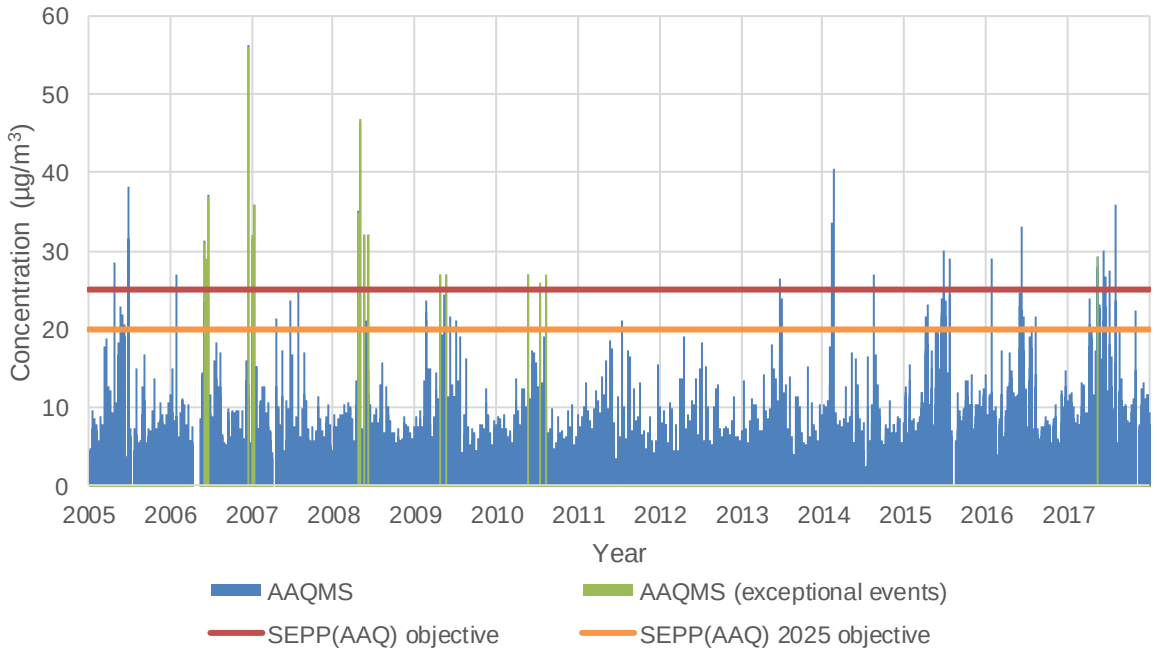


Figure 26: Alphington AAQMS $PM_{2.5}$ - 2005 to 2017 (24 hour average)

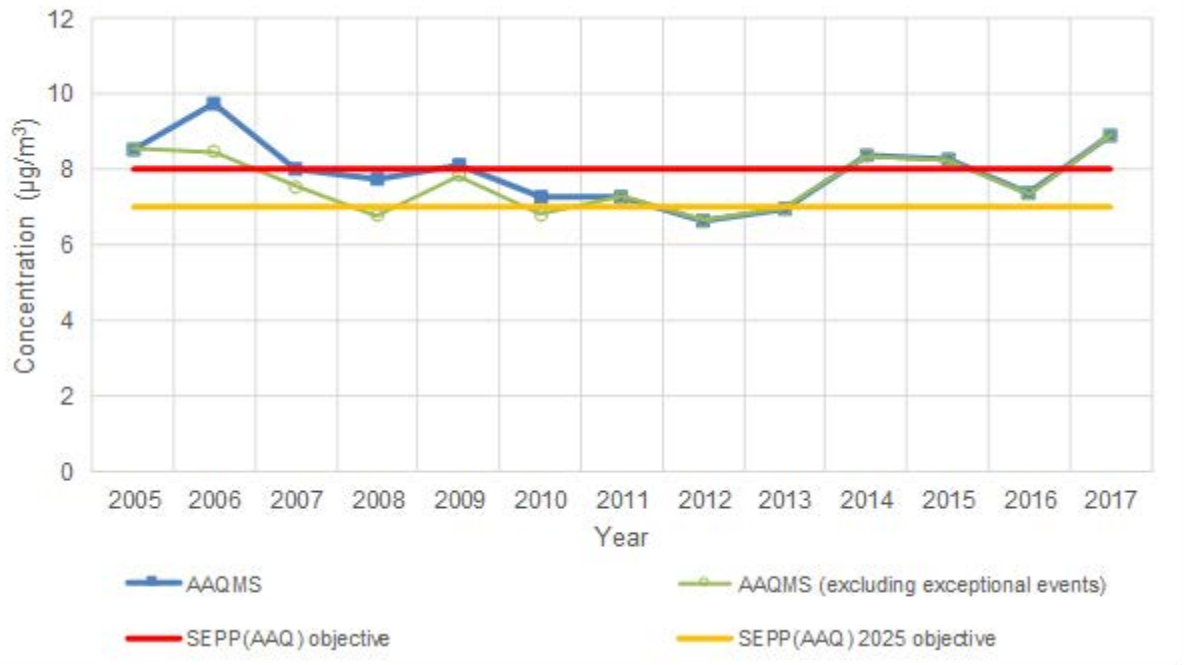


Figure 27: Alphington AAQMS $PM_{2.5}$ - 2005 to 2017 (annual average)

4.6.6 PAH and VOCs

EPA Victoria has conducted air toxics monitoring at various locations across the Melbourne metropolitan area from 1996 to 2013. The results are compared to the Air Toxics NEPM MILs for benzene, toluene, xylene isomers, PAH (benzo(a)pyrene) and formaldehyde.

The Air Toxics NEPM does not specify a MIL for ethyl benzene or 1,3 butadiene so the Texas Commission for Environmental Quality (TCEQ), long term Effects Screening Levels (ESL) were included for comparison.

The results are presented in Table 14 to Table 17.

Table 14: Air toxics monitoring data summary 1996 - 2004

Pollutant	Statistic	Units	Concentration (24 hour averages)							Air Toxics NEPM MIL		TCEQ
			West Gate Freeway 1996/1997	Francis Street, Yarraville 2002	Alphington 2003	Paisley (Altona North) 2003	Francis Street, Yarraville 2003	Nunawading (Springvale Road) 2003/2004	West Gate Freeway 2004	24 hour average	Annual	Long term ESL
Benzene	Maximum	ppb	4.5	NM	NA	NR	NR	NR	2.3	NA	3	NA
	Average		1.7		0.6	0.6	0.4	1.7	0.8			
Toluene	Maximum	ppb	19.3	NM	NA	NR	NR	NR	11.5	1,000	100	NA
	Average		4.4		2.1	2.1	1.2	3.1	6.0			
Ethylbenzene	Maximum	ppb	1.8	NM	NM	NM	NM	NM	1.1	NA	NA	135
	Average		0.4						0.5			
m,p-Xylenes	Maximum	ppb	7.6	NM	NA	NR	NR	NM	3.5	250	200	NA
	Average		1.3		1.4	1.4	1.3		1.1			
o-Xylenes	Maximum	ppb	2.2	NM	Not specified	Not specified	Not specified	NM	1.2			
	Average		0.4						0.5			
Formaldehyde	Maximum	ppb	NM	NM	NM	NM	NM	NM	NM	40	NA	NA
	Average		NM									
1,3-Butadiene	Maximum	ppb	ND	NM	NM	NM	NM	NM	<0.2	NA	NA	4.5
	Average		ND						<0.2			
Benzo(a)pyrene	Maximum	ng/m^3	NM	3.7	NA	NM	NM	NM	0.8	NA	0.3	NA
	Average		NM	1.2	0.2	0.1		0.1	0.2			

NM Not monitored
ND Not detected

Table 15: Air toxics monitoring data summary 2004 - 2007

Pollutant	Statistic	Units	Concentration (24 hour averages)						Air Toxics NEPM MIL		TCEQ
			Corio 2004/2005	Eltham 2005/2006	Carlton 2006/2007	Newport 2006/2007	Spotswood 2006/2007	South Melbourne 2006/2007	24 hour average	Annual	Long term ESL
Benzene	Maximum	ppb	NR	1.7	1.9	2.6	2.5	1.4	NA	3	NA
	Average		0.5	0.5	0.7	1.0	0.8	0.5			
Toluene	Maximum	ppb	NR	4.9	7.0	15.1	16.6	5.1	1,000	100	NA
	Average		1.0	1.8	2.4	4.3	4.4	1.6			
Ethylbenzene	Maximum	ppb	NM	NM	NM	NM	NM	NM	NA	NA	135
	Average										
m,p-Xylenes	Maximum	ppb	NR	2.0	3.4	6.6	6.6	2.4	250	200	NA
	Average		0.5	0.7	1.0	1.0	1.0	0.5			
o-Xylenes	Maximum	ppb	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified			
	Average										
Formaldehyde	Maximum	ppb	NM	28.4	4.0	NM	NM	NM	40	NA	NA
	Average			2.6	2.2						
1,3-Butadiene	Maximum	ppb	NM	NM	NM	NM	NM	NM	NA	NA	4.5
	Average										
Benzo(a)pyrene	Maximum	ng/m^3	NM	NM	3.2	NM	NM	NM	NA	0.3	NA
	Average		0.1		0.2						

NM Not monitored
ND Not detected

Table 16: Air toxics monitoring data summary 2007 - 2013

Pollutant	Statistic	Units	Concentration (24 hour averages)				Air Toxics NEPM MIL		TCEQ
			Mooroolbark 2007/2008	Traralgon 2007/2008	Campbellfield 2008/2009	Yarraville 2012/2013	24 hour average	Annual	Long term ESL
Benzene	Maximum	ppb	NM	0.4	NM	NM	NA	3	NA
	Average			0.2					
Toluene	Maximum	ppb	NM	1.2	NM	NM	1,000	100	NA
	Average			0.3					
Ethylbenzene	Maximum	ppb	NM	NM	NM	NM	NA	NA	135
	Average								
m,p-Xylenes	Maximum	ppb	NM	0.5	NM	NM	250	200	NA
	Average			0.2					
o-Xylenes	Maximum	ppb	NM	Not specified	NM	NM			
	Average								
Formaldehyde	Maximum	ppb	NM	4.1	NM	NM	40	NA	NA
	Average			1.5					
1,3-Butadiene	Maximum	ppb	NM	NM	NM	NM	NA	NA	4.5
	Average								
Benzo(a)pyrene	Maximum	ng/m^3	1.1	0.8	0.6	0.55	NA	0.3	NA
	Average		0.1	0.1	0.1	0.14			

NM Not monitored

Table 17: Air toxics monitoring data summary for Dandenong 2011/2012

Pollutant	Statistic	Units	Concentration (24 hour averages)					Air Toxics NEPM MIL		TCEQ
			Dandenong (Bangholme) 2011/2012	Dandenong (Lynbrook) 2011/2012	Dandenong (Hampton Park) 2011/2012	Dandenong (Doveton) 2011/2012	Dandenong (Dandenong South) 2011/2012	24 hour average	Annual	Long term ESL
Benzene	Maximum	ppb	3.3	1.1	1.0	1.2	1.3	NA	3	NA
	Average		BDL	BDL	BDL	BDL	BDL			
Toluene	Maximum	ppb	5.4	14.4	5.3	5.0	7.1	1,000	100	NA
	Average		1.2	1.5	1.2	1.5	1.8			
Ethylbenzene	Maximum	ppb	0.6	0.6	0.6	0.6	0.9	NA	NA	135
	Average		BDL	BDL	BDL	BDL	BDL			
m,p-Xylenes	Maximum	ppb	4.1	2.5	3.2	4.2	3.6	250	200	NA
	Average		0.6	0.7	0.6	0.7	0.9			
o-Xylenes	Maximum	ppb	0.9	0.9	0.9	0.8	1.3			
	Average		BDL	BDL	BDL	BDL	BDL			
Formaldehyde	Maximum	ppb	NM	NM	NM	NM	NM	40	NA	NA
	Average									
1,3-Butadiene	Maximum	ppb	ND	ND	ND	ND	ND	NA	NA	4.5
	Average									
Benzo(a)pyrene	Maximum	ng/m^3	NM	NM	NM	NM	NM	NA	0.3	NA
	Average									

BDL Below detection limit
NM Not monitored
ND Not detected

4.6.7 Background data

Background air quality data is used to quantify existing air quality in the assessment of air quality impacts from the proposed North East Link tunnel ventilation systems.

Schedule C, Part B, of the SEPP(AQM) requires proponents to include appropriate hourly background data or "*the 70th percentile of one year's observed hourly concentrations as a constant value*" where no appropriate hourly data exists.

The preceding sections have demonstrated that the Alphington AAQMS results are a good indicator of existing air quality within the project domain, therefore this dataset has been adopted to represent background air quality for CO, NO_2, PM_{10} and $PM_{2.5}$.

The adopted background parameters are detailed in Table 18.

Table 18: Background air quality for CO, NO_2, PM_{10} and $PM_{2.5}$

Pollutant	Units	Averaging period[1]	Background concentration	Period	Source
CO	mg/m^3	1 hour	Time-varying	2013 – 2017	Alphington AAQMS
NO_2	µg/m^3	1 hour and annual	Time-varying	2013 - 2017	
PM_{10}	µg/m^3	1 hour, 24 hour and annual	Time-varying	2013 - 2017	
$PM_{2.5}$	µg/m^3	1 hour, 24 hour and annual	Time-varying	2014 - 2017	

Note:
1 24 hour and annual average PM_{10} and $PM_{2.5}$ concentrations and one hour and annual average NO_2 concentrations only apply to the surface roads and combined impacts assessments

EPA Victoria has recommended background air quality values for PAH and VOCs which are presented in Table 19. The values are considered conservative for most pollutants as their concentrations in ambient air are decreasing in-line with international trends and continuing improvements in vehicle fleet emissions.

Table 19: Background air quality for PAH and VOCs

Pollutant	Average concentration		Units	Source
	Maximum 24 hour	Annual		
PAH (benzo(a)pyrene)	0.55	0.14	ng/m^3	Yarraville, Francis Street, May 2012 to May 2013 (EPA Victoria, 2013)
Benzene	2.3	0.8	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)
Toluene	11.5	6.0	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)
Ethylbenzene	1.1	0.5	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)
m&p Xylenes	3.5	1.1	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)
o-Xylene	1.2	0.5	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)

Pollutant	Average concentration		Units	Source
	Maximum 24 hour	Annual		
Formaldehyde	4.0	2.2	ppb	Carlton 2006 (EPA Victoria, 2014)
1,3-Butadiene	0.2	0.1	ppb	West Gate Freeway (Brooklyn) 2004 (EPA Victoria, 2004)

4.7 Summary

The environment was characterised using meteorological data from the BoM Viewbank AWS and historical air quality data from the EPA Victoria AAQMS at Alphington. The five most recent calendar years of data (2013 to 2017) were analysed with the results demonstrating that:

- Wind is mostly commonly blowing from either the south-south west or north-north east quadrants. The five year period has an average wind speed of 3.1 metres per second
- CO eight hour daily maximum concentrations ranged between 0.017 and 0.30 parts per million and were compliant with the SEPP(AAQ) EQO
- NO_2 results were also compliant with the one hour and annual average SEPP(AAQ) EQOs
- PM_{10} 24 hour average results ranged from 2.1 to 64 micrograms per cubic metre with several SEPP(AAQ) exceedances recorded in the period 2013 to 2017. Annual average results were compliant with the SEPP(AAQ) EQO.
- $PM_{2.5}$ 24 hour average results also showed days of non-compliance with the SEPP(AAQ) EQO. The exceedances were attributed to bushfires, planned burns and urban sources, including smoke from wood heaters. Annual average results exceeded the existing SEPP(AAQ) EQO on one occasion (2017)

Long term results for Alphington AAQMS were presented for CO, NO_2, PM_{10} and $PM_{2.5}$. The long term dataset showed similar trends to the period 2013 to 2017.

The background air quality data was designated as the Alphington AAQMS 2013 to 2017 dataset for CO, NO_2, PM_{10} and $PM_{2.5}$. PAH and VOC background data were based on a conservative assessment of air toxics concentrations measured by EPA Victoria during campaign monitoring events.

In general, air quality at EPA Victoria's monitoring stations (including Alphington) has been in the 'good' to 'very good' air quality categories at least 75 per cent of the time, meaning air quality is typically good (EPA Victoria, 2018).

5.0 DISPERSION MODELLING APPROACH

The American Meteorological Society/Environmental Protection Agency (AMS/USEPA) Regulatory Model (AERMOD Version 15181) was specifically designed to support USEPA's regulatory programs, however it is also the Victorian regulatory model, as defined under SEPP(AQM). AERMOD is a steady-state plume modelling system with three components: AERMOD (dispersion model), AERMAP (terrain data pre-processor) and AERMET (meteorological data pre-processor).

AERMOD was used to predict pollutant ground level concentrations resulting from North East Link tunnel ventilation system emissions to air.

When modelling sources in urban areas, AERMOD's urban option uses algorithms designed to enhance turbulence levels during night time stable conditions, to account for the urban heat island effect. The urban dispersion option was utilised for the assessment based on consultation with EPA Victoria, Akula Venkatram[1] and Lakes Environmental[2]. The urban option defaults to a surface roughness length of one metre, in accordance with USEPA regulatory guidance.

AERMOD requires a range of inputs:

- topography
- meteorology
- background pollutant concentrations
- vehicle emissions.

These inputs are discussed in the following sections.

5.1 Topography

Shuttle Radar Topography Mission (SRTM) one arc-second (approximately 30 metres) global digital surface model data is commonly used for plume dispersion modelling purposes. However, raw SRTM data cannot distinguish between ground surface topography and other elevated features such as tree canopies and buildings and is therefore subject to editing and processing, such as: delineating and flattening water bodies, better defining coastlines, removing spikes and wells and filling small voids. For this reason, the topographical dataset input into the model was developed from *Department of Environment, Land, Water and Planning (DELWP), 2015: Metro Contour 1-5 Metre - Vicmap Elevation* data, which contains relief features represented at one metre intervals with some areas at five metre intervals.

The topography for the project area is illustrated in Figure 3 and described in Section 4.3.

5.2 Meteorology

Meteorological input files were developed in accordance with guidelines provided in EPA Victoria Publication No. 1550 (EPA Victoria 2014) for meteorological pre-processing using USEPA formulae.

Meteorological data sources described in Table 20 were used in conjunction with AERMET to generate five 12 month meteorological data files for 2013 to 2017. These years were considered representative of meteorology for the local area and correspond to the period selected for background air quality data. The meteorological stations were chosen such that each of the required parameters for meteorological pre-processing were

[1] Professor of Mechanical Engineering at University of California Riverside who formulated the AERMOD urban option equations and was a member of the American Meteorological Society and US EPA Regulatory Model Improvement Committee (AERMIC) which developed. AERMOD Personal communication, A. Venkatram, University of California Riverside, 23 June 2018.

[2] Developers of air quality modelling software that utilises AERMOD. Personal communication, M. Hammer, Lakes Environmental, 21 June 2018

Table 20: Meteorological data

Meteorological station	Meteorological parameters	Approximate distance and direction from project [1]	Data source
Viewbank	Wind speed [2] Wind direction [3] Temperature [2] Sigma theta [2]	2.0 km north-east	Bureau of Meteorology
Essendon Airport	Cloud cover [4]	15 km west	Bureau of Meteorology
Melbourne Airport	Twice daily sonde data [5]	24 km west-north-west	Bureau of Meteorology

Notes:
1 Approximate centre of North East Link tunnel alignment
2 Scalar 1-hour averages
3 Vector 1-hour averages
4 Average of two 30-minute ceilometer means for each hour
5 Pressure, height, temperature, dew point, wind direction and wind speed

sourced from stations nearest to the project area. Cloud cover and sonde data are not measured at the nearest meteorological station, Viewbank, and were therefore sourced from Essendon Airport and Melbourne Airport respectively.

Table 21 provides surface characteristics of the meteorological site used to develop the model input meteorological files, determined in accordance with EPA Victoria 2014, in conjunction with aerial imagery maps.

Table 21: Meteorological modelling surface characteristics

Surface characteristic	Sector dependency	Sector	Summer	Autumn	Winter	Spring
Albedo	No	NA	0.16	0.16	0.18	0.16
Bowen ratio	No	NA	0.8	1.0	1.0	0.8
Surface roughness (m)	Yes	0 – 30	0.7	0.7	0.5	0.6
		30 – 60	0.6	0.6	0.5	0.6
		60 – 90	0.5	0.5	0.4	0.5
		90 – 120	0.4	0.4	0.3	0.4
		120 – 150	0.4	0.4	0.3	0.4
		150 – 180	0.4	0.4	0.3	0.4
		180 – 210	0.4	0.4	0.3	0.4
		210 – 240	0.3	0.3	0.3	0.3
		240 – 270	0.3	0.3	0.3	0.3
		270 – 300	0.3	0.3	0.3	0.3
		300 – 330	0.7	0.7	0.5	0.7
		330 – 0	0.7	0.7	0.5	0.7

Figure 28 illustrates the relative locations of the Viewbank, Essendon Airport and Melbourne Airport meteorological stations.

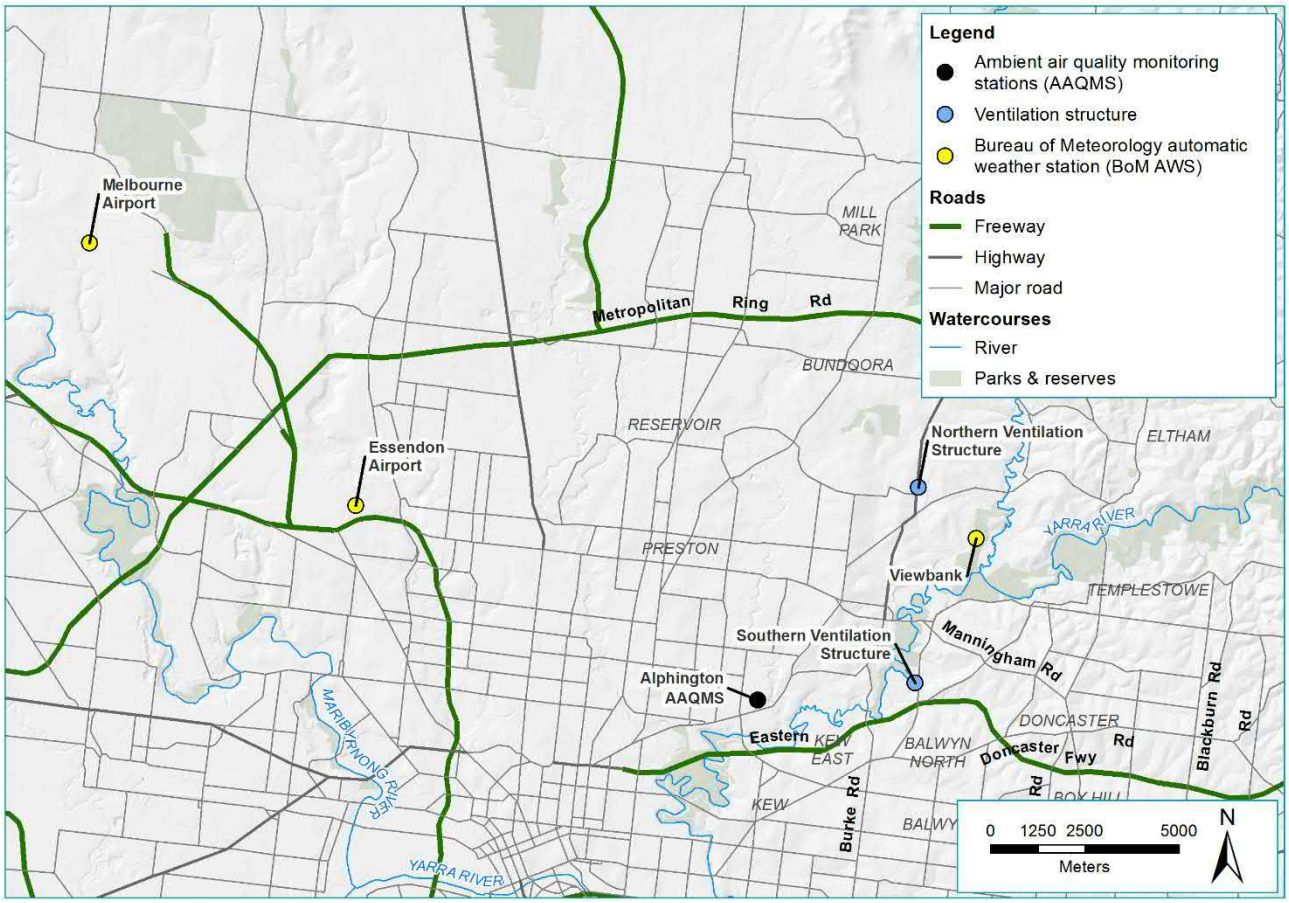


Figure 28: Viewbank, Essendon Airport and Melbourne Airport AWS locations

Calm winds (less than 0.3 metres per second) and hours where there is insufficient data between each of the three meteorological stations for AERMET to generate a valid meteorological datum, are not considered by AERMOD. Summary statistics of the meteorological files produced by AERMET for use in AERMOD are provided in Table 22.

Table 22: AERMOD meteorological file summary statistics

Year	Total hours	Calm hours [1]	Missing hours [2]	Modelling hours
2013	8760	210	75	8475 (96.7%)
2014	8760	285	114	8361 (95.4%)
2015	8760	396	40	8324 (95.0%)
2016	8784	400	94	8290 (94.4%)
2017	8760	542	124	8094 (92.4%)

Notes:
1 Wind speed less than 0.3 m/s
2 No data available from meteorological station.

5.3 Background pollutant concentrations

Schedule C of SEPP(AQM) requires a modelling assessment to consider background air quality in order to conduct a cumulative assessment (background plus project incremental impact). Where available, time-varying hourly background concentrations should be added to hourly predicted GLCs to present a contemporaneous assessment.

EPA Victoria's Alphington AAQMS provides the most comprehensive datasets for PM_{10}, $PM_{2.5}$, CO and NO_2 in the vicinity of the project and is therefore used to represent background air quality for the air quality impact assessment. There is, however, no hourly average $PM_{2.5}$ data available for the year 2013.

Twenty-four hour and annual average air toxics background concentrations for the project were as recommended by EPA Victoria.

Details of the background concentrations incorporated in the assessment are discussed in Section 4.6.7.

5.4 Vehicle emissions

Traffic modelling was undertaken by VLC and Smedtech to predict traffic volumes and fleet mixes [passenger cars (PC), light commercial vehicles (LCV) and heavy commercial vehicles (HCV)] for the years 2026 (the expected North East Link opening year) and 2036 (ten years following project opening). This traffic data formed the basis for the air quality impact assessment.

The upper limit of the predicted traffic volume range for each hour was conservatively selected.

5.4.1 Diesel passenger cars

Traffic modelling did not distinguish between petrol and diesel passenger cars.

The Australian Bureau of Statistics motor vehicle census for 2017 indicates that the Australian passenger car fleet consisted of approximately 13 per cent diesel vehicles, up from 12 per cent in 2016 and 7.7 per cent in 2012. Data suggests that the rise in SUV sales (32 per cent diesel) has balanced a decline in diesel for other classes of passenger cars.

In the absence of other data, passenger car traffic for North East Link has been assumed to be 15 per cent diesel and 85 per cent petrol fuelled cars. In general terms, a higher percentage of diesel fuelled cars would mean lower CO emissions and higher particulate matter (PM_{10} and $PM_{2.5}$) and NO_2 emissions. Improvements in emission control technology in the intervening period may offset this potential increase in particulate matter and NO_2 emissions. The effect of the assumed ratio of diesel to petrol fuelled cars on modelled outcomes is discussed further in Section 6.4.3.

5.4.2 Hybrid and electric vehicles

Consistent with the conservative approach to estimating emissions, hybrid and electric vehicles (EVs) were not considered in the impact assessment, however they are likely to have a significant effect in reducing Victorian fleet emissions by 2036, as described below.

The proportion of EVs in fleets worldwide is predicted to increase dramatically during the next two decades, due to a broad range of factors which include:

- Decreased purchase costs compared with internal combustion engine (ICE) vehicles, driven by the decrease in battery production costs, manufacturing economies of scale, higher levels of automation and lower labour intensity.
- Lower operating costs, due to electricity versus fuel costs and lower repair and maintenance costs associated with a less complex powertrain.

- Increased availability of charging infrastructure, together with decreased charging times
- Increased driving range before charging is required.
- Government intervention, through regulation, taxes and subsidies.

Europe currently has approximately 25 per cent of global passenger vehicle production. ING Economics Department predicts that 100 per cent of European new passenger vehicle registrations will be electric by 2035 (ING 2017).

Volvo has announced plans to build only electric and hybrid vehicles from 2019, with Porsche predicting that 50 per cent of production will be electric by 2023. Other European manufacturers are expected to make similar adjustments.

Approximately 30 per cent of all passenger vehicles produced globally are from China, with the Chinese market representing 43 per cent of global EV sales in 2016 (ING 2017).

The Californian Zero Emissions Vehicle (ZEV) regulation requires manufacturers to increase EV sales to approximately 15 per cent by 2025 (Sperling & Brown, 2018). The California Air Resources Board manages the ZEV programme, however it has also been adopted by nine other USA States (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island and Vermont).

The Victorian Automobile Chamber of Commerce (VACC) made a submission to Infrastructure Victoria in response to an inquiry on automated and zero emission vehicle infrastructure (VACC 2018). VACC note that EVs are forecast to reach price parity with internal combustion engine (ICE) vehicles around 2025 to 2026, with the cost continuing to decrease such that EVs may be 15 per cent cheaper than equivalent ICEs by 2030.

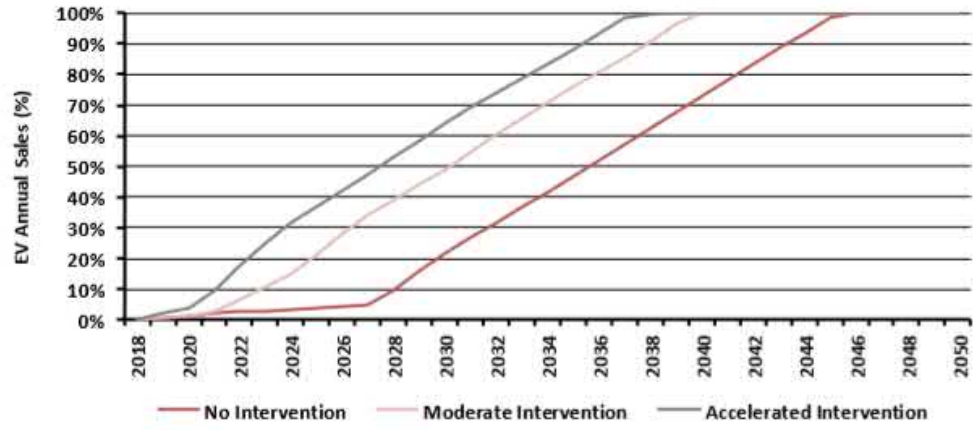
The submission focussed on the anticipated effects of both high and low level EV uptake in Victoria. The low uptake scenario examined assumes a one per cent adoption rate in 2021, rising to 10 per cent by 2030, with the high up-take scenario assuming two per cent in 2021 and 20 per cent by 2030. However, the basis of these assumptions is not described.

In 2017 the Australian Renewable Energy Agency and the Clean Energy Finance Corporation engaged Energeia to undertake an Electric Vehicle Market Study (Energeia, 2018). The study noted that previous research had indicated that the uptake of Plug-in Electric Vehicles (PEV) is dependent on purchase premiums and model availability, with future drivers including:

- PEV driving ranges expected to reach parity with ICE vehicles by 2024
- PEV refuelling times expected to reach parity with ICE vehicles by 2020 at current battery sizes
- Stationary wireless charging technology to become standard within 10 years
- Manufacturers reporting production of over 165 new PEV models by 2030.

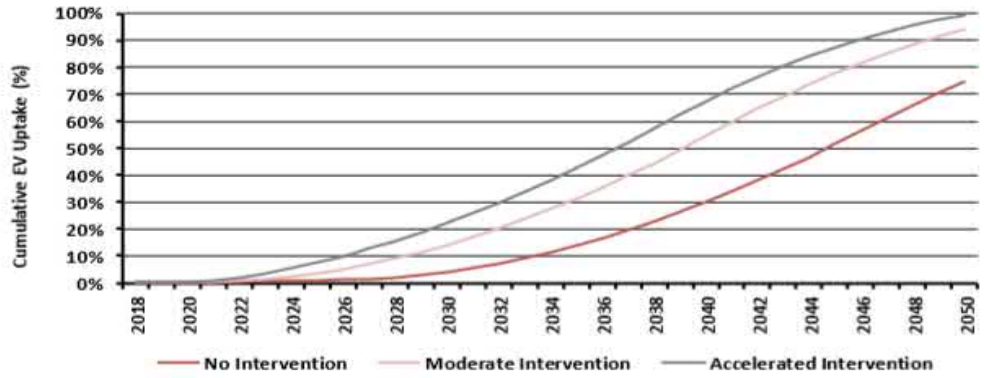
The possibility of fuel cell EVs supplanting PEVs during the next 20 to 30 years is considered remote, given the slow rate of technological development and limited model availability.

Energeia conducted modelling to predict the percentage of PEV sales and fleet percentages, with the results for Australia reproduced in Figure 29 and Figure 30.



Source: Energeia Modelling

Figure 29: PEV Sale Projections



Source: Energeia Modelling

Figure 30: PEV Fleet Percentage

The no intervention scenario assumes that there is no additional action by any stakeholder in Australia, with PEV uptake driven solely by economic considerations. The moderate intervention scenario assumes a mix of policy support from federal, state and local governments, with no long-term decarbonisation target. The accelerated intervention scenario assumes that policy intervention occurs earlier with a higher level of support, together with the additional assumption that ICE vehicle sales will be banned toward the end of the period evaluated.

The PEV forecasts account for passenger cars, sport utility vehicles (SUV), light commercial (vans and trucks), buses and rigid vehicles, but exclude hybrid EVs, articulated trucks and speciality vehicles such as bucket trucks.

In 2016 the PEV share of vehicle sales in Australia was 0.1 per cent, compared with 28.8 per cent for Norway and 6.4 per cent for the Netherlands. Based on the moderate intervention scenario the PEV share of vehicle sales in Victoria is predicted to increase to 28 per cent in 2026 and 80 per cent in 2036.

5.4.3 Emission factors

The World Road Association (PIARC) publishes country-specific emission factors that are widely used to estimate pollutant emission rates generated in tunnels and assess ventilation requirements to maintain acceptable in-tunnel air quality and visibility. PIARC published Australian specific road tunnel emission factors in 2012, based on vehicle fleet composition, vehicle speed and road gradient (PIARC 2012).

The PIARC base year is 2010, with emission factors for future years (up to 2020) adjusted by reduction factors, accounting for improvements in average engine performance. Emission factors for CO, NO_x and visibility are provided for petrol passenger cars (PCP, CO and NO_x only), diesel passenger cars (PCD), light commercial vehicles (LCV) and heavy commercial vehicles (HCV) at various speeds and gradients between minus six per cent and plus six per cent, with a factor provided for converting visibility factors to $PM_{2.5}$.

However, PIARC does not provide visibility ($PM_{2.5}$) emission factors for PCP, nor PM_{10}, NO_2, VOCs or PAH emission factors for any vehicle class.

Vehicle emission factors were therefore developed from the COPERT Australia road transport air pollutant emission inventory model. COPERT is used primarily for developing emission inventories at a city, state or national network level, processing a variety of additional and more detailed inputs than those required for PIARC. The software has been adopted by the National Pollutant Inventory (NPI) as the recommended model for motor vehicle emission inventories.

While PIARC provides base emission factors for four classes of vehicle and addresses reductions in emissions due to improvements in technology, with reduction factors for future years, COPERT Australia includes emission factors for vehicles meeting various Australian vehicle emission standards.

This approach permits a more accurate representation of the fleet mix but requires a greater level of detail to be provided in the first instance, including the mix of PCP, PCD, LCV and HCV, as well as the mix of vehicle types within each of these classes. For example, COPERT Australia classifies PCPs as small, medium and large, with each of these sub-classes divided into 10 vehicle emission standards (including ADR27; ADR37-00; ADR37-01; ADR79-00).

In total, COPERT Australia includes 226 individual vehicle classes. The mean fleet mileage of each of these sub-classes is also taken into consideration to estimate the effect of engine degradation on emissions, together with fuel quality and meteorology.

In the absence of this level of detail, the North East Link model was configured on a state based level, including vehicle fleet mix and mean fleet mileage statistics for Victoria in 2010. This information was developed as part of the NPI Australian Motor Vehicle Emissions Inventory (MVEI) and compiled in a COPERT Australia input file.

By modifying the input file to suit [such as setting all vehicle class populations (PCP, PCD) to zero except for the one of interest and specifying all vehicles travelling at 80 kilometres per hour for Scenarios A1, A2, B1 and B2 (as described in the following section), emission factors for that class in grams per vehicle kilometre travelled (g/VKT) were calculated by dividing the model output annual emissions (in tonnes per year) by the annual mileage of that vehicle class.

A (partial) validation study (Smit et al 2015) of COPERT Australia with in-ventilation system monitoring data from Brisbane's Clem Jones Tunnel (CLEM7) suggests that COPERT Australia is generally accurate at fleet level for PM_{10}, $PM_{2.5}$, CO and NO_X. COPERT was found to underestimates emissions by between 7 per cent and 37 per cent for the particular characteristics of CLEM7 and the fleet mix observed within. The results indicate that overall underestimation for particulate matter emissions are small, but more significant for HCVs, with the study concluding that, given the range of factors that complicate validation for particulate matter, the results show a remarkably good performance for COPERT Australia. Golder undertook a similar, smaller scale, study on another Australian road tunnel ventilation system. As noted by Smit el al. (2015), hours of the day with small traffic volumes can be significantly impacted by potential errors in estimated background concentration levels. Golder's study found that for peak traffic hours (6 am to 9 am and 4 pm to 7 pm), COPERT Australia represented the tunnel data reasonably (and more closely than PIARC), with a

comparative factor (ratio of COPERT emissions to observed emissions) of between 0.9 and 3.3 for PM_{10}, and between 1.0 and 3.9 for $PM_{2.5}$,

For the purposes of this assessment, the conservative assumptions included in the estimation of the emission rates (refer Section 5.5) are considered to compensate for any potential underestimation by COPERT Australia.

Scenarios A1 and B1

In the absence of current (2018) or future year Victorian vehicle fleet mix and mean fleet mileage statistics with which to configure COPERT Australia, adjustments to the Victoria 2010 derived emission factors were subsequently made based on PIARC future year factors for PM_{10}, $PM_{2.5}$, CO and NO_x in 2020 (refer to Table 23) and the following equation:

2020 emissions factors = 2010 assessment emission factors x 2020 future year factor

Table 23: 2020 future year factors for adjusting 2010 emission factors

Pollutant	Vehicle class			
	PCP	PCD	LCD	HCV
PM_{10}	0.37	0.37	0.41	0.49
$PM_{2.5}$	0.37	0.37	0.41	0.49
CO	0.42	0.43	0.51	0.50
NO_x	0.31	0.61	0.48	0.52

Scenarios A2 and B2

Composite vehicle emission factors for Brisbane for the years 2010 and 2025 (Brisbane City Council 2016) developed using COPERT Australia were used to estimate future year factors with which to adjust the PM_{10}, $PM_{2.5}$ and NO_2 assessment emission factors out to 2025:

2025 emissions factors = 2010 assessment emission factors x 2025 future year factor

The derived 2025 factors are provided in Table 24.

Table 24: 2025 factors for adjusting 2010 emission factors

Pollutant	Vehicle class			
	PCP	PCD	LCD	HCV
PM_{10}	0.4	0.4	0.4	0.18
$PM_{2.5}$	0.31	0.31	0.31	0.16
NO_2	0.15	0.15	0.15	0.18

The resultant 2025 emission rates are significantly below the 2020 emission rates, with diurnal PM_{10} emissions 22 to 47 per cent lower, $PM_{2.5}$ emissions 40 to 57 per cent lower and NO_2 emissions approximately 67 per cent lower.

It is noted that Brisbane City Council vehicle emission factors also do not take into account the expected increase in EVs in the future fleet mix, which would reduce these factors further.

COPERT Australia does not include ethylbenzene emission information for HCVs. For this compound, an emission factor was derived from the HCV benzene emission factor, scaled using the PCD benzene to PCD ethylbenzene ratio.

It is noted that COPERT Australia emission factors are not gradient dependent and the PAH emission factors are not speed dependent. In the absence of gradient dependencies, adjustments informed by the gradient dependencies described by PIARC were made for PM_{10}, $PM_{2.5}$, CO and NO_2 as provided in Table 25. No adjustments were made for VOCs or PAH.

Table 25: Gradient scaling for emission factors

Vehicle class	Vehicle speed (kph)	Gradient (%)														
		PM_{10} and $PM_{2.5}$					CO					NO_2				
		-4	-2	0	+2	+4	-4	-2	0	+2	+4	-4	-2	0	+2	+4
PCP	20	28	34	100	154	205	79	90	100	115	132	42	48	100	135	165
	40	17	32	100	155	216	61	77	100	128	167	30	46	100	146	209
	50	16	31	100	163	231	55	74	100	136	189	28	39	100	160	240
	60	14	28	100	169	238	50	71	100	144	206	25	41	100	176	264
	80	9	40	100	160	218	41	62	100	163	253	17	46	100	174	256
	100	6	50	100	148	196	35	56	100	191	363	11	46	100	163	237
PCD	20	28	34	100	154	205	87	89	100	108	102	42	48	100	135	165
	40	17	32	100	155	216	80	84	100	103	111	30	46	100	146	209
	50	16	31	100	163	231	83	87	100	119	94	28	39	100	160	240
	60	14	28	100	169	238	86	91	100	118	79	25	41	100	176	264
	80	9	40	100	160	218	79	93	100	72	65	17	46	100	174	256
	100	6	50	100	148	196	98	117	100	80	100	11	46	100	163	237
LCV	20	21	39	100	150	200	32	49	100	89	50	29	44	100	110	115
	40	13	43	100	151	205	48	118	100	91	204	30	78	100	109	181
	50	11	41	100	157	214	64	169	100	193	436	34	96	100	166	276
	60	9	44	100	157	212	62	204	100	318	696	31	115	100	211	342
	80	6	53	100	146	193	19	72	100	262	418	15	56	100	136	265
	100	25	62	100	137	174	21	31	100	172	258	20	47	100	154	214
HCV	20	52	74	100	123	148	46	81	100	112	133	24	70	100	141	199
	40	41	76	100	134	183	39	82	100	130	172	17	62	100	167	255
	50	36	71	100	148	203	35	77	100	143	189	13	55	100	188	282
	60	31	64	100	161	221	29	68	100	155	204	9	43	100	203	302
	80	21	53	100	169	236	21	58	100	158	215	6	33	100	198	289

Vehicle class	Vehicle speed (kph)	Gradient (%)														
		PM_{10} and $PM_{2.5}$					CO					NO_2				
		-4	-2	0	+2	+4	-4	-2	0	+2	+4	-4	-2	0	+2	+4
	100	21	51	100	155	215	20	55	100	147	201	6	35	100	171	242

Overall, the emission factors representing the year 2020 used for this assessment are considered conservatively high because there is a general trend towards lower emission vehicles, with potential improvements in vehicle technology by 2026 and beyond not accounted for.

5.5 Summary of modelling conservative assumptions

The assessment used a range of conservative assumptions, including:

- Five years of meteorological data were assessed such that the years corresponding to the greatest predicted impact from the tunnel ventilation system and surface roads were selected for the air quality impact assessment.
- Background pollutant concentrations for the modelled years (2026 and 2036) were assumed to remain at levels recorded for the period 2013 to 2017. EPA Victoria predicts a significant reduction in CO and NO_2 concentrations over the next 20 years through cleaner exhaust emissions from petrol, diesel and LPG engines and improvements in national motor vehicle emission standards. Similarly, a significant reduction in particle emissions ($PM_{2.5}$) from diesel vehicle engines is expected by 2030. Concentrations of these pollutants in 2026 and, in particular, 2036, will therefore be lower than those used as background levels in the air quality impact assessment.
- The upper limit of the predicted traffic volume range provided for all roads was selected.
- The adopted background concentrations for PM_{10}, $PM_{2.5}$, CO and NO_2 include exceptional events [as defined in the SEPP(AAQ)] such as bushfires, controlled burns and dust storms. During these periods, concentrations of particulate matter (PM_{10} and $PM_{2.5}$) can reach extremely high levels. Inclusion of data during these periods as representative background concentrations for the project can be highly conservative, contributing a significant proportion of the overall impact (background plus predicted).
- Vehicle emission factors used in Scenarios A1 and B1, representing 2026 and 2036 traffic, were assumed to remain at levels predicted for 2020. Vehicle emission factors used in Scenarios A2 and B2 were assumed to remain at levels predicted for 2025. Emission factors used for this assessment are considered conservatively high because there is a general trend towards lower emission vehicles (older technology vehicles being replaced over time with newer, improved technology vehicles) and expected improvements in vehicle technology beyond 2020 and 2025, which are not accounted for in the air quality impact assessment.
- Hybrid and EVs were not considered in the fleet mix. The percentages of lower emission and zero emission vehicles in the Victorian vehicle fleet are expected to increase in future years.

Acoustic barriers were not considered to have any effect on pollutant concentrations downwind. There is a significant body of evidence to suggest that acoustic barriers reduce pollutant concentrations immediately downwind of roadways at the most impacted sensitive receptors.

6.0 IMPACT ASSESSMENT

Emissions from vehicles travelling through the tunnels are discharged through the tunnel ventilation systems and dispersed into the atmosphere. Dispersion modelling techniques are used to predict pollutant GLCs which are subsequently added to background levels and assessed against applicable air quality criteria.

6.1 Tunnel ventilation system design

Tunnel ventilation systems are designed to provide adequate air quality during normal operation in addition to supporting self evacuation and rescue efforts during emergency incidents. The capacity of the tunnel ventilation system for normal operation is defined by the air demand required to maintain acceptable in-tunnel visibility and air quality.

The required volume of fresh air for a given tunnel traffic condition depends on the number of vehicles in the tunnel, the average pollutant emission per vehicle, the allowable pollutant in-tunnel concentration and the ambient concentration for the pollutant under consideration.

Fresh air entering the tunnel through the entry portal is drawn through the tunnel due to the movement of vehicles (piston effect) and the action of jet fans installed along the length of the tunnel. Prior to the tunnel exit portal air is withdrawn from the tunnel into ventilation structures and discharged to the atmosphere. Additional jet fans are installed immediately prior to the exit portal to reverse the air flow and prevent emissions of pollutants from the portal.

The North East Link air quality impact assessment has assumed that there are no emissions from the tunnel portals and that all vehicle emissions within the tunnels are discharged via the tunnel ventilation structures.

6.2 Assessment approach

Plume dispersion modelling was used to predict pollutant ground level concentrations resulting from tunnel ventilation system emissions to air.

The modelling assessment was conducted in accordance with the requirements of Schedule C of the SEPP(AQM), using the regulatory model, AERMOD. The model was prepared in accordance with EPA Victoria Guidance Notes for Using the Regulatory Air Pollution Model (EPA Victoria 2015), with the exception being use of the AERMOD urban option, as discussed in Section 5.0.

6.3 Model inputs

In addition to the environmental inputs discussed in Section 5.0, AERMOD requires modelling domain receptors and source emission characteristics particular to the assessment required. These inputs are discussed in the following sections.

6.3.1 Model domain and receptors

A 10 kilometre by 16 kilometre model domain centred on the project (half-way between the tunnel ventilation structures) was included in the model. Within this domain, three uniform Cartesian receptor grids with the following characteristics were included:

- an outer grid measuring 10 kilometres by 16 kilometres (160 square kilometres) centred on the project with a 100 metre resolution
- an inner grid measuring 2.5 kilometres by 2.5 kilometres (6.25 square kilometres) centred on the northern tunnel ventilation structure with a 25 metre resolution
- an inner grid measuring 2.5 kilometres by 2.5 kilometres (6.25 square kilometres) centred on the southern tunnel ventilation structure with a 25 metre resolution.

All gridded receptor points were input at ground level.

Discrete receptors were used to represent selected sensitive receptors (refer Section 4.2) within the model domain. All discrete receptor points were input at ground level.

Figure 31 presents the inner and outer grid of the model domain.

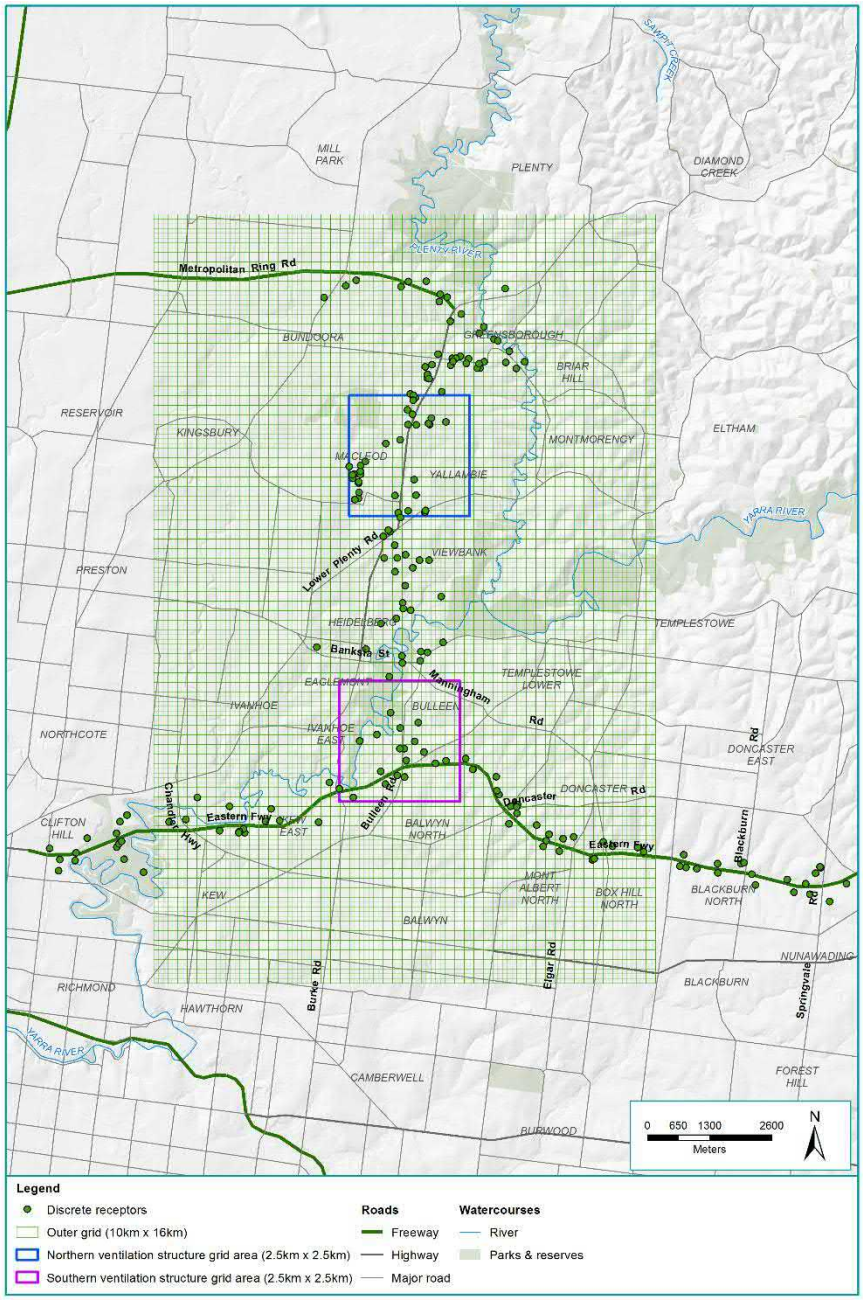


Figure 31: Model domain gridded and discrete receptors

6.3.2 Emission sources

The North East link design includes duty fans serving each tunnel ventilation structure, the speed of which is controlled such that vitiated air flowing through the tunnel in the direction of traffic, plus incoming air from the downstream portal, is captured and dispersed. Due to the increase in elevation to the north, traffic emissions from the northbound tunnel are predicted to be greater than those from the southbound. The tunnel ventilation

systems of each are designed to account for this with a larger diameter northern tunnel ventilation system permitting greater ventilation rates.

Each tunnel ventilation structure consists of a primary and secondary vent. Utilising the primary and secondary vents in combination enables the exhaust air velocity to be maintained between approximately 18 and 22 metres per second, with combined ventilation rates of approximately 590 to 970 cubic metres per second in the southern structure and 740 to 1,290 cubic meters per second in the northern structure. The primary vent of each tunnel ventilation structure will operate at all times, with use of the secondary vent dependent on the time of day, vehicle volumes, in-tunnel air quality and maintenance schedules. For the purposes of modelling, the primary and secondary vent configurations of each tunnel ventilation structure have been represented by two discharge points. The southern tunnel ventilation structure vent diameters are 6.5 metres and 4.7 metres (corresponding to cross sectional areas of 33 and 17 square metres) respectively, and the northern tunnel ventilation structure diameters are 7.1 and 5.0 meters (corresponding to cross sectional areas of 40 and 20 square metres) respectively.

In the absence of other information, tunnel ventilation structure exhaust temperatures have been assumed to be equal to ambient temperatures (as determined from the modelling meteorological file). In reality, the exhaust temperature would be greater than the ambient temperature under most circumstances, due to the heat generated from vehicles inside the tunnel.

The tunnel structure itself, having a large thermal mass, remains at a relatively constant temperature (closely linked to the surrounding ground temperature) and either heats or cools the ventilation air depending on the relative temperatures.

The heat input from vehicles is significant and in a form (exhaust and radiator rejected heat) that is readily mixed with tunnel ventilation air. The result would be a degree of heating positively related to traffic load and negatively to ventilation rate. The net effect would be to raise the tunnel ventilation structure exhaust temperature above ambient levels.

A tunnel ventilation structure temperature greater than ambient results in a more buoyant plume, thereby increasing dispersal. Consequently, by modelling the exhaust temperature equal to ambient, model predictions are considered conservatively high.

Based on the tunnel ventilation system design, the northbound and southbound tunnel ventilation structures are represented in the model as point sources, as described in Table 26.

Other pollutant sources within the model domain were not assessed, however background concentrations representative of the local area have been included.

Table 26: Tunnel ventilation structure parameters

Vent parameter	Northern	Southern
Location (UTM coordinates; m): Primary Secondary	 330961 E, 5823137 S 330962 E, 5823147 S	 330740 E, 5817394 S 330749 E, 5817394 S
Release height above ground level (m)	40	40
Base elevation (m)	71	15
Exhaust temperature (°C)	Ambient	Ambient
Vent diameter (m) Primary Secondary	 7.1 5.0	 6.5 4.7

The magnitude of pollutant rates emitted from the tunnel ventilation structures depends on the type and volume of vehicles using the tunnels. The predicted vehicular traffic through the tunnels in conjunction with vehicle specific emission factors (Section 5.4.3) and tunnel gradients were used to generate hourly tunnel ventilation structure emission inventories.

6.3.3 Traffic data

Predicted traffic volumes and fleet mixes for 2026 (the expected opening year of the tunnels) and 2036 (ten years following project opening) were used as the basis for the air quality impact assessment:

- Scenarios A1 and A2 – normal operation projected traffic volume and fleet mix for 2026
- Scenarios B1 and B2 – normal operation projected traffic volume and fleet mix for 2036.

Traffic modelling provided the hourly volumes of passenger cars (PC), light commercial vehicles (LCV) and heavy commercial vehicles (HCV) for the northbound and southbound tunnels for 2026 and 2036 between Blamey Road and Manningham Road (herein the 'north section') and between Manningham Road and Bulleen Oval (herein the 'south section').

Hourly traffic fleet mix developed from the traffic data for petrol fuelled passenger cars (PCP), diesel fuelled passenger cars (PCD), LCV and HCV for Scenarios A and B are presented in Figure 32 to Figure 39. Hourly traffic fleet composition data are provided in APPENDIX A.

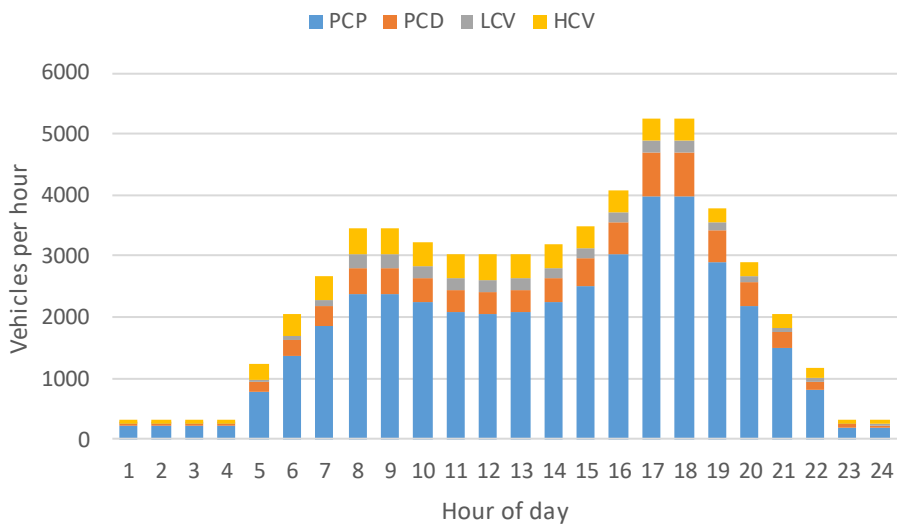


Figure 32: Scenarios A1 and A2 northbound traffic – north section

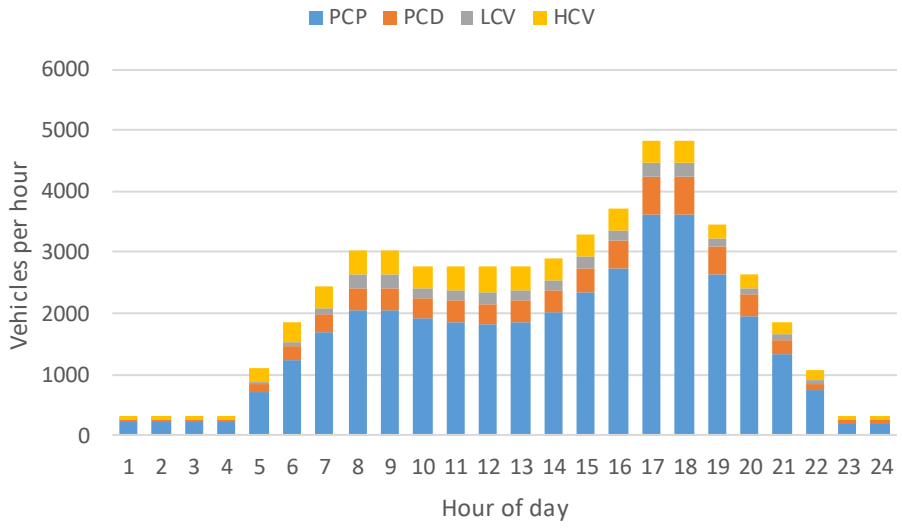


Figure 33: Scenarios A1 and A2 northbound traffic – south section

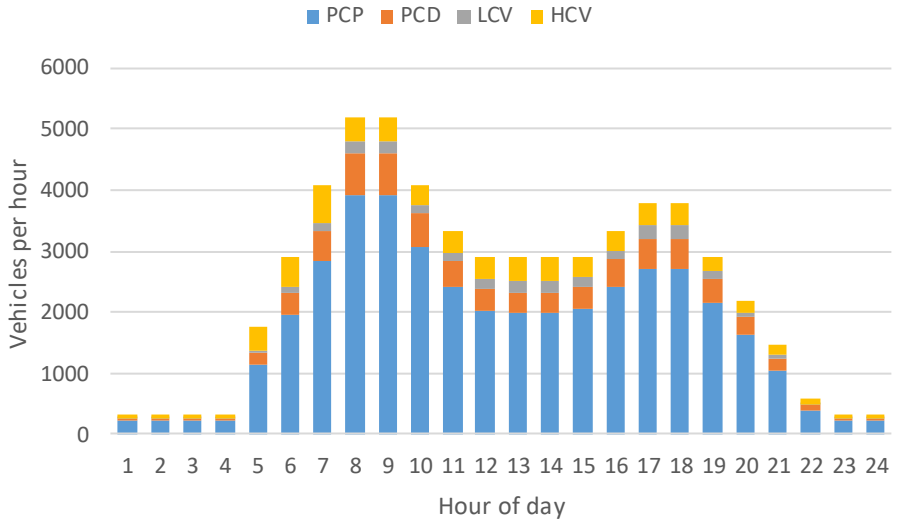


Figure 34: Scenarios A1 and A2 southbound traffic – north section

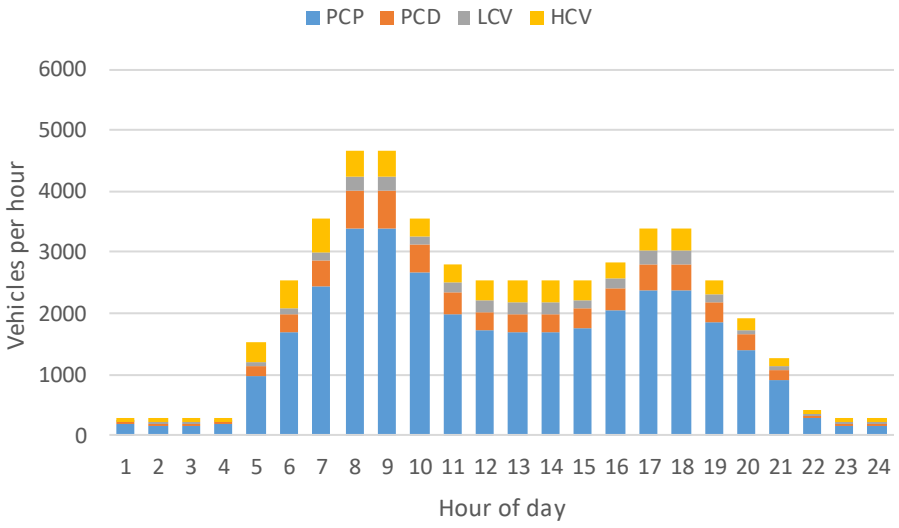


Figure 35: Scenarios A1 and A2 southbound traffic – south section

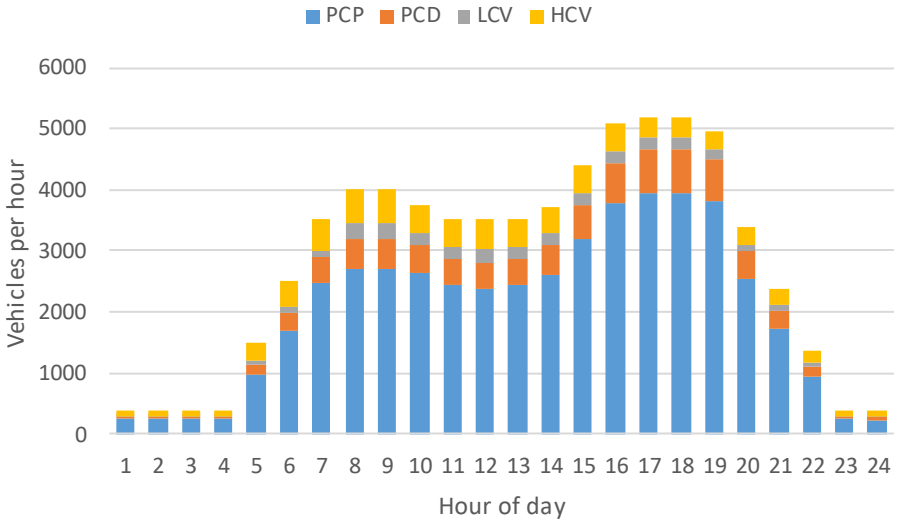


Figure 36: Scenarios B1 and B2 northbound traffic – north section

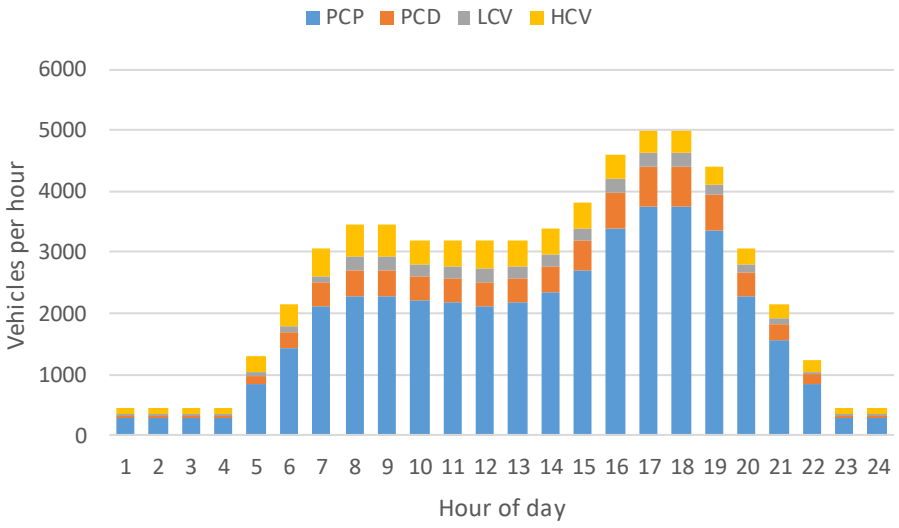


Figure 37: Scenarios B1 and B2 northbound traffic – south section

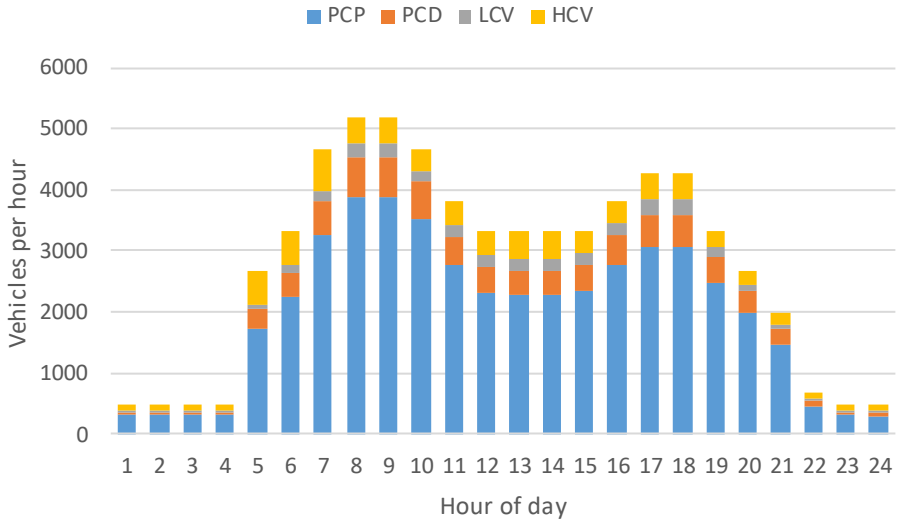


Figure 38: Scenarios B1 and B2 southbound traffic – north section

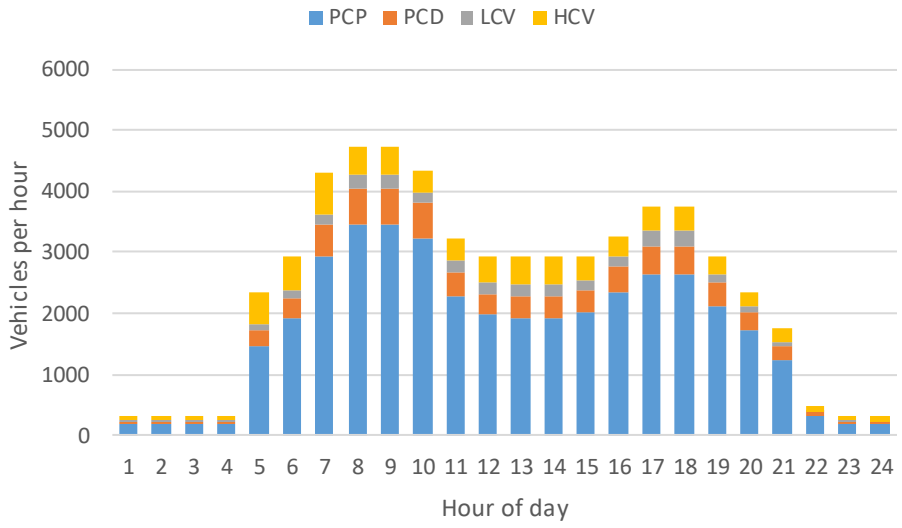


Figure 39: Scenarios B1 and B2 southbound traffic – south section

6.3.4 Tunnel gradients

For the purposes of calculating emission factors, the North East Link tunnel gradients were conservatively approximated, as presented in Table 27.

Table 27: Tunnel gradients and lengths

Tunnel	Section length at gradient (km)							Total length (km)
	-6°	-4°	-2°	0°	+2°	+4°	+6°	
Northbound	0	0.84	1.0	0.23	2.5	1.5	0	6.1
Southbound	0	1.5	2.5	0	1.3	0.84	0	6.1

6.3.5 Emission inventory

The pollutant emission inventories developed from the predicted Scenarios A1 and B1 traffic fleet mixes and 2020 emission factors discussed above are summarised in Figure 40 to Figure 43.

Scenarios A2 and B2 (2025 emission factors) northbound and southbound emissions inventories (PM_{10}, $PM_{2.5}$ and NO_2) are summarised and compared with the corresponding Scenario A1 and B1 inventories in Figure 44 to Figure 47.

The emission inventory data is provided in APPENDIX B.

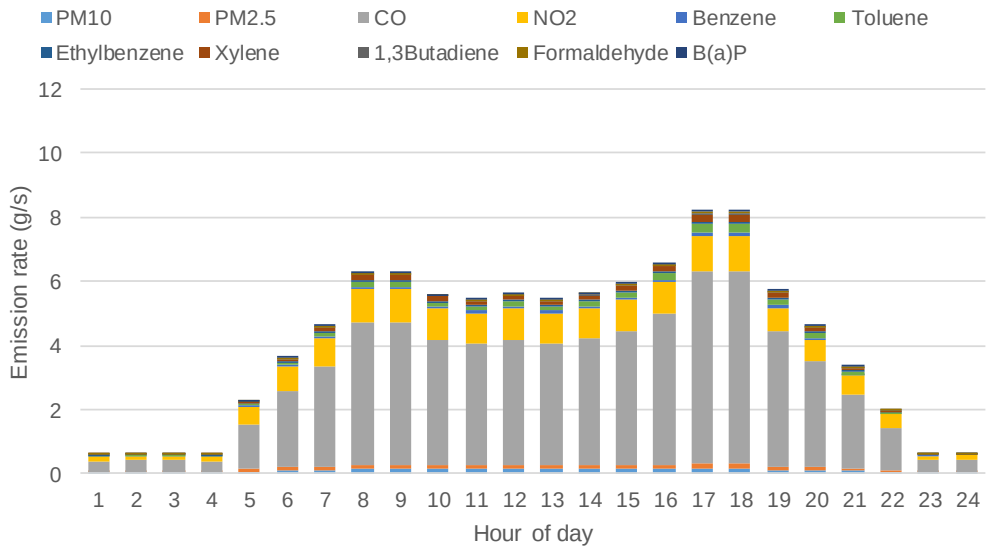


Figure 40: Scenario A1 northbound traffic emission rates

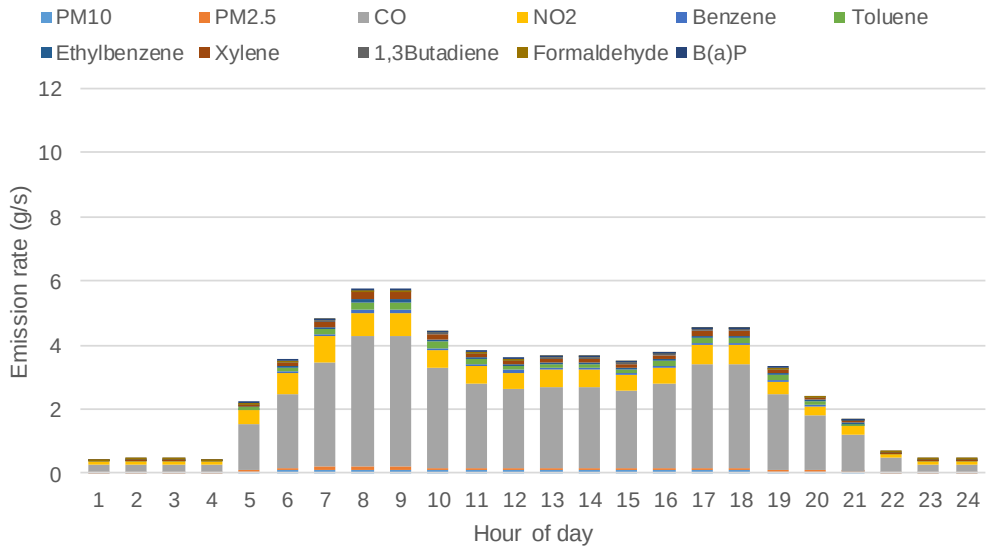


Figure 41: Scenario A1 southbound traffic emission rates

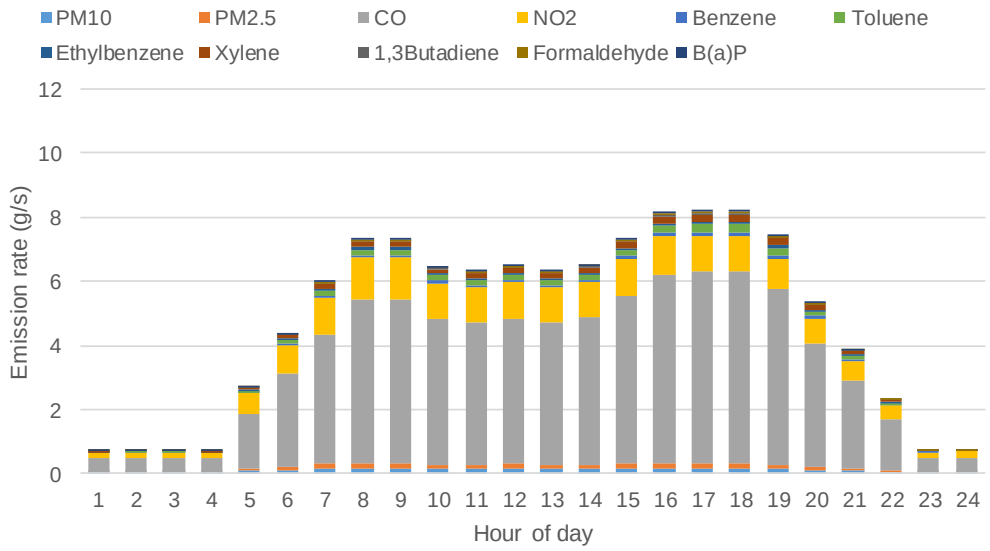


Figure 42: Scenario B1 northbound traffic emission rates

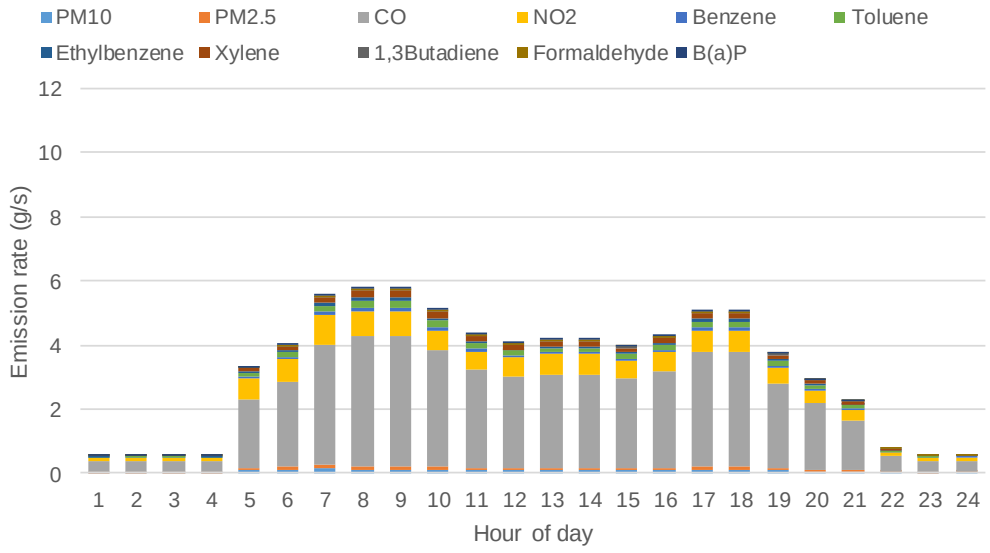


Figure 43: Scenario B1 southbound traffic emission rates

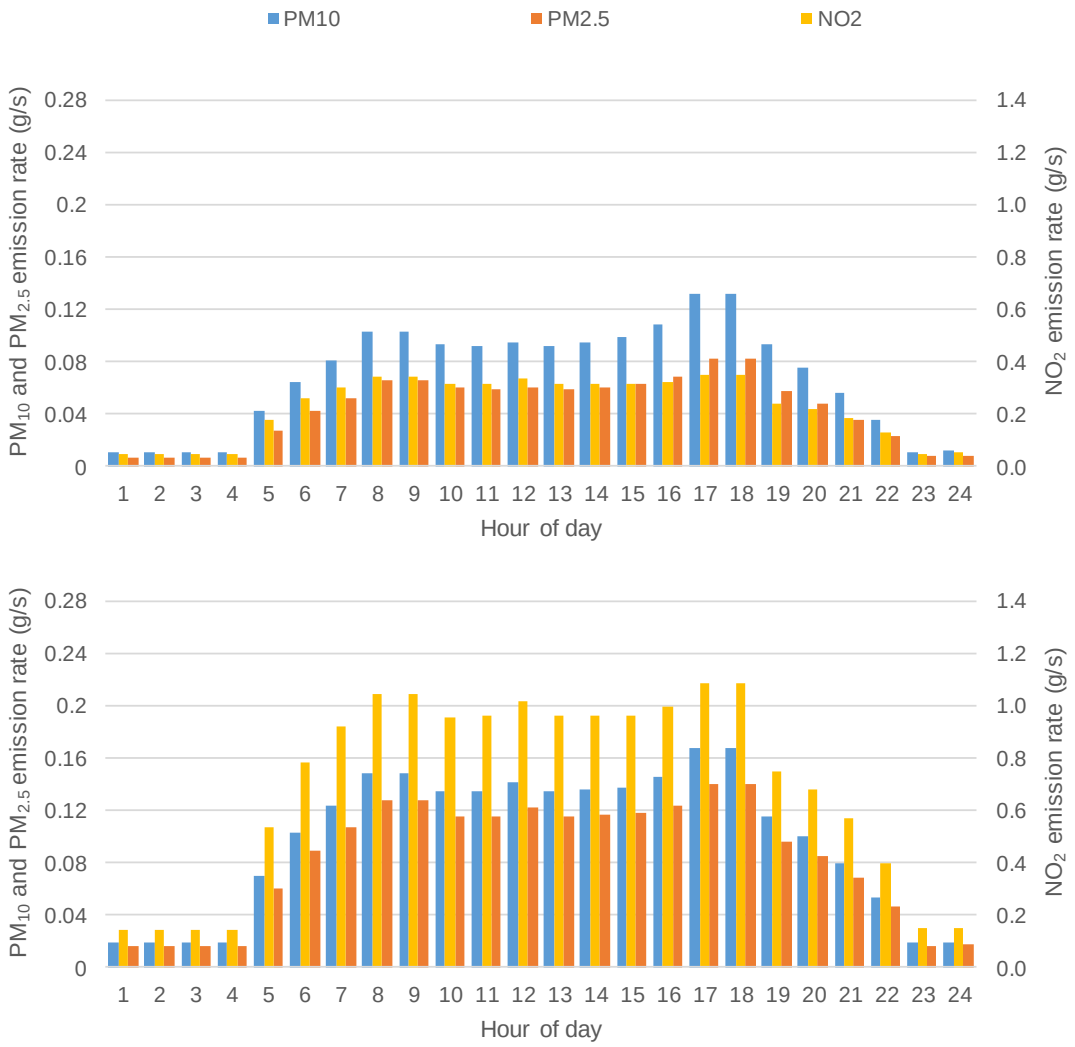


Figure 44: Scenario A2 northbound emissions (top) and Scenario A1 northbound emissions (bottom)

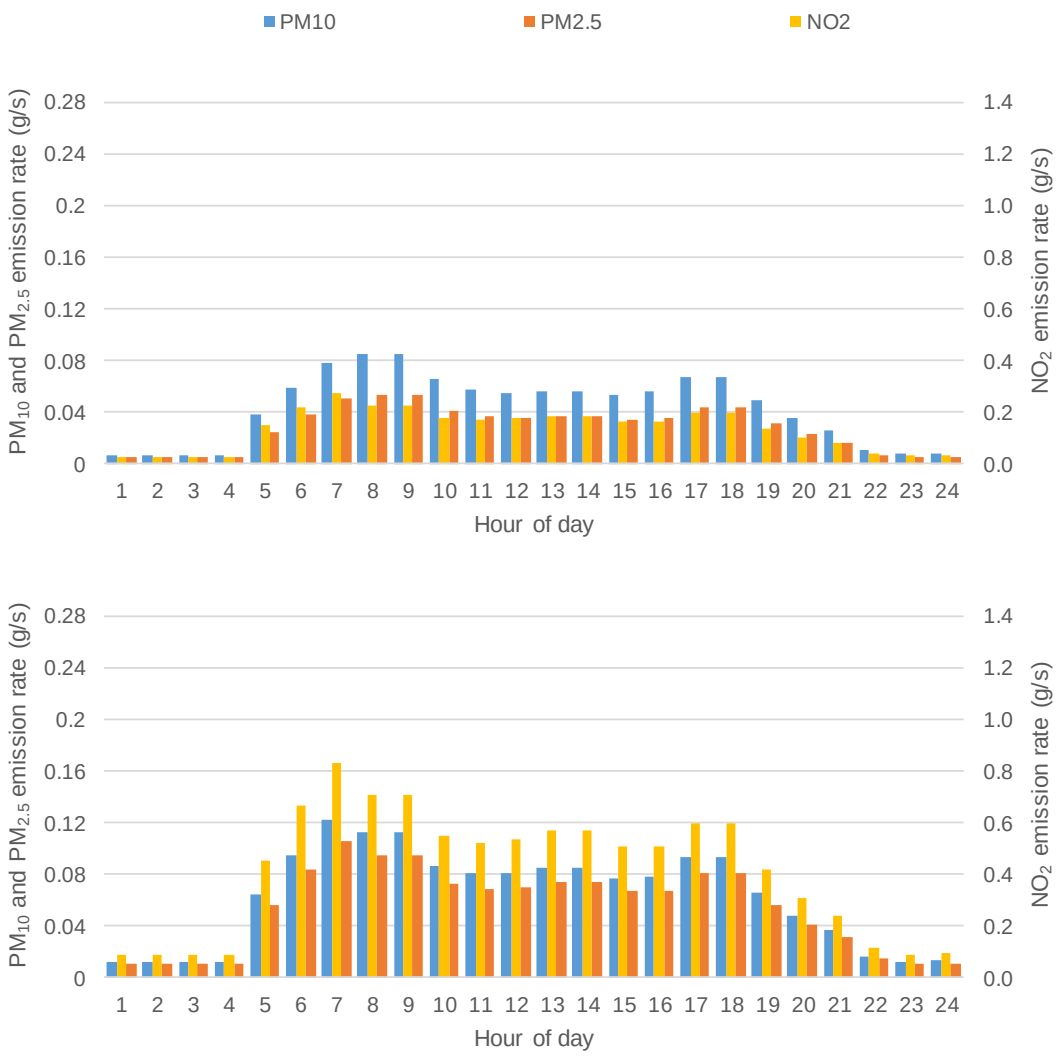


Figure 45: Scenario A2 southbound emissions (top) and Scenario A1 southbound emissions (bottom)

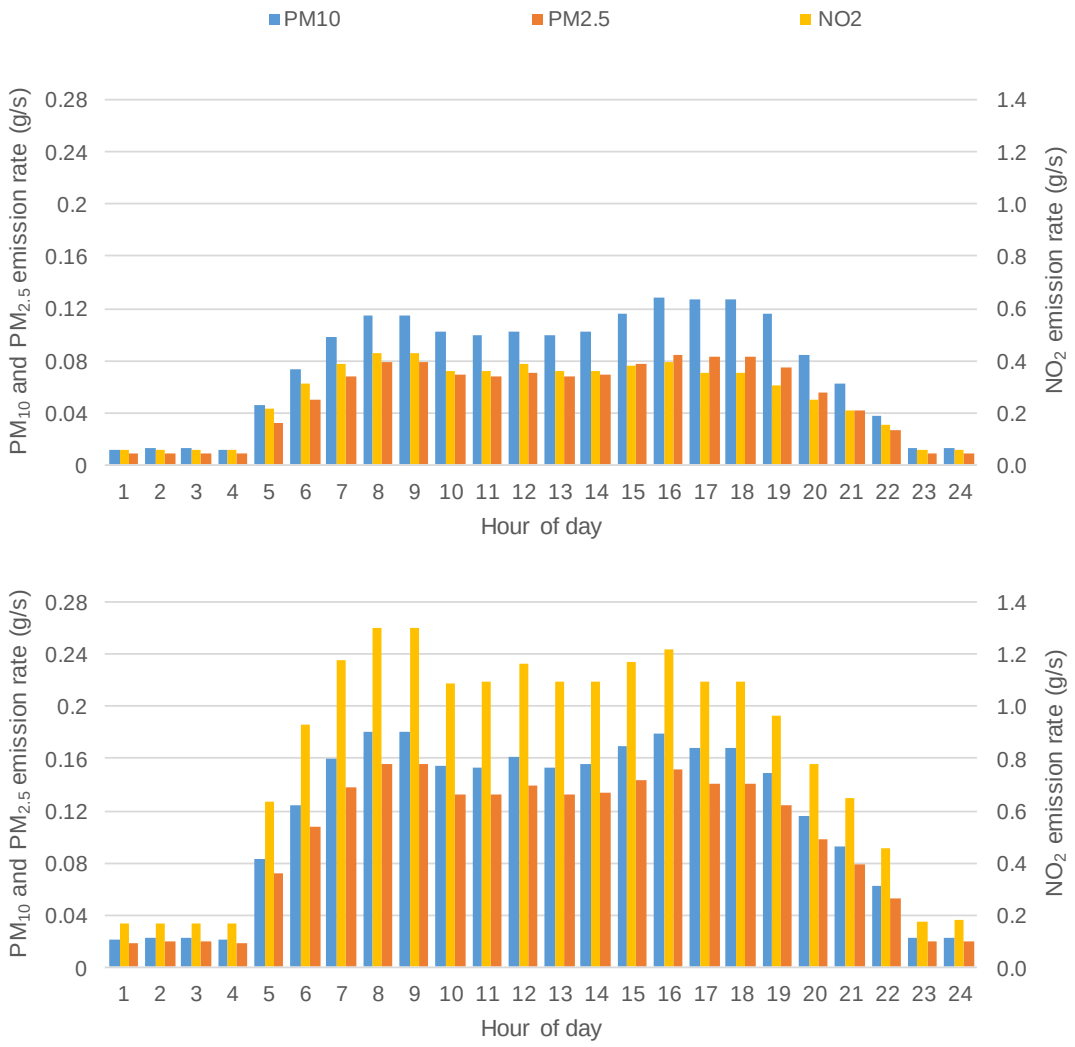


Figure 46: Scenario B2 northbound emissions (top) and Scenario B1 northbound emissions (bottom)

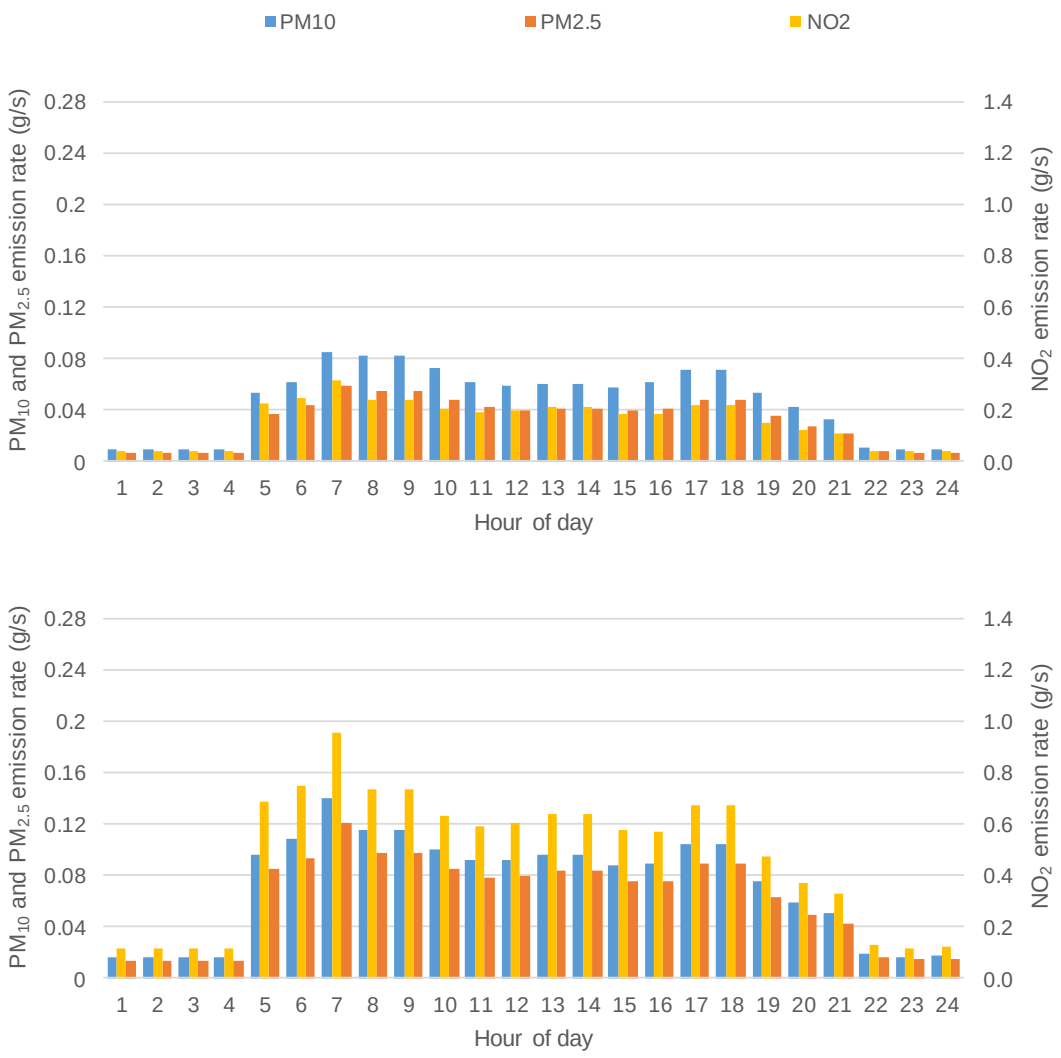


Figure 47: Scenario B2 southbound emissions (top) and Scenario B1 southbound emissions (bottom)

6.3.6 Tunnel ventilation rates

Hourly ventilation rates provided by GHD for Scenarios A1 and A2 and Scenarios B1 and B2 are presented in Figure 48 and Figure 49, respectively.

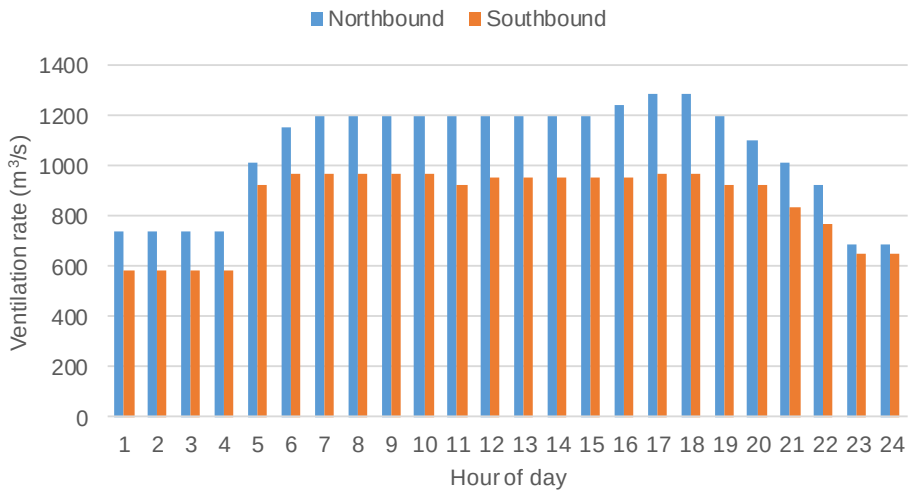


Figure 48: Scenario A1 ventilation rates

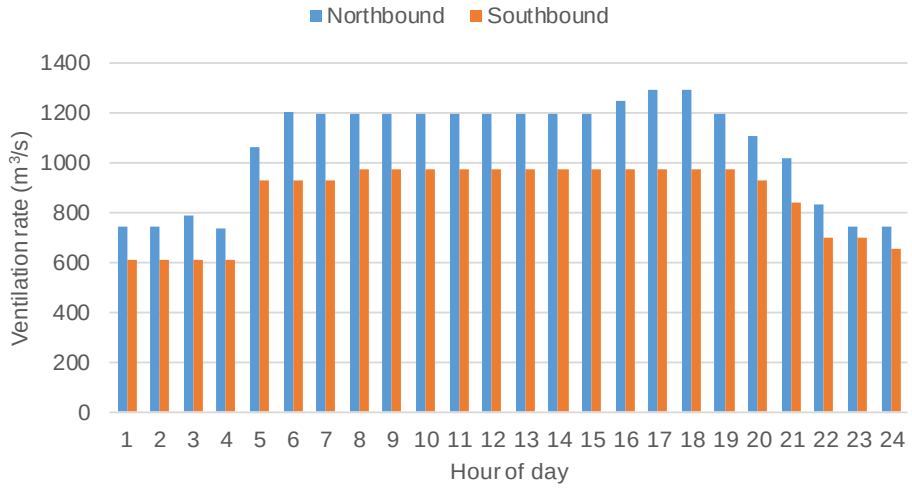


Figure 49: Scenario B1 ventilation rates

6.4 Sensitivity analyses

In addition to the sensitivity analysis which considers more realistic emission factors for 2025 (Scenarios A2 and B2), a number of additional sensitivity analyses were considered:

- the North East Link tunnels operating at maximum capacity (24 hours a day, 365 days a year)
- emissions occurring at in-tunnel air quality limits (24 hours a day, 365 days a year)
- increased diesel to petrol fuelled passenger car ratios
- alternative tunnel ventilation structure locations within potential construction footprints.

The results of the additional sensitivity analyses are presented in Section 6.6.2 and discussed in Section 6.7.2.

6.4.1 Maximum lane capacity, 24 hours a day, 365 days a year

The lane capacity of the tunnels is defined as the maximum traffic density that the tunnels can support before traffic flow breaks down. Lane capacity is fleet mix dependent, with the slowing down of HCVs on the up-gradient section of tunnels primarily responsible for the breakdown in traffic flow. In general, the lane capacity of a road tunnel is considered to be approximately 2,000 vehicles per hour. These can be considered worst case traffic conditions generating worst case emissions from the tunnel ventilation systems.

Dispersion modelling was conservatively undertaken for maximum lane capacity conditions with a 2036 fleet mix, travelling at 40 kilometres per hour in three lanes in each direction, 24 hours a day and 365 days a year. This is an unrealistic scenario that has not occurred in any Australian road tunnel and is highly unlikely to occur in the future.

Hourly traffic volume and fleet mix distributions for the inbound and outbound tunnels are presented in Figure 50 to Figure 53. Hourly traffic fleet composition data are provided in APPENDIX A.

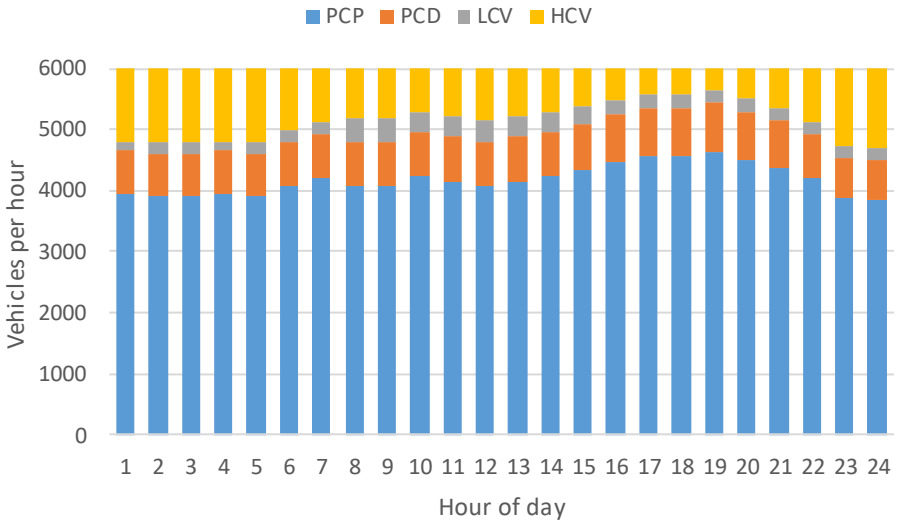


Figure 50: Maximum lane capacity northbound traffic - north section

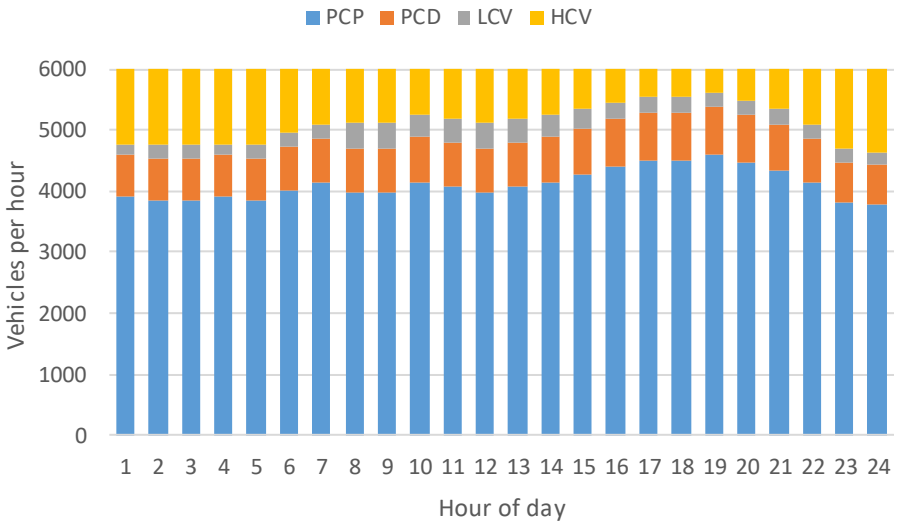


Figure 51: Maximum lane capacity northbound traffic – south section

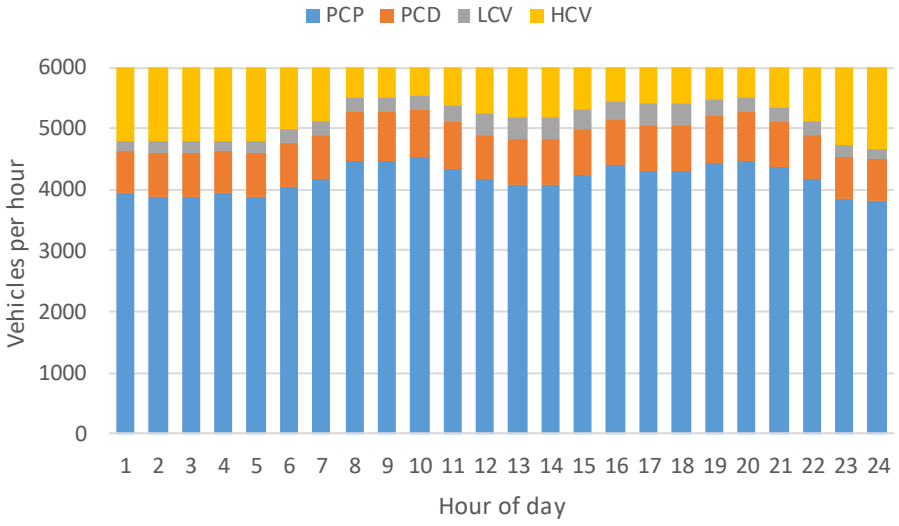


Figure 52: Maximum lane capacity southbound traffic – north section

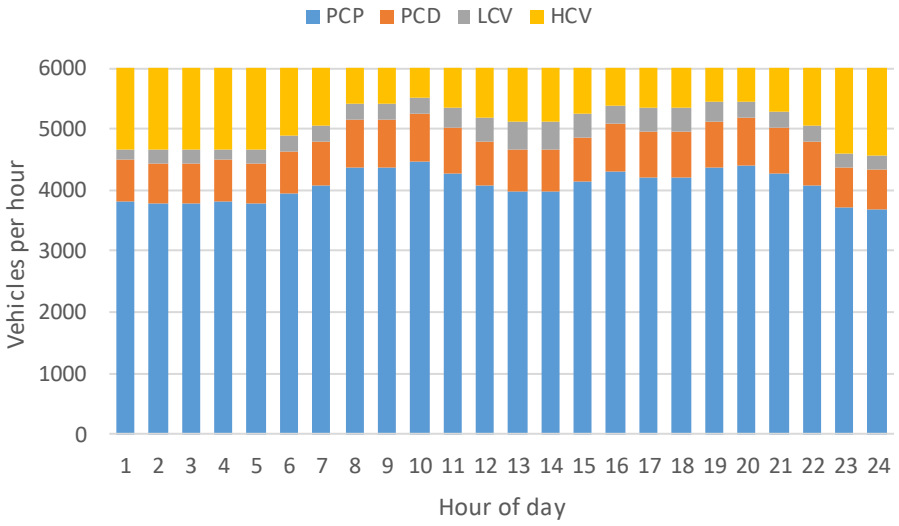


Figure 53: Maximum lane capacity southbound traffic – south section

A ventilation rate of 1,290 cubic metres per second has been assumed for the northern tunnel ventilation structure and 970 cubic metres per second for the southern tunnel ventilation structure. for all hours. The pollutant emission inventories developed from the predicted traffic fleet mixes and emission factors for 2036 are summarised in Figure 54 and Figure 55. The emission inventory data is provided in APPENDIX A.

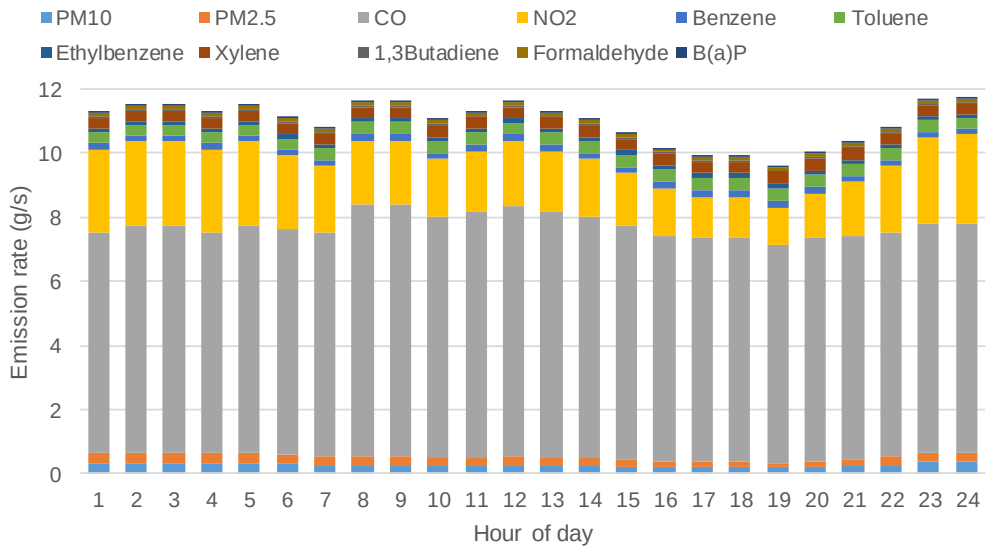


Figure 54: Maximum lane capacity northbound traffic emission rates

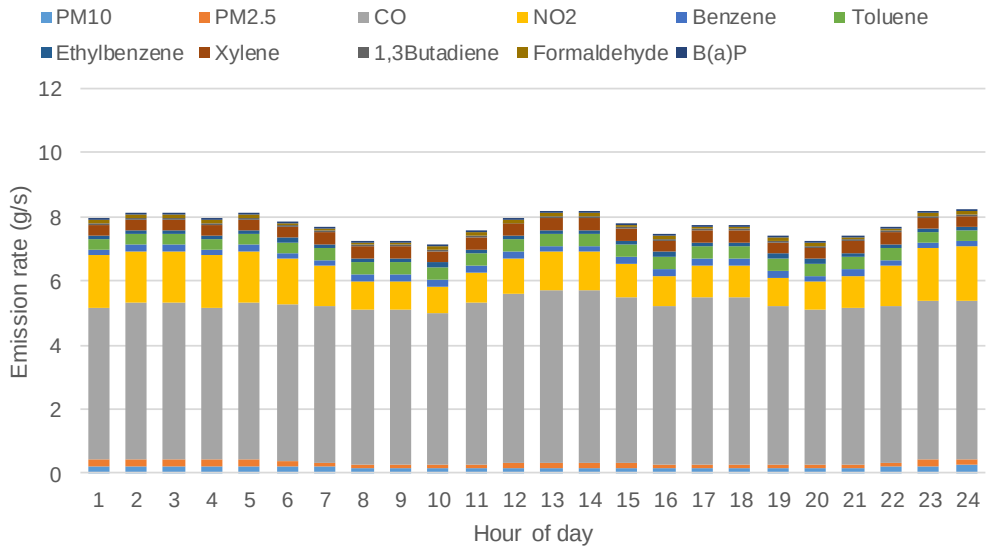


Figure 55: Maximum lane capacity southbound traffic emission rates

6.4.2 Emissions at in-tunnel air quality limits

To understand the potential impacts of North East Link on the receiving environment, and to demonstrate that appropriate measures have been incorporated into the design, a theoretical worst case scenario was modelled with tunnel ventilation structure exhaust concentrations equal to in-tunnel air quality limits at maximum tunnel ventilation flow rates.

Australian road tunnel projects are subject to environmental and/or planning approval conditions which specify the parameters to be monitored in-tunnel. These typically include air velocity, CO, NO_2 and visibility, with a requirement that the tunnel ventilation system be controlled to:

- prevent or reduce portal emissions and resultant environmental impacts

- ensure appropriate visibility for different tunnel operating conditions
- control public in-tunnel exposure to CO and NO_2 within the tunnel, through compliance with criteria for various averaging periods.

Historically, NO_2 in-tunnel concentrations have been estimated from NO measurements by assuming that NO_2 represented 10 per cent of NO_X, in accordance with PIARC recommendations. More recent road tunnel installations however utilise open path instruments for direct measurement of NO_2 concentrations.

Public exposure is typically assessed by averaging CO and NO (and/or NO_2) concentrations measured by a number of instruments located on possible travel paths throughout the road tunnel system.

Environmental requirements relating to in-tunnel air quality and tunnel ventilation system emissions to air for the CityLink and EastLink road tunnels are contained in EPA Victoria Licence No.'s 1278 (Translink Operations Pty. Ltd.) and 2043 (ConnectEast Pty. Ltd.) respectively.

In both instances the following CO in-tunnel concentration limits apply:

- 150 parts per million (parts per million) (maximum)
- 50 parts per million (15 minute average)
- 25 parts per million (two hour average).

For the purposes of a modelling sensitivity analysis, a maximum concentration of CO in the tunnel ventilation structure exhaust gases of 50 parts per million, conservatively assumed to occur over a one hour period, has been utilised.

CO has historically been used as the basis for defining in-tunnel air quality and as such the CityLink and EastLink licences do not specify an NO_2 in-tunnel concentration limit. However, advances in engine technology have achieved greater reductions in CO in comparison with NO_2, meaning that in-tunnel criteria for CO alone may no longer be adequate to protect human health.

PIARC suggests a 1 part per million NO_2 criterion (15-minute average) at any point within a road tunnel. The New South Wales Government Advisory Committee on Tunnel Air Quality (NSW Government, 2016) adopted a policy for new road tunnels over one kilometre in length that requires a NO_2 average concentration less than 0.5 parts per million (rolling 15-minute average) over the length of the tunnel.

The outcomes from an air quality impact assessment viewpoint are likely to be similar. Consequently, an NO_2 concentration equal to the NSW criterion in the ventilation system exhaust gases has been adopted for the purposes of the modelling sensitivity analysis.

The modelling sensitivity analysis was based on emission rates derived from in-tunnel pollutant concentrations, as summarised in Table 28.

Table 28: In-tunnel air quality limits

Pollutant	Limit (ppm)	Tunnel ventilation structure	Equivalent emission rate (g/s)	Ventilation flow rate (m^3/s)
CO	50	Northern	81	1,290
		Southern	61	970
NO_2	0.5	Northern	1.3	1,290
		Southern	1.0	970

Due to the inherent conservatism of the emission factors used to generate the emissions inventory, NO_2 emission rates for the maximum lane capacity sensitivity analysis are greater than the equivalent in-tunnel limit emission rate for the southern tunnel ventilation structure for several hours and for the northern tunnel ventilation structure for all hours.

6.4.3 Increased diesel to petrol fuelled car ratio

For the modelling of Scenarios A and B, a 15 per cent diesel to 85 per cent petrol split for passenger car traffic data was assumed. In order to assess the sensitivity of the model to this assumption, in particular to PM_{10}, $PM_{2.5}$ and NO_2 predictions, additional modelling was conducted based on a diesel to petrol fuelled passenger car split of 30 per cent to 70 per cent.

The model run was based on Scenario B (2036), giving the traffic volume and fleet mix distributions presented in Figure 56 to Figure 59. Hourly traffic fleet composition data are provided in APPENDIX A.

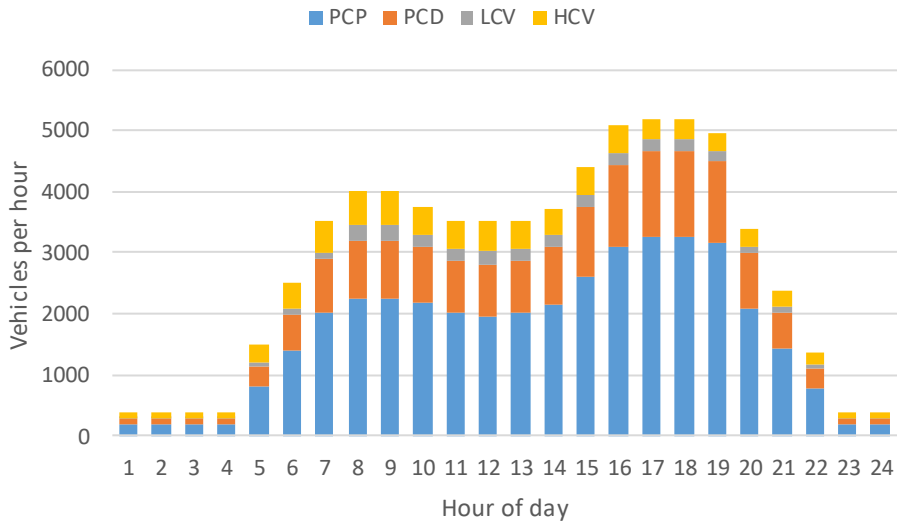


Figure 56: Increased diesel to petrol passenger car ratio northbound traffic – north section

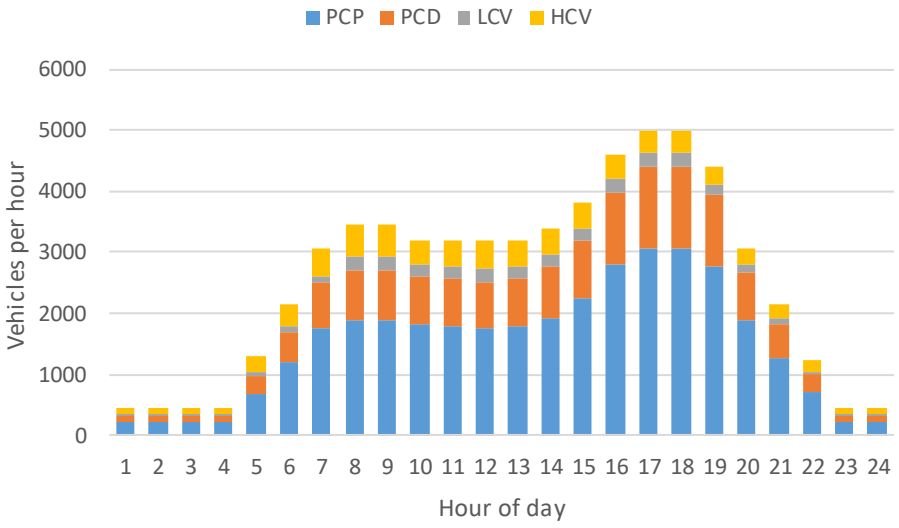


Figure 57: Increased diesel to petrol passenger car ratio northbound traffic – south section

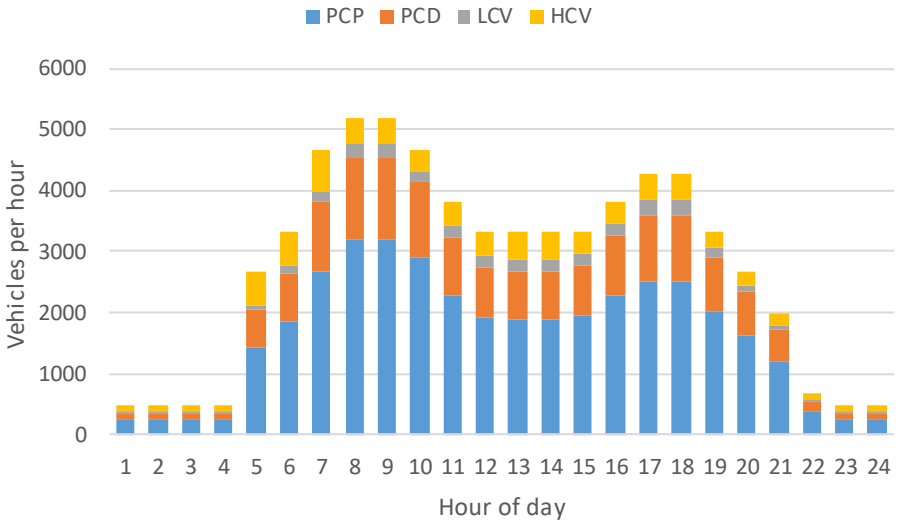


Figure 58: Increased diesel to petrol passenger car ratio southbound traffic – north section

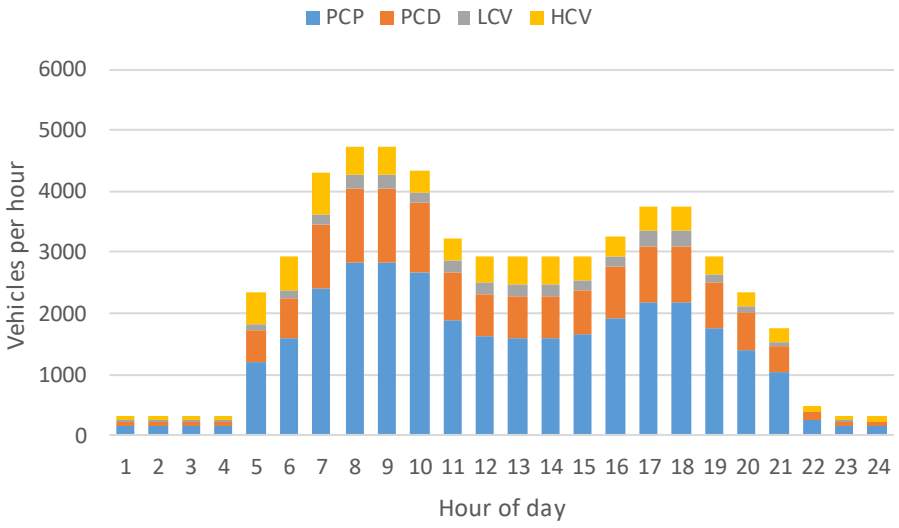


Figure 59: Increased diesel to petrol passenger car ratio southbound traffic – south section

The pollutant emissions inventories developed from these traffic fleet mixes and emission factors for 2036 are summarised in Figure 60 and Figure 61. The emissions inventory data is provided in APPENDIX A.

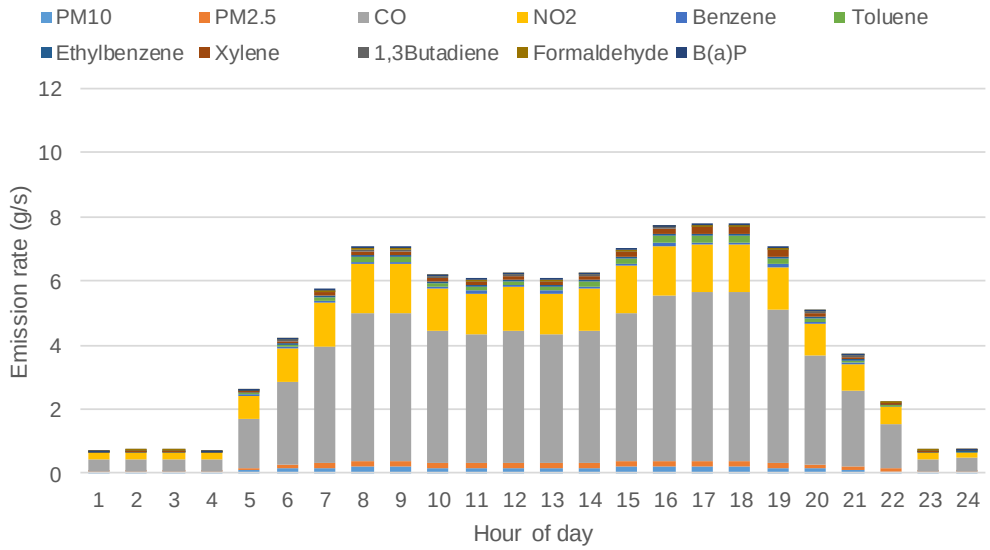


Figure 60: Increased diesel to petrol passenger car ratio northbound emission rates

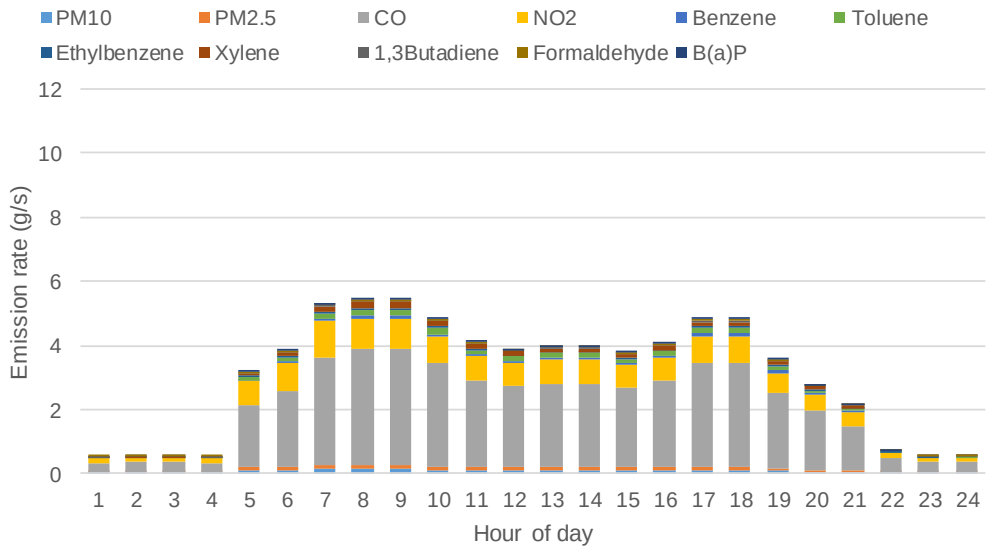


Figure 61: Increased diesel to petrol passenger car ratio southbound emission rates

6.4.4 Alternative tunnel ventilation structure locations

The impact of alternative locations for the tunnel ventilation structures was assessed by locating the structures at a finite number of locations towards the extremities of the identified areas. Modelling was undertaken at the proposed location and these alternative locations for $PM_{2.5}$ under Scenario B conditions. Northern and southern tunnel ventilation structures were assessed separately.

The tunnel ventilation structure locations assessed are provided in Table 29 and shown in Figure 62 and Figure 63.

Table 29: Ventilation structures - reference project and sensitivity testing locations

Tunnel ventilation structure	Location	Primary vent	Secondary vent
Northern	Reference project	330961 E, 5823137 S	330962 E, 5823147 S
	2	330886 E, 5823254 S	330876 E, 5823256 S
	3	330982 E, 5823232 S	330983 E, 5823242 S
	4	330862 E, 5823028 S	330582 E, 5823030 S
	5	330957 E, 5823024 S	330958 E, 5823034 S
Southern	Reference project	330740 E, 5817394 S	330749 E, 5817394 S
	2	330678 E, 5817546 S	330687 E, 5817546 S
	3	330802 E, 5817546 S	330811 E, 5817546 S
	4	330682 E, 5817302 S	330691 E, 5817302 S
	5	330762 E, 5817167 S	330771 E, 5817167 S



Figure 62: Northern ventilation structure - reference project and sensitivity testing locations



Figure 63: Southern ventilation structure - reference project and sensitivity testing locations

6.5 Model assumptions

6.5.1 Stack-tip downwash and building downwash

Stack-tip downwash occurs when airflow passing by a stack is rapidly mixed to the ground as frictional forces and pressure gradients cause stagnations and eddies to develop in the wake of the stack. This effect is greatest when the stack exit velocity is small compared to the wind speed. Stack-tip downwash was included in the model for the North East Link tunnel ventilation structures.

Building downwash is the same phenomenon, but caused by structures near to pollutant emission sources, influencing atmospheric turbulence. Building downwash is a major consideration in the design of stacks and their positioning in relation to buildings. USEPA established a Good Engineering Practice (GEP) stack height defined as the "*height necessary to ensure that emissions from the stack do not result in excessive concentrations of any air pollutants in the immediate vicinity of the source as a result of atmospheric downwash, eddies or wakes which may be created by the source itself, nearby structures or nearby terrain obstacles*". The definition of GEP stack height is the stack height plus 1.5 times the lesser of the building height or projected building width.

A stack is considered to be wake affected when the stack and building are located less than five times the lesser of the building height or project building width apart.

The dimensions of the buildings from which the tunnel ventilation structures extend were approximated from design drawings. Based on aerial photography, no existing buildings are likely to wake affect the proposed tunnel ventilation structures, consideration of building downwash was therefore restricted to the tunnel ventilation structure buildings.

6.5.2 Three-minute average GLCs

SEPP(AQM) design criteria (refer to Section 2.4) for air toxics are based on three minute average GLCs. AERMOD outputs for averaging periods less than one hour require post-processing of hourly average predictions. In accordance with EPA Victoria (2015) the following formula for converting one hour average concentrations to other averaging times was used:

$c(t) = c(t_0) \times (t_0/t)^{0.2}$

where t is the averaging time of interest (three minutes in this case), and t_0 is the modelling output averaging time (60 minutes).

6.6 Model outputs

6.6.1 Design assessment

For the 2013 to 2017 meteorological data files, the 99.9th percentile corresponds to the 8th highest one hour average concentration prediction for each year. Model predictions for the hours corresponding to the top seven predictions without background were consequently removed from the data set. A single pollutant ($PM_{2.5}$) was used to determine which of the five modelled years predicted the highest one hour average 99.9th percentile GLC, with results presented in Table 30.

Table 30: Project only results by meteorological year

Meteorological year	Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]
2013	$PM_{2.5}$	µg/m^3	1 hour	3.4
2014	$PM_{2.5}$	µg/m^3	1 hour	3.2
2015	$PM_{2.5}$	µg/m^3	1 hour	3.4
2016	$PM_{2.5}$	µg/m^3	1 hour	3.5
2017	$PM_{2.5}$	µg/m^3	1 hour	3.6

Note:
1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.

Results from each year were within approximately 10 per cent of each other, with the meteorological year 2017 giving the highest result. All subsequent modelling was conducted using the 2017 meteorological and background concentration datasets.

The results of the plume dispersion modelling assessments for Scenarios A1, A2, B1 and B2 are presented in Table 31 to Table 34.

Where time-varying background concentrations have been included in the assessments (PM_{10}, $PM_{2.5}$, CO and NO_2), the background concentration can have a strong influence on the assessment outcomes and in particular the hour at which the assessed maximum (99.9th percentile) occurs. Table 35 to Table 37 present the maximum (99.9th percentile) results for PM_{10}, $PM_{2.5}$, CO and NO_2 for Scenarios A1, A2, B1 and B2 without consideration of the background concentration (project only).

Table 39 and Table 42Table 41 present the maximum (99.9th percentile) project only PM_{10}, $PM_{2.5}$, NO_2 and benzene results for discrete receptors for Scenarios A1, A2, B1 and B2. The maximum results for each of the discrete receptors are provided in APPENDIX B.

SEPP(AQM) defines the maximum predicted concentration as the 99.9th percentile concentration (for averaging periods of one hour or less) at any receptor, including background. However, when the background concentration file contains exceedances of the design criterion, contour plots of the cumulative predictions have limited value. Therefore, in order to provide a more transparent representation of the predicted impacts associated with the project, the concentration isopleth plots presented in APPENDIX C are for the 100th percentile predicted concentrations excluding background.

Table 31: Results: Scenario A1

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	$\mu g/m^3$	1 hour	Time-varying	200	80	331550, 5823322 [4]	0.17	200	0.22	No [11]
$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331324, 5818194 [5]	0.063	74	0.13	No [11]
CO	mg/m^3	1 hour	Time-varying	2.5	29	331000, 5822997 [6]	0.032	2.5	0.11	Yes
NO_2	$\mu g/m^3$	1 hour	Time-varying	130	190	330475, 5822747 [7]	11	120	5.6	Yes
Benzene	$\mu g/m^3$	3 minute	Constant	13	53	330825, 5823122 [8]	5.6	7.3	11	Yes
Toluene	$\mu g/m^3$	3 minute	Constant	55	650	330825, 5823122 [8]	11	43	1.7	Yes
Ethylbenzene	$\mu g/m^3$	3 minute	Constant	9.0	14,500	330825, 5823122 [8]	4.2	4.8	0.029	Yes
Xylene isomers	$\mu g/m^3$	3 minute	Constant	31	350	330825, 5823122 [8]	11	20	3.1	Yes
1,3-Butadiene	$\mu g/m^3$	3 minute	Constant	1.7	73	330624, 5817419 [9]	1.2	0.44	1.6	Yes
Formaldehyde	$\mu g/m^3$	3 minute	Constant	7.2	40	330599, 5817444 [10]	2.3	4.9	5.8	Yes
PAHs [as B(a)P TEQ]	$\mu g/m^3$	3 minute	Constant	0.0011	0.73	330599, 5817444 [10]	0.00056	0.00055	0.077	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period. A constant background concentration refers to one concentration used to represent background conditions (without the project).

2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP (AQM) design criterion.

4 600 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.

5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.

6 150 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.

7 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.

8 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

9 120 m west of the southern tunnel ventilation structure within Carey Grammar Sports Complex.

10 150 m west of the southern tunnel ventilation structure within Carey Grammar Sports Complex.

11 See Section6.7.1.

Table 32: Results: Scenario A2

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	$\mu g/m^3$	1 hour	Time-varying	200	80	331550, 5823322 [4]	0.13	200	0.16	No [7]
$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331324, 5818194 [5]	0.027	74	0.055	No [7]
NO_2	$\mu g/m^3$	1 hour	Time-varying	120	190	330475, 5822747 [6]	3.4	120	1.8	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time varying or constant background concentration (refer to Section 5.3). Hourly time varying concentrations change from hour to hour over a 24-hour period.

2 99.9^{th} percentile (8^{th} highest value) as required for assessment against SEPP(AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP(AQM) design criterion.

4 600 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.

5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.

6 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.

7 See Section 6.7.1.

Table 33: Results: Scenario B1

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	$\mu g/m^3$	1 hour	Time-varying	200	80	331550, 5823322 [4]	0.21	200	0.27	No [11]
$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331324, 5818194 [5]	0.083	74	0.17	No [11]
CO	mg/m^3	1 hour	Time-varying	2.5	29	331000, 5822997 [6]	0.037	2.5	0.13	Yes
NO_2	$\mu g/m^3$	1 hour	Time-varying	130	190	330475, 5822747 [7]	11	120	5.7	Yes
Benzene	$\mu g/m^3$	3 minute	Constant	13	53	330825, 5823122 [8]	5.6	7.3	11	Yes
Toluene	$\mu g/m^3$	3 minute	Constant	55	650	330599, 5817444 [9]	11	43	1.7	Yes
Ethylbenzene	$\mu g/m^3$	3 minute	Constant	9.0	14,500	330599, 5817444 [9]	4.2	4.8	0.029	Yes
Xylene isomers	$\mu g/m^3$	3 minute	Constant	31	350	330825, 5823122 [8]	11	20	3.1	Yes
1,3-Butadiene	$\mu g/m^3$	3 minute	Constant	1.7	73	330599, 5817444 [9]	1.2	0.44	1.6	Yes
Formaldehyde	$\mu g/m^3$	3 minute	Constant	7.2	40	330825, 5823122 [8]	2.3	4.9	5.8	Yes
PAHs [as B(a)P TEQ]	$\mu g/m^3$	3 minute	Constant	0.0011	0.73	330624, 5817469 [10]	0.00058	0.00055	0.079	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period. A constant background concentration refers to one concentration used to represent background conditions (without the project).

2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP (AQM) design criterion.

4 600 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.

5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.

6 150 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.

7 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.

8 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

9 150 m west of the southern tunnel ventilation structure within Carey Grammar Sports Complex.

10 140 m northwest of the southern tunnel ventilation structure within Carey Grammar Sports Complex.

11 See Section6.7.1.

Table 34: Results: Scenario B2

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	$\mu g/m^3$	1 hour	Time-varying	200	80	331550, 5823322 [4]	0.16	200	0.20	No [7]
$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331324, 5818194 [5]	0.037	74	0.073	No [7]
NO_2	$\mu g/m^3$	1 hour	Time-varying	120	190	330475, 5822747 [6]	3.5	120	1.8	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time varying or constant background concentration (refer to Section 5.3). Hourly time varying concentrations change from hour to hour over a 24-hour period.

2 99.9^{th} percentile (8^{th} highest value) as required for assessment against SEPP(AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP(AQM) design criterion.

4 600 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.

5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.

6 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.

7 See Section 6.7.1.

Table 35: Results: Scenario A1 - project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	4.2	80	331000, 5822997 [3]	5.3
$PM_{2.5}$	$\mu g/m^3$	1 hour	3.6	50	331000, 5822997 [3]	7.2
CO	mg/m^3	1 hour	0.15	29	331000, 5822997 [3]	0.52
NO_2	$\mu g/m^3$	1 hour	29	190	330825, 5823122 [4]	15

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 145 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.
4 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

Table 36: Results: Scenario A2 – project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	3.2	80	331000, 5822997 [3]	4.0
$PM_{2.5}$	$\mu g/m^3$	1 hour	2.0	50	331000, 5822997 [3]	4.0
NO_2	$\mu g/m^3$	1 hour	9.4	190	330825, 5823122 [4]	4.9

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP(AQM) design criterion.
2 SEPP(AQM) design criterion.
3 145 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.
4 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

Table 37: Results: Scenario B1 - project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	4.8	80	330825, 5823122 [3]	6.0
$PM_{2.5}$	$\mu g/m^3$	1 hour	4.1	50	330825, 5823122 [3]	8.2
CO	mg/m^3	1 hour	0.15	29	331000, 5822997 [4]	0.52
NO_2	$\mu g/m^3$	1 hour	35	190	330825, 5823122 [3]	18

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 140 m west of the northern tunnel ventilation structure within residential area of Macleod.
4 145 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.

Table 38: Results: Scenario B2 – project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	3.4	80	331000, 5822997 [3]	4.2
$PM_{2.5}$	$\mu g/m^3$	1 hour	2.2	50	330825, 5823122 [4]	4.4
NO_2	$\mu g/m^3$	1 hour	11	190	330825, 5823122 [4]	5.8

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP(AQM) design criterion.
2 SEPP(AQM) design criterion.
3 145 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.
4 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

Table 39: Results: Scenario A1 - project only, discrete receptors

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Receptor ID	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	2.9	80	105 [3]	3.6
$PM_{2.5}$	$\mu g/m^3$	1 hour	2.5	50	105 [3]	5.0
NO_2	$\mu g/m^3$	1 hour	20	190	105 [3]	10
Benzene	$\mu g/m^3$	1 hour	2.7	53	105 [3]	5.0

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 Carey Grammar Sports Complex

Table 40: Results: Scenario A2 - project only, discrete receptors

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Receptor ID	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	2.1	80	68 [3]	2.6
$PM_{2.5}$	$\mu g/m^3$	1 hour	1.3	50	68 [3]	2.6
NO_2	$\mu g/m^3$	1 hour	6.4	190	105 [4]	3.4

Notes:

Concentrations rounded to two significant figures.

1 99.9th percentile (8th highest value) as required for assessment against SEPP(AQM) design criterion.
2 SEPP(AQM) design criterion.
3 Simpson Barracks
4 Carey Grammar Sports Complex

Table 41: Results: Scenario B1 - project only, discrete receptors

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Receptor ID	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	3.3	80	105 [3]	4.1

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Receptor ID	Project contribution relative to design criterion (%)
$PM_{2.5}$	$\mu g/m^3$	1 hour	2.9	50	105 [3]	5.7
NO_2	$\mu g/m^3$	1 hour	22	190	105 [3]	12
Benzene	$\mu g/m^3$	1 hour	2.7	53	105 [3]	5.0

Notes:

Concentrations rounded to two significant figures.

1 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.

2 SEPP (AQM) design criterion.

3 Carey Grammar Sports Complex

Table 42: Results: Scenario B2 - project only, discrete receptors

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Receptor ID	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	2.2	80	105 [3]	2.7
$PM_{2.5}$	$\mu g/m^3$	1 hour	1.4	50	105 [3]	2.8
NO_2	$\mu g/m^3$	1 hour	7.4	190	105 [3]	3.9

Notes:

Concentrations rounded to two significant figures.

1 99.9^{th} percentile (8^{th} highest value) as required for assessment against SEPP(AQM) design criterion.

2 SEPP(AQM) design criterion.

3 Carey Grammar Sports Complex

6.6.2 Sensitivity analyses

Results of the other sensitivity analyses [the maximum predicted (99.9th percentile) pollutant GLC] are presented in Table 43 to Table 47. Maximum predicted (99.9th percentile) results for the sensitivity analyses without time-varying background concentrations are presented in Table 48 to Table 52.

The maximum lane capacity sensitivity analysis results for the each of the discrete receptors are provided in APPENDIX B.

Table 43: Sensitivity analysis results: maximum lane capacity

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	µg/m^3	1 hour	Time-varying	200	80	331575, 5823322 [4]	0.25	200	0.31	No [8]
$PM_{2.5}$	µg/m^3	1 hour	Time-varying	75	50	331324, 5818194 [5]	1.2	74	2.3	No [8]
CO	mg/m^3	1 hour	Time-varying	2.7	29	331000, 5822997 [6]	0.17	2.5	0.58	Yes
NO_2	µg/m^3	1 hour	Time-varying	140	190	331000, 5822997 [6]	71	66	37	No
Benzene	µg/m^3	3 minute	Constant	17	53	330825, 5823122 [7]	10	7.3	19	Yes
Toluene	µg/m^3	3 minute	Constant	63	650	330825, 5823122 [7]	20	43	3.1	Yes
Ethylbenzene	µg/m^3	3 minute	Constant	12	14500	330825, 5823122 [7]	7.1	4.8	0.049	Yes
Xylene isomers	µg/m^3	3 minute	Constant	39	350	330825, 5823122 [7]	19	20	5.4	Yes
1,3-Butadiene	µg/m^3	3 minute	Constant	3.2	73	330825, 5823122 [7]	2.7	0.44	3.7	Yes
Formaldehyde	µg/m^3	3 minute	Constant	11	40	330825, 5823122 [7]	5.7	4.9	14	Yes
PAHs [as B(a)P TEQ]	µg/m^3	3 minute	Constant	0.0014	0.73	330825, 5823122 [7]	0.00089	0.00055	0.12	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period. A constant background concentration refers to one concentration used to represent background conditions (without the project).

2 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100th percentile refers to the maximum value.

3 SEPP (AQM) design criterion.

4 630 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.

5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.

6 150 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.

7 150 m west of the northern tunnel ventilation structure within residential area of Macleod.

8 See Section6.7.2.

Table 44: Sensitivity analysis results: in-tunnel air quality

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
CO	mg/m^3	1 hour	Time-varying	4.4	29	331000, 5822997 [4]	2.5	1.9	6.7	Yes
NO_2	$\mu g/m^3$	1 hour	Time-varying	130	190	330475, 5822747 [5]	13	120	6.9	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant (70^{th} percentile) background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period.
2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criteria. 100^{th} percentile refers to the maximum value.
3 SEPP (AQM) design criterion.
4 150 m south-south-east of the northern tunnel ventilation structure within Simpson Barracks.
5 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.

Table 45: Sensitivity analysis results: increased ratio of diesel to petrol cars

Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
							Project	Background		
PM_{10}	$\mu g/m^3$	1 hour	Time-varying	200	80	331550, 5823322 [4]	0.25	200	0.31	No [7]
$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331324, 5818194 [5]	0.090	74	0.18	No [7]
NO_2	$\mu g/m^3$	1 hour	Time-varying	130	190	330475, 5822747 [6]	14	120	7.5	Yes

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period.
2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100^{th} percentile refers to the maximum value.
3 SEPP (AQM) design criterion.
4 600 m east-north-east of the northern tunnel ventilation structure within Simpson Barracks.
5 990 m northeast of the southern tunnel ventilation structure within residential area of Bulleen.
6 620 m southwest of the northern tunnel ventilation structure within residential area of Macleod.
7 See Section 6.7.2.

Table 46: Sensitivity analysis results: alternative northern tunnel ventilation structure locations

Option	Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
								Project	Background		
Proposed	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331587, 5824142 [4]	0.071	74	0.14	No [9]
2	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331481, 5824230 [5]	0.073	74	0.15	No [9]
3	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331733, 5824312 [6]	0.073	74	0.15	No [9]
4	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331082, 5823429 [7]	0.086	74	0.17	No [9]
5	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331433, 5823804 [8]	0.071	74	0.14	No [9]

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period.

2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP (AQM) design criterion.

4 1170 m northeast of the proposed northern tunnel ventilation structure within residential area of Macleod.

5 1130 m northeast of the Option 2 northern tunnel ventilation structure within residential area of Macleod.

6 1300 m northeast of the Option 3 northern tunnel ventilation structure within residential area of Macleod.

7 450 m northeast of the Option 4 northern tunnel ventilation structure within Simpson Barracks.

8 910 m northeast of the Option 5 northern tunnel ventilation structure within residential area of Macleod.

9 See Section6.7.2.

Table 47: Sensitivity analysis results: alternative southern tunnel ventilation structure locations

Option	Pollutant	Units	Averaging period	Assessment background type [1]	Maximum predicted GLC [2]	Design criterion [3]	Location of predicted maximum	Contribution to maximum predicted GLC		Project contribution relative to design criterion (%)	Compliance
								Project	Background		
Proposed	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331320, 5818194 [4]	0.083	74	0.17	No [9]
2	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331208, 5818271 [5]	0.088	74	00.18	No [9]
3	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331306, 5818221 [6]	0.10	74	0.19	No [9]
4	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331312, 5818177 [7]	0.076	74	0.15	No [9]
5	$PM_{2.5}$	$\mu g/m^3$	1 hour	Time-varying	74	50	331392, 5818117 [8]	0.071	74	0.15	No [9]

Notes:

Concentrations rounded to two significant figures.

1 Hourly time-varying or constant background concentration (refer to Section 5.3). Hourly time-varying concentrations change from hour to hour over a 24-hour period.

2 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion. 100^{th} percentile refers to the maximum value.

3 SEPP (AQM) design criterion.

4 990 m northeast of the proposed southern tunnel ventilation structure within residential area of Bulleen.

5 900 m northeast of the Option 2 southern tunnel ventilation structure within residential area of Bulleen.

6 840 m northeast of the Option 3 southern tunnel ventilation structure within residential area of Bulleen.

7 1070 m northeast of the Option 4 southern tunnel ventilation structure within residential area of Bulleen.

8 1120 m northeast of the Option 5 southern tunnel ventilation structure within residential area of Bulleen.

9 See Section 6.7.2.

Table 48: Sensitivity analysis results: maximum lane capacity – project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	9.6	80	330825, 5823122 [3]	12
$PM_{2.5}$	$\mu g/m^3$	1 hour	8.4	50	330825, 5823122 [3]	17
CO	mg/m^3	1 hour	0.21	29	330825, 5823122 [3]	0.72
NO_2	$\mu g/m^3$	1 hour	75	190	330825, 5823122 [3]	39

Notes:

Concentrations rounded to two significant figures.
1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

Table 49: Sensitivity analysis results: in-tunnel air quality – project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
CO	mg/m^3	1 hour	2.2	29	330825, 5823122 [3]	7.6
NO_2	$\mu g/m^3$	1 hour	37	190	330825, 5823122 [3]	19

Notes:

Concentrations rounded to two significant figures.
1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 Carey Grammar Sports Complex.

Table 50: Sensitivity analysis results: increased ratio of diesel to petrol cars – project only

Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
PM_{10}	$\mu g/m^3$	1 hour	5.4	80	330825, 5823122 [3]	6.8
$PM_{2.5}$	$\mu g/m^3$	1 hour	4.7	50	330825, 5823122 [3]	9.4
NO_2	$\mu g/m^3$	1 hour	41	190	330825, 5823122 [3]	22

Notes:

Concentrations rounded to two significant figures.
1 99.9th percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 140 m west of the northern tunnel ventilation structure within residential area of Macleod.

Table 51: Sensitivity analysis results: alternative northern tunnel ventilation structure locations – project only

Option	Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
Proposed	$PM_{2.5}$	$\mu g/m^3$	1 hour	4.0	50	330837, 5823117 [3]	8.1
2	$PM_{2.5}$	$\mu g/m^3$	1 hour	4.0	50	330781, 5823155 [4]	8.1

Option	Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
3	$PM_{2.5}$	$\mu g/m^3$	1 hour	4.0	50	331033, 5823112 [5]	8.1
4	$PM_{2.5}$	$\mu g/m^3$	1 hour	4.0	50	330757, 5822929 [6]	8.1
5	$PM_{2.5}$	$\mu g/m^3$	1 hour	4.1	50	330833, 5823079 [7]	8.1

Notes:
Concentrations rounded to two significant figures.
1 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 130 m west of the proposed northern tunnel ventilation structure within residential area of Macleod.
4 150 m southwest of the Option 2 northern tunnel ventilation structure within residential area of Macleod.
5 130 m south-south-east of the Option 3 northern tunnel ventilation structure within Simpson Barracks.
6 140 m southwest of the Option 4 northern tunnel ventilation structure within residential area of Macleod.
7 140 m west-north-west of the Option 5 northern tunnel ventilation structure within residential area of Macleod.

Table 52: Sensitivity analysis results: alternative southern tunnel ventilation structure locations – project only

Option	Pollutant	Units	Averaging period	Maximum predicted project contribution GLC [1]	Design criterion [2]	Location of predicted maximum	Project contribution relative to design criterion (%)
Proposed	$PM_{2.5}$	$\mu g/m^3$	1 hour	3.1	50	330620, 5817469 [3]	6.3
2	$PM_{2.5}$	$\mu g/m^3$	1 hour	3.2	50	330558, 5817471 [4]	6.4
3	$PM_{2.5}$	$\mu g/m^3$	1 hour	3.2	50	330706, 5817646 [5]	6.5
4	$PM_{2.5}$	$\mu g/m^3$	1 hour	3.2	50	330587, 5817202 [6]	6.4
5	$PM_{2.5}$	$\mu g/m^3$	1 hour	3.2	50	330867, 5817267 [7]	6.4

Notes:
Concentrations rounded to two significant figures.
1 99.9^{th} percentile (8th highest value) as required for assessment against SEPP (AQM) design criterion.
2 SEPP (AQM) design criterion.
3 140 m northwest of the proposed southern tunnel ventilation structure within Carey Grammar Sports Complex.
4 140 m southwest of the Option 2 southern tunnel ventilation structure within Carey Grammar Sports Complex.
5 140 m northwest of the Option 3 southern tunnel ventilation structure within Veneto Club.
6 140 m southwest of the Option 4 southern tunnel ventilation structure within Carey Grammar Sports Complex.
7 140 m southwest of the Option 5 southern tunnel ventilation structure within Marcellin College.

6.7 Discussion

6.7.1 Design assessment

Emissions from the North East Link tunnel ventilation system were calculated for projected diurnal weekday traffic conditions in 2026 and 2036 using 2010 emission factors, adjusted to 2020 and 2025 to account for anticipated reductions in vehicle fleet emissions.

In accordance with the requirements of SEPP(AQM), modelling was conducted to predict the potential impacts of pollutant emissions from the proposed tunnel ventilation system on ground level concentrations, with the 99.9^{th} percentile maximum predicted concentrations assessed against Schedule A design criteria. EPA Victoria guidance states that modelling be conducted using five years of meteorological data (2013 to 2017), reporting the worst case year results. The year 2017 was found to predict the highest one hour average 99.9^{th} percentile GLC for a single pollutant ($PM_{2.5}$) and was therefore used for all subsequent modelling.

When available, SEPP(AQM) requires model predictions to incorporate time varying background concentration data. Time varying hourly average background concentration data were used for PM_{10}, $PM_{2.5}$, CO and NO_2. When appropriate time varying background concentration data are unavailable, SEPP(AQM) indicates that the 70th percentile of observed concentrations, as a constant value, should be incorporated. Constant background concentrations provided by EPA Victoria were used for air toxics.

Hourly PM_{10} and $PM_{2.5}$ background concentrations at the Alphington AAQMS exceed the one hour average design criteria on multiple occasions in 2017. This effectively imposes exceedances for all Scenarios assessed before the additional impact of the tunnel ventilation system is considered.

Analysis of the hourly PM_{10} concentrations showed that exceedances of the 80 micrograms per cubic metre design criterion (one hour average) occurred on eight occasions during 2017, without any contribution from the project (Figure 64).

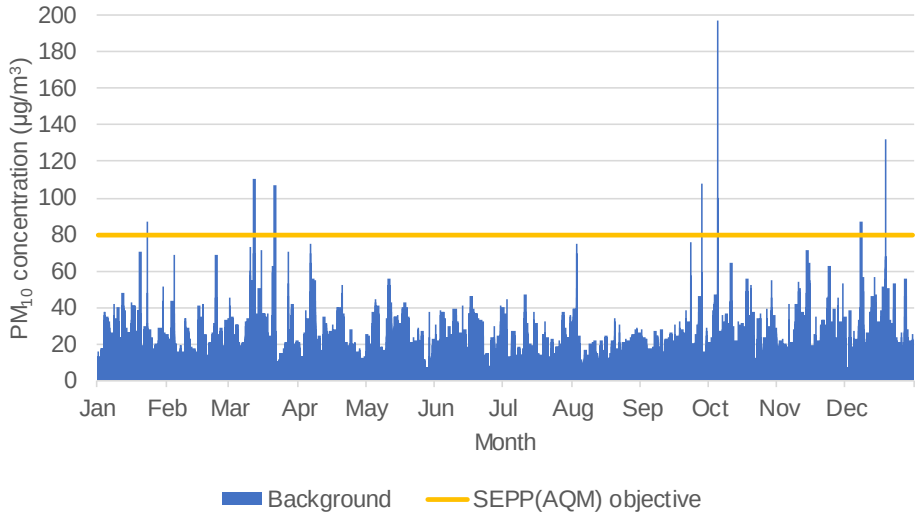


Figure 64: 2017 hourly background PM_{10} concentration

The hourly background concentrations for $PM_{2.5}$ at the Alphington AAQMS exceeded the 50 micrograms per cubic metre design criterion (one hour average) on 20 occasions during 2017 (Figure 65).

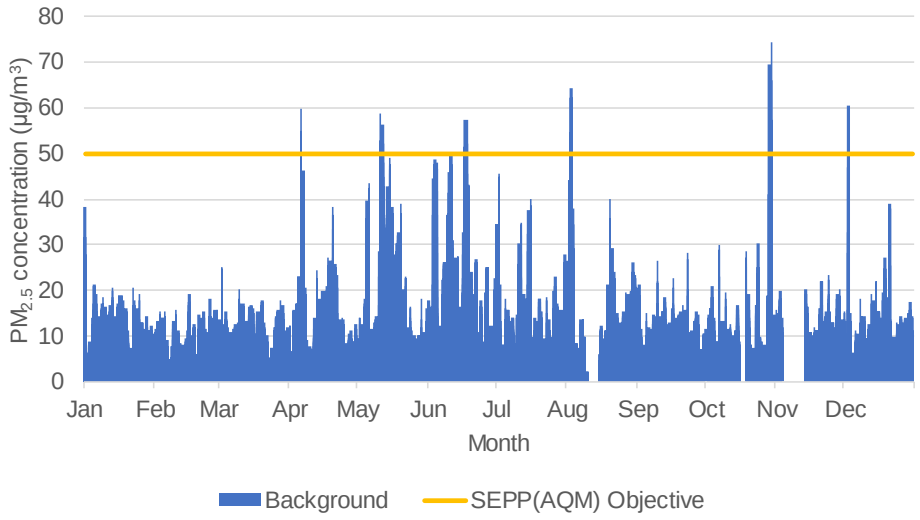


Figure 65: 2017 hourly background $PM_{2.5}$ concentration

Scenario A1 (2026 traffic; 2020 emission factors)

Tunnel ventilation system emissions result in no additional PM_{10} exceedances of the design criterion to those already imposed by the background contribution.

The air quality impact assessment indicated that, while the one hour average PM_{10} design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.087 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.22 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 600 metres east-north-east of the northern tunnel ventilation structure within the Simpson Barracks.

The maximum predicted project contribution to the PM_{10} GLC (no background) is 4.2 micrograms per cubic metre, or 5.3 per cent of the design criterion, approximately 145 metres south of the northern tunnel ventilation structure within the Simpson Barracks.

Tunnel ventilation system emissions result in one additional $PM_{2.5}$ exceedance, with a project contribution less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that, while the one hour average $PM_{2.5}$ design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.084 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.13 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 990 metres northeast of the southern tunnel ventilation structure within a Bulleen residential area.

The maximum predicted project contribution to the $PM_{2.5}$ GLC (no background) is 3.6 micrograms per cubic metre, or 7.2 per cent of the design criterion, approximately 145 metres south of the northern tunnel ventilation structure within the Simpson Barracks.

The maximum predicted project contributions for PM_{10} and $PM_{2.5}$ each represent the eighth worst hour of the year (rank 8 of 8,290 hours data for 2017) at the most impacted receptor. It is noted that during all other hours, all receptors are less impacted than this. Figure 66 presents the next 1,000 highest PM_{10} and $PM_{2.5}$ results, each representing the concentrations predicted at the most impacted receptor for that hour. Figure 66

illustrates that for most of the time the predicted PM_{10} and $PM_{2.5}$ impacts are significantly below the maximum results of 4.2 and 3.6 micrograms per cubic metre respectively.

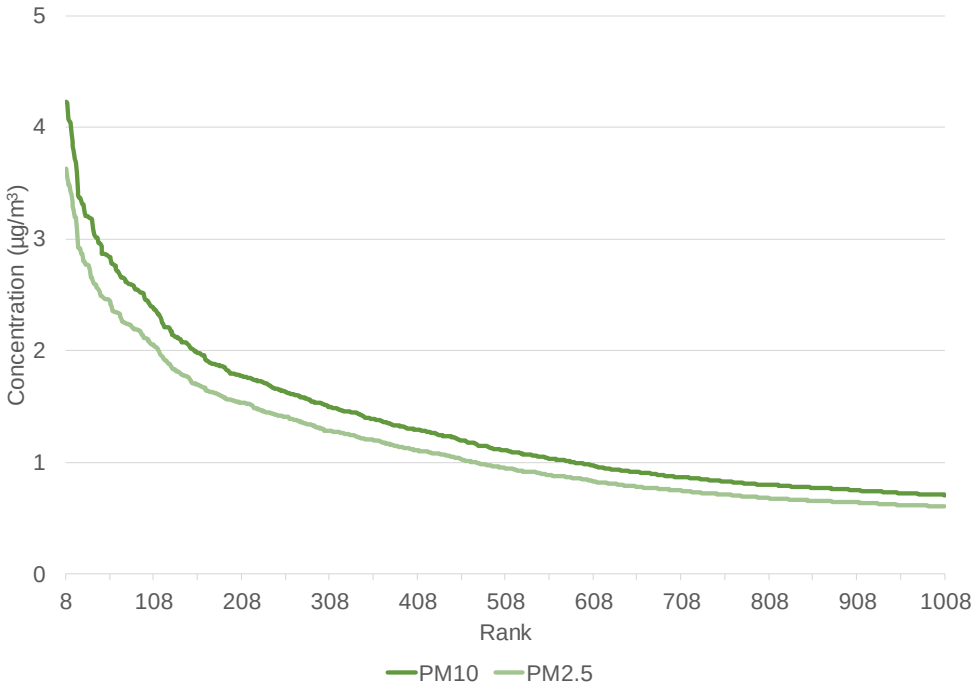


Figure 66: Scenario A1 PM_{10} and $PM_{2.5}$ 1,000 highest results

Predicted CO, NO_2, BTEX, 1,3-butadiene, formaldehyde and PAH [as B(a)P TEQ] concentrations comply with the applicable design criteria in 2026.

The most impacted discrete receptor was the same for each of the pollutants assessed with a maximum NO_2 project contribution equal to 10 per cent of the criterion (20 micrograms per cubic metre) at Carey Grammar Sports Complex (Receptor ID 105).

Scenario A2 (2026 traffic; 2025 emission factors)

Tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion to those already imposed by the background contribution.

The air quality impact assessment indicated that while the one hour average PM_{10} design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.065 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.16 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 600 metres east-north-east of the northern tunnel ventilation structure within the Simpson Barracks.

The maximum predicted project contribution to the PM_{10} GLC (no background) is 3.2 micrograms per cubic metre, or 4.0 per cent of the design criterion, approximately 145 metres south of the northern tunnel ventilation structure within the Simpson Barracks.

Tunnel ventilation system emissions result in one additional $PM_{2.5}$ exceedance, with a project contribution of less than 0.3 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that, while the one hour average $PM_{2.5}$ design criterion was exceeded in 2026, the tunnel ventilation system emissions only contributed 0.037 per cent of the predicted 99.9th percentile GLC,

which is equivalent to 0.055 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 990 metres northeast of the southern tunnel ventilation structure within a Bulleen residential area.

The maximum predicted project contribution to the $PM_{2.5}$ GLC (no background) is 2.0 micrograms per cubic metre, or 4.0 per cent of the design criterion, approximately 145 metres south of the northern tunnel ventilation structure, within the Simpson Barracks.

Figure 67 presents the rank 8 to rank 1008 PM_{10} and $PM_{2.5}$ concentrations predicted at the most impacted receptor for that hour and illustrates that for most of the time the predicted PM_{10} and $PM_{2.5}$ impacts are significantly below the maximum results of 3.2 and 2.0 micrograms per cubic metre respectively.

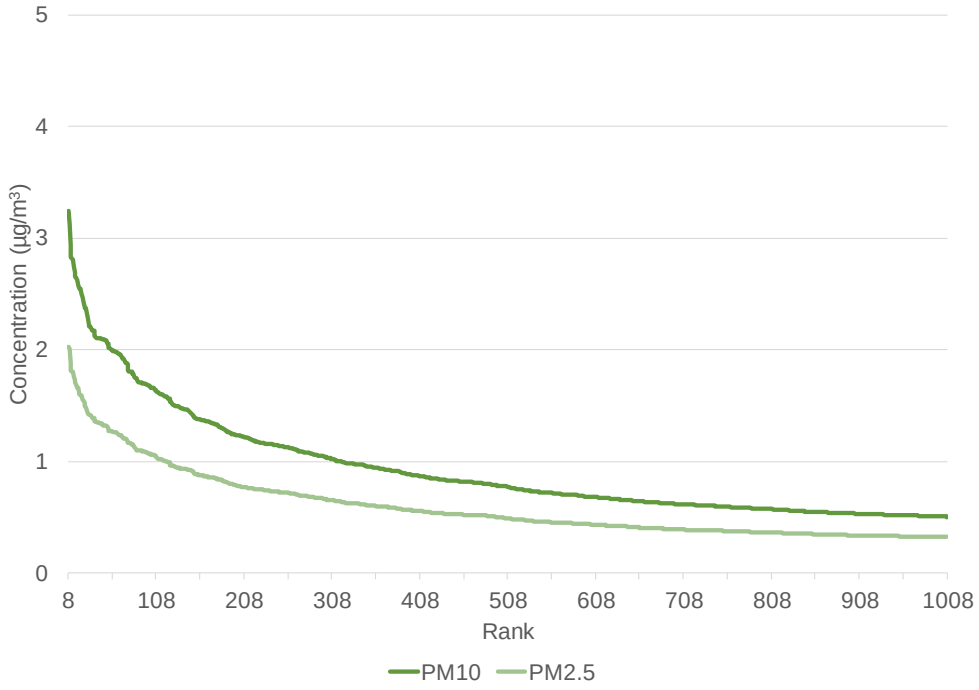


Figure 67: Scenario A2 PM_{10} and $PM_{2.5}$ 1,000 highest results

Predicted NO_2 concentrations comply with the applicable design criteria in 2026.

The most impacted discrete receptor for PM_{10} and $PM_{2.5}$ was the Simpson Barracks (Receptor 68) with maximum project contributions equal to 2.6 per cent of the criteria (2.1 and 1.3 micrograms per cubic metre) respectively. The most impacted discrete receptor for NO_2 was Carey Grammar Sports Complex (Receptor ID 105) with a maximum project contribution equal to 3.4 per cent of the criterion (6.4 micrograms per cubic metre).

Scenario B1 (2036 traffic; 2020 vehicle emission factors)

Tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion to those already imposed by the background contribution.

The assessment indicated that, while the one hour average PM_{10} design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.11 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.27 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 600 metres east-north-east of the northern tunnel ventilation structure within the Simpson Barracks.

The maximum predicted project contribution to the PM_{10} GLC (no background) is 4.8 micrograms per cubic metre, or 6.0 per cent of the design criterion, approximately 140 metres west of the northern tunnel ventilation structure within the Simpson Barracks.

Tunnel ventilation system emissions result in one additional exceedance of the $PM_{2.5}$ design criterion with a project contribution of less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that, while the one hour average $PM_{2.5}$ design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.11 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.17 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 990 metres northeast of the southern tunnel ventilation structure within a Bulleen residential area.

The maximum predicted project contribution to the $PM_{2.5}$ GLC (no background) is 4.1 micrograms per cubic metre, or 8.2 per cent of the design criterion, approximately 140 metres west of the northern tunnel ventilation structure within the residential area of Macleod.

Figure 68 presents the rank 8 to rank 1008 PM_{10} and $PM_{2.5}$ concentrations predicted at the most impacted receptor for that hour and illustrates that for most of the time the predicted PM_{10} and $PM_{2.5}$ impacts are significantly below the maximum results of 4.8 and 4.1 micrograms per cubic metre respectively.

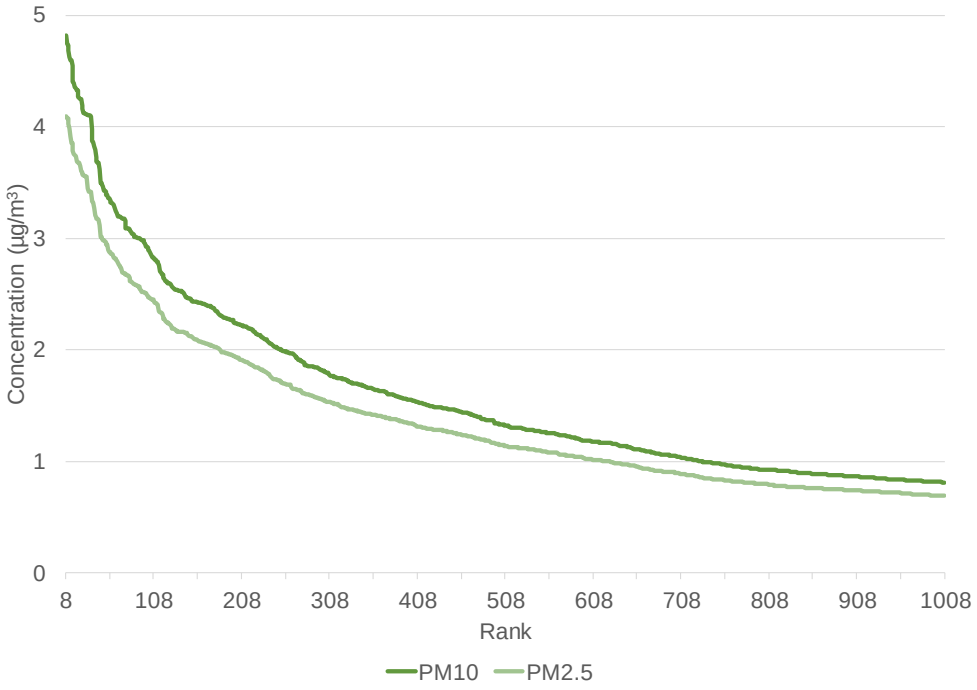


Figure 68: Scenario B1 PM_{10} and $PM_{2.5}$ 1,000 highest results

Predicted CO, NO_2, BTEX, 1,3-butadiene, formaldehyde and PAH [as B(a)P TEQ] concentrations comply with the applicable design criteria in 2036.

The most impacted discrete receptor was the same for each of the pollutants assessed, with a maximum NO_2 project contribution equal to 12 per cent of the criterion (22 micrograms per cubic metre) at Carey Grammar Sports Complex (Receptor ID 105).

Scenario B2 (2036 traffic; 2025 vehicle emission factors)

Tunnel ventilation system emissions result in no additional exceedances of the PM_{10} design criterion to those already imposed by the background contribution.

The assessment indicated that, while the one hour average PM_{10} design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.081 per cent of the predicted 99.9th percentile GLC, which is equivalent to 0.20 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 600 metres east-north-east of the northern tunnel ventilation structure within the Simpson Barracks.

The maximum predicted project contribution to the PM_{10} GLC (no background) is 3.4 micrograms per cubic metre, or 4.2 per cent of the design criterion, approximately 145 metres south of the northern tunnel ventilation structure within the Simpson Barracks.

Project tunnel ventilation system emissions result in one additional exceedance of the $PM_{2.5}$ design criterion, with a project contribution of less than 0.4 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

The assessment indicated that, while the one hour average $PM_{2.5}$ design criterion was exceeded in 2036, the tunnel ventilation system emissions only contributed 0.049 per cent of the predicted 99.9th percentile $PM_{2.5}$ GLC, which is equivalent to 0.073 per cent of the design criterion. This exceedance applies to all receptors assessed due to the elevated background concentration, with the maximum predicted GLC 990 metres northeast of the southern tunnel ventilation structure within a Bulleen residential area.

The maximum predicted project contribution to the $PM_{2.5}$ GLC (no background) is 2.2 micrograms per cubic metre, or 4.4 per cent of the design criterion, approximately 140 metres west of the northern tunnel ventilation structure within a Macleod residential area.

Figure 69 presents the rank 8 to rank 1008 PM_{10} and $PM_{2.5}$ concentrations predicted at the most impacted receptor for that hour and illustrates that for most of the time the predicted PM_{10} and $PM_{2.5}$ impacts are significantly below the maximum results of 3.4 and 2.2 micrograms per cubic metre respectively.

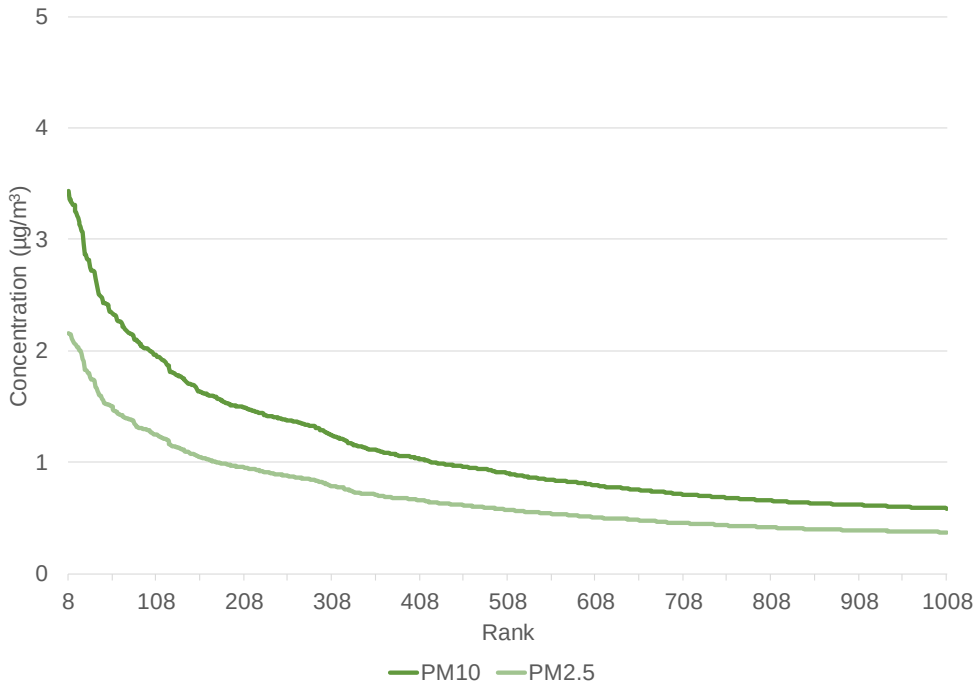


Figure 69: Scenario B2 PM_{10} and $PM_{2.5}$ 1,000 highest results

The most impacted discrete receptor was the same for each of the three pollutants assessed, with a maximum NO_2 project contribution equal to 3.9 per cent of the criterion (7.4 micrograms per cubic metre) at Carey Grammar Sports Complex (Receptor ID 105).

Summary

In summary, with the exception of PM_{10} and $PM_{2.5}$, compliance with all applicable SEPP(AQM) design criteria was demonstrated for the proposed North East Link tunnel ventilation system under normal operating conditions. The PM_{10} and $PM_{2.5}$ exceedances were due to the high background concentrations.

In their assessment report for the West Gate Tunnel project, EPA Victoria (EPA Victoria, 2017) noted that '*the proposed ventilation stacks meet the criteria for all air pollutants under the Policy, except for PM_{10} emissions, where the prevailing hourly PM_{10} background levels (the design criterion) are exceeded by the predicted cumulative PM_{10} levels'.* The '*exceedance is not considered to conflict with the intent of the Policy'*, primarily due to the small contribution that emissions from the tunnel ventilation system made to the predicted concentrations. Consistent with the West Gate Tunnel ventilation system air quality impact assessment, the primary contributors to the exceedances associated with the North East Link tunnel ventilation system are the PM_{10} and $PM_{2.5}$ background concentrations. The exceedances of PM_{10} and $PM_{2.5}$ criteria are consequently not considered to conflict with the intent of the SEPP(AQM).

The sensitivity analysis provided in Scenarios A2 and B2 (2025 emission rates) provides some context as to the conservatism of the 2020 emission rates used in Scenarios A1 and B1.

The project contributions to the Scenario A2 99.9th percentile PM_{10}, $PM_{2.5}$ and NO_2 GLCs were found to decrease by approximately 26 per cent, 56 per cent and 68 per cent respectively, compared with the Scenario A1 predictions. Overall this resulted in a decrease to the resultant maximum predicted (99.9th percentile) PM_{10}, $PM_{2.5}$ and NO_2 GLCs of approximately 0.044, 0.035 and 7.3 micrograms per cubic metre, or 0.022 per cent, 0.048 per cent and 5.7 per cent. That is, due to the background contribution, the reduction in the maximum predicted (99.9th percentile) GLCs is minimal. The corresponding decreases in the maximum predicted project

contribution GLCs (no background) are 1.0, 1.6 and 19 micrograms per cubic metre for PM_{10}, $PM_{2.5}$ and NO_2 respectively.

The project contributions to the Scenario B2 99.9th percentile PM_{10}, $PM_{2.5}$ and NO_2 GLCs were found to decrease by approximately 25 per cent, 56 per cent and 68 per cent respectively, compared with the Scenario B1 predictions. Overall this resulted in a decrease to the resultant maximum predicted (99.9th percentile) PM_{10}, $PM_{2.5}$ and NO_2 GLCs of approximately 0.054, 0.046 and 7.3 micrograms per cubic metre, or 0.027 per cent, 0.062 per cent and 5.7 per cent. As with the Scenario A1 and A2 comparison, due to the background contribution, the reduction in the maximum predicted (99.9th percentile) GLCs is minimal. The corresponding decreases in the maximum predicted project contribution GLCs (no background) are 1.4, 1.9 and 23 micrograms per cubic metre for PM_{10}, $PM_{2.5}$ and NO_2 respectively.

6.7.2 Sensitivity analyses

Maximum tunnel capacity (2036; 2020 emission factors)

Again, the hourly PM_{10} and $PM_{2.5}$ background concentrations exceed the design criteria on several occasions effectively imposing exceedances before the additional impact of the tunnel ventilation system is considered.

Project tunnel ventilation system emissions result in no additional PM_{10} exceedances.

Project tunnel ventilation system emissions result in additional 16 $PM_{2.5}$ exceedances, with project contributions of 2.1 to 8.3 micrograms per cubic metre and corresponding background concentrations of 42.4 to 49.8 micrograms per cubic metre.

The tunnel ventilation system emissions contributed 0.12 per cent of the predicted 99.9th percentile PM_{10} GLC, equal to 0.31 per cent of the design criterion, and 1.5 per cent of the predicted 99.9th percentile $PM_{2.5}$ GLC, equal to 2.3 per cent of the design criterion.

The maximum predicted project contribution to the PM_{10} and $PM_{2.5}$ GLCs (no background) is 9.6 micrograms per cubic metre, or 12 per cent of the design criterion, and 8.4 micrograms per cubic metre, or 17 per cent of the design criterion respectively, both approximately 140 metres west of the northern tunnel ventilation structure within the Simpson Barracks.

Predicted CO, NO_2, BTEX, 1,3-butadiene, formaldehyde and PAH [as B(a)P TEQ] concentrations comply with the applicable design criteria for maximum lane capacity conditions (24 hours a day and 365 days per year) in 2036.

Emissions at in-tunnel air quality limits (2036; 2020 emission factors)

A theoretical worst-case traffic scenario was modelled for 2036, with tunnel ventilation system emission rates based on pollutant concentrations equal to in-tunnel air quality limits. Modelling indicated compliance with both the CO and NO_2 SEPP(AQM) design criteria.

Although maximum ventilation rates were assumed, the contribution from the project relative to the design criteria (6.7 per cent and 6.9 per cent for CO and NO_2 respectively) indicates that a lower ventilation rate would also achieve compliance.

Increased diesel to petrol fuelled cars ratio (2036; 2020 emission factors)

Due to the uncertainty regarding the future proportion of diesel and petrol fuelled passenger cars, a scenario incorporating a conservative doubling of the proportion of diesel cars from 15 per cent of all cars to 30 per cent of all cars in 2036 was modelled. This focused on the primary pollutants associated with diesel fuel combustion, PM_{10}, $PM_{2.5}$ and NO_2.

The project contributions to the maximum predicted one hour average PM_{10} and $PM_{2.5}$ GLCs were found to increase by approximately 15 per cent and 8.5 per cent respectively compared with the Scenario B1 predictions. Overall, this resulted in an increase to the resultant maximum predicted (99.9th percentile) GLCs of approximately 0.032 and 0.0070 micrograms per cubic metre for PM_{10} and $PM_{2.5}$ respectively.

The project contribution to the maximum predicted one hour average NO_2 GLC increased by approximately 32 per cent (3.4 micrograms per cubic metre), again compared with Scenario B1 prediction.

Alternative tunnel ventilation structure locations (2036; 2020 emission factor)

Four alternative locations were modelled for both the north and south tunnel ventilation structures to assess the sensitivity of the compliance assessment to the location within potential construction footprints. The northern and southern tunnel ventilation structures were assessed separately.

As discussed above, $PM_{2.5}$ background concentrations exceed the design criteria on several occasions effectively imposing exceedances before the additional impacts of the tunnel ventilation system were considered. The assessment of the proposed and alternative northern tunnel ventilation structure locations indicates that each results in one additional exceedance of the $PM_{2.5}$ design criterion. The assessment of the alternative southern tunnel ventilation structure locations also indicates that each results in one additional exceedance of the $PM_{2.5}$ design criterion.

With the exception of Option 4, the maximum predicted GLCs for each of the northern tunnel ventilation structure locations are approximately one kilometre to the northeast of the tunnel ventilation structure within a Macleod residential area. The maximum predicted GLC for Option 4 is less than 500 metres to the northeast within the Simpson Barracks. The ground elevation at this location is approximately 20 metres higher than at the Option 4 tunnel ventilation structure. The results indicate that the plume is impacting in this area due to the increased elevation. The location of the other options is such that the plume clears this rise in terrain (Proposed, Option 2 and Option 3) or passes to the side of it (Option 5).

The maximum predicted project contributions to the $PM_{2.5}$ GLC (no background) for the northern and southern tunnel ventilation structure options differ by less than 1.0 per cent and 3.0 per cent respectively. The distances from each of the tunnel ventilation structure options at which the maxima occur are similar, however, due to the near calm, night time stable conditions for the hours at which the maxima occur, the direction from the tunnel ventilation structure varies.

Overlayed 100th percentile incremental GLC (without background) isopleth plots for the tunnel ventilation structure options are provided in APPENDIX C. These plots (one for the north and one for the south) consist of the maximum result for each of the five options at each modelled grid point.

Summary

The additional sensitivity analyses demonstrated that, while the project contribution to the maximum predicted GLC could increase significantly (up to 100 per cent in the case of NO_2 for a doubling in the proportion of diesel cars), due to the relatively low project contribution, there was relatively little change in the maximum predicted GLCs (project plus background).

It should be emphasised that a number of the sensitivity analyses represent unrealistic scenarios that have not occurred in any Australian road tunnel and are highly unlikely to occur in the future. In particular, while traffic at maximum tunnel capacity can occur during peak periods, the volume of vehicles used in the modelling assessment is extremely conservative and the maximum capacity conditions would not occur constantly, as assumed in the sensitivity analysis.

Alternative locations for the tunnel ventilation structures had a negligible effect on the maximum predicted $PM_{2.5}$ GLCs, only changing the locations at which the maxima would occur.

7.0 BEST PRACTICE

As noted in Section 2.2.3 SEPP(AQM) Clause 19 requires the application of best practice to the management of new air emission sources. Consequently, the North East Link tunnel ventilation system would require the application of best practice in managing emissions to air.

For Class 3 indicators (such as benzene, 1,3 butadiene and PAHs), emissions would need to be reduced to the Maximum Extent Achievable (MEA). MEA is defined in the SEPP(AQM) as:

'*a degree of reduction in the emission of wastes from a particular source that uses the most effective, practicable means to minimise the risk to human health from those emissions and is at least equivalent to or greater than that which can be achieved through the application of best practice*'.

Best practice management of air emissions released from vehicles in tunnels requires consideration of factors which include:

- design of the tunnel ventilation structures
- the receiving environment into which emissions from the tunnel ventilation structures are discharged
- the potential impact of emissions on the receiving environment
- air pollution control technology options and efficacy, together with capital and operating costs
- whether other sources of pollution in the local environment can achieve greater pollutant reduction at a lower cost.

EPA Victoria's '*Demonstrating Best Practice*' (2013) provides a methodology to demonstrate best practice, as well as guidelines on the requirements for a Works Approval Application (WAA).

Best practice for air quality management of emissions from the tunnel ventilation system principally relates to whether or not air pollution control technology should be installed on the North East Link tunnel ventilation structures.

Emissions from the tunnel ventilation system were assessed using the AERMOD plume dispersion model, based on forecast traffic conditions for the years 2026 and 2036 and five years of meteorological data (2013 to 2017).

The outcomes of the tunnel ventilation system air dispersion modelling assessment suggest that pollution control technology would not be required. The design of the tunnel ventilation structures, including their location, discharge height and efflux velocities are aimed at minimising the impact of pollutant emissions. Further discussion of potential pollution control technology is provided in the following sections.

7.1 Air pollution control equipment

Air pollution control equipment has been installed in road tunnels in several countries, including Norway, Japan, Austria, Italy, Spain and Australia (Sydney's M5 East Motorway tunnel trial).

The main types of control equipment utilised to remove pollutants from road tunnel air include:

- electrostatic precipitators (ESP) that remove particles
- absorption and adsorption ($DeNO_x$ filtration) technologies that remove NO and NO_2.

Pollution control equipment is installed for the purposes of either treating in-tunnel air to improve air quality (principally visibility) for tunnel users, or prior to discharge to atmosphere to improve ambient air quality in the vicinity of the tunnel ventilation structures. There are approximately 60 ESPs installed in tunnels worldwide,

three quarters of which are located in Japan and eight in Norway. The treatment of nitrogen oxides is much less common, with control technology installed in only five tunnels worldwide.

While the operational performance and efficacy of these control technologies has been demonstrated in the control of industrial source emissions, where pollutant concentrations are orders of magnitude higher than in road tunnels, limited information is available on their performance in road tunnel applications. The available evidence suggests, however, that their efficacy is less than expected when applied to the removal of the low concentrations of pollutants in road tunnels.

The removal efficiencies of particulate matter (PM) using ESPs depends on factors such as air speeds, particle size, particle concentration and the composition of the waste gas stream. PM removal efficiencies for ESPs installed in road tunnels are of the order of 70 per cent (EPA 2006) which is low in comparison with up to 99.9 per cent for ESPs in industrial applications.

There are several reasons for this, including:

- ESPs operate more efficiently when PM concentrations are high. This is not the case for road tunnels where PM concentrations are low due to the high ventilation rates used to maintain in-tunnel air quality for human health and visibility reasons
- ESPs are more efficient at removing larger particles than smaller particles. A large proportion of particulate matter generated from vehicular emissions is small (less than 2.5 microns).

ESP technology is considered most appropriate for situations where PM is high relative to gaseous emissions (NHMRC 2008), or where an increased supply of fresh air is unavailable or particularly expensive to provide.

In considering whether best practice comprises the use of ESPs to achieve ambient air quality objectives for the project, a removal efficiency of 70 per cent is not expected to achieve significant benefits (including health, environmental and cost) by reducing ground level particulate matter concentrations, due to the predicted small contributions the tunnel ventilation structures make to background PM_{10} and $PM_{2.5}$ concentrations. Furthermore, consideration should be given to energy costs associated with ESP operation and the costs for waste treatment and disposal.

De-nitrification ($DeNO_x$) technology is primarily used for the removal of nitrogen dioxide (NO_2), with prior removal of PM needed to enhance removal efficiency. The filter system consists of a framework supporting a number of filter modules and a fan to draw air through the modules. Each module comprises a wire basket containing carbon as the filter medium.

Only limited data on the performance of this technology is available. The most recent information is for a $DeNO_x$ system installed on the M5 East tunnel in Sydney on a trial basis. The trial outcomes indicated a lower than expected NO_2 removal efficiency.

Sections 7.1.1 to 7.1.5 provide a review of air pollution control technology installed in road tunnels throughout the world.

7.1.1 Japan

Japan has the largest number of ESPs installed in road tunnels worldwide, the majority of which are used to maintain in-tunnel visibility.

In more recent times, ESPs have been used on at least seven road tunnels to comply with ambient air quality objectives, particularly for areas with poor air quality.

Operation of ESPs in Japan is on an as-needs-basis, as determined by air quality monitoring. Available information indicates that operating hours vary. As an example, the Tokyo Bay ‘Aqualine’ tunnel records only

12 to13 hours of operation per year (CETU 2010). In the case of the Kan'etsu tunnel, the filtration system operates on average 143 hours per month at the northern portal and 40 hours per month at the southern portal.

Data demonstrating the effectiveness of ESPs in improving ambient air quality in Japan is not available.

In Tokyo, the Central Circular Shinjuku tunnel is 10 kilometres in length, with nine tunnel ventilation structures located in a highly urbanised area with poor ambient air quality. The tunnel has been fitted with at least two types of NO_x removal systems using the absorption method. The systems are combined with ESPs enabling greater NO_x removal efficiencies. Information about the performance of this filtration system is again unavailable.

7.1.2 Norway

Of the eight road tunnels in Norway fitted with ESP technology, the majority were installed to maintain adequate in-tunnel visibility, caused by high particulate matter concentrations resulting from the use of metal studded snow/ice tyres in winter.

The Laerdal tunnel, due to its length (over 22 kilometres) and depth (under a mountain), required ESP technology and a $DeNO_x$ removal system to maintain both in-tunnel air quality and visibility, primarily in winter, due to a lack of available fresh air. Neither system is currently being used.

Only one tunnel in Norway (Festning tunnel) was designed to improve ambient air quality, although the ESP system is no longer used.

Overall, the majority of tunnels fitted with ESPs in Norway are infrequently used and only on an as-needs-basis. They are switched on when visibility is expected to be poor or during high levels of traffic.

7.1.3 Other locations worldwide

ESPs have been installed in tunnels in Korea and Vietnam for the purposes of maintaining visibility. These tunnels are located in mountainous regions where construction of tunnel ventilation structures or fresh air inlets is impractical. ESPs maintain air quality and in-tunnel visibility in locations where fresh air dilution is not practical. No information on the efficacy of these ESPs is available.

In Italy, a refined ESP technology was installed in a tunnel in Cesena (south of Bologna) in 2006. Features of this technology include a novel electrostatic charged filter type technology and low power consumption, with the potential to be coupled to NO_x removal technologies. To date no information on its effectiveness is available.

7.1.4 Australia

A. M5 East Tunnel trial, Sydney

The most comprehensive study to date on the effectiveness of air pollution control equipment installed in tunnel ventilation structures was conducted for the M5 East tunnel in Sydney.

From March 2010 to September 2011, the Sydney M5 East tunnel trialled an ESP and a $DeNO_x$ system. The principal purpose of the trial was to reduce haze caused by particles.

In 2011, The Commonwealth Scientific and Industrial Research Organisation (CSIRO) was commissioned by the Roads and Transport Authority (RTA) to evaluate the removal efficiencies of the ESP and $DeNO_x$ systems. The findings of the study concluded that the removal efficiencies of $PM_{2.5}$, PM_{10} and NO_2 were 69 per cent, 70 per cent and 55 per cent respectively (CSIRO 2011a; CSIRO 2011b).

AMOG (AMOG 2012) conducted a review of the M5 East tunnel air pollution control system operational performance in February 2012.

AMOG concluded that for the ESP:

- approximately 65 per cent of PM_{10} was captured, much lower than the target 80 per cent efficiency
- modifications, including expansion of the collector plate area or decreased air flow, may increase the system effectiveness
- the system was unreliable, with an availability of only 84 per cent in comparison with the design value of 99.5 per cent.

For the $DeNO_x$ system:

- approximately 55 per cent of NO_2 was removed which was lower than expected
- NO_2 was being converted to NO and released to the atmosphere rather than being captured by the filter
- the filter only processed 14 per cent of the air flow in the westbound tunnel and consequently could not have a large impact on in-tunnel NO_2 levels
- using activated carbon to reduce NO_2 in the tunnel only slightly reduced total NO_x emissions from the tunnel ventilation structure.

The report concluded that the air pollution control system should cease operation in its current form and that alternative methods for effectively removing particulate matter and NO_2 should be investigated.

Trial costs

The cost of installing and operating the air pollution control technology was evaluated as part of the AMOG (AMOG 2012) operational performance review of the M5 East tunnel trial. Cost estimates were presented per tonne of pollutant removed, with and without capital costs.

The cost to remove PM_{10} was calculated at:

- $17 million per tonne including operating costs and capital costs amortised over 20 years
- $3.8 million per tonne for operating costs only.

The cost of NO_2 removal was calculated at:

- $4 million per tonne including operating costs and capital costs amortised over 20 years
- $874,000 per tonne for operating costs only.

By comparison, the estimated cost of removing particulate matter using filters fitted to vehicle exhausts ranged from $150,000 per tonne to $300,000 per tonne. This indicates that the cost of ESP and $DeNO_x$ control technology is very high.

Comparative costs

In 2012, the then New South Wales Department of Environment Climate Change and Water (DECCW) commissioned Sinclair Knight Merz (SKM 2010) to identify and analyse a range of pollutant abatement initiatives. The study identified 12 initiatives in the Sydney region, with costs of PM_{10} reduction ranging from $1,000 to $274,000 per tonne. This information is presented below along with the estimated M5 East tunnel filtration costs for comparative purposes.

Table 53: Cost of PM_{10} reduction measures

PM_{10} reduction measure	Cost of PM_{10} reduction ($ per tonne)	PM_{10} reduction (tonnes per annum)
National emission standards for wood heater (1 g/kg limit)	1,000	1,701
National emission standards for wood heater (3 g/kg limit)	1,000	45
Emission limits for industry	5,000	359
Tier 4 emission standards for off-road vehicles and equipment	12,000	31
Wood heater – reduced moisture content of firewood	20,000	93
Small engines (2-stroke to 4-stroke) for recreational boating and lawn mowing	39,000	261
Truck and bus diesel retrofit program	151,000	1
Diesel locomotive replacement (USEPA Tier 0 to Tier 2)	156,000	53
Diesel locomotive replacement (USEPA Tier 0 to Tier 2 + Retrofit Tier 2 Locomotives with selective catalytic reduction)	191,000	72
Euro 5/6 emission standards for new passenger vehicles	209,000	131
Recommission and electrification of Enfield Port Botany freight line	244,000	3
Port Botany shore-side power	274,000	11
M5 East tunnel ESP (operating cost only)	**3,800,000**	**0.2**
M5 East tunnel ESP	**17,400,000**	**0.2**

Table 53 indicates that the operating cost alone for the M5 East tunnel ESP is significantly greater than the cost of implementing emission standards for wood heaters, replacing diesel locomotives and providing shore-side power at Port Botany.

Health benefits

The NSW Environment Protection Authority (NSW EPA) engaged PAE Holmes to develop a valuation methodology to account for the health impacts associated with a reduction in particulate matter emissions. The study estimated the health benefit of removing one tonne of $PM_{2.5}$ to be valued at $280,000. As the majority of particulate matter removed in the M5 East ESP trial comprised $PM_{2.5}$, its operating costs were more than 10 times higher than the estimated health benefit. Furthermore, all the pollution reduction initiatives presented in Table 53 cost less than one tenth of the M5 East ESP system, with the potential for removing significantly more particulate matter.

B. East West Link project, Melbourne

The East West Link project (now cancelled) comprised an 18 kilometre tollway to connect the Eastern Freeway at Clifton Hill with the Western Ring Road at Sunshine West. The first stage included twin 4.4 kilometre three lane tunnels from Hoddle Street, Clifton Hill to CityLink at Parkville. The tunnel component of the project was subject to an EPA Victoria Works Approval, granted with conditions in June 2014.

During the WAA process, EPA Victoria (2014a) reviewed the requirement for treating tunnel air emissions and considered that:

- "*The combination of good tunnel air quality and high exhaust gas volume makes the use of air pollution control technology unnecessary, as demonstrated by the M5 East tunnel experience in Sydney. The relatively small gain in air quality impact is not justified by the cost, which needs to be considered as a part of best practice as prescribed in SEPP(AQM) under 7(1)(c) which states 'the measures adopted should be cost-effective and in proportion to the significance of the environmental problems being addressed.*
- *The need to use air pollution control equipment to maintain in-tunnel visibility is more applicable in colder climates e.g. Norway, Japan. However, this is not considered a requirement where good in-tunnel visibility will be maintained as a function of tunnel length and design of the ventilation system including access to outside air.*
- *The need to use air pollution control technology to protect air quality in areas around the tunnel ventilation stacks, does not exist for this project.*
- *Tunnel ventilation system can achieve adequate dispersion of emissions during normal operation ensuring all emissions are discharged from the ventilation stacks and not from the tunnel portals.*
- *For Class 3 indicators, it is not feasible to use emission control technology to remove these from the discharge stacks. The most effective way is to remove them at source through improvements in fuel quality and motor vehicle technology. The improved emission quality associated with the introduction of tighter fuel quality requirements and Euro vehicle emission standards is considered to represent MEA for Class 3 indicators*".

EPA Victoria concluded that the Reference Project for the East West Link, which did not include air pollution control technology, constituted best practice air emission management and that Class 3 indicators had been reduced to the MEA, in accordance with SEPP(AQM) requirements.

C. CityLink and East Link, Melbourne

In its submission on the East West Link Comprehensive Impact Statement, EPA Victoria (2014b), stated that:

"as part of its assessment EPA has reviewed the need to filter emissions before leaving the vent stack. In previous tunnel ventilation system approvals (CityLink and East Link) filters were not required as the fans direct air flow through the tunnels to provide a safe in-tunnel air quality and dilute the emissions to a point where filters would not provide a significant benefit to air quality".

To date no permanent air pollution control equipment has been installed in Australian road tunnels to control vehicle emissions to air.

7.1.5 Summary

Based on the information presented, air pollution control technology cannot be considered best practice for the North East Link tunnel ventilation structures on the basis of health, environmental or cost considerations.

The tunnel ventilation structures have been optimised to ensure that air quality impacts on the receiving environment are minimised.

The French Government conducted an international assessment of the treatment of air in road tunnels (CETU 2010) and concluded that systems incorporating control equipment are 'still bulky and less cost effective than conventional systems, both in terms of investment and operation. Generally speaking these systems are also energy-intensive given the surplus ventilation requirements'. The report also indicated that very few air filtration systems used in tunnels are routinely operated.

The NHMRC report (NHMRC 2008) on air quality in tunnels states that the ‘most effective way to manage air quality both in and around tunnels is through vehicle fleet emission reductions’. Furthermore, the New Zealand Transport Agency (NZ Transport Agency 2013) states that the available evidence to date suggests that the effectiveness of pollution control technology for removing emissions from vehicles in tunnels is questionable. Current technologies are pollutant specific, only address local and not regional road transport related air pollution, generate chemical waste and have significant capital and operating costs.

Evidence to date indicates there are more cost-effective mechanisms for reducing air pollution in metropolitan Melbourne with the potential for greater health benefits (such as reducing the use of wood heaters). In addition, introducing and enforcing more stringent fuel standards and adopting new vehicle technology through State and Commonwealth legislation are more practicable measures for controlling pollutant emissions from vehicles. These measures would have a flow on effect through the reduction of pollutant emissions from the North East Link tunnel ventilation structures.

8.0 CONCLUSIONS

Air dispersion modelling of pollutant emissions from the North East Link tunnel ventilation system was conducted using AERMOD, in accordance with SEPP(AQM) Schedule C, to predict ground level concentrations. Dispersal of the following emitted pollutants was predicted; PM_{10}, $PM_{2.5}$, NO_2, CO, BTEX, 1,3 butadiene, formaldehyde and PAH using meteorology for the years 2013 to 2017, with the effect of topography in the modelling domain considered.

For each pollutant, the following model scenarios were assessed:

- Scenarios A1 and A2 – Projected traffic volume and fleet mix (normal operation) for 2026
- Scenarios B1 and B2 – Projected traffic volume and fleet mix (normal operations) for 2036

Scenarios A1 and B1 were modelled based on the 2010 COPERT factors adjusted by World Road Association (PIARC) factors that account for the future year 2020 and road gradient. Scenarios A2 and B2 were modelled based on the 2010 COPERT factors adjusted by the relative factors for the Brisbane vehicle fleet in 2010 and 2025 and PIARC road gradient factors.

SEPP(AQM) requires modelling to be conducted based on the worst case scenario during normal operations. This is considered to be reflected by Scenarios A1, A2, B1 and B2.

Compliance with SEPP(AQM) design criteria was demonstrated for the tunnel ventilation systems for NO_2, CO, BTEX, 1,3 butadiene, formaldehyde and PAH for all scenarios. Non-compliances were predicted using hourly time-varying background concentrations for PM_{10} and $PM_{2.5}$ in 2026 and 2036, primarily due to the background concentrations exceeding the criteria.

The hourly PM_{10} background concentrations showed that exceedances of the 80 micrograms per cubic metre design criterion occurred on eight occasions during 2017 without any contribution from the project. The tunnel ventilation system emissions result in no additional exceedances for all scenarios.

The hourly $PM_{2.5}$ background concentrations showed that exceedances of the 50 micrograms per cubic metre design criterion occurred on 20 occasions during 2017 without any contribution from the project. Tunnel ventilation system emissions resulted in one additional exceedance for all scenarios with project contributions of less than 0.7 micrograms per cubic metre and a corresponding background concentration of 49.8 micrograms per cubic metre.

the project contributions of PM_{10}, $PM_{2.5}$ and NO_2 to the 99.9th percentile GLCs for Scenarios A2 and B2 were found to decrease by approximately 25 per cent, 56 per cent and 68 per cent respectively compared with the Scenario A1 and B1 predictions.

The additional sensitivity analyses demonstrated that, while the project contribution to the maximum predicted GLC could increase significantly (up to 100 per cent in the case of NO_2 for a doubling in the proportion of diesel cars), due to the relatively low project contribution, there was relatively little change in the maximum predicted GLCs (project plus background).

The North East Link road tunnel ventilation system are considered to comply with the principles and objectives of the *Environment Protection Act 1970* and SEPP(AQM), with predicted pollutant concentrations due to the tunnel ventilation system making only minor contributions above existing background levels. Where the one hour average PM_{10} and $PM_{2.5}$ design criteria were exceeded, it was due to either existing background concentration exceedances or high background concentrations requiring only small additional increments to cause an exceedance.

SEPP(AQM) does, however, note that in circumstances where design criteria are not met, the proponent may carry out a health risk assessment to demonstrate that there will be no adverse impact from the proposal. A Health Impact Assessment (HIA) has been conducted by enRiskS as part of the North East Link EES.

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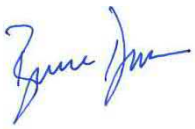
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APPENDIX A

Road tunnel traffic fleet mix and emissions inventory

Forecast fleet composition data and resulting emissions inventories for each of the modelled scenarios is presented as follows:

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Table 1: Scenario A northbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	208	37	7	66	318	211	37	9	68	325
2	206	36	10	66	318	208	37	12	68	325
3	206	36	10	66	318	208	37	12	68	325
4	208	37	7	66	318	211	37	9	68	325
5	792	140	37	253	1222	713	126	41	234	1113
6	1376	243	65	353	2037	1239	219	71	326	1855
7	1861	328	88	399	2677	1678	296	96	369	2438
8	2380	420	225	425	3450	2040	360	225	400	3025
9	2380	420	225	425	3450	2040	360	225	400	3025
10	2255	398	167	394	3214	1906	336	171	343	2756
11	2087	368	170	401	3026	1871	330	185	370	2756
12	2046	361	185	435	3026	1831	323	200	402	2756
13	2087	368	170	401	3026	1871	330	185	370	2756
14	2245	396	167	393	3201	2016	356	181	363	2915
15	2516	444	159	373	3492	2339	413	178	356	3286
16	3021	533	155	365	4074	2724	481	168	337	3710
17	3995	705	200	350	5250	3613	638	225	350	4825
18	3995	705	200	350	5250	3613	638	225	350	4825
19	2913	514	120	236	3783	2632	465	130	218	3445
20	2178	384	104	244	2910	1965	347	113	225	2650
21	1481	261	71	225	2037	1335	236	76	207	1855
22	809	143	38	173	1164	729	129	42	160	1060
23	203	36	10	69	318	205	36	12	72	325
24	202	36	10	72	318	203	36	12	74	325

Table 2: Scenario A southbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	220	39	8	71	338	175	31	8	59	273
2	218	38	11	71	338	173	30	10	59	273
3	218	38	11	71	338	173	30	10	59	273
4	220	39	8	71	338	175	31	8	59	273
5	1127	199	56	367	1749	966	171	58	332	1527
6	1959	346	98	513	2915	1683	297	101	464	2545
7	2824	498	141	618	4081	2429	429	147	559	3563
8	3910	690	200	400	5200	3400	600	225	425	4650
9	3910	690	200	400	5200	3400	600	225	425	4650
10	3077	543	141	320	4081	2658	469	146	290	3563
11	2403	424	152	345	3323	1995	352	152	301	2800
12	2019	356	165	374	2915	1730	305	171	339	2545
13	1980	349	179	407	2915	1692	299	186	368	2545
14	1980	349	179	407	2915	1692	299	186	368	2545
15	2053	362	153	347	2915	1762	311	159	314	2545
16	2428	428	143	324	3323	2054	363	145	288	2850
17	2720	480	225	375	3800	2380	420	225	375	3400
18	2720	480	225	375	3800	2380	420	225	375	3400
19	2150	379	130	256	2915	1852	327	135	231	2545
20	1630	288	82	187	2186	1406	248	85	169	1909
21	1055	186	53	164	1458	909	160	55	148	1273
22	403	71	20	88	583	278	49	17	64	407
23	215	38	11	74	338	170	30	10	62	273
24	213	38	11	77	338	169	30	10	64	273

Table 3: Scenario B northbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	244	43	8	75	370	284	50	12	91	437
2	242	43	11	75	370	281	50	16	91	437
3	242	43	11	75	370	281	50	16	91	437
4	244	43	8	75	370	284	50	12	91	437
5	972	172	46	300	1489	830	146	47	268	1292
6	1702	300	80	422	2505	1442	255	82	374	2153
7	2460	434	116	510	3520	2121	374	121	459	3075
8	2720	480	250	550	4000	2295	405	250	500	3450
9	2720	480	250	550	4000	2295	405	250	500	3450
10	2634	465	195	445	3739	2216	391	198	393	3198
11	2439	430	198	453	3520	2176	384	214	424	3198
12	2392	422	215	492	3520	2130	376	232	460	3198
13	2439	430	198	453	3520	2176	384	214	424	3198
14	2623	463	194	444	3724	2344	414	209	415	3383
15	3182	562	200	457	4401	2719	480	206	408	3813
16	3776	666	193	442	5078	3391	598	209	414	4613
17	3953	698	200	350	5200	3740	660	225	375	5000
18	3953	698	200	350	5200	3740	660	225	375	5000
19	3823	675	157	301	4955	3366	594	165	275	4401
20	2540	448	121	276	3385	2284	403	130	258	3075
21	1729	305	82	254	2370	1552	274	89	238	2153
22	946	167	45	196	1354	848	150	48	184	1230
23	238	42	11	78	370	277	49	16	95	437
24	236	42	11	81	370	275	48	16	98	437

Table 4: Scenario B southbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	311	55	12	96	474	200	35	9	69	313
2	308	54	15	96	474	197	35	12	69	313
3	308	54	15	96	474	197	35	12	69	313
4	311	55	12	96	474	200	35	9	69	313
5	1733	306	87	542	2668	1470	259	90	516	2336
6	2255	398	114	568	3335	1922	339	118	541	2920
7	3247	573	165	684	4669	2935	518	180	689	4322
8	3868	683	200	425	5175	3443	608	225	450	4725
9	3868	683	200	425	5175	3443	608	225	450	4725
10	3527	622	165	355	4669	3242	572	181	360	4355
11	2757	486	177	382	3802	2282	403	176	351	3212
12	2319	409	192	415	3335	1978	349	198	395	2920
13	2274	401	209	450	3335	1934	341	216	429	2920
14	2274	401	209	450	3335	1934	341	216	429	2920
15	2357	416	178	384	3335	2015	356	184	366	2920
16	2785	491	166	359	3802	2351	415	169	336	3270
17	3060	540	250	425	4275	2635	465	250	400	3750
18	3060	540	250	425	4275	2635	465	250	400	3750
19	2465	435	151	283	3335	2120	374	156	270	2920
20	1993	352	102	221	2668	1717	303	106	210	2336
21	1453	256	74	218	2001	1248	220	77	207	1752
22	464	82	24	98	667	317	56	19	75	467
23	304	54	15	101	474	194	34	12	73	313
24	301	53	15	104	474	193	34	12	75	313

Table 5: Scenario A northbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	1.8E-02	1.6E-02	3.7E-01	1.4E-01	6.2E-03	1.2E-02	4.6E-03	1.2E-02	1.8E-03	3.6E-03	9.4E-07
2	1.8E-02	1.6E-02	3.8E-01	1.4E-01	6.2E-03	1.3E-02	4.6E-03	1.2E-02	1.8E-03	3.7E-03	9.4E-07
3	1.8E-02	1.6E-02	3.8E-01	1.4E-01	6.2E-03	1.3E-02	4.6E-03	1.2E-02	1.8E-03	3.7E-03	9.4E-07
4	1.8E-02	1.6E-02	3.7E-01	1.4E-01	6.2E-03	1.2E-02	4.6E-03	1.2E-02	1.8E-03	3.6E-03	9.4E-07
5	6.9E-02	6.1E-02	1.4E+00	5.4E-01	2.3E-02	4.7E-02	1.7E-02	4.6E-02	6.7E-03	1.4E-02	3.5E-06
6	1.0E-01	9.0E-02	2.4E+00	7.8E-01	4.0E-02	8.2E-02	3.0E-02	8.0E-02	1.1E-02	2.2E-02	5.5E-06
7	1.2E-01	1.1E-01	3.1E+00	9.2E-01	5.5E-02	1.1E-01	4.1E-02	1.1E-01	1.4E-02	2.7E-02	6.9E-06
8	1.5E-01	1.3E-01	4.4E+00	1.0E+00	7.3E-02	1.5E-01	5.4E-02	1.4E-01	1.7E-02	3.5E-02	8.6E-06
9	1.5E-01	1.3E-01	4.4E+00	1.0E+00	7.3E-02	1.5E-01	5.4E-02	1.4E-01	1.7E-02	3.5E-02	8.6E-06
10	1.3E-01	1.2E-01	3.9E+00	9.6E-01	6.7E-02	1.4E-01	5.0E-02	1.3E-01	1.6E-02	3.2E-02	7.9E-06
11	1.3E-01	1.2E-01	3.8E+00	9.6E-01	6.4E-02	1.3E-01	4.7E-02	1.3E-01	1.5E-02	3.1E-02	7.7E-06
12	1.4E-01	1.2E-01	3.9E+00	1.0E+00	6.3E-02	1.3E-01	4.7E-02	1.2E-01	1.6E-02	3.2E-02	7.9E-06
13	1.3E-01	1.2E-01	3.8E+00	9.6E-01	6.4E-02	1.3E-01	4.7E-02	1.3E-01	1.5E-02	3.1E-02	7.7E-06
14	1.4E-01	1.2E-01	4.0E+00	9.6E-01	6.8E-02	1.4E-01	5.1E-02	1.3E-01	1.6E-02	3.2E-02	7.9E-06
15	1.4E-01	1.2E-01	4.2E+00	9.6E-01	7.6E-02	1.5E-01	5.6E-02	1.5E-01	1.7E-02	3.4E-02	8.4E-06
16	1.5E-01	1.2E-01	4.7E+00	9.9E-01	8.9E-02	1.8E-01	6.7E-02	1.8E-01	2.0E-02	3.8E-02	9.3E-06
17	1.7E-01	1.4E-01	6.0E+00	1.1E+00	1.2E-01	2.4E-01	8.8E-02	2.3E-01	2.5E-02	4.7E-02	1.1E-05
18	1.7E-01	1.4E-01	6.0E+00	1.1E+00	1.2E-01	2.4E-01	8.8E-02	2.3E-01	2.5E-02	4.7E-02	1.1E-05
19	1.2E-01	9.6E-02	4.2E+00	7.5E-01	8.5E-02	1.7E-01	6.3E-02	1.7E-01	1.8E-02	3.3E-02	8.0E-06
20	1.0E-01	8.5E-02	3.3E+00	6.8E-01	6.4E-02	1.3E-01	4.8E-02	1.3E-01	1.4E-02	2.7E-02	6.5E-06
21	8.0E-02	6.8E-02	2.3E+00	5.7E-01	4.3E-02	8.8E-02	3.2E-02	8.6E-02	1.0E-02	2.0E-02	4.9E-06
22	5.4E-02	4.7E-02	1.3E+00	4.0E-01	2.4E-02	4.8E-02	1.8E-02	4.7E-02	6.0E-03	1.2E-02	3.0E-06
23	1.9E-02	1.7E-02	3.8E-01	1.5E-01	6.1E-03	1.2E-02	4.6E-03	1.2E-02	1.8E-03	3.7E-03	9.6E-07
24	1.9E-02	1.7E-02	3.8E-01	1.5E-01	6.1E-03	1.2E-02	4.5E-03	1.2E-02	1.8E-03	3.8E-03	9.7E-07

Table 6: Scenario A southbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	1.2E-02	1.1E-02	2.5E-01	8.6E-02	6.2E-03	1.3E-02	4.7E-03	1.2E-02	1.8E-03	3.7E-03	9.6E-07
2	1.2E-02	1.1E-02	2.6E-01	8.6E-02	6.3E-03	1.3E-02	4.7E-03	1.3E-02	1.8E-03	3.7E-03	9.6E-07
3	1.2E-02	1.1E-02	2.6E-01	8.6E-02	6.3E-03	1.3E-02	4.7E-03	1.3E-02	1.8E-03	3.7E-03	9.6E-07
4	1.2E-02	1.1E-02	2.5E-01	8.6E-02	6.2E-03	1.3E-02	4.7E-03	1.2E-02	1.8E-03	3.7E-03	9.6E-07
5	6.4E-02	5.6E-02	1.4E+00	4.6E-01	3.3E-02	6.7E-02	2.5E-02	6.6E-02	9.5E-03	2.0E-02	5.1E-06
6	9.5E-02	8.3E-02	2.3E+00	6.6E-01	5.7E-02	1.2E-01	4.3E-02	1.1E-01	1.5E-02	3.1E-02	7.9E-06
7	1.2E-01	1.1E-01	3.2E+00	8.3E-01	8.2E-02	1.7E-01	6.2E-02	1.6E-01	2.1E-02	4.2E-02	1.1E-05
8	1.1E-01	9.5E-02	4.1E+00	7.1E-01	1.1E-01	2.3E-01	8.6E-02	2.3E-01	2.5E-02	4.7E-02	1.2E-05
9	1.1E-01	9.5E-02	4.1E+00	7.1E-01	1.1E-01	2.3E-01	8.6E-02	2.3E-01	2.5E-02	4.7E-02	1.2E-05
10	8.7E-02	7.3E-02	3.1E+00	5.5E-01	8.9E-02	1.8E-01	6.7E-02	1.8E-01	1.9E-02	3.7E-02	9.0E-06
11	8.1E-02	6.9E-02	2.7E+00	5.2E-01	7.1E-02	1.4E-01	5.3E-02	1.4E-01	1.6E-02	3.1E-02	7.8E-06
12	8.1E-02	7.0E-02	2.5E+00	5.3E-01	6.1E-02	1.2E-01	4.5E-02	1.2E-01	1.5E-02	2.9E-02	7.3E-06
13	8.5E-02	7.4E-02	2.5E+00	5.7E-01	6.0E-02	1.2E-01	4.5E-02	1.2E-01	1.5E-02	3.0E-02	7.5E-06
14	8.5E-02	7.4E-02	2.5E+00	5.7E-01	6.0E-02	1.2E-01	4.5E-02	1.2E-01	1.5E-02	3.0E-02	7.5E-06
15	7.7E-02	6.6E-02	2.4E+00	5.1E-01	6.2E-02	1.2E-01	4.6E-02	1.2E-01	1.5E-02	2.9E-02	7.1E-06
16	7.8E-02	6.7E-02	2.6E+00	5.0E-01	7.1E-02	1.4E-01	5.3E-02	1.4E-01	1.6E-02	3.1E-02	7.7E-06
17	9.4E-02	8.0E-02	3.2E+00	6.0E-01	8.3E-02	1.7E-01	6.2E-02	1.6E-01	1.9E-02	3.7E-02	9.0E-06
18	9.4E-02	8.0E-02	3.2E+00	6.0E-01	8.3E-02	1.7E-01	6.2E-02	1.6E-01	1.9E-02	3.7E-02	9.0E-06
19	6.6E-02	5.6E-02	2.3E+00	4.2E-01	6.3E-02	1.3E-01	4.7E-02	1.2E-01	1.4E-02	2.7E-02	6.6E-06
20	4.8E-02	4.1E-02	1.7E+00	3.1E-01	4.8E-02	9.6E-02	3.6E-02	9.4E-02	1.0E-02	2.0E-02	4.9E-06
21	3.7E-02	3.2E-02	1.1E+00	2.4E-01	3.1E-02	6.2E-02	2.3E-02	6.1E-02	7.2E-03	1.4E-02	3.5E-06
22	1.7E-02	1.4E-02	4.3E-01	1.1E-01	1.1E-02	2.3E-02	8.5E-03	2.2E-02	2.9E-03	5.7E-03	1.5E-06
23	1.3E-02	1.1E-02	2.6E-01	9.0E-02	6.2E-03	1.2E-02	4.6E-03	1.2E-02	1.8E-03	3.8E-03	9.8E-07
24	1.3E-02	1.1E-02	2.6E-01	9.2E-02	6.1E-03	1.2E-02	4.6E-03	1.2E-02	1.8E-03	3.8E-03	1.0E-06

Table 7: Scenario B northbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	2.2E-02	1.9E-02	4.4E-01	1.7E-01	7.5E-03	1.5E-02	5.6E-03	1.5E-02	2.1E-03	4.3E-03	1.1E-06
2	2.2E-02	1.9E-02	4.5E-01	1.7E-01	7.5E-03	1.5E-02	5.6E-03	1.5E-02	2.1E-03	4.4E-03	1.1E-06
3	2.2E-02	1.9E-02	4.5E-01	1.7E-01	7.5E-03	1.5E-02	5.6E-03	1.5E-02	2.1E-03	4.4E-03	1.1E-06
4	2.2E-02	1.9E-02	4.4E-01	1.7E-01	7.5E-03	1.5E-02	5.6E-03	1.5E-02	2.1E-03	4.3E-03	1.1E-06
5	8.2E-02	7.2E-02	1.7E+00	6.4E-01	2.8E-02	5.7E-02	2.1E-02	5.6E-02	8.0E-03	1.6E-02	4.2E-06
6	1.2E-01	1.1E-01	2.9E+00	9.3E-01	4.9E-02	1.0E-01	3.7E-02	9.8E-02	1.3E-02	2.6E-02	6.7E-06
7	1.6E-01	1.4E-01	4.0E+00	1.2E+00	7.2E-02	1.4E-01	5.4E-02	1.4E-01	1.8E-02	3.6E-02	9.0E-06
8	1.8E-01	1.6E-01	5.1E+00	1.3E+00	8.3E-02	1.7E-01	6.2E-02	1.6E-01	2.0E-02	4.1E-02	1.0E-05
9	1.8E-01	1.6E-01	5.1E+00	1.3E+00	8.3E-02	1.7E-01	6.2E-02	1.6E-01	2.0E-02	4.1E-02	1.0E-05
10	1.5E-01	1.3E-01	4.6E+00	1.1E+00	7.9E-02	1.6E-01	5.9E-02	1.6E-01	1.9E-02	3.7E-02	9.1E-06
11	1.5E-01	1.3E-01	4.4E+00	1.1E+00	7.4E-02	1.5E-01	5.5E-02	1.5E-01	1.8E-02	3.6E-02	8.9E-06
12	1.6E-01	1.4E-01	4.5E+00	1.2E+00	7.4E-02	1.5E-01	5.5E-02	1.5E-01	1.8E-02	3.6E-02	9.1E-06
13	1.5E-01	1.3E-01	4.4E+00	1.1E+00	7.4E-02	1.5E-01	5.5E-02	1.5E-01	1.8E-02	3.6E-02	8.9E-06
14	1.6E-01	1.3E-01	4.6E+00	1.1E+00	7.9E-02	1.6E-01	5.9E-02	1.6E-01	1.9E-02	3.7E-02	9.2E-06
15	1.7E-01	1.4E-01	5.2E+00	1.2E+00	9.4E-02	1.9E-01	7.0E-02	1.9E-01	2.1E-02	4.2E-02	1.0E-05
16	1.8E-01	1.5E-01	5.9E+00	1.2E+00	1.1E-01	2.3E-01	8.3E-02	2.2E-01	2.4E-02	4.7E-02	1.2E-05
17	1.7E-01	1.4E-01	6.0E+00	1.1E+00	1.2E-01	2.4E-01	8.8E-02	2.3E-01	2.5E-02	4.7E-02	1.1E-05
18	1.7E-01	1.4E-01	6.0E+00	1.1E+00	1.2E-01	2.4E-01	8.8E-02	2.3E-01	2.5E-02	4.7E-02	1.1E-05
19	1.5E-01	1.2E-01	5.5E+00	9.6E-01	1.1E-01	2.2E-01	8.3E-02	2.2E-01	2.3E-02	4.3E-02	1.0E-05
20	1.2E-01	9.8E-02	3.9E+00	7.8E-01	7.4E-02	1.5E-01	5.6E-02	1.5E-01	1.6E-02	3.1E-02	7.6E-06
21	9.2E-02	7.8E-02	2.7E+00	6.5E-01	5.1E-02	1.0E-01	3.8E-02	1.0E-01	1.2E-02	2.3E-02	5.6E-06
22	6.2E-02	5.3E-02	1.6E+00	4.6E-01	2.8E-02	5.6E-02	2.1E-02	5.5E-02	6.9E-03	1.4E-02	3.5E-06
23	2.2E-02	2.0E-02	4.5E-01	1.7E-01	7.4E-03	1.5E-02	5.5E-03	1.5E-02	2.1E-03	4.4E-03	1.1E-06
24	2.3E-02	2.0E-02	4.5E-01	1.8E-01	7.3E-03	1.5E-02	5.5E-03	1.5E-02	2.2E-03	4.5E-03	1.2E-06

Table 8: Scenario B southbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	1.6E-02	1.4E-02	3.4E-01	1.1E-01	8.5E-03	1.7E-02	6.4E-03	1.7E-02	2.4E-03	5.0E-03	1.3E-06
2	1.6E-02	1.4E-02	3.5E-01	1.1E-01	8.6E-03	1.7E-02	6.4E-03	1.7E-02	2.4E-03	5.0E-03	1.3E-06
3	1.6E-02	1.4E-02	3.5E-01	1.1E-01	8.6E-03	1.7E-02	6.4E-03	1.7E-02	2.4E-03	5.0E-03	1.3E-06
4	1.6E-02	1.4E-02	3.4E-01	1.1E-01	8.5E-03	1.7E-02	6.4E-03	1.7E-02	2.4E-03	5.0E-03	1.3E-06
5	9.7E-02	8.5E-02	2.1E+00	6.9E-01	5.0E-02	1.0E-01	3.8E-02	1.0E-01	1.4E-02	3.0E-02	7.7E-06
6	1.1E-01	9.4E-02	2.6E+00	7.5E-01	6.6E-02	1.3E-01	4.9E-02	1.3E-01	1.7E-02	3.5E-02	9.0E-06
7	1.4E-01	1.2E-01	3.7E+00	9.6E-01	9.6E-02	1.9E-01	7.2E-02	1.9E-01	2.4E-02	4.8E-02	1.2E-05
8	1.2E-01	9.8E-02	4.1E+00	7.3E-01	1.1E-01	2.3E-01	8.5E-02	2.2E-01	2.5E-02	4.8E-02	1.2E-05
9	1.2E-01	9.8E-02	4.1E+00	7.3E-01	1.1E-01	2.3E-01	8.5E-02	2.2E-01	2.5E-02	4.8E-02	1.2E-05
10	1.0E-01	8.4E-02	3.6E+00	6.3E-01	1.0E-01	2.1E-01	7.8E-02	2.0E-01	2.2E-02	4.2E-02	1.0E-05
11	9.2E-02	7.8E-02	3.0E+00	5.9E-01	8.1E-02	1.6E-01	6.1E-02	1.6E-01	1.8E-02	3.6E-02	8.8E-06
12	9.2E-02	7.9E-02	2.8E+00	6.0E-01	7.0E-02	1.4E-01	5.2E-02	1.4E-01	1.7E-02	3.3E-02	8.3E-06
13	9.6E-02	8.4E-02	2.9E+00	6.4E-01	6.9E-02	1.4E-01	5.2E-02	1.4E-01	1.7E-02	3.4E-02	8.5E-06
14	9.6E-02	8.4E-02	2.9E+00	6.4E-01	6.9E-02	1.4E-01	5.2E-02	1.4E-01	1.7E-02	3.4E-02	8.5E-06
15	8.8E-02	7.5E-02	2.8E+00	5.7E-01	7.1E-02	1.4E-01	5.3E-02	1.4E-01	1.7E-02	3.3E-02	8.1E-06
16	8.9E-02	7.6E-02	3.0E+00	5.7E-01	8.2E-02	1.7E-01	6.1E-02	1.6E-01	1.8E-02	3.5E-02	8.7E-06
17	1.0E-01	9.0E-02	3.6E+00	6.7E-01	9.2E-02	1.9E-01	6.9E-02	1.8E-01	2.1E-02	4.1E-02	1.0E-05
18	1.0E-01	9.0E-02	3.6E+00	6.7E-01	9.2E-02	1.9E-01	6.9E-02	1.8E-01	2.1E-02	4.1E-02	1.0E-05
19	7.5E-02	6.3E-02	2.7E+00	4.7E-01	7.3E-02	1.5E-01	5.4E-02	1.4E-01	1.6E-02	3.1E-02	7.5E-06
20	5.9E-02	5.0E-02	2.1E+00	3.7E-01	5.8E-02	1.2E-01	4.4E-02	1.1E-01	1.3E-02	2.4E-02	6.0E-06
21	5.0E-02	4.3E-02	1.6E+00	3.3E-01	4.2E-02	8.6E-02	3.2E-02	8.4E-02	9.8E-03	1.9E-02	4.7E-06
22	1.9E-02	1.6E-02	5.0E-01	1.3E-01	1.3E-02	2.6E-02	9.7E-03	2.6E-02	3.3E-03	6.5E-03	1.6E-06
23	1.7E-02	1.5E-02	3.5E-01	1.2E-01	8.4E-03	1.7E-02	6.3E-03	1.7E-02	2.5E-03	5.1E-03	1.3E-06
24	1.7E-02	1.5E-02	3.5E-01	1.2E-01	8.4E-03	1.7E-02	6.3E-03	1.7E-02	2.5E-03	5.2E-03	1.3E-06

Table 9: Sensitivity analysis: maximum lane capacity northbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	3956	698	138	1208	6000	3902	689	164	1245	6000
2	3917	691	184	1208	6000	3856	680	218	1245	6000
3	3917	691	184	1208	6000	3856	680	218	1245	6000
4	3956	698	138	1208	6000	3902	689	164	1245	6000
5	3917	691	184	1208	6000	3856	680	218	1245	6000
6	4078	720	192	1011	6000	4020	709	228	1042	6000
7	4193	740	198	869	6000	4139	730	235	895	6000
8	4080	720	375	825	6000	3991	704	435	870	6000
9	4080	720	375	825	6000	3991	704	435	870	6000
10	4227	746	312	715	6000	4158	734	371	737	6000
11	4158	734	337	771	6000	4083	721	401	795	6000
12	4076	719	366	838	6000	3996	705	435	864	6000
13	4158	734	337	771	6000	4083	721	401	795	6000
14	4227	746	312	715	6000	4158	734	371	737	6000
15	4339	766	272	623	6000	4279	755	324	642	6000
16	4462	787	228	523	6000	4411	778	272	539	6000
17	4561	805	231	404	6000	4488	792	270	450	6000
18	4561	805	231	404	6000	4488	792	270	450	6000
19	4629	817	190	364	6000	4589	810	226	375	6000
20	4503	795	214	488	6000	4456	786	255	503	6000
21	4377	772	208	643	6000	4327	764	247	662	6000
22	4193	740	198	869	6000	4139	730	235	895	6000
23	3866	682	181	1270	6000	3804	671	215	1309	6000
24	3833	676	179	1311	6000	3770	665	213	1351	6000

Table 10: Sensitivity analysis: maximum lane capacity southbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	3939	695	147	1219	6000	3825	675	173	1327	6000
2	3897	688	196	1219	6000	3776	666	231	1327	6000
3	3897	688	196	1219	6000	3776	666	231	1327	6000
4	3939	695	147	1219	6000	3825	675	173	1327	6000
5	3897	688	196	1219	6000	3776	666	231	1327	6000
6	4057	716	205	1022	6000	3949	697	242	1112	6000
7	4172	736	212	879	6000	4074	719	250	957	6000
8	4484	791	232	493	6000	4371	771	286	571	6000
9	4484	791	232	493	6000	4371	771	286	571	6000
10	4532	800	212	456	6000	4466	788	249	496	6000
11	4350	768	280	602	6000	4263	752	329	656	6000
12	4172	736	346	746	6000	4063	717	408	812	6000
13	4091	722	376	810	6000	3974	701	443	882	6000
14	4091	722	376	810	6000	3974	701	443	882	6000
15	4240	748	321	691	6000	4140	731	378	752	6000
16	4395	776	263	566	6000	4313	761	309	616	6000
17	4295	758	351	596	6000	4216	744	400	640	6000
18	4295	758	351	596	6000	4216	744	400	640	6000
19	4435	783	272	510	6000	4356	769	321	555	6000
20	4482	791	230	496	6000	4410	778	271	540	6000
21	4356	769	223	652	6000	4274	754	262	710	6000
22	4172	736	212	879	6000	4074	719	250	957	6000
23	3847	679	193	1281	6000	3722	657	227	1394	6000
24	3815	673	191	1321	6000	3687	651	225	1438	6000

Table 11: Sensitivity analysis: maximum lane capacity northbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	3.4E-01	3.0E-01	6.9E+00	2.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.3E-02	1.1E-01	1.7E-05
2	3.4E-01	3.0E-01	7.1E+00	2.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
3	3.4E-01	3.0E-01	7.1E+00	2.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
4	3.4E-01	3.0E-01	6.9E+00	2.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.3E-02	1.1E-01	1.7E-05
5	3.4E-01	3.0E-01	7.1E+00	2.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
6	3.0E-01	2.6E-01	7.1E+00	2.3E+00	1.8E-01	3.5E-01	1.3E-01	3.4E-01	5.1E-02	1.0E-01	1.6E-05
7	2.8E-01	2.4E-01	7.0E+00	2.1E+00	1.8E-01	3.6E-01	1.3E-01	3.4E-01	5.0E-02	1.0E-01	1.6E-05
8	2.8E-01	2.4E-01	7.9E+00	2.0E+00	1.9E-01	3.7E-01	1.3E-01	3.5E-01	5.0E-02	1.0E-01	1.6E-05
9	2.8E-01	2.4E-01	7.9E+00	2.0E+00	1.9E-01	3.7E-01	1.3E-01	3.5E-01	5.0E-02	1.0E-01	1.6E-05
10	2.6E-01	2.2E-01	7.5E+00	1.8E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.9E-02	9.6E-02	1.5E-05
11	2.7E-01	2.3E-01	7.7E+00	1.9E+00	1.9E-01	3.8E-01	1.3E-01	3.5E-01	4.9E-02	9.9E-02	1.5E-05
12	2.8E-01	2.4E-01	7.9E+00	2.0E+00	1.9E-01	3.7E-01	1.3E-01	3.5E-01	5.0E-02	1.0E-01	1.6E-05
13	2.7E-01	2.3E-01	7.7E+00	1.9E+00	1.9E-01	3.8E-01	1.3E-01	3.5E-01	4.9E-02	9.9E-02	1.5E-05
14	2.6E-01	2.2E-01	7.5E+00	1.8E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.9E-02	9.6E-02	1.5E-05
15	2.4E-01	2.0E-01	7.3E+00	1.6E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.8E-02	9.3E-02	1.4E-05
16	2.2E-01	1.8E-01	7.0E+00	1.5E+00	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.9E-02	1.4E-05
17	2.0E-01	1.6E-01	7.0E+00	1.3E+00	2.0E-01	4.0E-01	1.4E-01	3.7E-01	4.5E-02	8.5E-02	1.3E-05
18	2.0E-01	1.6E-01	7.0E+00	1.3E+00	2.0E-01	4.0E-01	1.4E-01	3.7E-01	4.5E-02	8.5E-02	1.3E-05
19	1.8E-01	1.5E-01	6.8E+00	1.2E+00	2.0E-01	4.0E-01	1.4E-01	3.7E-01	4.4E-02	8.3E-02	1.3E-05
20	2.1E-01	1.8E-01	7.0E+00	1.4E+00	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.8E-02	1.4E-05
21	2.4E-01	2.0E-01	7.0E+00	1.7E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.7E-02	9.3E-02	1.4E-05
22	2.8E-01	2.4E-01	7.0E+00	2.1E+00	1.8E-01	3.6E-01	1.3E-01	3.4E-01	5.0E-02	1.0E-01	1.6E-05
23	3.5E-01	3.1E-01	7.1E+00	2.7E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
24	3.6E-01	3.1E-01	7.1E+00	2.8E+00	1.7E-01	3.3E-01	1.2E-01	3.2E-01	5.5E-02	1.1E-01	1.8E-05

Table 12: Sensitivity analysis: maximum lane capacity southbound traffic emission rates

Hour	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	CO (g/s)	NO_2 (g/s)	Benzene (g/s)	Toluene (g/s)	Ethylbenzene (g/s)	Xylene isomers (g/s)	1,3-Butadiene (g/s)	Formaldehyde (g/s)	B(a)P TEQ (g/s)
1	2.2E-01	2.0E-01	4.8E+00	1.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
2	2.3E-01	2.0E-01	4.9E+00	1.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
3	2.3E-01	2.0E-01	4.9E+00	1.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
4	2.2E-01	2.0E-01	4.8E+00	1.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
5	2.3E-01	2.0E-01	4.9E+00	1.6E+00	1.7E-01	3.4E-01	1.2E-01	3.2E-01	5.4E-02	1.1E-01	1.8E-05
6	2.0E-01	1.8E-01	4.9E+00	1.4E+00	1.8E-01	3.5E-01	1.3E-01	3.3E-01	5.2E-02	1.1E-01	1.7E-05
7	1.8E-01	1.6E-01	4.9E+00	1.3E+00	1.8E-01	3.6E-01	1.3E-01	3.4E-01	5.0E-02	1.0E-01	1.6E-05
8	1.4E-01	1.2E-01	4.9E+00	8.7E-01	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.8E-02	1.4E-05
9	1.4E-01	1.2E-01	4.9E+00	8.7E-01	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.8E-02	1.4E-05
10	1.3E-01	1.1E-01	4.8E+00	8.3E-01	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.7E-02	1.4E-05
11	1.5E-01	1.3E-01	5.0E+00	9.8E-01	1.9E-01	3.9E-01	1.4E-01	3.6E-01	4.7E-02	9.2E-02	1.4E-05
12	1.7E-01	1.5E-01	5.3E+00	1.1E+00	1.9E-01	3.8E-01	1.4E-01	3.5E-01	4.9E-02	9.8E-02	1.5E-05
13	1.8E-01	1.6E-01	5.4E+00	1.2E+00	1.9E-01	3.7E-01	1.3E-01	3.5E-01	5.0E-02	1.0E-01	1.6E-05
14	1.8E-01	1.6E-01	5.4E+00	1.2E+00	1.9E-01	3.7E-01	1.3E-01	3.5E-01	5.0E-02	1.0E-01	1.6E-05
15	1.6E-01	1.4E-01	5.2E+00	1.1E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.9E-02	9.6E-02	1.5E-05
16	1.5E-01	1.2E-01	5.0E+00	9.4E-01	2.0E-01	3.9E-01	1.4E-01	3.6E-01	4.7E-02	9.1E-02	1.4E-05
17	1.5E-01	1.3E-01	5.2E+00	9.8E-01	2.0E-01	3.9E-01	1.4E-01	3.6E-01	4.8E-02	9.3E-02	1.5E-05
18	1.5E-01	1.3E-01	5.2E+00	9.8E-01	2.0E-01	3.9E-01	1.4E-01	3.6E-01	4.8E-02	9.3E-02	1.5E-05
19	1.4E-01	1.2E-01	5.0E+00	8.8E-01	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.9E-02	1.4E-05
20	1.4E-01	1.2E-01	4.8E+00	8.7E-01	2.0E-01	3.9E-01	1.4E-01	3.7E-01	4.6E-02	8.8E-02	1.4E-05
21	1.6E-01	1.3E-01	4.9E+00	1.0E+00	1.9E-01	3.8E-01	1.4E-01	3.6E-01	4.8E-02	9.3E-02	1.5E-05
22	1.8E-01	1.6E-01	4.9E+00	1.3E+00	1.8E-01	3.6E-01	1.3E-01	3.4E-01	5.0E-02	1.0E-01	1.6E-05
23	2.3E-01	2.0E-01	4.9E+00	1.7E+00	1.7E-01	3.3E-01	1.2E-01	3.2E-01	5.5E-02	1.1E-01	1.8E-05
24	2.4E-01	2.1E-01	4.9E+00	1.7E+00	1.7E-01	3.3E-01	1.2E-01	3.2E-01	5.5E-02	1.2E-01	1.8E-05

Table 13: Sensitivity analysis: increased diesel to petrol passenger car ratio northbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	201	86	8	75	370	234	100	12	91	437
2	199	85	11	75	370	231	99	16	91	437
3	199	85	11	75	370	231	99	16	91	437
4	201	86	8	75	370	234	100	12	91	437
5	801	343	46	300	1489	683	293	47	268	1292
6	1402	601	80	422	2505	1188	509	82	374	2153
7	2026	868	116	510	3520	1747	749	121	459	3075
8	2240	960	250	550	4000	1890	810	250	500	3450
9	2240	960	250	550	4000	1890	810	250	500	3450
10	2169	930	195	445	3739	1825	782	198	393	3198
11	2009	861	198	453	3520	1792	768	214	424	3198
12	1970	844	215	492	3520	1754	752	232	460	3198
13	2009	861	198	453	3520	1792	768	214	424	3198
14	2160	926	194	444	3724	1931	827	209	415	3383
15	2621	1123	200	457	4401	2239	960	206	408	3813
16	3109	1333	193	442	5078	2793	1197	209	414	4613
17	3255	1395	200	350	5200	3080	1320	225	375	5000
18	3255	1395	200	350	5200	3080	1320	225	375	5000
19	3148	1349	157	301	4955	2772	1188	165	275	4401
20	2092	897	121	276	3385	1881	806	130	258	3075
21	1424	610	82	254	2370	1278	548	89	238	2153
22	779	334	45	196	1354	699	299	48	184	1230
23	196	84	11	78	370	228	98	16	95	437
24	195	83	11	81	370	226	97	16	98	437

Table 14: Sensitivity analysis: increased diesel to petrol passenger car ratio southbound traffic fleet composition

Hour	North section					South section				
	PCP	PCD	LCV	HCV	Total	PCP	PCD	LCV	HCV	Total
1	256	110	12	96	474	165	71	9	69	313
2	254	109	15	96	474	162	70	12	69	313
3	254	109	15	96	474	162	70	12	69	313
4	256	110	12	96	474	165	71	9	69	313
5	1427	612	87	542	2668	1211	519	90	516	2336
6	1857	796	114	568	3335	1583	678	118	541	2920
7	2674	1146	165	684	4669	2417	1036	180	689	4322
8	3185	1365	200	425	5175	2835	1215	225	450	4725
9	3185	1365	200	425	5175	2835	1215	225	450	4725
10	2905	1245	165	355	4669	2670	1144	181	360	4355
11	2270	973	177	382	3802	1879	805	176	351	3212
12	1910	818	192	415	3335	1629	698	198	395	2920
13	1873	803	209	450	3335	1593	683	216	429	2920
14	1873	803	209	450	3335	1593	683	216	429	2920
15	1941	832	178	384	3335	1659	711	184	366	2920
16	2294	983	166	359	3802	1936	830	169	336	3270
17	2520	1080	250	425	4275	2170	930	250	400	3750
18	2520	1080	250	425	4275	2170	930	250	400	3750
19	2030	870	151	283	3335	1746	748	156	270	2920
20	1641	703	102	221	2668	1414	606	106	210	2336
21	1196	513	74	218	2001	1028	440	77	207	1752
22	382	164	24	98	667	261	112	19	75	467
23	250	107	15	101	474	160	69	12	73	313
24	248	106	15	104	474	159	68	12	75	313

Table 15: Sensitivity analysis: increased diesel to petrol passenger car ratio traffic emission rates

Hour	Northbound			Southbound		
	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
1	2.3E-02	2.1E-02	1.9E-01	1.7E-02	1.5E-02	1.3E-01
2	2.4E-02	2.1E-02	1.9E-01	1.7E-02	1.5E-02	1.3E-01
3	2.4E-02	2.1E-02	1.9E-01	1.7E-02	1.5E-02	1.3E-01
4	2.3E-02	2.1E-02	1.9E-01	1.7E-02	1.5E-02	1.3E-01
5	8.9E-02	7.9E-02	7.2E-01	1.0E-01	9.2E-02	7.8E-01
6	1.4E-01	1.2E-01	1.1E+00	1.2E-01	1.0E-01	8.7E-01
7	1.8E-01	1.5E-01	1.4E+00	1.5E-01	1.4E-01	1.1E+00
8	2.0E-01	1.8E-01	1.5E+00	1.3E-01	1.1E-01	9.4E-01
9	2.0E-01	1.8E-01	1.5E+00	1.3E-01	1.1E-01	9.4E-01
10	1.7E-01	1.5E-01	1.3E+00	1.2E-01	1.0E-01	8.2E-01
11	1.7E-01	1.5E-01	1.3E+00	1.0E-01	9.0E-02	7.4E-01
12	1.8E-01	1.6E-01	1.4E+00	1.0E-01	8.9E-02	7.3E-01
13	1.7E-01	1.5E-01	1.3E+00	1.1E-01	9.3E-02	7.6E-01
14	1.7E-01	1.5E-01	1.3E+00	1.1E-01	9.3E-02	7.6E-01
15	1.9E-01	1.7E-01	1.4E+00	9.8E-02	8.5E-02	7.0E-01
16	2.1E-01	1.8E-01	1.5E+00	1.0E-01	8.8E-02	7.2E-01
17	2.0E-01	1.7E-01	1.4E+00	1.2E-01	1.0E-01	8.3E-01
18	2.0E-01	1.7E-01	1.4E+00	1.2E-01	1.0E-01	8.3E-01
19	1.8E-01	1.5E-01	1.3E+00	8.6E-02	7.4E-02	6.1E-01
20	1.3E-01	1.2E-01	1.0E+00	6.7E-02	5.8E-02	4.8E-01
21	1.0E-01	9.1E-02	8.0E-01	5.7E-02	4.9E-02	4.1E-01
22	6.9E-02	6.0E-02	5.4E-01	2.1E-02	1.8E-02	1.5E-01
23	2.4E-02	2.1E-02	2.0E-01	1.8E-02	1.6E-02	1.3E-01
24	2.5E-02	2.2E-02	2.0E-01	1.8E-02	1.6E-02	1.4E-01

Table 16: Sensitivity analysis: 2025 future year adjusted traffic emission rates

	Northbound			Southbound		
	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2
Hour	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
1	1.2E-02	8.4E-03	5.6E-02	8.7E-03	6.2E-03	3.8E-02
2	1.2E-02	8.5E-03	5.6E-02	8.8E-03	6.2E-03	3.8E-02
3	1.2E-02	8.5E-03	5.6E-02	8.8E-03	6.2E-03	3.8E-02
4	1.2E-02	8.4E-03	5.6E-02	8.7E-03	6.2E-03	3.8E-02
5	4.6E-02	3.2E-02	2.1E-01	5.3E-02	3.7E-02	2.3E-01
6	7.3E-02	5.0E-02	3.1E-01	6.2E-02	4.3E-02	2.5E-01
7	9.8E-02	6.7E-02	3.9E-01	8.5E-02	5.8E-02	3.2E-01
8	1.1E-01	7.9E-02	4.3E-01	8.2E-02	5.4E-02	2.4E-01
9	1.1E-01	7.9E-02	4.3E-01	8.2E-02	5.4E-02	2.4E-01
10	1.0E-01	6.9E-02	3.6E-01	7.3E-02	4.8E-02	2.0E-01
11	9.9E-02	6.8E-02	3.6E-01	6.2E-02	4.2E-02	1.9E-01
12	1.0E-01	7.0E-02	3.8E-01	5.9E-02	4.0E-02	2.0E-01
13	9.9E-02	6.8E-02	3.6E-01	6.1E-02	4.2E-02	2.1E-01
14	1.0E-01	6.9E-02	3.6E-01	6.1E-02	4.2E-02	2.1E-01
15	1.2E-01	7.7E-02	3.8E-01	5.7E-02	3.9E-02	1.9E-01
16	1.3E-01	8.5E-02	3.9E-01	6.1E-02	4.1E-02	1.9E-01
17	1.3E-01	8.3E-02	3.5E-01	7.2E-02	4.8E-02	2.2E-01
18	1.3E-01	8.3E-02	3.5E-01	7.2E-02	4.8E-02	2.2E-01
19	1.2E-01	7.5E-02	3.1E-01	5.3E-02	3.5E-02	1.5E-01
20	8.4E-02	5.5E-02	2.5E-01	4.2E-02	2.8E-02	1.2E-01
21	6.2E-02	4.2E-02	2.1E-01	3.3E-02	2.2E-02	1.1E-01
22	3.8E-02	2.6E-02	1.5E-01	1.1E-02	7.8E-03	4.2E-02
23	1.2E-02	8.7E-03	5.8E-02	9.0E-03	6.4E-03	3.9E-02
24	1.2E-02	8.8E-03	6.0E-02	9.1E-03	6.5E-03	4.0E-02

APPENDIX B

Tunnel ventilation system impacts at discrete receptors

The results of the plume dispersion modelling assessments at the sensitive receptors for Scenarios A1, A2, B1 and B2, and for the maximum tunnel capacity sensitivity analysis are presented as follows:

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Table 1: Sensitive receptor results: Scenario A1

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
1	Greensborough bypass path	0.28	0.23	2.0	0.33
2	Plenty River Linear Reserve	0.27	0.22	1.8	0.35
3	Greensborough Collendina Reserve	0.19	0.16	1.4	0.23
4	Metropolitan Ring Road Linear Reserve	0.27	0.23	1.9	0.29
5	Unnamed reserve	0.18	0.15	1.2	0.22
6	Hughes Circuit Reserve	0.24	0.21	1.8	0.24
7	Maroonday Aqueduct	0.18	0.15	1.3	0.22
8	Garvey Oval	0.25	0.22	1.9	0.24
9	Northpark Private Hospital	0.28	0.24	2.0	0.26
10	Gillingham Reserve	0.25	0.22	1.7	0.28
11	Trist Street Reserve	0.36	0.30	2.5	0.41
12	Greensborough Preschool	0.49	0.42	3.3	0.59
13	Abacus Child Care Centre	0.46	0.40	3.1	0.54
14	Kalparrin Early Intervention Program child care	0.29	0.24	1.9	0.38
15	Greensborough Road Surgery	0.47	0.40	3.2	0.59
16	Diaverum Diamond Valley Dialysis Clinic	0.32	0.27	2.2	0.42
17	Greensborough Maternal and Child Health	0.49	0.41	3.3	0.62
18	St Mary's Church	0.43	0.37	3.0	0.54
19	St Mary's School	0.46	0.39	3.2	0.55
20	Greensborough College	0.69	0.57	4.7	0.77
21	Greensborough Primary School	0.44	0.37	3.0	0.54
22	Banyule City Council Greensborough Service Centre	0.35	0.30	2.4	0.44
23	Greensborough RSL	0.31	0.26	2.1	0.38
24	Kalparrin Gardens	0.28	0.24	1.9	0.37
25	Poulter Avenue Reserve	0.26	0.22	1.8	0.34
26	Whatmough Park	0.30	0.25	2.0	0.36
27	Fell Reserve	0.42	0.35	2.8	0.56
28	Plenty River Drive Reserve	0.26	0.21	1.7	0.34
29	St Mary's Reserve	0.46	0.40	3.1	0.57

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
30	Sarah's Reserve	0.28	0.24	2.1	0.34
31	Metropolitan Ring Road Path	0.24	0.21	1.6	0.26
32	Greensborough Police Station	0.47	0.40	3.1	0.61
33	Greensborough MFB Fire Station	0.46	0.39	3.1	0.59
34	Watsonia Occasional Child Care Centre	0.92	0.79	6.2	1.1
35	MS Society Retirement Village	0.77	0.67	5.6	0.90
36	Watsonia scout hall	0.40	0.34	2.8	0.43
37	Watsonia RSL	0.46	0.39	3.4	0.56
38	North East Citizen Advocacy (NECA)	0.91	0.79	6.1	1.1
39	Watsonia Library	0.57	0.48	3.9	0.60
40	Holy Spirit Anglican Church	0.51	0.45	3.8	0.59
41	Grace Baptist Church	0.47	0.41	3.4	0.52
42	Watsonia Uniting Church	0.58	0.50	4.2	0.67
43	Concord School	0.44	0.38	3.2	0.49
44	Watsonia Primary School	0.50	0.42	3.5	0.53
45	AK Lines Reserve	0.40	0.35	2.9	0.45
46	Elder Street Reserve	0.90	0.79	6.1	0.99
47	West Mayling Reserve	0.86	0.74	6.2	0.91
48	Gabonia Avenue Reserve	0.91	0.79	6.4	1.1
49	Watsonia Station Carpark Reserve	0.68	0.58	4.5	0.71
50	Watsonia Road Reserve	0.54	0.47	4.0	0.62
51	Greensborough Road Early Learning and Kinder	0.65	0.55	4.6	0.70
52	Macleod Recreation and Fitness & CC	0.85	0.73	6.0	0.94
53	Macleod Preschool	0.85	0.72	5.8	0.95
54	Baptcare Strathalan Macleod	1.3	1.1	9.0	1.4
55	Regis Macleod	1.1	0.93	7.9	1.2
56	Macleod Maternal and Child Health	0.82	0.71	6.0	0.95
57	IDV	0.84	0.72	5.9	0.87
58	YMCA Recreation and Fitness Centre	0.84	0.72	6.0	0.92
59	Nets Stadium Banyule	0.90	0.78	6.4	1.0

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
60	Macleod Organic Community Garden	1.00	0.83	6.9	1.1
61	Winsor Reserve	1.4	1.2	9.5	1.3
62	Macleod College Oval	1.1	0.91	7.3	1.1
63	Macleod Netball Stadium	0.91	0.78	6.7	1.0
64	Harry Pottage Reserve	0.81	0.70	5.7	0.92
65	Macleod Park	0.83	0.71	5.8	0.83
66	Macleod Tennis Club	0.85	0.73	6.1	0.91
67	Junior Football Club and Macleod Cricket	0.79	0.68	5.6	0.80
68	Simpson Barracks	2.7	2.3	18	3.4
69	Coleen Reserve	1.1	0.96	8.2	1.3
70	Borlase Reserve	0.58	0.50	4.1	0.63
71	Melbourne Water easement	0.69	0.60	4.9	0.74
72	Goodstart Early Learning	0.28	0.24	2.0	0.28
73	Assisi Centre Aged Care	0.40	0.34	2.6	0.43
74	Japara Rosanna Views Nursing Home	0.50	0.42	3.5	0.57
75	St Martin of Tours Catholic Church	0.50	0.41	3.3	0.53
76	St Martin of Tours Catholic Primary School	0.51	0.43	3.5	0.56
77	Banyule Primary School	0.31	0.27	2.3	0.32
78	Maleela Grove, Rosanna	0.37	0.32	2.8	0.42
79	Mercedes Court Reserve	0.32	0.27	2.3	0.34
80	River Gum Walk	0.25	0.22	1.9	0.28
81	Creekbend Reserve	0.32	0.28	2.3	0.35
82	Viewbank College	0.30	0.25	2.1	0.35
83	Viewbank family medical group	0.70	0.60	5.0	0.71
84	Viewbank podiatry	0.71	0.61	5.0	0.75
85	Simla Close Reserve	0.30	0.26	2.2	0.31
86	Banyule Flats	0.24	0.20	1.7	0.28
87	River Gum Walk	0.22	0.19	1.6	0.25
88	Warringal Parklands	0.21	0.18	1.5	0.25
89	Banyule Tennis Club	0.21	0.18	1.5	0.25

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
90	Heidelberg Park and Heidelberg cricket ground	0.22	0.19	1.5	0.34
91	Banyule Theatre Complex	0.22	0.19	1.5	0.25
92	Heidelberg Police Station	0.42	0.36	2.9	0.56
93	Austin Hospital Precinct	0.28	0.24	1.9	0.44
94	Yarra Flats Park	0.43	0.37	2.7	0.64
95	Yarra Flats Park	1.1	0.95	7.6	1.6
96	Creative Play Early Learning Centre	0.45	0.39	3.1	0.53
97	Kalker Montessori Centre	1.0	0.86	6.5	1.5
98	Veneto Club	2.0	1.7	13	3.3
99	Heide Museum of Modern Art	0.38	0.32	2.6	0.46
100	Bulleen Art and Garden	0.31	0.26	2.0	0.39
101	Marcellin College	1.7	1.5	11	2.9
102	Trinity Grammar School Sporting Complex	0.97	0.84	6.5	1.5
104	Bolin Bolin Billabong	0.85	0.74	5.8	1.3
105	Carey Grammar Sports Complex	2.9	2.5	20	4.8
106	Yarra Valley parklands	0.27	0.23	1.8	0.36
107	Sandra Street Reserve	1.7	1.4	11	2.4
108	Bulleen Park	1.3	1.1	8.9	1.9
109	Koonung Reserve	0.97	0.82	6.3	1.4
110	Koonung Creek Reserve	0.72	0.61	4.6	1.0
111	Willow Bend Reserve	0.58	0.49	3.8	0.81
112	Pipe Line Reserve	0.86	0.74	5.7	1.2
113	Yarra Valley Country Club	0.40	0.34	2.8	0.53
114	Bulleen Golf Driving Range	0.34	0.29	2.2	0.46
115	Wonderland Childcare and Kinder	0.33	0.28	2.1	0.47
116	Applewood Residence	0.18	0.16	1.2	0.26
117	Tende Beck Scout Hall	0.30	0.26	2.1	0.47
118	North Eastern Jewish Centre-Yeshurun Congregation	0.33	0.28	2.1	0.45
119	Birralee Primary School	0.23	0.20	1.6	0.33
120	Wilsons Road Reserve	0.25	0.21	1.7	0.35

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
121	Katrina Street Reserve	0.21	0.18	1.3	0.29
122	Davis Street Reserve	0.19	0.17	1.4	0.28
123	Tram Road Reserve	0.17	0.14	1.2	0.25
124	Frank Sedgman Reserve	0.16	0.14	1.1	0.24
125	Koonung Creek Linear Park	0.17	0.14	1.1	0.22
126	Stanton Street Reserve	0.25	0.21	1.6	0.36
127	Doncaster Park and Ride	0.28	0.25	1.9	0.43
128	Tino Ceberano Martial Arts Academy	0.30	0.26	2.0	0.44
129	Greythorn Bowling Club	0.40	0.34	2.6	0.53
130	Manningham Park Reserve	0.42	0.36	2.8	0.57
131	Japara Sydney Williams Apartments	0.15	0.13	1.0	0.20
132	Japara Millward Nursing home	0.15	0.13	1.0	0.20
133	Koonung Creek Reserve	0.17	0.14	1.2	0.23
134	Boronia Grove Reserve	0.15	0.13	1.1	0.18
135	Heatherwood School	0.10	0.086	0.65	0.13
136	State Vision Resource Centre	0.099	0.086	0.65	0.13
137	Koonung Creek Linear Park	0.13	0.11	0.88	0.17
138	Aranga Reserve	0.10	0.091	0.71	0.14
139	Oxford Street Reserve	0.099	0.086	0.66	0.14
140	Belle Vue Primary School	0.93	0.79	6.0	1.4
141	Boroondara Tennis Centre	1.2	1.0	8.0	2.1
142	Musca Street Reserve	0.61	0.51	4.0	0.90
143	Columba Street Reserve	0.87	0.75	5.9	1.3
144	Leonis Avenue Reserve	1.1	0.95	7.2	1.8
145	Koonung Creek Reserve	0.72	0.61	4.6	1.0
146	Winfield Road Reserve	0.32	0.27	2.1	0.41
147	Yarra Flats Reserve	0.52	0.45	3.5	0.90
148	Freeway Public Golf Course	1.2	1.0	8.0	1.7
149	Kew Golf Club	0.31	0.26	2.0	0.47
150	Hays Paddock/Reserve	0.33	0.28	2.2	0.51

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
151	Hyde Park	0.20	0.18	1.4	0.32
152	Burke Rd. billabong reserve	0.53	0.46	3.5	0.84
153	Green Acres Golf Club	0.32	0.28	2.2	0.51
154	Willsmere-Chandler Park	0.26	0.23	1.8	0.41
155	Guide Dogs Victoria	0.17	0.15	1.2	0.27
156	Royal Talbot Rehabilitation Centre	0.20	0.17	1.3	0.27
157	Yarra Bend Park	0.12	0.11	0.84	0.19
158	Kate Campbell Reserve	0.18	0.15	1.2	0.27
159	Jack O'Toole Reserve	0.21	0.18	1.4	0.32
160	North Kew Tennis Club	0.20	0.17	1.4	0.31
161	1st Kew Scout Group	0.20	0.17	1.4	0.31
162	Elgar Park	0.22	0.19	1.4	0.30
163	Koonung Creek Wetlands	0.24	0.20	1.6	0.31
164	Presbyterian Theological College	0.18	0.15	1.2	0.22
165	Koonung Creek Linear Park	0.18	0.15	1.2	0.24
166	Frank Sedgemen Reserve	0.16	0.14	1.1	0.24
167	Bounce Inc.	0.14	0.12	0.98	0.19
168	Flow Through Yoga	0.13	0.12	0.94	0.19
169	Melbourne Badminton Centre	0.14	0.12	0.97	0.19
170	Eastern Freeway Linear Park	0.15	0.13	0.98	0.19
171	Koonung Creek Linear Park	0.14	0.12	0.95	0.16
172	Slater Reserve	0.12	0.11	0.84	0.17
173	Warekila Preschool	0.11	0.099	0.79	0.13
174	Eastern Freeway Linear Reserve	0.11	0.097	0.77	0.13
175	R E Gray Reserve	0.10	0.088	0.70	0.12
176	Koonung Creek Linear Park	0.12	0.10	0.81	0.16
177	Alphington Park	0.21	0.18	1.4	0.32
178	Latrobe Golf Club	0.20	0.17	1.3	0.30
179	Thomas Embling Hospital	0.14	0.12	0.91	0.21
180	Melbourne Polytechnic	0.15	0.13	0.96	0.22

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
181	RMIT Surveying Field Station	0.13	0.11	0.87	0.19
182	Victorian Indigenous Nurseries Co-Operative	0.13	0.11	0.88	0.20
183	Yarra Bend Park	0.12	0.11	0.85	0.19
184	Fairlea Reserve	0.13	0.11	0.87	0.21
185	Yarra Bend Public Golf Course	0.13	0.12	0.92	0.20
186	Petit Early Learning Journey	0.093	0.080	0.62	0.14
187	Gray Street Reserve	0.086	0.074	0.58	0.13
188	Ramden Street Reserve	0.11	0.095	0.73	0.16
189	Dights Falls Reserve	0.084	0.073	0.58	0.13
190	Victoria Park	0.091	0.078	0.62	0.14
191	Maugie Street Reserve	0.092	0.078	0.61	0.14
Maximum					
105	Carey Grammar Sports Complex	2.9	2.5	20	4.8

Table 2: Sensitive receptor results: Scenario A2

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour
1	Greensborough bypass path	0.20	0.12	0.63
2	Plenty River Linear Reserve	0.21	0.13	0.59
3	Greensborough Collendina Reserve	0.15	0.096	0.46
4	Metropolitan Ring Road Linear Reserve	0.18	0.12	0.61
5	Unnamed reserve	0.13	0.085	0.39
6	Hughes Circuit Reserve	0.16	0.10	0.60
7	Maroonday Aqueduct	0.13	0.081	0.42
8	Garvey Oval	0.17	0.11	0.63
9	Northpark Private Hospital	0.20	0.13	0.63
10	Gillingham Reserve	0.18	0.11	0.58
11	Trist Street Reserve	0.25	0.15	0.83
12	Greensborough Preschool	0.36	0.23	1.1
13	Abacus Child Care Centre	0.33	0.21	1.0
14	Kalparrin Early Intervention Program child care	0.23	0.14	0.63
15	Greensborough Road Surgery	0.36	0.23	1.0
16	Diaverum Diamond Valley Dialysis Clinic	0.26	0.16	0.70
17	Greensborough Maternal and Child Health	0.38	0.23	1.1
18	St Mary's Church	0.34	0.21	0.98
19	St Mary's School	0.34	0.21	1.0
20	Greensborough College	0.48	0.31	1.5
21	Greensborough Primary School	0.33	0.21	0.95
22	Banyule City Council Greensborough Service Centre	0.27	0.17	0.76
23	Greensborough RSL	0.24	0.15	0.67
24	Kalparrin Gardens	0.23	0.14	0.63
25	Poulter Avenue Reserve	0.21	0.13	0.57
26	Whatmough Park	0.22	0.14	0.64
27	Fell Reserve	0.34	0.21	0.91
28	Plenty River Drive Reserve	0.20	0.13	0.58
29	St Mary's Reserve	0.35	0.22	0.99

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
30	Sarah's Reserve	0.21	0.13	0.68
31	Metropolitan Ring Road Path	0.18	0.11	0.55
32	Greensborough Police Station	0.38	0.24	1.0
33	Greensborough MFB Fire Station	0.35	0.22	0.99
34	Watsonia Occasional Child Care Centre	0.69	0.43	2.0
35	MS Society Retirement Village	0.56	0.36	1.8
36	Watsonia scout hall	0.28	0.18	0.93
37	Watsonia RSL	0.35	0.22	1.1
38	North East Citizen Advocacy (NECA)	0.66	0.42	2.0
39	Watsonia Library	0.39	0.25	1.2
40	Holy Spirit Anglican Church	0.37	0.23	1.2
41	Grace Baptist Church	0.33	0.21	1.1
42	Watsonia Uniting Church	0.43	0.27	1.4
43	Concord School	0.31	0.20	1.1
44	Watsonia Primary School	0.34	0.21	1.2
45	AK Lines Reserve	0.29	0.18	0.96
46	Elder Street Reserve	0.62	0.39	2.0
47	West Mayling Reserve	0.61	0.39	2.1
48	Gabonia Avenue Reserve	0.66	0.41	2.1
49	Watsonia Station Carpark Reserve	0.47	0.29	1.4
50	Watsonia Road Reserve	0.39	0.25	1.3
51	Greensborough Road Early Learning and Kinder	0.46	0.29	1.5
52	Macleod Recreation and Fitness & CC	0.60	0.38	2.0
53	Macleod Preschool	0.62	0.40	1.9
54	Baptcare Strathalan Macleod	0.89	0.57	3.0
55	Regis Macleod	0.82	0.52	2.6
56	Macleod Maternal and Child Health	0.61	0.39	2.0
57	IDV	0.58	0.37	1.9
58	YMCA Recreation and Fitness Centre	0.59	0.37	2.0
59	Nets Stadium Banyule	0.65	0.41	2.1

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
60	Macleod Organic Community Garden	0.70	0.44	2.3
61	Winsor Reserve	0.97	0.61	3.1
62	Macleod College Oval	0.75	0.48	2.4
63	Macleod Netball Stadium	0.67	0.42	2.2
64	Harry Pottage Reserve	0.57	0.36	1.9
65	Macleod Park	0.60	0.38	1.9
66	Macleod Tennis Club	0.64	0.40	2.0
67	Junior Football Club and Macleod Cricket	0.57	0.37	1.8
68	Simpson Barracks	2.1	1.3	5.8
69	Coleen Reserve	0.86	0.54	2.7
70	Borlase Reserve	0.41	0.26	1.4
71	Melbourne Water easement	0.50	0.32	1.6
72	Goodstart Early Learning	0.20	0.13	0.66
73	Assisi Centre Aged Care	0.29	0.18	0.87
74	Japara Rosanna Views Nursing Home	0.39	0.24	1.1
75	St Martin of Tours Catholic Church	0.37	0.23	1.1
76	St Martin of Tours Catholic Primary School	0.39	0.25	1.2
77	Banyule Primary School	0.23	0.14	0.75
78	Maleela Grove, Rosanna	0.27	0.17	0.91
79	Mercedes Court Reserve	0.22	0.14	0.77
80	River Gum Walk	0.19	0.12	0.61
81	Creekbend Reserve	0.22	0.14	0.75
82	Viewbank College	0.22	0.14	0.70
83	Viewbank family medical group	0.50	0.32	1.6
84	Viewbank podiatry	0.50	0.31	1.6
85	Simla Close Reserve	0.21	0.14	0.72
86	Banyule Flats	0.15	0.096	0.55
87	River Gum Walk	0.15	0.093	0.52
88	Warringal Parklands	0.14	0.089	0.49
89	Banyule Tennis Club	0.14	0.090	0.48

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
90	Heidelberg Park and Heidelberg cricket ground	0.16	0.10	0.51
91	Banyule Theatre Complex	0.14	0.090	0.51
92	Heidelberg Police Station	0.27	0.17	0.97
93	Austin Hospital Precinct	0.21	0.13	0.64
94	Yarra Flats Park	0.29	0.18	0.91
95	Yarra Flats Park	0.73	0.46	2.5
96	Creative Play Early Learning Centre	0.28	0.18	1.0
97	Kalker Montessori Centre	0.72	0.46	2.1
98	Veneto Club	1.4	0.90	4.4
99	Heide Museum of Modern Art	0.25	0.16	0.85
100	Bulleen Art and Garden	0.21	0.13	0.65
101	Marcellin College	1.2	0.79	3.8
102	Trinity Grammar School Sporting Complex	0.66	0.42	2.1
104	Bolin Bolin Billabong	0.62	0.39	1.9
105	Carey Grammar Sports Complex	2.0	1.3	6.4
106	Yarra Valley parklands	0.18	0.11	0.59
107	Sandra Street Reserve	1.1	0.70	3.8
108	Bulleen Park	0.81	0.52	2.9
109	Koonung Reserve	0.67	0.43	2.0
110	Koonung Creek Reserve	0.51	0.32	1.5
111	Willow Bend Reserve	0.41	0.26	1.2
112	Pipe Line Reserve	0.58	0.36	1.9
113	Yarra Valley Country Club	0.25	0.16	0.91
114	Bulleen Golf Driving Range	0.24	0.15	0.71
115	Wonderland Childcare and Kinder	0.23	0.15	0.69
116	Applewood Residence	0.12	0.075	0.39
117	Tende Beck Scout Hall	0.22	0.14	0.69
118	North Eastern Jewish Centre-Yeshurun Congregation	0.23	0.15	0.69
119	Birralee Primary School	0.16	0.10	0.51
120	Wilsons Road Reserve	0.17	0.11	0.56

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
121	Katrina Street Reserve	0.14	0.087	0.45
122	Davis Street Reserve	0.13	0.080	0.45
123	Tram Road Reserve	0.11	0.071	0.37
124	Frank Sedgman Reserve	0.11	0.069	0.38
125	Koonung Creek Linear Park	0.11	0.069	0.38
126	Stanton Street Reserve	0.19	0.12	0.55
127	Doncaster Park and Ride	0.19	0.12	0.64
128	Tino Ceberano Martial Arts Academy	0.21	0.14	0.67
129	Greythorn Bowling Club	0.26	0.17	0.84
130	Manningham Park Reserve	0.27	0.17	0.91
131	Japara Sydney Williams Apartments	0.093	0.060	0.33
132	Japara Millward Nursing home	0.092	0.060	0.33
133	Koonung Creek Reserve	0.11	0.071	0.38
134	Boronia Grove Reserve	0.100	0.064	0.35
135	Heatherwood School	0.071	0.046	0.21
136	State Vision Resource Centre	0.071	0.046	0.21
137	Koonung Creek Linear Park	0.080	0.052	0.28
138	Aranga Reserve	0.071	0.046	0.23
139	Oxford Street Reserve	0.064	0.041	0.21
140	Belle Vue Primary School	0.68	0.43	2.0
141	Boroondara Tennis Centre	0.88	0.56	2.6
142	Musca Street Reserve	0.41	0.26	1.3
143	Columba Street Reserve	0.58	0.38	1.9
144	Leonis Avenue Reserve	0.80	0.51	2.4
145	Koonung Creek Reserve	0.52	0.32	1.5
146	Winfield Road Reserve	0.22	0.14	0.69
147	Yarra Flats Reserve	0.37	0.24	1.2
148	Freeway Public Golf Course	0.87	0.55	2.6
149	Kew Golf Club	0.21	0.14	0.66
150	Hays Paddock/Reserve	0.22	0.14	0.71

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
151	Hyde Park	0.14	0.091	0.45
152	Burke Rd. billabong reserve	0.36	0.23	1.2
153	Green Acres Golf Club	0.23	0.15	0.73
154	Willsmere-Chandler Park	0.19	0.12	0.59
155	Guide Dogs Victoria	0.12	0.077	0.39
156	Royal Talbot Rehabilitation Centre	0.13	0.084	0.42
157	Yarra Bend Park	0.086	0.054	0.28
158	Kate Campbell Reserve	0.12	0.080	0.39
159	Jack O'Toole Reserve	0.15	0.093	0.46
160	North Kew Tennis Club	0.14	0.091	0.45
161	1st Kew Scout Group	0.14	0.090	0.45
162	Elgar Park	0.16	0.10	0.47
163	Koonung Creek Wetlands	0.15	0.098	0.52
164	Presbyterian Theological College	0.13	0.085	0.39
165	Koonung Creek Linear Park	0.11	0.073	0.39
166	Frank Sedgemen Reserve	0.10	0.068	0.37
167	Bounce Inc.	0.091	0.058	0.32
168	Flow Through Yoga	0.090	0.058	0.31
169	Melbourne Badminton Centre	0.090	0.058	0.31
170	Eastern Freeway Linear Park	0.092	0.059	0.32
171	Koonung Creek Linear Park	0.089	0.057	0.31
172	Slater Reserve	0.080	0.051	0.28
173	Warekila Preschool	0.075	0.048	0.26
174	Eastern Freeway Linear Reserve	0.073	0.047	0.25
175	R E Gray Reserve	0.066	0.042	0.23
176	Koonung Creek Linear Park	0.074	0.048	0.26
177	Alphington Park	0.14	0.090	0.45
178	Latrobe Golf Club	0.14	0.087	0.44
179	Thomas Embling Hospital	0.095	0.061	0.30
180	Melbourne Polytechnic	0.10	0.065	0.32

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
181	RMIT Surveying Field Station	0.084	0.054	0.29
182	Victorian Indigenous Nurseries Co-Operative	0.088	0.056	0.29
183	Yarra Bend Park	0.086	0.054	0.28
184	Fairlea Reserve	0.088	0.055	0.29
185	Yarra Bend Public Golf Course	0.092	0.058	0.30
186	Petit Early Learning Journey	0.063	0.040	0.20
187	Gray Street Reserve	0.057	0.037	0.19
188	Ramden Street Reserve	0.074	0.047	0.23
189	Dights Falls Reserve	0.056	0.035	0.19
190	Victoria Park	0.062	0.039	0.20
191	Maugie Street Reserve	0.060	0.038	0.20
Maximum				
68	Simpson Barracks	2.1	1.3	-
105	Carey Grammar Sports Complex	-	-	6.4

Table 3: Sensitive receptor results: Scenario B1

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
1	Greensborough bypass path	0.32	0.27	2.3	0.38
2	Plenty River Linear Reserve	0.31	0.26	2.2	0.39
3	Greensborough Collendina Reserve	0.25	0.21	1.6	0.28
4	Metropolitan Ring Road Linear Reserve	0.31	0.26	2.2	0.34
5	Unnamed reserve	0.21	0.18	1.4	0.27
6	Hughes Circuit Reserve	0.29	0.25	2.1	0.29
7	Maroonday Aqueduct	0.21	0.18	1.5	0.26
8	Garvey Oval	0.31	0.26	2.2	0.29
9	Northpark Private Hospital	0.34	0.29	2.4	0.29
10	Gillingham Reserve	0.29	0.25	2.1	0.34
11	Trist Street Reserve	0.41	0.35	3.0	0.46
12	Greensborough Preschool	0.57	0.47	3.9	0.69
13	Abacus Child Care Centre	0.52	0.45	3.5	0.65
14	Kalparrin Early Intervention Program child care	0.34	0.29	2.4	0.44
15	Greensborough Road Surgery	0.57	0.48	3.9	0.64
16	Diaverum Diamond Valley Dialysis Clinic	0.36	0.31	2.5	0.45
17	Greensborough Maternal and Child Health	0.58	0.49	4.0	0.73
18	St Mary's Church	0.52	0.44	3.6	0.61
19	St Mary's School	0.53	0.45	3.6	0.62
20	Greensborough College	0.77	0.65	5.0	0.92
21	Greensborough Primary School	0.47	0.41	3.5	0.59
22	Banyule City Council Greensborough Service Centre	0.38	0.32	2.5	0.46
23	Greensborough RSL	0.33	0.28	2.2	0.41
24	Kalparrin Gardens	0.33	0.28	2.3	0.42
25	Poulter Avenue Reserve	0.29	0.25	2.1	0.37
26	Whatmough Park	0.32	0.28	2.4	0.41
27	Fell Reserve	0.47	0.40	3.2	0.60
28	Plenty River Drive Reserve	0.31	0.26	2.2	0.39
29	St Mary's Reserve	0.55	0.46	3.8	0.61

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
30	Sarah's Reserve	0.35	0.29	2.5	0.38
31	Metropolitan Ring Road Path	0.28	0.24	2.0	0.32
32	Greensborough Police Station	0.53	0.46	3.7	0.66
33	Greensborough MFB Fire Station	0.52	0.45	3.7	0.67
34	Watsonia Occasional Child Care Centre	1.1	0.95	7.6	1.3
35	MS Society Retirement Village	0.93	0.79	6.5	0.97
36	Watsonia scout hall	0.46	0.39	3.3	0.53
37	Watsonia RSL	0.58	0.49	4.0	0.70
38	North East Citizen Advocacy (NECA)	1.1	0.95	7.4	1.3
39	Watsonia Library	0.68	0.58	4.7	0.71
40	Holy Spirit Anglican Church	0.62	0.53	4.4	0.70
41	Grace Baptist Church	0.56	0.47	4.0	0.62
42	Watsonia Uniting Church	0.69	0.58	5.0	0.81
43	Concord School	0.53	0.45	3.8	0.59
44	Watsonia Primary School	0.57	0.49	4.1	0.62
45	AK Lines Reserve	0.48	0.41	3.4	0.53
46	Elder Street Reserve	0.95	0.80	6.2	1.2
47	West Mayling Reserve	1.0	0.89	7.4	1.0
48	Gabonia Avenue Reserve	1.1	0.92	7.1	1.3
49	Watsonia Station Carpark Reserve	0.79	0.67	5.5	0.87
50	Watsonia Road Reserve	0.66	0.56	4.6	0.74
51	Greensborough Road Early Learning and Kinder	0.81	0.69	5.6	0.77
52	Macleod Recreation and Fitness & CC	1.0	0.89	7.4	1.1
53	Macleod Preschool	1.0	0.87	7.3	1.1
54	Baptcare Strathalan Macleod	1.6	1.3	11	1.4
55	Regis Macleod	1.3	1.1	9.4	1.2
56	Macleod Maternal and Child Health	1.0	0.90	7.5	1.1
57	IDV	1.0	0.88	7.3	1.1
58	YMCA Recreation and Fitness Centre	1.0	0.89	7.4	1.1
59	Nets Stadium Banyule	1.1	0.96	8.1	1.3

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
60	Macleod Organic Community Garden	1.2	1.0	8.3	1.2
61	Winsor Reserve	1.6	1.4	11	1.4
62	Macleod College Oval	1.3	1.1	9.4	1.3
63	Macleod Netball Stadium	1.1	0.99	8.2	1.2
64	Harry Pottage Reserve	0.99	0.85	7.1	1.1
65	Macleod Park	0.98	0.83	6.8	0.95
66	Macleod Tennis Club	1.0	0.87	7.4	1.1
67	Junior Football Club and Macleod Cricket	0.95	0.80	6.5	0.93
68	Simpson Barracks	3.0	2.6	22	3.4
69	Coleen Reserve	1.3	1.1	9.0	1.4
70	Borlase Reserve	0.71	0.61	5.2	0.68
71	Melbourne Water easement	0.85	0.73	6.1	0.83
72	Goodstart Early Learning	0.35	0.30	2.5	0.31
73	Assisi Centre Aged Care	0.46	0.39	3.1	0.52
74	Japara Rosanna Views Nursing Home	0.61	0.52	4.1	0.67
75	St Martin of Tours Catholic Church	0.59	0.49	4.1	0.66
76	St Martin of Tours Catholic Primary School	0.61	0.53	4.4	0.69
77	Banyule Primary School	0.39	0.34	2.7	0.37
78	Maleela Grove, Rosanna	0.48	0.41	3.4	0.45
79	Mercedes Court Reserve	0.37	0.32	2.8	0.38
80	River Gum Walk	0.32	0.28	2.4	0.31
81	Creekbend Reserve	0.39	0.34	2.9	0.36
82	Viewbank College	0.38	0.31	2.6	0.41
83	Viewbank family medical group	0.86	0.73	6.3	0.78
84	Viewbank podiatry	0.86	0.75	6.1	0.81
85	Simla Close Reserve	0.37	0.32	2.7	0.36
86	Banyule Flats	0.28	0.25	2.0	0.33
87	River Gum Walk	0.27	0.23	1.9	0.28
88	Warringal Parklands	0.25	0.22	1.7	0.29
89	Banyule Tennis Club	0.25	0.22	1.8	0.29

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
90	Heidelberg Park and Heidelberg cricket ground	0.27	0.23	1.8	0.37
91	Banyule Theatre Complex	0.26	0.22	1.9	0.28
92	Heidelberg Police Station	0.50	0.43	3.4	0.62
93	Austin Hospital Precinct	0.39	0.34	2.8	0.49
94	Yarra Flats Park	0.53	0.47	3.8	0.72
95	Yarra Flats Park	1.3	1.1	8.6	1.7
96	Creative Play Early Learning Centre	0.51	0.45	3.6	0.64
97	Kalker Montessori Centre	1.1	0.90	7.3	1.7
98	Veneto Club	2.3	2.0	15	3.4
99	Heide Museum of Modern Art	0.43	0.37	2.9	0.53
100	Bulleen Art and Garden	0.36	0.30	2.4	0.45
101	Marcellin College	1.9	1.7	13	2.9
102	Trinity Grammar School Sporting Complex	1.2	1.1	8.6	1.6
104	Bolin Bolin Billabong	1.1	0.97	7.9	1.3
105	Carey Grammar Sports Complex	3.3	2.9	22	4.8
106	Yarra Valley parklands	0.31	0.27	2.2	0.41
107	Sandra Street Reserve	1.9	1.6	13	2.5
108	Bulleen Park	1.5	1.3	10	1.9
109	Koonung Reserve	1.1	0.94	7.6	1.5
110	Koonung Creek Reserve	0.75	0.64	4.9	1.2
111	Willow Bend Reserve	0.61	0.52	4.0	0.94
112	Pipe Line Reserve	0.92	0.80	6.4	1.3
113	Yarra Valley Country Club	0.45	0.39	3.1	0.61
114	Bulleen Golf Driving Range	0.42	0.36	2.9	0.53
115	Wonderland Childcare and Kinder	0.40	0.35	2.8	0.51
116	Applewood Residence	0.21	0.18	1.4	0.28
117	Tende Beck Scout Hall	0.38	0.33	2.6	0.51
118	North Eastern Jewish Centre-Yeshurun Congregation	0.39	0.35	2.8	0.52
119	Birralee Primary School	0.28	0.25	2.0	0.36
120	Wilsons Road Reserve	0.31	0.27	2.2	0.41

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
121	Katrina Street Reserve	0.25	0.22	1.7	0.31
122	Davis Street Reserve	0.23	0.20	1.6	0.29
123	Tram Road Reserve	0.20	0.17	1.3	0.27
124	Frank Sedgman Reserve	0.19	0.17	1.4	0.25
125	Koonung Creek Linear Park	0.19	0.17	1.3	0.24
126	Stanton Street Reserve	0.29	0.24	1.9	0.42
127	Doncaster Park and Ride	0.36	0.31	2.5	0.46
128	Tino Ceberano Martial Arts Academy	0.38	0.33	2.6	0.51
129	Greythorn Bowling Club	0.46	0.40	3.2	0.59
130	Manningham Park Reserve	0.48	0.41	3.3	0.59
131	Japara Sydney Williams Apartments	0.17	0.14	1.1	0.20
132	Japara Millward Nursing home	0.17	0.14	1.1	0.20
133	Koonung Creek Reserve	0.19	0.16	1.2	0.23
134	Boronia Grove Reserve	0.17	0.15	1.1	0.21
135	Heatherwood School	0.11	0.090	0.71	0.15
136	State Vision Resource Centre	0.11	0.091	0.71	0.15
137	Koonung Creek Linear Park	0.14	0.12	0.92	0.17
138	Aranga Reserve	0.12	0.099	0.76	0.15
139	Oxford Street Reserve	0.11	0.092	0.72	0.14
140	Belle Vue Primary School	1.2	1.0	7.7	1.5
141	Boroondara Tennis Centre	1.3	1.2	9.2	2.1
142	Musca Street Reserve	0.68	0.59	4.5	0.92
143	Columba Street Reserve	1.1	0.93	7.6	1.4
144	Leonis Avenue Reserve	1.2	1.0	7.9	1.8
145	Koonung Creek Reserve	0.75	0.64	4.9	1.2
146	Winfield Road Reserve	0.35	0.30	2.4	0.48
147	Yarra Flats Reserve	0.58	0.49	3.7	0.89
148	Freeway Public Golf Course	1.3	1.2	8.8	2.0
149	Kew Golf Club	0.33	0.28	2.2	0.50
150	Hays Paddock/Reserve	0.36	0.31	2.3	0.51

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
151	Hyde Park	0.23	0.20	1.6	0.33
152	Burke Rd. billabong reserve	0.58	0.50	4.0	0.89
153	Green Acres Golf Club	0.37	0.32	2.5	0.54
154	Willsmere-Chandler Park	0.30	0.26	2.0	0.43
155	Guide Dogs Victoria	0.20	0.17	1.4	0.28
156	Royal Talbot Rehabilitation Centre	0.21	0.19	1.4	0.29
157	Yarra Bend Park	0.14	0.12	0.97	0.20
158	Kate Campbell Reserve	0.19	0.17	1.3	0.29
159	Jack O'Toole Reserve	0.23	0.20	1.6	0.33
160	North Kew Tennis Club	0.23	0.20	1.5	0.32
161	1st Kew Scout Group	0.23	0.20	1.5	0.32
162	Elgar Park	0.24	0.21	1.7	0.34
163	Koonung Creek Wetlands	0.26	0.23	1.8	0.34
164	Presbyterian Theological College	0.21	0.18	1.4	0.27
165	Koonung Creek Linear Park	0.21	0.18	1.4	0.24
166	Frank Sedgemen Reserve	0.20	0.17	1.4	0.24
167	Bounce Inc.	0.17	0.14	1.1	0.19
168	Flow Through Yoga	0.15	0.13	1.0	0.19
169	Melbourne Badminton Centre	0.16	0.14	1.1	0.19
170	Eastern Freeway Linear Park	0.16	0.14	1.1	0.19
171	Koonung Creek Linear Park	0.15	0.13	1.0	0.18
172	Slater Reserve	0.14	0.12	0.94	0.17
173	Warekila Preschool	0.13	0.11	0.86	0.15
174	Eastern Freeway Linear Reserve	0.13	0.11	0.83	0.15
175	R E Gray Reserve	0.11	0.098	0.75	0.13
176	Koonung Creek Linear Park	0.13	0.11	0.85	0.16
177	Alphington Park	0.23	0.20	1.5	0.35
178	Latrobe Golf Club	0.22	0.19	1.5	0.31
179	Thomas Embling Hospital	0.15	0.13	1.0	0.23
180	Melbourne Polytechnic	0.16	0.14	1.1	0.25

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
181	RMIT Surveying Field Station	0.14	0.12	0.98	0.20
182	Victorian Indigenous Nurseries Co-Operative	0.15	0.13	1.00	0.20
183	Yarra Bend Park	0.14	0.12	0.94	0.20
184	Fairlea Reserve	0.15	0.12	0.97	0.21
185	Yarra Bend Public Golf Course	0.15	0.13	1.0	0.22
186	Petit Early Learning Journey	0.10	0.087	0.66	0.15
187	Gray Street Reserve	0.096	0.084	0.66	0.13
188	Ramden Street Reserve	0.12	0.10	0.79	0.18
189	Dights Falls Reserve	0.097	0.083	0.66	0.13
190	Victoria Park	0.10	0.088	0.70	0.15
191	Maugie Street Reserve	0.100	0.086	0.69	0.14
Maximum					
105	Carey Grammar Sports Complex	3.3	2.9	22	4.8

Table 4: Sensitive receptor results: Scenario B2

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour
1	Greensborough bypass path	0.24	0.15	0.78
2	Plenty River Linear Reserve	0.23	0.15	0.70
3	Greensborough Collendina Reserve	0.18	0.11	0.54
4	Metropolitan Ring Road Linear Reserve	0.21	0.14	0.70
5	Unnamed reserve	0.16	0.10	0.45
6	Hughes Circuit Reserve	0.21	0.14	0.70
7	Maroonday Aqueduct	0.15	0.098	0.49
8	Garvey Oval	0.20	0.13	0.71
9	Northpark Private Hospital	0.23	0.15	0.78
10	Gillingham Reserve	0.21	0.13	0.68
11	Trist Street Reserve	0.31	0.19	0.97
12	Greensborough Preschool	0.43	0.27	1.3
13	Abacus Child Care Centre	0.40	0.25	1.1
14	Kalparrin Early Intervention Program child care	0.26	0.16	0.75
15	Greensborough Road Surgery	0.42	0.26	1.2
16	Diaverum Diamond Valley Dialysis Clinic	0.28	0.18	0.82
17	Greensborough Maternal and Child Health	0.45	0.29	1.3
18	St Mary's Church	0.39	0.25	1.2
19	St Mary's School	0.39	0.24	1.2
20	Greensborough College	0.57	0.36	1.6
21	Greensborough Primary School	0.37	0.23	1.1
22	Banyule City Council Greensborough Service Centre	0.29	0.18	0.80
23	Greensborough RSL	0.25	0.16	0.69
24	Kalparrin Gardens	0.25	0.16	0.74
25	Poulter Avenue Reserve	0.23	0.14	0.68
26	Whatmough Park	0.25	0.16	0.77
27	Fell Reserve	0.37	0.23	1.1
28	Plenty River Drive Reserve	0.24	0.16	0.70
29	St Mary's Reserve	0.41	0.26	1.2

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
30	Sarah's Reserve	0.24	0.15	0.81
31	Metropolitan Ring Road Path	0.21	0.13	0.65
32	Greensborough Police Station	0.40	0.25	1.2
33	Greensborough MFB Fire Station	0.40	0.25	1.2
34	Watsonia Occasional Child Care Centre	0.82	0.52	2.4
35	MS Society Retirement Village	0.66	0.42	2.1
36	Watsonia scout hall	0.33	0.21	1.1
37	Watsonia RSL	0.41	0.26	1.3
38	North East Citizen Advocacy (NECA)	0.83	0.52	2.3
39	Watsonia Library	0.47	0.30	1.6
40	Holy Spirit Anglican Church	0.43	0.27	1.4
41	Grace Baptist Church	0.39	0.24	1.3
42	Watsonia Uniting Church	0.51	0.32	1.7
43	Concord School	0.37	0.23	1.2
44	Watsonia Primary School	0.42	0.26	1.4
45	AK Lines Reserve	0.34	0.21	1.1
46	Elder Street Reserve	0.71	0.45	2.1
47	West Mayling Reserve	0.74	0.47	2.4
48	Gabonia Avenue Reserve	0.83	0.53	2.3
49	Watsonia Station Carpark Reserve	0.54	0.34	1.8
50	Watsonia Road Reserve	0.46	0.29	1.5
51	Greensborough Road Early Learning and Kinder	0.55	0.35	1.8
52	Macleod Recreation and Fitness & CC	0.74	0.46	2.5
53	Macleod Preschool	0.74	0.46	2.4
54	Baptcare Strathalan Macleod	1.1	0.69	3.7
55	Regis Macleod	0.91	0.58	3.0
56	Macleod Maternal and Child Health	0.72	0.46	2.4
57	IDV	0.71	0.44	2.4
58	YMCA Recreation and Fitness Centre	0.73	0.45	2.5
59	Nets Stadium Banyule	0.81	0.50	2.7

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
60	Macleod Organic Community Garden	0.86	0.55	2.7
61	Winsor Reserve	1.1	0.69	3.7
62	Macleod College Oval	0.89	0.57	3.1
63	Macleod Netball Stadium	0.81	0.51	2.7
64	Harry Pottage Reserve	0.73	0.46	2.3
65	Macleod Park	0.71	0.45	2.2
66	Macleod Tennis Club	0.74	0.46	2.4
67	Junior Football Club and Macleod Cricket	0.68	0.43	2.1
68	Simpson Barracks	2.1	1.4	7.1
69	Coleen Reserve	0.97	0.61	3.0
70	Borlase Reserve	0.50	0.32	1.7
71	Melbourne Water easement	0.57	0.37	2.0
72	Goodstart Early Learning	0.24	0.15	0.83
73	Assisi Centre Aged Care	0.34	0.22	1.0
74	Japara Rosanna Views Nursing Home	0.43	0.27	1.4
75	St Martin of Tours Catholic Church	0.42	0.27	1.3
76	St Martin of Tours Catholic Primary School	0.45	0.28	1.4
77	Banyule Primary School	0.26	0.17	0.87
78	Maleela Grove, Rosanna	0.32	0.21	1.1
79	Mercedes Court Reserve	0.27	0.17	0.91
80	River Gum Walk	0.21	0.14	0.78
81	Creekbend Reserve	0.27	0.17	0.94
82	Viewbank College	0.26	0.17	0.85
83	Viewbank family medical group	0.59	0.38	2.1
84	Viewbank podiatry	0.60	0.38	2.0
85	Simla Close Reserve	0.25	0.16	0.89
86	Banyule Flats	0.19	0.12	0.67
87	River Gum Walk	0.17	0.11	0.62
88	Warringal Parklands	0.16	0.10	0.57
89	Banyule Tennis Club	0.16	0.11	0.59

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
90	Heidelberg Park and Heidelberg cricket ground	0.18	0.12	0.61
91	Banyule Theatre Complex	0.17	0.11	0.61
92	Heidelberg Police Station	0.31	0.20	1.1
93	Austin Hospital Precinct	0.23	0.15	0.91
94	Yarra Flats Park	0.33	0.22	1.2
95	Yarra Flats Park	0.82	0.53	2.9
96	Creative Play Early Learning Centre	0.32	0.21	1.2
97	Kalker Montessori Centre	0.76	0.48	2.4
98	Veneto Club	1.5	0.94	5.1
99	Heide Museum of Modern Art	0.29	0.18	0.97
100	Bulleen Art and Garden	0.24	0.15	0.81
101	Marcellin College	1.3	0.81	4.3
102	Trinity Grammar School Sporting Complex	0.73	0.47	2.9
104	Bolin Bolin Billabong	0.69	0.44	2.6
105	Carey Grammar Sports Complex	2.2	1.4	7.4
106	Yarra Valley parklands	0.21	0.13	0.72
107	Sandra Street Reserve	1.2	0.80	4.3
108	Bulleen Park	0.91	0.59	3.4
109	Koonung Reserve	0.74	0.47	2.5
110	Koonung Creek Reserve	0.54	0.34	1.6
111	Willow Bend Reserve	0.42	0.27	1.3
112	Pipe Line Reserve	0.64	0.41	2.1
113	Yarra Valley Country Club	0.28	0.18	1.0
114	Bulleen Golf Driving Range	0.27	0.17	0.94
115	Wonderland Childcare and Kinder	0.26	0.17	0.93
116	Applewood Residence	0.14	0.092	0.47
117	Tende Beck Scout Hall	0.24	0.16	0.87
118	North Eastern Jewish Centre-Yeshurun Congregation	0.26	0.17	0.94
119	Birralee Primary School	0.17	0.11	0.67
120	Wilsons Road Reserve	0.19	0.12	0.73

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
121	Katrina Street Reserve	0.16	0.10	0.57
122	Davis Street Reserve	0.14	0.093	0.52
123	Tram Road Reserve	0.14	0.089	0.44
124	Frank Sedgman Reserve	0.12	0.079	0.45
125	Koonung Creek Linear Park	0.13	0.081	0.43
126	Stanton Street Reserve	0.19	0.12	0.62
127	Doncaster Park and Ride	0.22	0.14	0.84
128	Tino Ceberano Martial Arts Academy	0.25	0.16	0.87
129	Greythorn Bowling Club	0.30	0.19	1.0
130	Manningham Park Reserve	0.31	0.20	1.1
131	Japara Sydney Williams Apartments	0.11	0.068	0.35
132	Japara Millward Nursing home	0.11	0.068	0.34
133	Koonung Creek Reserve	0.12	0.080	0.40
134	Boronia Grove Reserve	0.11	0.073	0.37
135	Heatherwood School	0.077	0.048	0.23
136	State Vision Resource Centre	0.076	0.048	0.23
137	Koonung Creek Linear Park	0.092	0.059	0.30
138	Aranga Reserve	0.081	0.051	0.25
139	Oxford Street Reserve	0.074	0.047	0.23
140	Belle Vue Primary School	0.72	0.45	2.5
141	Boroondara Tennis Centre	0.93	0.59	3.0
142	Musca Street Reserve	0.46	0.29	1.5
143	Columba Street Reserve	0.66	0.43	2.5
144	Leonis Avenue Reserve	0.89	0.56	2.6
145	Koonung Creek Reserve	0.54	0.34	1.6
146	Winfield Road Reserve	0.23	0.14	0.79
147	Yarra Flats Reserve	0.39	0.25	1.2
148	Freeway Public Golf Course	0.92	0.59	2.9
149	Kew Golf Club	0.23	0.15	0.74
150	Hays Paddock/Reserve	0.25	0.16	0.76

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
151	Hyde Park	0.15	0.097	0.51
152	Burke Rd. billabong reserve	0.41	0.26	1.3
153	Green Acres Golf Club	0.24	0.15	0.82
154	Willsmere-Chandler Park	0.21	0.13	0.67
155	Guide Dogs Victoria	0.13	0.084	0.45
156	Royal Talbot Rehabilitation Centre	0.14	0.092	0.47
157	Yarra Bend Park	0.092	0.059	0.32
158	Kate Campbell Reserve	0.13	0.086	0.44
159	Jack O'Toole Reserve	0.16	0.100	0.51
160	North Kew Tennis Club	0.15	0.097	0.49
161	1st Kew Scout Group	0.15	0.095	0.49
162	Elgar Park	0.16	0.10	0.55
163	Koonung Creek Wetlands	0.17	0.11	0.59
164	Presbyterian Theological College	0.16	0.10	0.45
165	Koonung Creek Linear Park	0.13	0.083	0.44
166	Frank Sedgemen Reserve	0.12	0.078	0.45
167	Bounce Inc.	0.10	0.067	0.36
168	Flow Through Yoga	0.10	0.065	0.35
169	Melbourne Badminton Centre	0.11	0.069	0.36
170	Eastern Freeway Linear Park	0.10	0.066	0.36
171	Koonung Creek Linear Park	0.10	0.065	0.33
172	Slater Reserve	0.091	0.058	0.30
173	Warekila Preschool	0.085	0.055	0.28
174	Eastern Freeway Linear Reserve	0.083	0.054	0.27
175	R E Gray Reserve	0.075	0.048	0.24
176	Koonung Creek Linear Park	0.085	0.055	0.27
177	Alphington Park	0.16	0.100	0.50
178	Latrobe Golf Club	0.15	0.094	0.49
179	Thomas Embling Hospital	0.11	0.067	0.33
180	Melbourne Polytechnic	0.11	0.070	0.35

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
181	RMIT Surveying Field Station	0.095	0.061	0.32
182	Victorian Indigenous Nurseries Co-Operative	0.099	0.063	0.33
183	Yarra Bend Park	0.090	0.058	0.30
184	Fairlea Reserve	0.096	0.062	0.32
185	Yarra Bend Public Golf Course	0.10	0.064	0.33
186	Petit Early Learning Journey	0.068	0.043	0.22
187	Gray Street Reserve	0.063	0.041	0.22
188	Ramden Street Reserve	0.080	0.051	0.26
189	Dights Falls Reserve	0.063	0.040	0.22
190	Victoria Park	0.068	0.043	0.23
191	Maugie Street Reserve	0.067	0.043	0.22
Maximum				
105	Carey Grammar Sports Complex	2.2	1.4	7.4

Table 5: Sensitive receptor results: Sensitivity analysis – Maximum tunnel capacity

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
1	Greensborough bypass path	0.98	0.85	7.6	1.1
2	Plenty River Linear Reserve	0.79	0.69	6.1	0.80
3	Greensborough Collendina Reserve	0.87	0.76	6.7	0.96
4	Metropolitan Ring Road Linear Reserve	1.1	0.94	8.3	1.1
5	Unnamed reserve	0.81	0.71	6.0	0.90
6	Hughes Circuit Reserve	0.81	0.71	6.3	0.85
7	Maroonday Aqueduct	0.74	0.65	5.7	0.92
8	Garvey Oval	0.85	0.74	6.4	0.90
9	Northpark Private Hospital	0.92	0.80	7.1	0.93
10	Gillingham Reserve	1.0	0.90	7.9	1.2
11	Trist Street Reserve	1.3	1.1	9.9	1.4
12	Greensborough Preschool	1.4	1.2	11	1.5
13	Abacus Child Care Centre	1.4	1.2	11	1.4
14	Kalparrin Early Intervention Program child care	0.81	0.71	6.3	0.85
15	Greensborough Road Surgery	1.7	1.5	13	1.6
16	Diaverum Diamond Valley Dialysis Clinic	0.98	0.86	7.7	0.95
17	Greensborough Maternal and Child Health	1.4	1.2	11	1.5
18	St Mary's Church	1.5	1.3	11	1.5
19	St Mary's School	1.5	1.3	12	1.5
20	Greensborough College	2.2	1.9	17	2.3
21	Greensborough Primary School	1.2	1.1	9.3	1.2
22	Banyule City Council Greensborough Service Centre	0.98	0.86	7.6	0.98
23	Greensborough RSL	0.88	0.76	6.6	0.85
24	Kalparrin Gardens	0.84	0.73	6.5	0.85
25	Poulter Avenue Reserve	0.81	0.70	6.3	0.79
26	Whatmough Park	0.83	0.72	6.4	0.83
27	Fell Reserve	1.2	1.0	9.1	1.2
28	Plenty River Drive Reserve	0.81	0.71	6.3	0.82
29	St Mary's Reserve	1.6	1.4	12	1.6

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
30	Sarah's Reserve	0.99	0.87	7.6	1.1
31	Metropolitan Ring Road Path	1.0	0.90	8.0	1.2
32	Greensborough Police Station	1.4	1.2	11	1.4
33	Greensborough MFB Fire Station	1.3	1.1	9.9	1.4
34	Watsonia Occasional Child Care Centre	3.2	2.8	25	3.1
35	MS Society Retirement Village	3.1	2.7	23	3.4
36	Watsonia scout hall	1.6	1.4	12	1.7
37	Watsonia RSL	2.1	1.8	16	2.3
38	North East Citizen Advocacy (NECA)	3.1	2.7	24	3.1
39	Watsonia Library	2.2	2.0	17	2.5
40	Holy Spirit Anglican Church	2.2	1.9	17	2.3
41	Grace Baptist Church	1.9	1.6	14	2.0
42	Watsonia Uniting Church	2.5	2.2	19	2.6
43	Concord School	1.8	1.5	14	1.9
44	Watsonia Primary School	1.9	1.7	15	2.1
45	AK Lines Reserve	1.5	1.4	12	1.7
46	Elder Street Reserve	2.6	2.3	20	2.6
47	West Mayling Reserve	3.6	3.1	28	3.7
48	Gabonia Avenue Reserve	3.0	2.7	24	3.0
49	Watsonia Station Carpark Reserve	2.8	2.5	22	3.0
50	Watsonia Road Reserve	2.3	2.0	18	2.5
51	Greensborough Road Early Learning and Kinder	2.1	1.9	17	2.1
52	Macleod Recreation and Fitness & CC	2.3	2.0	18	2.3
53	Macleod Preschool	2.4	2.1	19	2.4
54	Baptcare Strathalan Macleod	3.6	3.1	28	3.5
55	Regis Macleod	4.2	3.6	32	4.2
56	Macleod Maternal and Child Health	2.5	2.2	19	2.4
57	IDV	2.4	2.1	18	2.3
58	YMCA Recreation and Fitness Centre	2.3	2.0	18	2.3
59	Nets Stadium Banyule	2.6	2.2	20	2.5

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
60	Macleod Organic Community Garden	2.8	2.5	22	2.8
61	Winsor Reserve	4.8	4.2	36	4.9
62	Macleod College Oval	3.1	2.7	24	3.0
63	Macleod Netball Stadium	2.6	2.3	20	2.6
64	Harry Pottage Reserve	2.4	2.1	19	2.3
65	Macleod Park	2.1	1.9	16	2.1
66	Macleod Tennis Club	2.3	2.0	18	2.2
67	Junior Football Club and Macleod Cricket	2.0	1.8	16	2.0
68	Simpson Barracks	5.7	5.0	44	6.1
69	Coleen Reserve	3.8	3.3	29	3.6
70	Borlase Reserve	1.9	1.7	15	1.9
71	Melbourne Water easement	2.2	2.0	17	2.3
72	Goodstart Early Learning	0.90	0.78	6.9	0.94
73	Assisi Centre Aged Care	1.3	1.1	10	1.3
74	Japara Rosanna Views Nursing Home	1.7	1.5	13	1.6
75	St Martin of Tours Catholic Church	1.6	1.4	13	1.6
76	St Martin of Tours Catholic Primary School	1.8	1.5	14	1.6
77	Banyule Primary School	1.00	0.87	7.7	1.0
78	Maleela Grove, Rosanna	1.3	1.1	9.9	1.2
79	Mercedes Court Reserve	1.0	0.90	8.0	1.0
80	River Gum Walk	0.81	0.70	6.2	0.96
81	Creekbend Reserve	1.0	0.89	7.8	1.0
82	Viewbank College	1.0	0.90	7.8	1.1
83	Viewbank family medical group	2.2	1.9	17	2.2
84	Viewbank podiatry	2.3	2.0	18	2.3
85	Simla Close Reserve	1.0	0.89	8.0	1.0
86	Banyule Flats	0.70	0.61	5.1	0.95
87	River Gum Walk	0.71	0.62	5.3	1.0
88	Warringal Parklands	0.66	0.58	4.7	0.97
89	Banyule Tennis Club	0.70	0.61	5.0	1.0

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
90	Heidelberg Park and Heidelberg cricket ground	0.68	0.60	5.1	1.1
91	Banyule Theatre Complex	0.70	0.61	5.2	1.0
92	Heidelberg Police Station	1.1	0.97	7.9	1.7
93	Austin Hospital Precinct	0.99	0.86	7.1	1.5
94	Yarra Flats Park	1.3	1.2	9.4	2.0
95	Yarra Flats Park	2.4	2.1	17	3.6
96	Creative Play Early Learning Centre	1.4	1.2	9.9	2.1
97	Kalker Montessori Centre	2.3	2.0	16	3.4
98	Veneto Club	3.8	3.4	28	6.2
99	Heide Museum of Modern Art	1.2	1.1	8.6	1.8
100	Bulleen Art and Garden	1.2	1.0	8.2	1.7
101	Marcellin College	3.3	2.9	24	5.4
102	Trinity Grammar School Sporting Complex	2.9	2.5	20	4.5
104	Bolin Bolin Billabong	2.6	2.2	18	3.6
105	Carey Grammar Sports Complex	5.7	5.0	40	8.8
106	Yarra Valley parklands	1.0	0.90	7.3	1.5
107	Sandra Street Reserve	3.7	3.2	26	5.8
108	Bulleen Park	3.3	2.9	24	4.7
109	Koonung Reserve	2.4	2.1	17	3.6
110	Koonung Creek Reserve	1.6	1.4	11	2.3
111	Willow Bend Reserve	1.2	1.1	8.8	1.9
112	Pipe Line Reserve	1.9	1.6	13	2.8
113	Yarra Valley Country Club	1.2	1.1	8.7	1.7
114	Bulleen Golf Driving Range	1.0	0.87	7.1	1.5
115	Wonderland Childcare and Kinder	1.0	0.89	7.3	1.4
116	Applewood Residence	0.56	0.49	4.0	0.83
117	Tende Beck Scout Hall	0.96	0.84	6.9	1.4
118	North Eastern Jewish Centre-Yeshurun Congregation	1.0	0.89	7.3	1.4
119	Birralee Primary School	0.66	0.58	4.7	0.98
120	Wilsons Road Reserve	0.74	0.65	5.3	1.1

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
121	Katrina Street Reserve	0.63	0.55	4.5	0.91
122	Davis Street Reserve	0.66	0.58	4.7	0.94
123	Tram Road Reserve	0.54	0.47	3.8	0.78
124	Frank Sedgman Reserve	0.50	0.44	3.6	0.70
125	Koonung Creek Linear Park	0.43	0.38	3.1	0.65
126	Stanton Street Reserve	0.60	0.52	4.3	0.92
127	Doncaster Park and Ride	0.87	0.76	6.2	1.3
128	Tino Ceberano Martial Arts Academy	0.98	0.86	7.0	1.4
129	Greythorn Bowling Club	1.2	1.0	8.2	1.6
130	Manningham Park Reserve	1.2	1.1	8.6	1.7
131	Japara Sydney Williams Apartments	0.31	0.27	2.2	0.49
132	Japara Millward Nursing home	0.31	0.27	2.2	0.49
133	Koonung Creek Reserve	0.38	0.33	2.7	0.58
134	Boronia Grove Reserve	0.33	0.29	2.3	0.53
135	Heatherwood School	0.22	0.19	1.6	0.32
136	State Vision Resource Centre	0.22	0.19	1.6	0.32
137	Koonung Creek Linear Park	0.27	0.23	1.9	0.42
138	Aranga Reserve	0.23	0.20	1.7	0.34
139	Oxford Street Reserve	0.22	0.19	1.6	0.32
140	Belle Vue Primary School	2.8	2.4	20	4.0
141	Boroondara Tennis Centre	3.1	2.7	22	4.6
142	Musca Street Reserve	1.3	1.1	8.9	1.9
143	Columba Street Reserve	2.5	2.2	18	3.5
144	Leonis Avenue Reserve	2.7	2.3	19	4.1
145	Koonung Creek Reserve	1.6	1.4	11	2.3
146	Winfield Road Reserve	0.74	0.65	5.3	1.1
147	Yarra Flats Reserve	1.1	0.99	8.1	1.7
148	Freeway Public Golf Course	2.6	2.2	18	3.8
149	Kew Golf Club	0.67	0.59	4.8	1.00
150	Hays Paddock/Reserve	0.71	0.63	5.1	1.1

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
151	Hyde Park	0.46	0.40	3.3	0.68
152	Burke Rd. billabong reserve	1.2	1.1	8.6	1.8
153	Green Acres Golf Club	0.77	0.67	5.5	1.1
154	Willsmere-Chandler Park	0.61	0.53	4.4	0.90
155	Guide Dogs Victoria	0.39	0.34	2.8	0.60
156	Royal Talbot Rehabilitation Centre	0.44	0.38	3.1	0.66
157	Yarra Bend Park	0.28	0.24	2.0	0.43
158	Kate Campbell Reserve	0.41	0.36	2.9	0.59
159	Jack O'Toole Reserve	0.46	0.40	3.3	0.70
160	North Kew Tennis Club	0.45	0.39	3.2	0.68
161	1st Kew Scout Group	0.45	0.39	3.2	0.67
162	Elgar Park	0.51	0.44	3.6	0.77
163	Koonung Creek Wetlands	0.54	0.48	3.9	0.84
164	Presbyterian Theological College	0.81	0.71	6.0	0.90
165	Koonung Creek Linear Park	0.44	0.39	3.2	0.66
166	Frank Sedgemen Reserve	0.51	0.44	3.6	0.72
167	Bounce Inc.	0.36	0.31	2.6	0.54
168	Flow Through Yoga	0.32	0.28	2.3	0.49
169	Melbourne Badminton Centre	0.36	0.31	2.6	0.54
170	Eastern Freeway Linear Park	0.35	0.31	2.5	0.51
171	Koonung Creek Linear Park	0.29	0.25	2.1	0.47
172	Slater Reserve	0.28	0.25	2.0	0.43
173	Warekila Preschool	0.24	0.21	1.7	0.39
174	Eastern Freeway Linear Reserve	0.24	0.21	1.7	0.38
175	R E Gray Reserve	0.21	0.18	1.6	0.34
176	Koonung Creek Linear Park	0.25	0.22	1.8	0.39
177	Alphington Park	0.47	0.42	3.4	0.71
178	Latrobe Golf Club	0.44	0.38	3.1	0.67
179	Thomas Embling Hospital	0.31	0.27	2.2	0.48
180	Melbourne Polytechnic	0.34	0.30	2.4	0.51

Receptor ID	Pollutant	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	Benzene ($\mu g/m^3$)
	Description / Averaging period	1 hour	1 hour	1 hour	3 minute
181	RMIT Surveying Field Station	0.29	0.25	2.0	0.44
182	Victorian Indigenous Nurseries Co-Operative	0.30	0.26	2.1	0.46
183	Yarra Bend Park	0.29	0.25	2.0	0.42
184	Fairlea Reserve	0.30	0.26	2.1	0.45
185	Yarra Bend Public Golf Course	0.32	0.28	2.3	0.46
186	Petit Early Learning Journey	0.21	0.18	1.5	0.31
187	Gray Street Reserve	0.19	0.17	1.4	0.29
188	Ramden Street Reserve	0.25	0.22	1.8	0.37
189	Dights Falls Reserve	0.19	0.17	1.3	0.28
190	Victoria Park	0.21	0.18	1.5	0.31
191	Maugie Street Reserve	0.20	0.18	1.5	0.31
Maximum					
68	Simpson Barracks	5.7	5.0	44	-
105	Carey Grammar Sports Complex	-	-	-	8.8

Table 6: Sensitive receptor results: Sensitivity analysis – increased ratio of diesel to petrol cars

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
1	Greensborough bypass path	0.37	0.32	2.8
2	Plenty River Linear Reserve	0.36	0.32	2.7
3	Greensborough Collendina Reserve	0.29	0.25	2.1
4	Metropolitan Ring Road Linear Reserve	0.36	0.31	2.7
5	Unnamed reserve	0.24	0.21	1.8
6	Hughes Circuit Reserve	0.34	0.29	2.5
7	Maroonday Aqueduct	0.24	0.21	1.8
8	Garvey Oval	0.35	0.30	2.7
9	Northpark Private Hospital	0.37	0.32	2.8
10	Gillingham Reserve	0.33	0.29	2.5
11	Trist Street Reserve	0.47	0.40	3.5
12	Greensborough Preschool	0.64	0.56	4.9
13	Abacus Child Care Centre	0.60	0.53	4.5
14	Kalparrin Early Intervention Program child care	0.40	0.34	2.9
15	Greensborough Road Surgery	0.65	0.56	4.9
16	Diaverum Diamond Valley Dialysis Clinic	0.42	0.36	3.1
17	Greensborough Maternal and Child Health	0.69	0.59	5.0
18	St Mary's Church	0.60	0.52	4.5
19	St Mary's School	0.60	0.52	4.7
20	Greensborough College	0.87	0.76	6.6
21	Greensborough Primary School	0.55	0.47	4.1
22	Banyule City Council Greensborough Service Centre	0.44	0.38	3.3
23	Greensborough RSL	0.38	0.34	2.9
24	Kalparrin Gardens	0.39	0.33	2.9
25	Poulter Avenue Reserve	0.34	0.29	2.5
26	Whatmough Park	0.38	0.32	2.8
27	Fell Reserve	0.55	0.48	4.1
28	Plenty River Drive Reserve	0.37	0.31	2.7
29	St Mary's Reserve	0.61	0.53	4.8

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
30	Sarah's Reserve	0.40	0.35	3.0
31	Metropolitan Ring Road Path	0.32	0.28	2.4
32	Greensborough Police Station	0.62	0.53	4.6
33	Greensborough MFB Fire Station	0.61	0.52	4.6
34	Watsonia Occasional Child Care Centre	1.3	1.1	9.6
35	MS Society Retirement Village	1.1	0.91	8.0
36	Watsonia scout hall	0.54	0.46	4.0
37	Watsonia RSL	0.63	0.56	5.0
38	North East Citizen Advocacy (NECA)	1.3	1.1	9.5
39	Watsonia Library	0.78	0.67	5.9
40	Holy Spirit Anglican Church	0.71	0.61	5.4
41	Grace Baptist Church	0.64	0.56	4.8
42	Watsonia Uniting Church	0.80	0.69	5.9
43	Concord School	0.61	0.53	4.6
44	Watsonia Primary School	0.66	0.57	5.0
45	AK Lines Reserve	0.55	0.48	4.2
46	Elder Street Reserve	1.1	0.95	8.2
47	West Mayling Reserve	1.2	1.0	9.1
48	Gabonia Avenue Reserve	1.2	1.1	9.4
49	Watsonia Station Carpark Reserve	0.89	0.77	6.8
50	Watsonia Road Reserve	0.75	0.65	5.7
51	Greensborough Road Early Learning and Kinder	0.91	0.79	6.9
52	Macleod Recreation and Fitness & CC	1.2	1.0	8.8
53	Macleod Preschool	1.2	1.0	8.8
54	Baptcare Strathalan Macleod	1.7	1.5	13
55	Regis Macleod	1.4	1.2	11
56	Macleod Maternal and Child Health	1.2	1.0	8.9
57	IDV	1.1	0.99	8.6
58	YMCA Recreation and Fitness Centre	1.1	1.0	8.7
59	Nets Stadium Banyule	1.2	1.1	9.7

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
60	Macleod Organic Community Garden	1.3	1.2	10
61	Winsor Reserve	1.8	1.6	14
62	Macleod College Oval	1.5	1.3	11
63	Macleod Netball Stadium	1.3	1.1	9.7
64	Harry Pottage Reserve	1.1	0.96	8.5
65	Macleod Park	1.1	0.98	8.5
66	Macleod Tennis Club	1.2	1.0	8.8
67	Junior Football Club and Macleod Cricket	1.1	0.93	8.2
68	Simpson Barracks	3.3	2.9	25
69	Coleen Reserve	1.5	1.3	11
70	Borlase Reserve	0.82	0.71	6.2
71	Melbourne Water easement	0.94	0.82	7.2
72	Goodstart Early Learning	0.39	0.34	3.0
73	Assisi Centre Aged Care	0.52	0.45	4.0
74	Japara Rosanna Views Nursing Home	0.69	0.60	5.2
75	St Martin of Tours Catholic Church	0.69	0.59	5.1
76	St Martin of Tours Catholic Primary School	0.68	0.59	5.3
77	Banyule Primary School	0.44	0.38	3.4
78	Maleela Grove, Rosanna	0.53	0.46	4.0
79	Mercedes Court Reserve	0.40	0.35	3.2
80	River Gum Walk	0.36	0.31	2.8
81	Creekbend Reserve	0.44	0.38	3.4
82	Viewbank College	0.43	0.38	3.3
83	Viewbank family medical group	0.96	0.84	7.4
84	Viewbank podiatry	0.98	0.84	7.5
85	Simla Close Reserve	0.42	0.36	3.2
86	Banyule Flats	0.31	0.28	2.4
87	River Gum Walk	0.29	0.26	2.3
88	Warringal Parklands	0.27	0.24	2.0
89	Banyule Tennis Club	0.28	0.24	2.1

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
90	Heidelberg Park and Heidelberg cricket ground	0.29	0.26	2.2
91	Banyule Theatre Complex	0.29	0.25	2.2
92	Heidelberg Police Station	0.55	0.48	4.1
93	Austin Hospital Precinct	0.42	0.37	3.2
94	Yarra Flats Park	0.58	0.51	4.3
95	Yarra Flats Park	1.4	1.2	10
96	Creative Play Early Learning Centre	0.56	0.49	4.2
97	Kalker Montessori Centre	1.2	1.1	8.7
98	Veneto Club	2.5	2.2	18
99	Heide Museum of Modern Art	0.49	0.43	3.5
100	Bulleen Art and Garden	0.41	0.35	2.9
101	Marcellin College	2.1	1.9	16
102	Trinity Grammar School Sporting Complex	1.3	1.2	9.8
104	Bolin Bolin Billabong	1.2	1.1	8.9
105	Carey Grammar Sports Complex	3.7	3.2	27
106	Yarra Valley parklands	0.35	0.31	2.5
107	Sandra Street Reserve	2.0	1.8	15
108	Bulleen Park	1.6	1.4	12
109	Koonung Reserve	1.2	1.0	8.6
110	Koonung Creek Reserve	0.86	0.74	6.1
111	Willow Bend Reserve	0.70	0.61	5.0
112	Pipe Line Reserve	1.0	0.90	7.5
113	Yarra Valley Country Club	0.49	0.43	3.7
114	Bulleen Golf Driving Range	0.46	0.40	3.4
115	Wonderland Childcare and Kinder	0.45	0.39	3.3
116	Applewood Residence	0.24	0.21	1.7
117	Tende Beck Scout Hall	0.43	0.37	3.1
118	North Eastern Jewish Centre-Yeshurun Congregation	0.43	0.38	3.2
119	Birralee Primary School	0.31	0.27	2.3
120	Wilsons Road Reserve	0.33	0.29	2.5

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
121	Katrina Street Reserve	0.28	0.24	2.0
122	Davis Street Reserve	0.25	0.22	1.9
123	Tram Road Reserve	0.23	0.20	1.6
124	Frank Sedgman Reserve	0.21	0.19	1.6
125	Koonung Creek Linear Park	0.21	0.19	1.6
126	Stanton Street Reserve	0.31	0.27	2.3
127	Doncaster Park and Ride	0.39	0.34	2.9
128	Tino Ceberano Martial Arts Academy	0.42	0.37	3.1
129	Greythorn Bowling Club	0.51	0.45	3.8
130	Manningham Park Reserve	0.53	0.46	3.9
131	Japara Sydney Williams Apartments	0.18	0.16	1.4
132	Japara Millward Nursing home	0.18	0.16	1.4
133	Koonung Creek Reserve	0.20	0.18	1.5
134	Boronia Grove Reserve	0.19	0.17	1.4
135	Heatherwood School	0.12	0.11	0.90
136	State Vision Resource Centre	0.12	0.11	0.91
137	Koonung Creek Linear Park	0.16	0.14	1.2
138	Aranga Reserve	0.13	0.12	0.95
139	Oxford Street Reserve	0.12	0.11	0.88
140	Belle Vue Primary School	1.2	1.1	9.3
141	Boroondara Tennis Centre	1.5	1.3	11
142	Musca Street Reserve	0.75	0.66	5.5
143	Columba Street Reserve	1.2	1.0	8.6
144	Leonis Avenue Reserve	1.4	1.2	9.8
145	Koonung Creek Reserve	0.86	0.74	6.1
146	Winfield Road Reserve	0.39	0.34	2.9
147	Yarra Flats Reserve	0.65	0.57	4.8
148	Freeway Public Golf Course	1.5	1.3	11
149	Kew Golf Club	0.38	0.33	2.7
150	Hays Paddock/Reserve	0.40	0.35	2.9

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
151	Hyde Park	0.26	0.22	1.9
152	Burke Rd. billabong reserve	0.65	0.56	4.7
153	Green Acres Golf Club	0.41	0.36	3.0
154	Willsmere-Chandler Park	0.33	0.29	2.4
155	Guide Dogs Victoria	0.22	0.19	1.6
156	Royal Talbot Rehabilitation Centre	0.24	0.21	1.7
157	Yarra Bend Park	0.16	0.14	1.1
158	Kate Campbell Reserve	0.21	0.19	1.6
159	Jack O'Toole Reserve	0.25	0.22	1.9
160	North Kew Tennis Club	0.25	0.22	1.8
161	1st Kew Scout Group	0.25	0.22	1.8
162	Elgar Park	0.27	0.23	1.9
163	Koonung Creek Wetlands	0.28	0.25	2.1
164	Presbyterian Theological College	0.24	0.21	1.8
165	Koonung Creek Linear Park	0.22	0.20	1.7
166	Frank Sedgemen Reserve	0.22	0.19	1.6
167	Bounce Inc.	0.18	0.16	1.3
168	Flow Through Yoga	0.17	0.15	1.2
169	Melbourne Badminton Centre	0.18	0.16	1.3
170	Eastern Freeway Linear Park	0.18	0.16	1.3
171	Koonung Creek Linear Park	0.17	0.15	1.3
172	Slater Reserve	0.15	0.13	1.1
173	Warekila Preschool	0.14	0.12	1.0
174	Eastern Freeway Linear Reserve	0.14	0.12	1.0
175	R E Gray Reserve	0.13	0.11	0.93
176	Koonung Creek Linear Park	0.15	0.13	1.1
177	Alphington Park	0.25	0.22	1.9
178	Latrobe Golf Club	0.25	0.22	1.8
179	Thomas Embling Hospital	0.17	0.15	1.2
180	Melbourne Polytechnic	0.18	0.16	1.3

Receptor ID	Pollutant	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	NO_2 (µg/m^3)
	Description / Averaging period	1 hour	1 hour	1 hour
181	RMIT Surveying Field Station	0.16	0.14	1.2
182	Victorian Indigenous Nurseries Co-Operative	0.16	0.14	1.2
183	Yarra Bend Park	0.15	0.13	1.1
184	Fairlea Reserve	0.16	0.14	1.2
185	Yarra Bend Public Golf Course	0.17	0.15	1.2
186	Petit Early Learning Journey	0.11	0.098	0.82
187	Gray Street Reserve	0.11	0.094	0.78
188	Ramden Street Reserve	0.14	0.12	0.97
189	Dights Falls Reserve	0.11	0.093	0.78
190	Victoria Park	0.11	0.099	0.83
191	Maugie Street Reserve	0.11	0.097	0.81
Maximum				
105	Carey Grammar Sports Complex	3.7	3.2	27

APPENDIX C

Tunnel ventilation system impact isopleths

Isopleths of the 100th percentile predicted incremental GLC (without background) for the ventilation structures are presented as follows:

FIGURES

Figure 1: Scenario A: Maximum predicted one hour average PM_{10} GLC 2

Figure 2: Scenario A: Maximum predicted one hour average $PM_{2.5}$ GLC.....3

Figure 3: Scenario A: Maximum predicted one hour average NO_2 GLC.....4

Figure 4: Scenario A: Maximum predicted three minute average benzene GLC.....5

Figure 5: Scenario B: Maximum predicted one hour average PM_{10} GLC 6

Figure 6: Scenario B: Maximum predicted one hour average $PM_{2.5}$ GLC.....7

Figure 7: Scenario B: Maximum predicted one hour average NO_2 GLC.....8

Figure 8: Scenario B: Maximum predicted three minute average benzene GLC.....9

Figure 9: Sensitivity analysis: Alternative northern and southern ventilation structure locations maximum predicted one hour average $PM_{2.5}$ GLC (combined) 10

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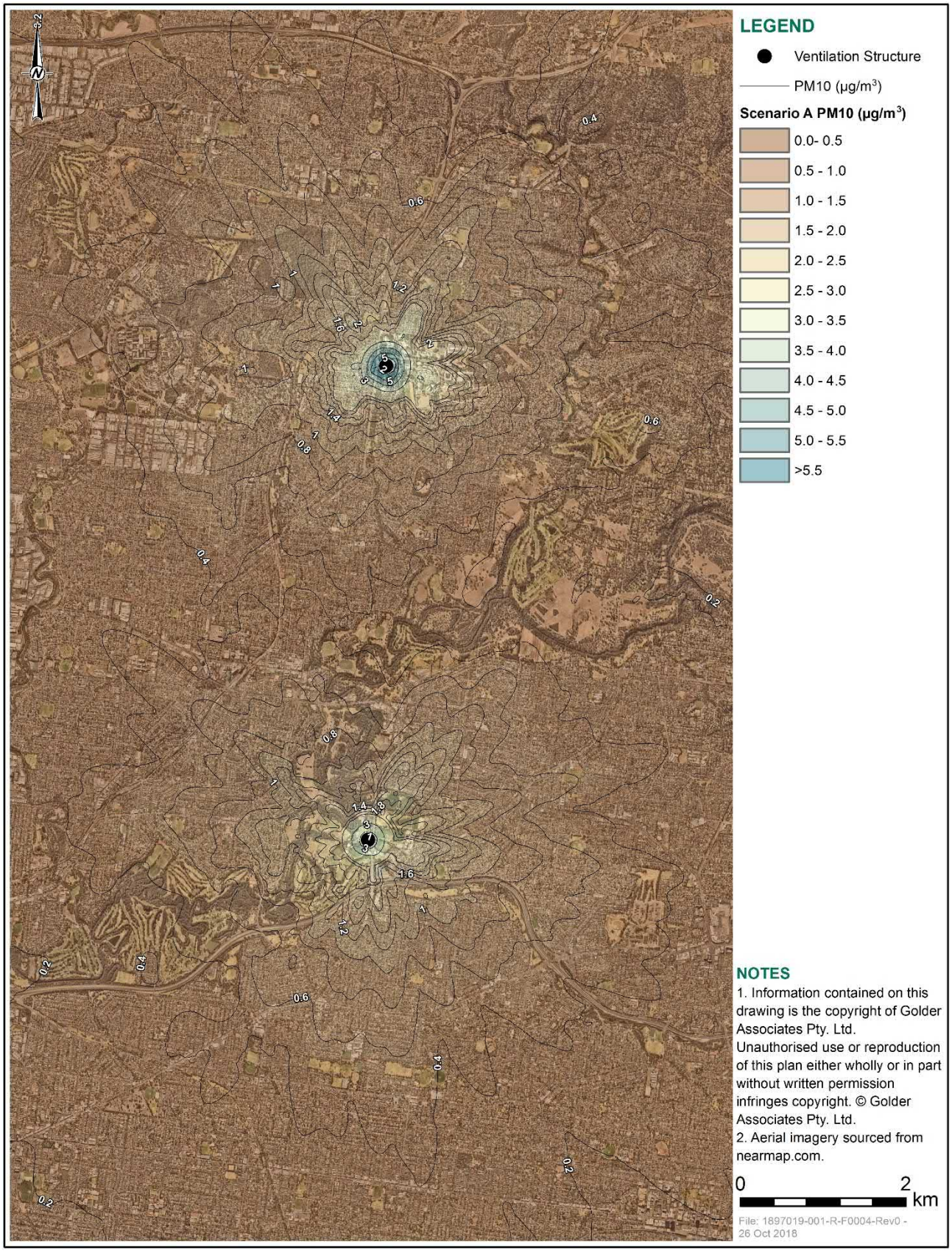


Figure 1: Scenario A: Maximum predicted one hour average PM_{10} GLC

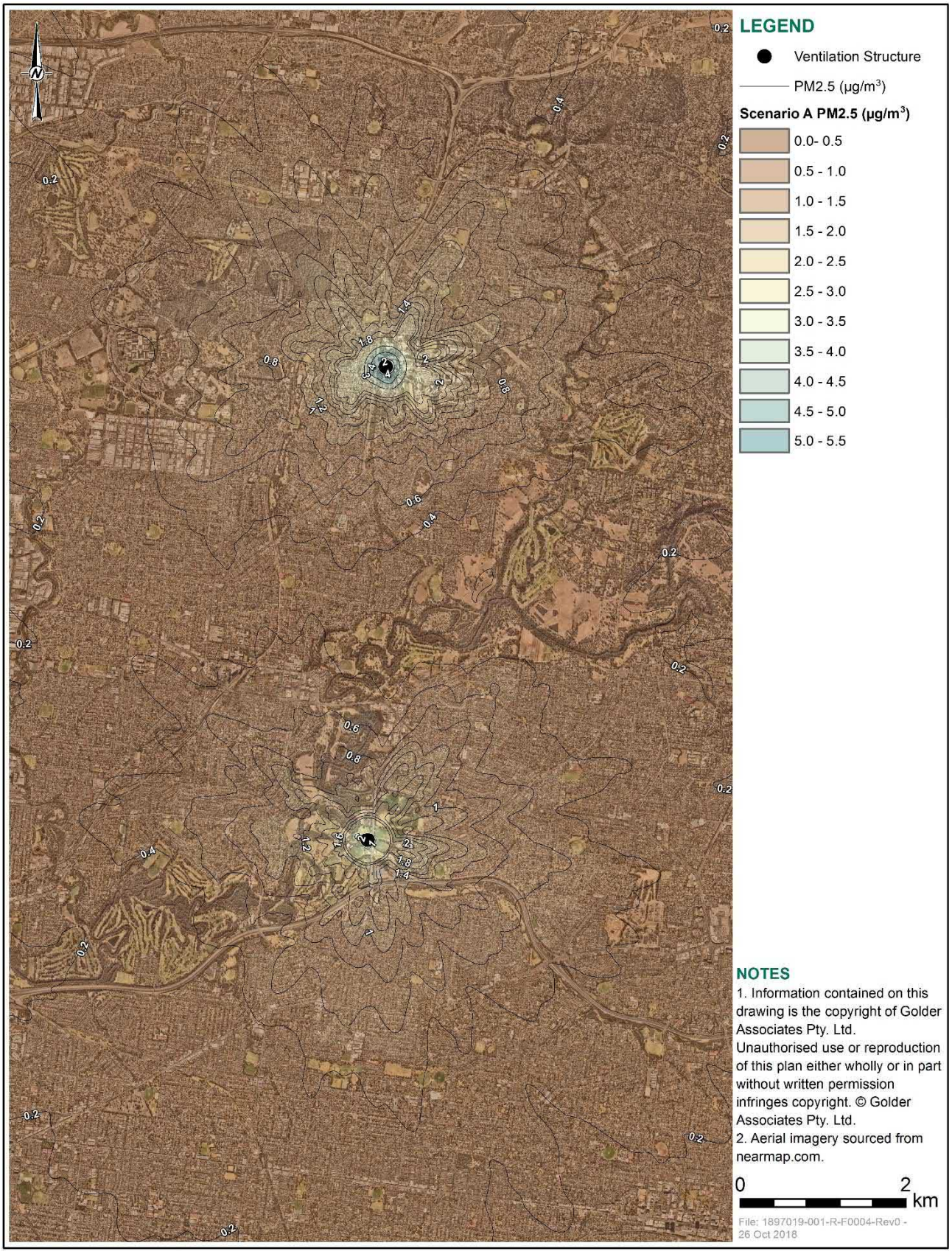


Figure 2: Scenario A: Maximum predicted one hour average $PM_{2.5}$ GLC

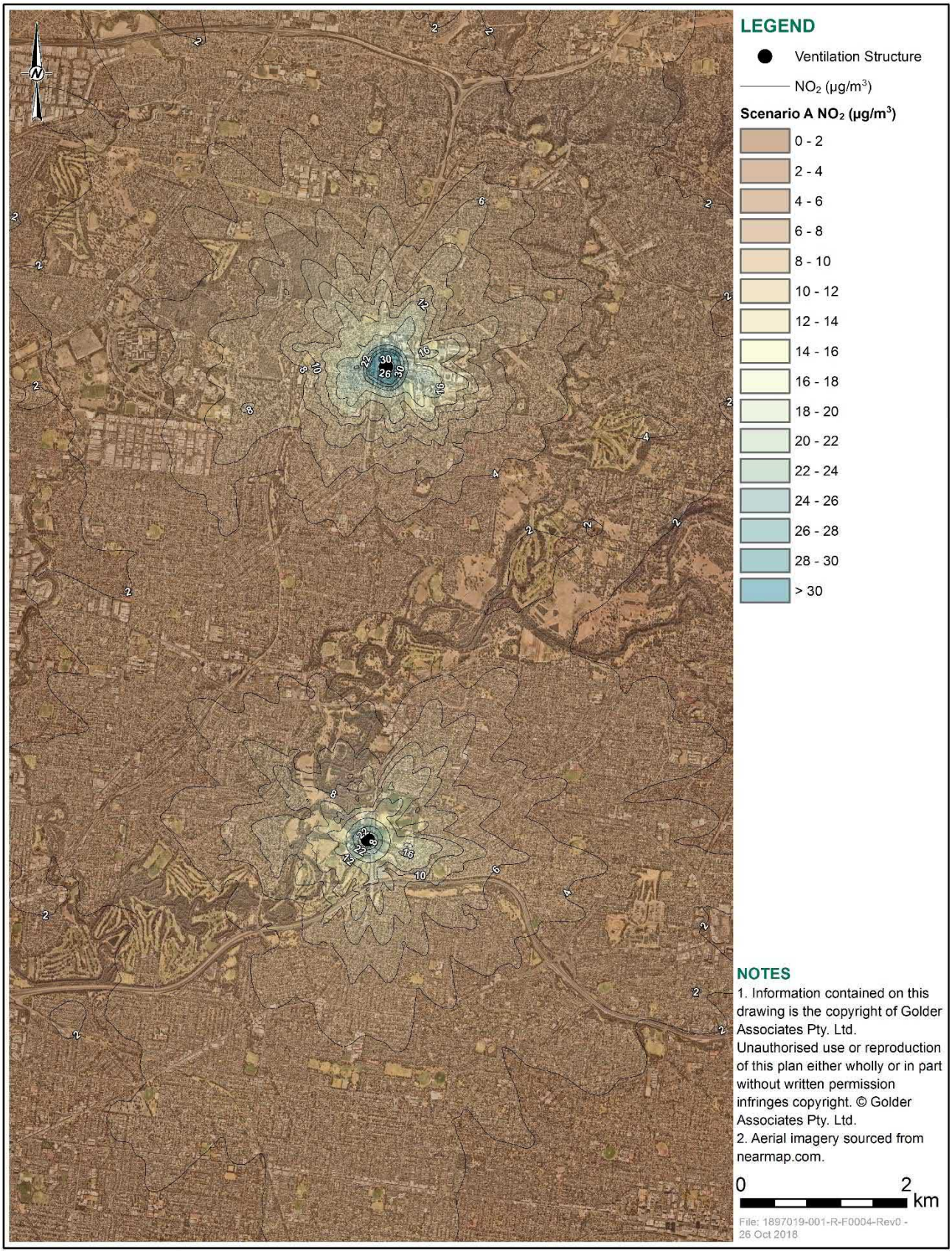


Figure 3: Scenario A: Maximum predicted one hour average NO_2 GLC

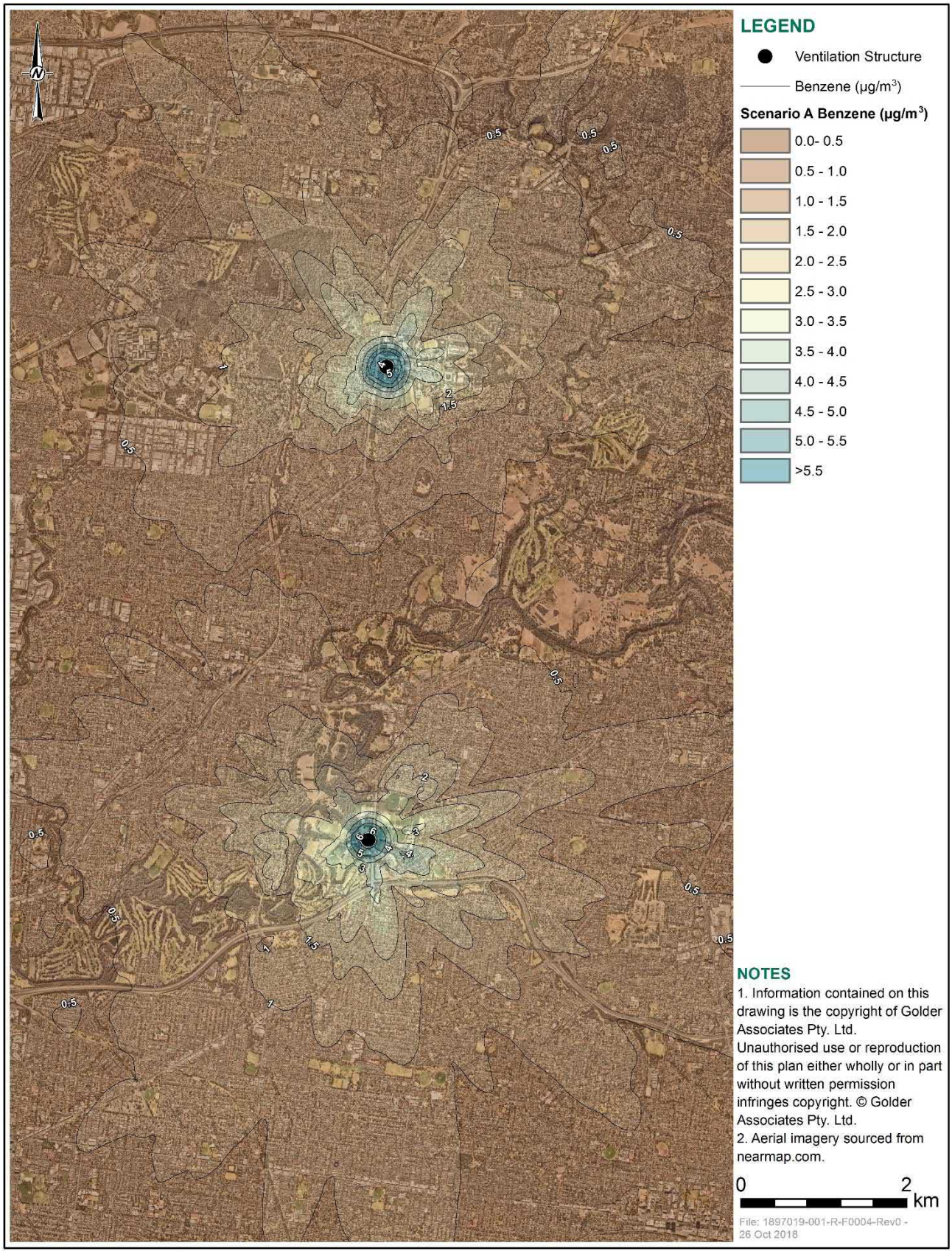


Figure 4: Scenario A: Maximum predicted three minute average benzene GLC

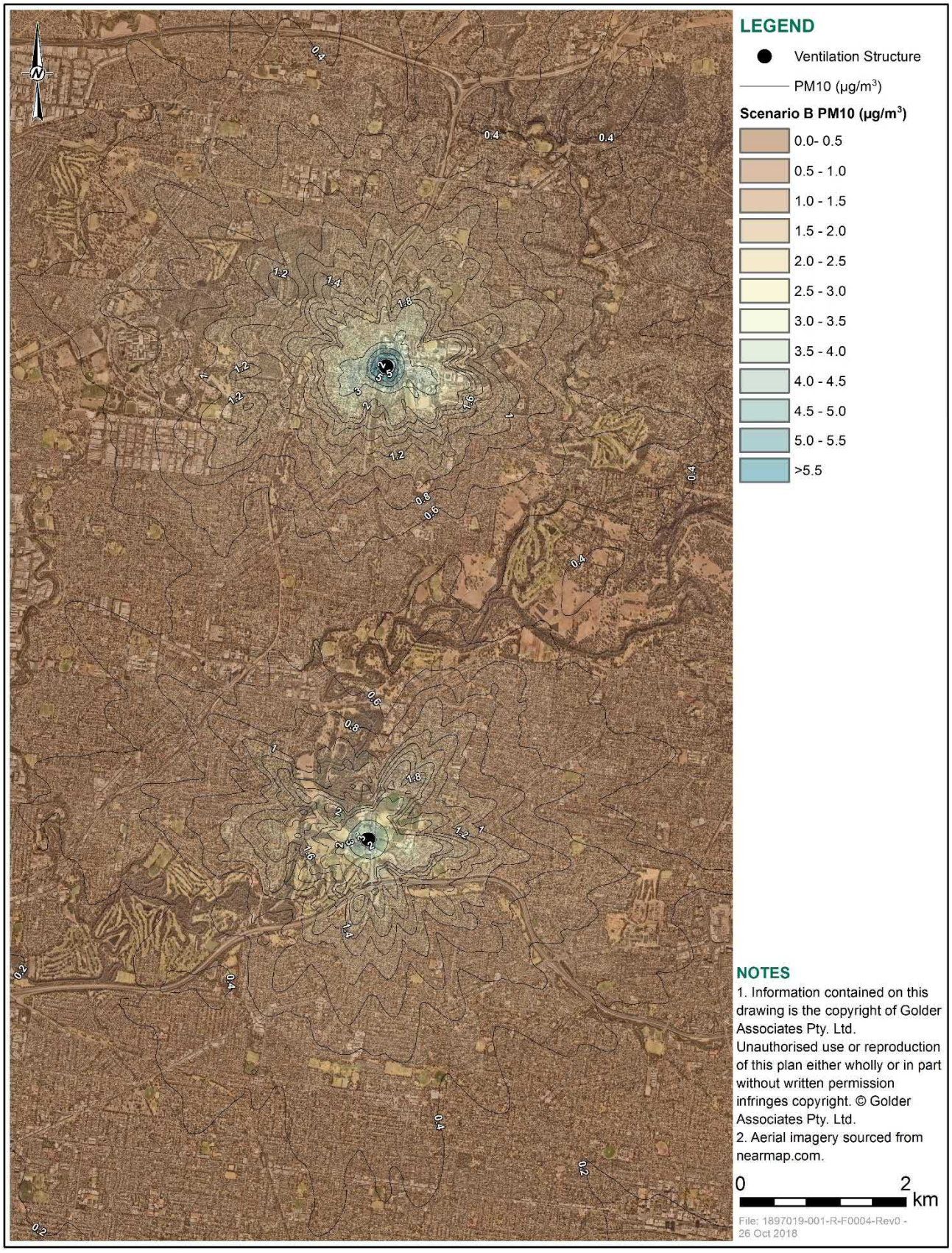


Figure 5: Scenario B: Maximum predicted one hour average PM_{10} GLC

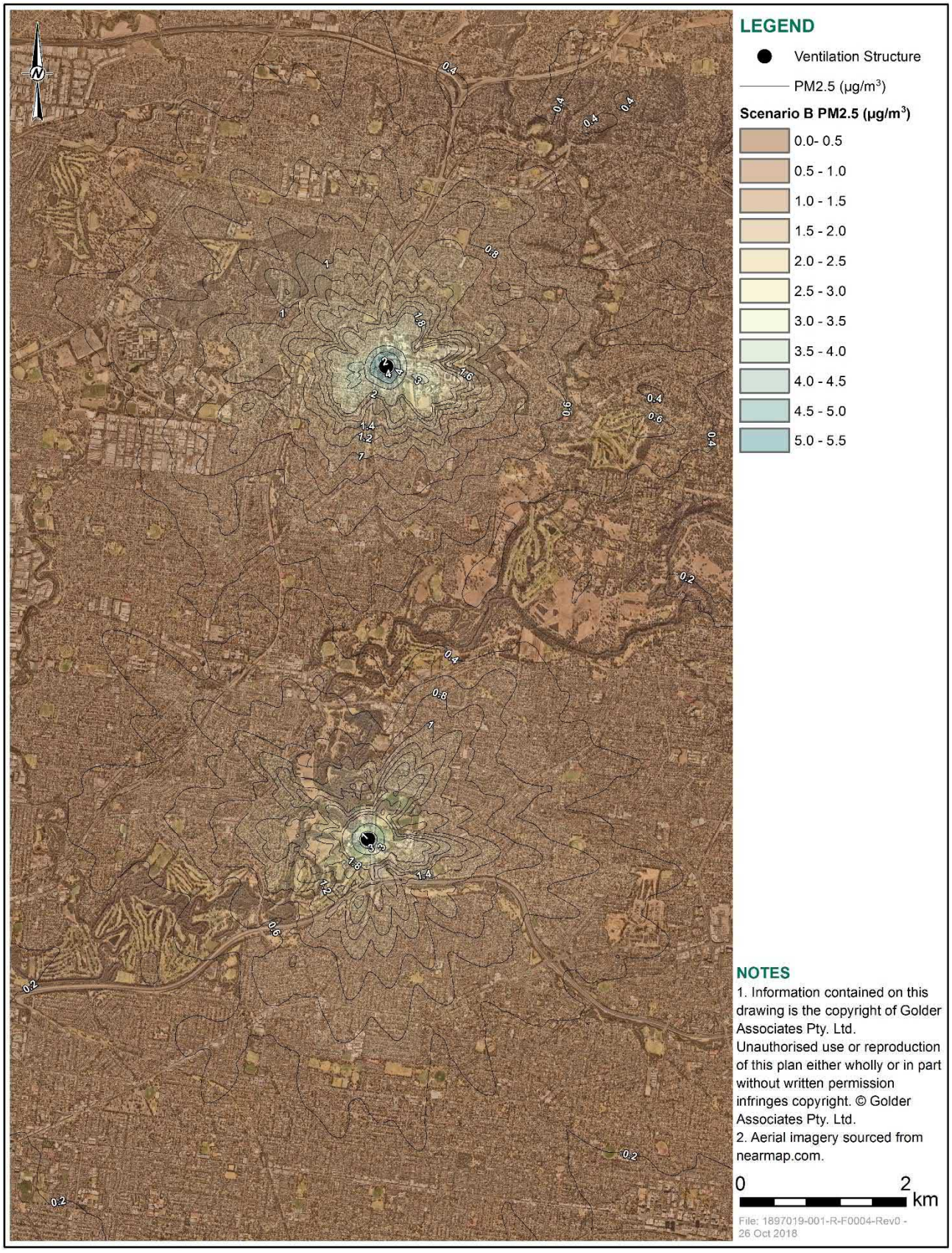


Figure 6: Scenario B: Maximum predicted one hour average $PM_{2.5}$ GLC

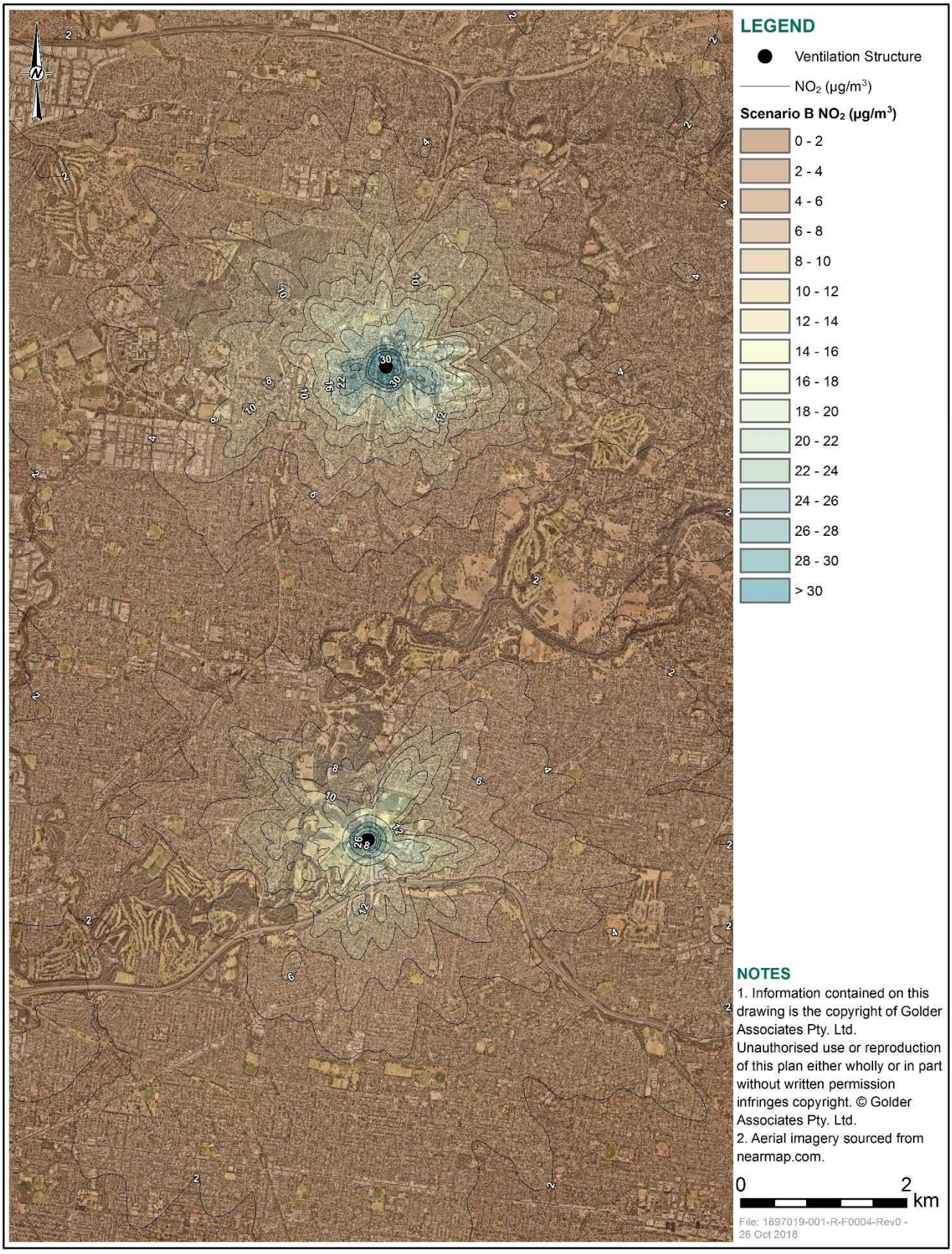


Figure 7: Scenario B: Maximum predicted one hour average NO_2 GLC

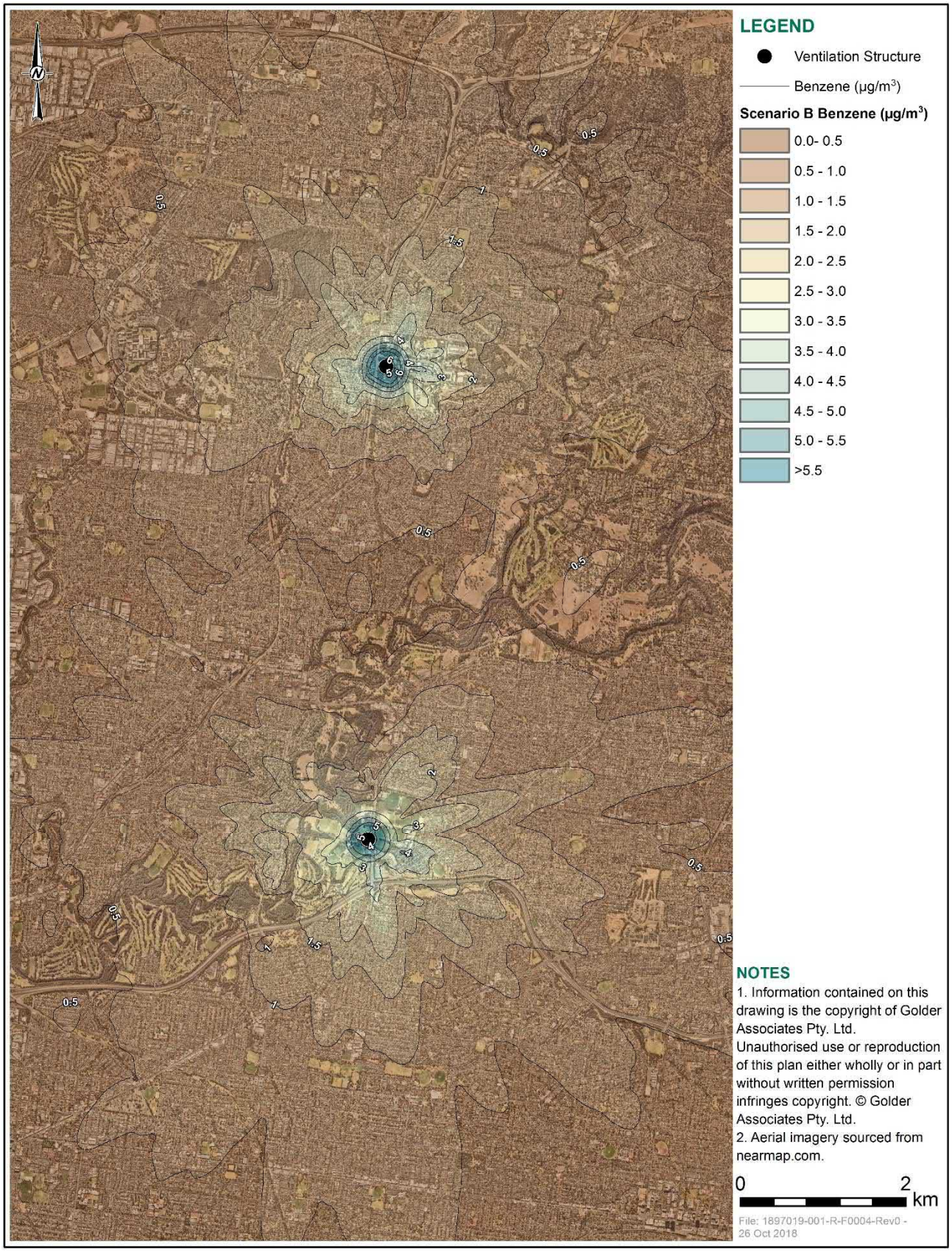


Figure 8: Scenario B: Maximum predicted three minute average benzene GLC

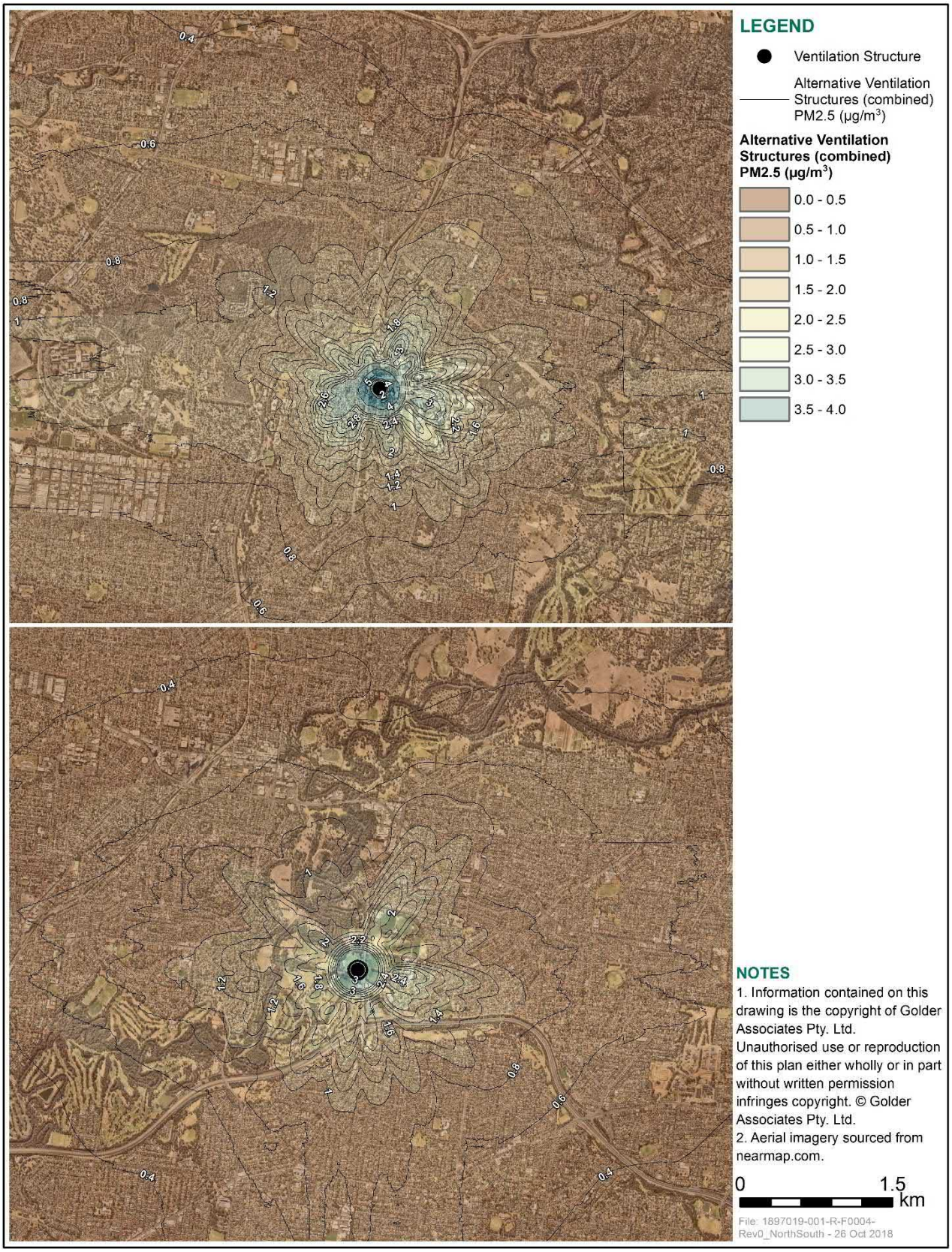


Figure 9: Sensitivity analysis: Alternative northern and southern ventilation structure locations maximum predicted one hour average $PM_{2.5}$ GLC (combined)

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Appendix B Air quality monitoring plan

REPORT

North East Link

Air Quality Monitoring Plan

Prepared for:

North East Link Project

Submitted by:

Golder Associates Pty Ltd

Building 7, Botanicca Corporate Park 570 – 588 Swan Street Richmond, Victoria 3121
Australia

1897019-017-R-Rev0 - FINAL

April 2019



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1.0 REGULATORY CONTEXT

Environment Protection Authority (EPA) Victoria has established best practice procedures for source emission testing and ambient air quality monitoring, as described in Publication 440.1 "*A guide to the sampling and analysis of air emissions and air quality*" (December 2002). These guidelines must be followed whenever emission testing or ambient air quality monitoring is undertaken for any purpose required by the *Environment Protection Act 1970*.

EPA Victoria requires organisations performing emission testing for licence compliance purposes and those conducting ambient air quality monitoring to be accredited by the National Association of Testing Authorities (NATA) for all tests.

For statutory testing, methods must be based on those listed or referenced in Publication 440.1, otherwise prior approval from EPA Victoria is required. When seeking approval from the Authority for alternative methods, method validation data, obtained in accordance with NATA requirements, must be submitted before approval can be granted.

2.0 AMBIENT AIR QUALITY MONITORING POST PROJECT COMPLETION

2.1 Monitoring locations

Post project completion, ambient air quality monitoring stations (AAQMSs) will be located to enable evaluation of community exposure and confirmation of air quality impact assessment modelling predictions.

All stations will be sited in accordance with the requirements of Australian Standards AS/NZS 3580.1.1 "*Methods for Sampling and Analysis of Ambient Air – Guide to Siting Air Monitoring Equipment*" and AS/NZS 3580.14 "*Methods for Sampling and Analysis of Ambient Air – Meteorological Monitoring for Ambient Air Quality Monitoring Applications*".

At a minimum, one AAQMS will be located adjacent to each ventilation structure to assess the impact of emissions on nearby sensitive receptors. The location of each AAQMS will be agreed through consultation with EPA Victoria and other external stakeholders.

2.2 Monitored parameters

Pollutants to be monitored will include:

- particulate matter with an equivalent aerodynamic diameter less than 10 microns (PM_{10})
- particulate matter with an equivalent aerodynamic diameter less than 2.5 microns ($PM_{2.5}$)
- oxides of nitrogen (NO_X)
- carbon monoxide (CO).

As these pollutants are the main components of vehicle emissions, monitoring of other pollutants (air toxics) assessed as part of this WAA is considered unnecessary.

The following meteorological parameters will be monitored:

- wind speed and direction
- temperature

- relative humidity
- barometric pressure
- total solar radiation
- rainfall.

2.3 Methodology

Table 1 lists the proposed ambient air quality monitoring equipment and reference method.

In order to provide real time data, continuous monitoring will be conducted, logged at a minimum interval of ten minutes. Each AAQMS will be equipped with an on-site data logger with telemetry capabilities, enabling remote access of data and instrument conditions.

Table 1: Ambient air quality monitoring equipment

Parameter	Instrument type	Measurement range	Reference method
$PM_{2.5}$	FDMS TEOM or BAM	0 – 2,000 µg/m^3 0 – 2,000 µg/m^3	AS/NZS 3580.9.13 AS/NZS 3580.9.12
PM_{10}	TEOM or BAM	0 – 2,000 µg/m^3 0 – 2,000 µg/m^3	AS 3580.9.8 AS/NZS 3580.9.11
NO / NO_2 / NO_x	Chemiluminescence analyser	0 – 20 ppm	AS 3580.5.1
CO	Infra-red gas filter correlation analyser	0 - 200 ppm	AS 3580.7.1
Wind speed and direction	Ultrasonic anemometer	0 – 30 m/s	AS/NZS 3580.14
Temperature	Resistance temperature detector	-10 – 50 °C	AS/NZS 3580.14
Relative humidity	Capacitance	0 -100%	AS/NZS 3580.14
Barometric pressure	Digital barometer	750 – 1,050 hPa	AS/NZS 3580.14
Total solar radiation	Pyranometer	0 – 2,000 W/m^2	AS/NZS 3580.14
Rainfall	Tipping bucket rain gauge	0 – 400 mm/h	AS/NZS 3580.14

NOTES:

FDMS – filter dynamics measurement system

TEOM – tapered element oscillating microbalance

BAM – beta attenuation monitor

Data will be downloaded on a continuous basis (every 10 minutes), with the system configured to provide SMS and email alerts to inform relevant personnel of abnormal instrument conditions or out of specification data. Data will be protected by daily system backups.

2.4 Calibration and maintenance

Routine equipment calibration and maintenance will be carried out at the frequency specified in the relevant Australian Standard or greater. Table 2 details the calibration and maintenance requirements together with the minimum frequency specified in the relevant Standard.

If instrument diagnostic parameters, calibration results or unrepresentative data indicate equipment malfunction, trained personnel will respond by the next working day to rectify the problem (where possible).

Table 2: Routine calibration and maintenance requirements

Equipment	Description	Required frequency[1]
PM_{10} and $PM_{2.5}$	Leak check	Three monthly
	Flow check	Three monthly
	Calibration	Six monthly
	Clean sample inlet	Six monthly
	Replace pump vanes	Annual
NO, NO_2 and NO_x chemiluminescence analyser	Level 1 zero and span check	Weekly
	Level 1 zero and span check	Monthly
	Leak check	Monthly
	Filter exchange	Monthly
	Converter efficiency check	Three monthly
	Linearity	Six monthly
	Service	Annual
CO infra-red gas filter correlation analyser	Level 1 zero and span check	Weekly
	Level 1 zero and span check	Monthly
	Leak check	Monthly
	Filter exchange	Monthly
	Linearity	Six monthly
	Service	Annual
Gas calibrator	NATA calibration	Annual
Span gas	NATA calibration	Four yearly
Zero air generator	Replace media	Six monthly
Wind speed and direction	NATA calibration	Two yearly

NOTE:
1 Gaseous pollutant analysers (NO_x and CO) will be configured to perform overnight calibrations on a daily basis enabling instrument drift to be monitored and corrected.

2.5 Data validation

AAQMS data will be remotely accessed and downloaded on a daily (weekday) basis and preliminary validation conducted. Data failing the validation process will be marked as invalid and not included in any further data processing.

Final data validation will occur on a monthly basis, involving a review of monthly equipment calibration records and long term data trends. Data that does not meet the validation process will be marked as invalid and not included in any further data processing.

2.6 Reporting

AAQMS data that has undergone final validation will be reported on a routine basis. Reports will include:

- trend plots of monitored air quality indicators and meteorological parameters
- statistical summary of monitored air quality indicators and meteorological parameters
- data capture details for each monitored air quality indicator and meteorological parameter
- comparison of results with ambient air quality objectives
- analysis of results, including a running comparison with previous data
- explanation/discussion of exceedances detected during the reporting period
- identification of quality assurance/quality control (QA/QC) measures carried out during the reporting period, including a statement on the reliability and accuracy of the data
- data exceptions table detailing periods of missing data and reason for data omissions
- NATA endorsed monitoring reports
- statement of AAQMS compliance with instrument siting guidelines contained in Australian Standards AS/NZS 3580.1.1 and AS/NZS 3580.14.

Ambient air quality monitoring and public reporting of AAQMS data will be undertaken for a period of five years post North East Link commissioning, or such lessor period as agreed with EPA Victoria (refer to recommended Environmental Performance Requirement AQ4).

3.0 CONTINUOUS EMISSION MONITORING SYSTEMS

Continuous emission monitoring systems (CEMS) will be installed on each ventilation structure to monitor the emission of the following pollutants, together with exhaust gas velocity, temperature and relative humidity:

- PM_{10}
- $PM_{2.5}$
- NO_x
- CO.

Installed equipment will include sample pumps, sample lines, gas conditioning equipment and automatic calibration systems.

Equipment calibration and maintenance will be conducted in accordance with EPA Victoria Publication No. 440.1, NATA requirements and relevant test method requirements.

CEMS maintenance issues or faults will be identified and actioned by the end of the following working day.

3.1 Data validation

CEMS data will be remotely accessed and downloaded on a daily (weekday) basis and preliminary validation conducted. Data failing the validation process will be marked as invalid and not included in any further data processing.

Final data validation will occur on a monthly basis, including a review of monthly equipment calibration records and long term data trends. Data that does not meet the validation process will be marked as invalid and not included in any further data processing.

Valid five minute average data will be transformed to one hour rolling average mass rates.

3.2 Reporting

Ventilation structure CEMS data that has undergone final validation will be reported on a routine basis. Reports will include:

- trend plots, statistical analysis and data capture percentages for each monitored pollutant
- comparison of results with EPA Victoria licence limits
- analysis of results, including a running comparison with previous data
- explanation/discussion of exceedances detected during the reporting period
- identification of QA/QC measures carried out during the reporting period, including a statement on the reliability and accuracy of the data
- data exceptions table detailing periods of missing data and reason for data omissions
- NATA endorsed monitoring reports.

4.0 VENTILATION STRUCTURE VERIFICATION TESTING

Manual emission tests will be conducted on a routine basis to verify CEMS performance and to establish the emission rates of pollutants not continuously monitored. Emission testing will be conducted during the first year of operation, with a minimum annual frequency thereafter.

4.1 Velocity and temperature

For both ventilation structures, exhaust gas velocities and temperatures will be measured at three different fan operating conditions, utilising a pitot tube and electronic manometer and a transfer standard electronic thermometer and thermocouple. The velocity measurement method will be in accordance with International Organisation for Standardization (ISO) Standard 10780 "*Stationary Source Emissions – Measurement of Concentration and Mass Flow Rate of Gas Streams in Ducts*".

The CEMS velocity and temperature transducer outputs will be correlated with the measured velocities and temperature for the corresponding periods.

4.2 NO_x and CO

For both ventilation structures, NO_x and CO verification tests will be conducted by collocating independent continuous analysers with the CEMS equipment. The concentrations of NO_x (as NO_2 equivalents) and CO emitted from the ventilation structure will be measured continuously over a minimum period of 16 hours, including both the morning and afternoon peak periods.

CEMS NO_x and CO outputs will be correlated with the measured NO_x and CO concentrations for the corresponding periods.

4.3 PM_{10} and $PM_{2.5}$

For both ventilation structures PM_{10} and $PM_{2.5}$ concentrations will be measured in accordance with USEPA Method 201A "*Determination of PM_{10} and $PM_{2.5}$ Emissions from Stationary Sources (Constant Sampling Rate Procedure)*".

A correlation will be established with the CEMS equipment outputs following collection of an acceptable number of manual emission test samples, PM_{10} and $PM_{2.5}$ verification emission tests will subsequently establish whether a single point falls within the original 95th percentile confidence intervals. If not, additional samples will be collected to update the correlation.

4.4 Air toxics

Air toxics emission monitoring will be conducted on each ventilation structure to determine the concentrations and mass rates of emission for the following pollutants:

- benzene, toluene, xylene isomers (BTX) and 1,3-butadiene
- polycyclic aromatic hydrocarbons (PAH)
- formaldehyde.

Low concentrations of air toxics are anticipated in the ventilation structures. Table 3 outlines the proposed methods to achieve the lowest practically achievable source reporting limits.

Table 3: Air toxics emission testing: recommended methods

Pollutant	Description	Reference method
BTX and 1,3-butadiene	SUMMA canister sampling and GC analysis	USEPA Method TO-14A/TO-15
PAH	Multicomponent sampling train	USEPA Publication SW-846 - Method 0010
Formaldehyde	Adsorbent cartridge and HPLC analysis	USEPA Method TO-11

NOTES:

SUMMA canister - stainless steel electropolished passivated vessel

GC – gas chromatography

HPLC – high performance liquid chromatography

4.5 Reporting

NATA endorsed test reports will be issued for each monitoring round describing test methods, measurement uncertainty and test results.

5.0 IN-TUNNEL AIR QUALITY MONITORING

Environmental Performance Requirement AQ3 prescribes the following in-tunnel air quality performance standards:

- achieve a longitudinal air velocity in the tunnels not exceeding 10 metres/second
- air quality must meet the following standards:
  - maximum peak CO concentration of 150 ppm
  - 15 minute average CO concentration of 50 ppm
  - 2 hour average CO concentration of 25 ppm
  - 15 minute average NO_2 concentration of 0.5 ppm (tunnel average).

In-tunnel air quality monitoring will be conducted to:

- demonstrate compliance with the proposed in-tunnel air quality limits for CO and NO_2
- ensure appropriate visibility for vehicle drivers under various tunnel operating conditions
- prevent tunnel portal emissions and resultant environmental impacts by monitoring air speed and direction.

Monitoring equipment will be installed at specific locations within each tunnel to monitor air speed and direction, visibility, CO and NO_2. Equipment performance specifications will comply with the limits specified in Australian Standard AS/NZS 3580.18:2017 "*Measurement of road tunnel air quality*", with equipment calibration and maintenance also conducted in accordance with AS/NZS 3580.18 and NATA requirements. AS/NZS 3580.18 represents worldwide best practice and is currently in the process of being adopted as an ISO Standard.

In-tunnel CO, NO_2 and visibility data will be used to control operation of the tunnel exhaust ventilation system variable speed drive fans.

Final data validation will occur on a monthly basis, including review of equipment calibration records and long term data trends. Data that does not meet the validation process will be marked as invalid and not included in any further data processing.

5.1 Reporting

Validated in-tunnel air quality data will be reported on a routine basis. Reports will include:

- trend plots, statistical analysis and data capture percentages for each monitored parameter
- analysis of results, including a running comparison with previous data
- explanation/discussion of exceedances detected during the reporting period
- identification of QA/QC measures that took place during the reporting period, including a statement on the reliability and accuracy of the data
- data exceptions table detailing periods of missing data and reason for data omissions.

Signature Page

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APPENDIX A

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Appendix C Noise impact assessment

TUNNEL VENTILATION SYSTEM

Noise Assessment
North East Link

Prepared for:

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SLR Ref: 640.11671-R02
Version No: -v1.4
March 2019

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BASIS OF REPORT

This report has been prepared for North East Link Project, a division of the Major Transport Infrastructure Authority, for the purposes of preparing the Environment Effects Statement for the project under the Environment Effects Act 1978, the draft planning scheme amendment under the Planning and Environment Act 1987 and EPA works approval application under the Environment Protection Act 1970. It is not intended to be used for any other purpose.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
640.11671-R02-v1. 4	5 March 2019	David Lindsey	Gustaf Reutersward	David Lindsey

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1 Introduction

North East Link ('the Project') is a proposed new freeway standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. The North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

On 2 February 2018, the Minister declared the works proposed for North East Link as Public Works and issued a decision confirming that an Environment Effects Statement (EES) is required for the project due to the potential for significant environmental effects.

The Project will include a number of fixed plant items that are assessable under State Environment Protection Policy N-1 (SEPP N-1). This assessment provides a discussion of the potential for acoustical impact from the operation of the tunnel ventilation system.

2 Description of plant

The reference design consists of the following three ventilation stations:

- North portal
- South portal
- Manningham Road Interchange – emergency smoke discharge only.

2.1 Tunnel exhaust

2.1.1 Ventilation Outlets

Fresh air supply to the tunnels and ventilation exhaust would be managed by the ventilation structures. These would generally consist of jet fans with baffle-type attenuators located within the ventilation building and outlets. It is assumed that the ventilation buildings (both intake and outlet buildings) will be constructed such that the breakout noise (where the noise transmitted externally through the building structure and walls of the ventilation structure) is at least 10 dBA below the noise emanating from the ventilation outlet at all receiver locations. The ventilation system is assumed to be operational 24 hours per day, seven days per week, noting that the duty cycle of the fans may vary throughout a 24 hour period, depending on the vehicle flow rate and the prevailing meteorological conditions.

The tunnel exhaust fans include several variable speed drive (VSD) duty ventilation fans at the tunnel structure. Dampers located at the structure exit enable the exhaust gas air velocity to be maintained between six to eight metres per second. Ventilation rates from each ventilation structure would be approximately 450 to 1,050 cubic metres per second. The configuration of the dampers would depend on the time of day, vehicle volumes, in-tunnel air quality and maintenance schedules.

The use of low static pressure fans was considered in equipment selection for the reference design, However, their use was discounted for the following reasons:

- Low pressure fans are larger in size than a high pressure fan (with at least twice the diameter) and are required to be arranged vertically resulting in an increased ventilation structure footprint, leading to increased visual impacts and an increased loss of parklands area

- Low pressure fans are unable to power the smoke extraction system, leading to a requirement for a separate smoke extraction system, further increasing the ventilation structure size and associated visual and land use impacts
- Little change to the energy usage, which is dominated by the use of jet fans to meet requirements for zero portal emissions
- For substantial energy savings to be achieved through the use of low static pressure fans, a large ventilation structure would need to be placed at every each of the exit portals (at least six exit portals) which would further increase impacts on community, visual amenity, land use as well as generating additional costs
- The technology is not new, however a road or rail tunnel using low pressure fans has not yet been constructed and applied in the Australian setting.

In accordance with Principle 1B of the Environment Protection Act 1970, the consideration of low static pressure fans has integrated social considerations alongside environmental considerations. In balancing the energy savings which could be achieved through the use of low static pressure fans against the large increase in community impacts which would result from an increase in the number and size of ventilation structures, it is considered that the use of low static pressure fans is not justified.

The northern and southern tunnel ventilation structures can be assumed to be almost identical. The design is based on six, 3600 mm diameter fans. Two sets of noise attenuators are to be installed:

- Between the fans and the tunnel roadway and;
- Between the fans and the discharge point

For the purposes of the reference design (so to predict pressure loss), noise attenuators have been assumed to be of the rectangular duct straight splitter type with 43% open-area, and 3 m long. These silencers have been included in this acoustic assessment.

For noise modelling purposes, the fans are represented as an area source at each location and set to a height of 40 metres above prevailing terrain. The sound power level near the top of ventilation structure has been based on a design criterion as shown in **Table 2.1**, **Table 2.3** and **Table 2.5**. Detailed information is currently unavailable, but the assumed levels are considered representative, based on project information.

Indicative sound power level data for the proposed ventilation outlets is presented in **Table 2.1** , for the peak load and non-peak load times, and the nominated insertion loss for the silencer (3000mm, 43% open area) is presented in **Table 2.2**. During detailed design, consideration must be given to:

- The long-term dynamic insertion loss performance of the silencer, having consideration of deterioration due to dust or wear.
- Flow noise across the silencer due to the movement of air across the face of the silencer, acknowledging that this effect is dependent on the flow rate of the air.

The net sound power level will be refined during detailed design stage of the Project, in-line with fan/silencer selection and siting. The peak cycle operating conditions are assumed to be operational at any time of the day or night. This conservative assumption will be reviewed/refined during the detailed design stage of the project.

Table 2.1 Indicative sound power level of ventilation outlets (northern and southern portal)

Ventilation exhaust	Octave band frequency (Hz) / sound power level SWL (dBL re 1pW)								Sound power level dBA
	63	125	250	500	1k	2k	4k	8k	
Outlet (peak cycle time)	120	118	120	120	119	116	111	109	123
Outlet (night-time)	110	108	110	110	109	106	101	99	113

Notes:

1. Fan sound power data, as supplied by Project Team
2. Equipment and sound power levels are indicative and may change subject to detailed design

Table 2.2 Proposed silencer insertion loss

Ventilation exhaust	Octave band frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Insertion loss (dB)	8	19	38	49	54	39	27	20

Notes: Based on NAP D47/300, subject to detailed design.

It is assumed that similar fans (but minimal silencers; so as not to restrict airflow during an emergency situation) would be used at the smoke exhaust structure within the Manningham Interchange. For modelling purposes, the 'peak cycle' noise emissions detailed in **Table 2.1** and the silencer loss detailed in **Table 2.2,** have been used at all ventilation discharge sites.

2.1.2 Tunnel jet fans

The nearest in-tunnel jet fans are assumed to be positioned a distance of 50 metres from the nearest jet fans to the various tunnel portals. Three jet fans have been included in the calculation for each assessment location and are assumed to be operational 24 hours per day, seven days per week.

Indicative sound power level data for the proposed tunnel jet fans is presented in **Table 2.3**.

Table 2.3 Indicative sound power level of jet fans in tunnel

Jet fan	Octave band frequency (Hz) / sound power level LW (dBL re 1pW)								Sound power level LWA
	63	125	250	500	1k	2k	4k	8k	
1250 mm	108	100	94	87	95	91	87	87	98

Notes:

1. Based on sound power data used by SLR on other tunnelling projects
2. Equipment and sound power levels are indicative and may change subject to detailed design

The fans will have in-line circular 1250, 1D silencers installed on the intake and discharge side of the fan unit.

Table 2.4 In-tunnel jet fans – typical attenuator insertion loss

Fan configuration	Minimum static insertion loss (dB)							
	Octave band centre frequency (Hz)							
	63	125	250	500	1K	2K	4K	8K
Circular (no pod) / 1D / 1250 mm	-	4	7	9	7	6	4	4

Based on NAP Circular Silencer (no pod) Model number: 1220-1D

2.1.3 Substations

There are multiple substations along the tunnelled section of the project. All substations except two will be below ground and consequently would have negligible acoustical influence on the prevailing noise environment, given they have appropriate space for acoustically treated ventilation systems to be incorporated into the scheme (which will be refined during the detailed design phase of the project). The two substations located on the surface, will be housed in new buildings with provisional space for ventilation and noise mitigation.

The two above ground buildings used during the operational phase of the project are located at:

- Northern Portal: incorporating four x 2MVA and one 20MVA transformers
- Manningham Interchange: one 20MVA transformer

Indicative sound power level data for the proposed transformers used in the noise model is based on previous studies and presented in **Table 2.5**.

Table 2.5 Indicative sound power level of transformers at substations

MVA	Octave band frequency (Hz) / sound power level LW (dBL re 1pW)						Sound power level LWA
	63	125	250	500	1k	2k	
3.15MVA per unit	75	83	73	67	67	65	73
Northern Portal (ten units)	90	98	88	82	82	80	88
Manningham Interchange: (six units)	88	96	86	80	80	78	86

Notes:

1. Used by SLR on similar commissions
2. Equipment and sound power levels are indicative and may change subject to detailed design.

2.1.4 Predicted modifying factors

This assessment has not allowed for modifying factors on the ventilation fan noise. This is based on SLR's previous measurement on other similar facilities, where no penalty was shown to be required. Notwithstanding, it is recommended that this be revised during detailed design, when final fan selection has been undertaken. If appropriate, modifying factors are to be included.

The in-tunnel fans and substations both include a 5 dBA tonality penalty within this assessment. This should be reviewed during detailed design.

It is recommended that during detailed design, all plant items (once selected) are assessed for consideration of the tonal, impulsive, or low-frequency modifying factors. Where modifying factors are found to be applicable, they should be added to the assessment and compliance with the criteria checked at all receivers.

2.1.5 Location of equipment

The proposed ventilation structures and the substation are shown in **Figure 1** to **Figure 3**.

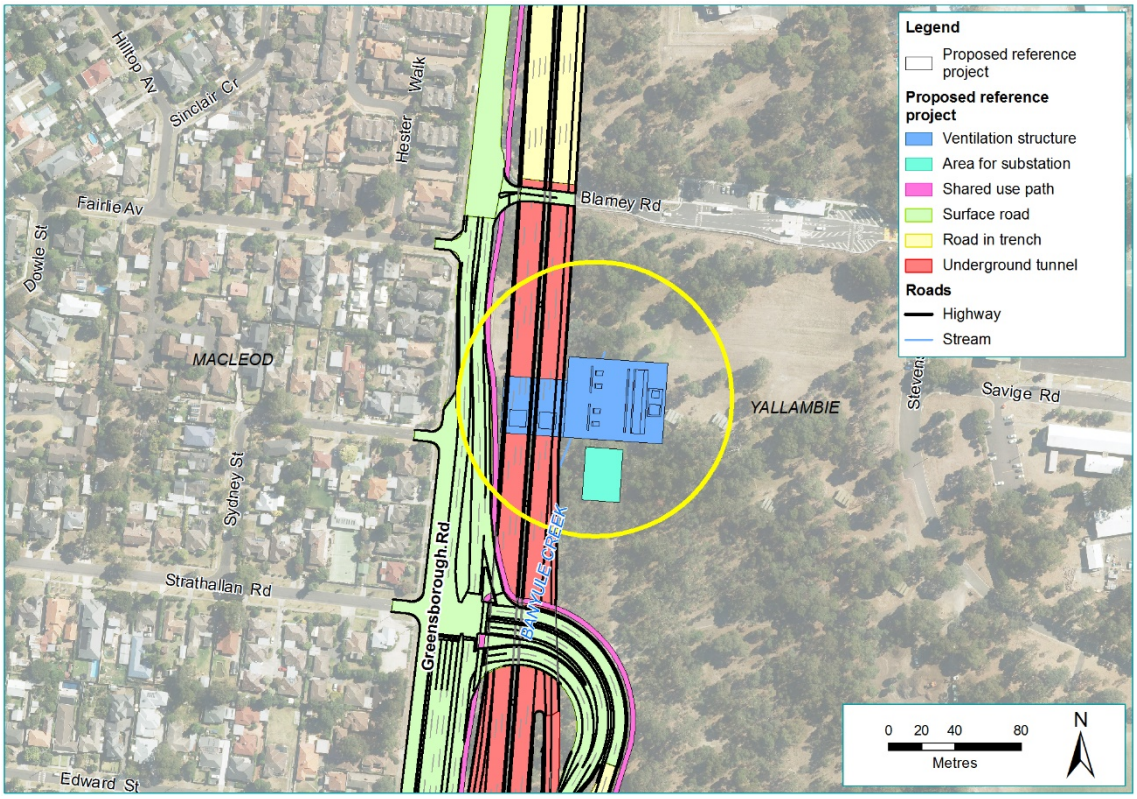


Figure 1 **Proposed location of ventilation structure and substation – Northern Portal**

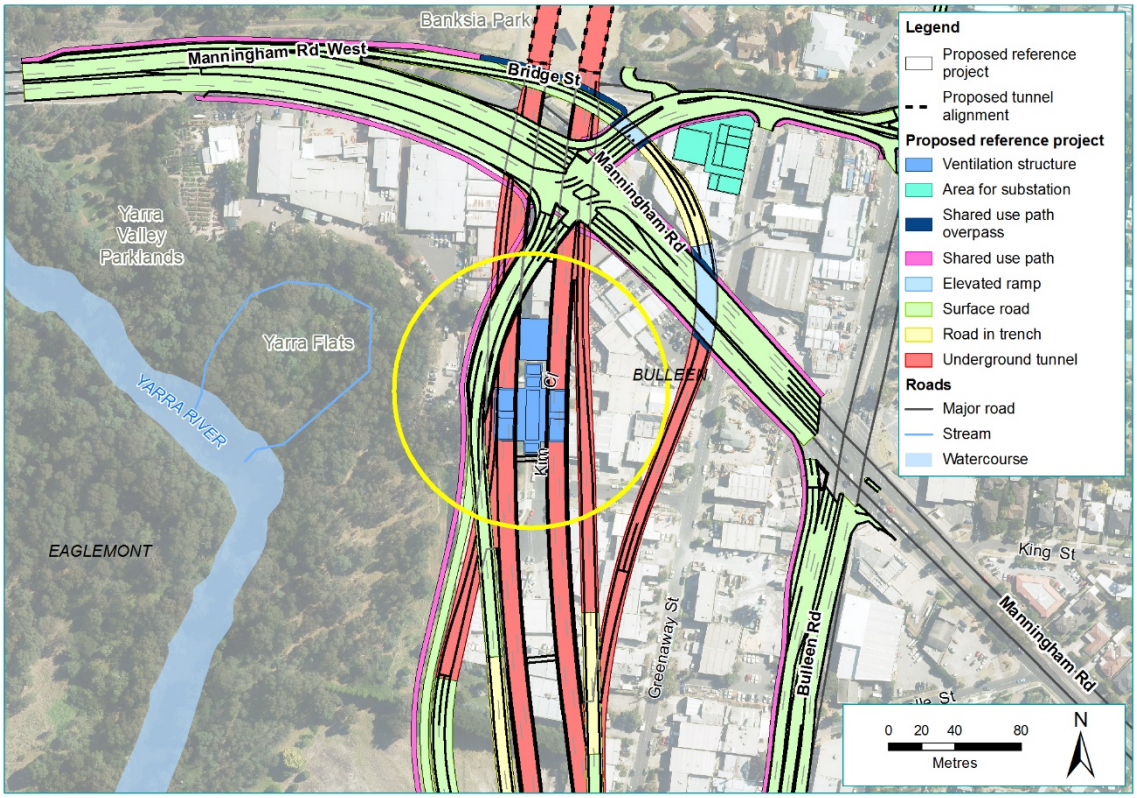


Figure 2 **Proposed location of emergency exhaust ventilation system and substation - Manningham Interchange**

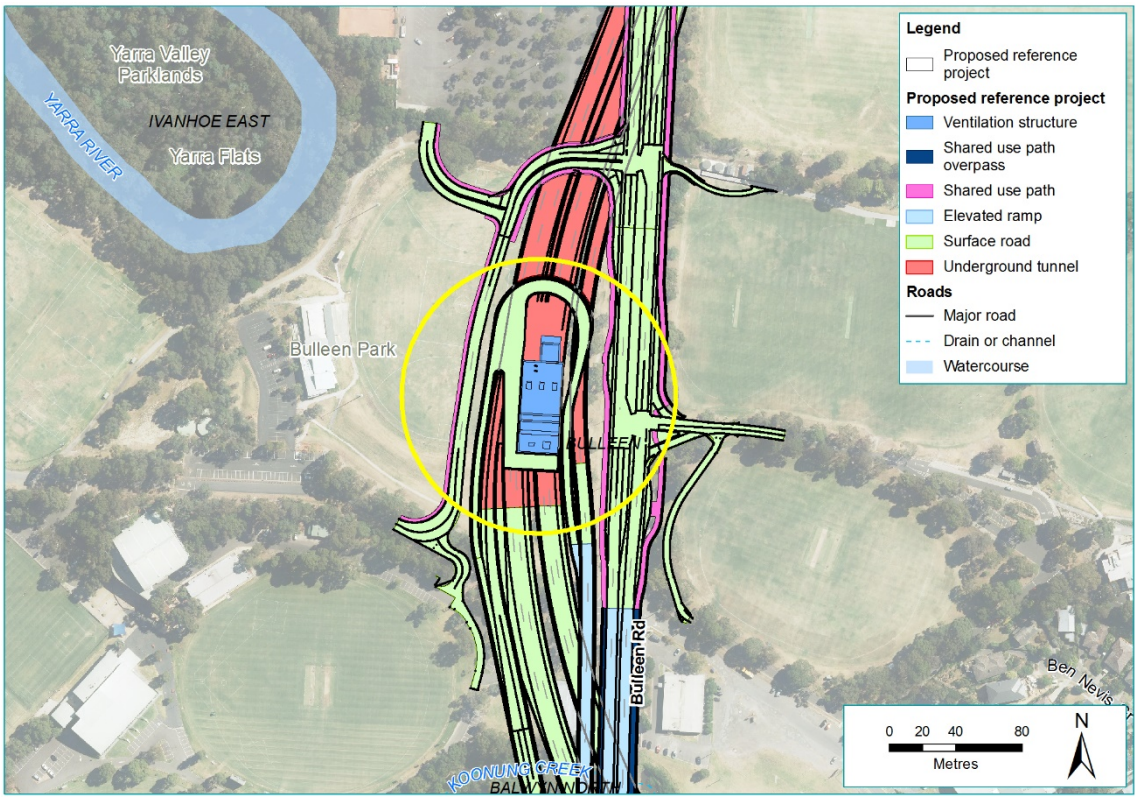


Figure 3 **Proposed location of ventilation structure and substation - Southern Interchange**

3 Noise from Commerce, Industry and Trade

In the Melbourne metropolitan area noise from commerce, industry and trade is subject to the provisions of the State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1). Under SEPP N-1 the noise limit is the maximum allowable "level of noise emitted from the commercial, industrial or trade premise", in a "noise sensitive area" as defined by the Policy. Noise limits are prescribed for residential premises for the day, evening and night periods, as defined in **Table 3.1**. The lowest limits usually apply to the night period.

Table 3.1 SEPP N-1 Definitions of SEPP N-1 day, evening and night-time periods

Period	Day	Time
Daytime	Monday to Friday Saturday	0700h to 1800h 0700h to 1300h
Evening	Monday to Friday Saturday Sunday and public holidays	1800h to 2200h 1300h to 2200h 0700h to 2200h
Night time	Monday to Sunday	2200h to 24:00h 0000h to 0700h

Noise limits are based on the land-use zoning of the area surrounding the residence, as defined by the relevant authority, and on the measured background noise levels when background levels are especially high or low.

Noise from commercial premises can be assessed over any single 30 minute period during which the premises operates.

The measured and predicted noise from a commercial, industrial or trade site is adjusted for character, including tonality, intermittency and duration. The adjusted noise level is compared with the noise limit to determine compliance or otherwise with SEPP N-1.

Noise limits apply to all noise from commercial and industrial activities from all sites contributing to the measured level at a residence. Where multiple activities take place on a site at the same time, the noise limits should be met by all activities at the one time. In such cases, the effective noise limit for each activity may be lower than the overall SEPP N-1 limit.

4 Noise Sensitive receivers

Noise sensitive receivers were selected around each of the three sites where the fans are to be located. This selection was based on:

- The proximity of the receivers to the ventilation structure;
- The nature of the receiver and surrounding land uses.
- The locations where baseline monitoring was undertaken.
- The results of the noise modelling showing the areas where predicted emissions were the highest.
- Contoured maps of the noise emissions from the fan units.
- For locations selected that are further set-back from the main roads, the background noise at those selected locations are not expected to significantly change with increased separation distance from the ventilation structures.

Specifically:

- At the southern portal: the selected location represents the receiver in the quietest area, where impacts would be the highest. At other locations, higher ambient noise from traffic would result in higher, less stringent criteria.
- At Manningham interchange: the fans will not be used as part of the normal ventilation and will only be active when removing smoke from the tunnel. Consequently, the unit requires testing every quarter, which is anticipated to last for approximately 5 minutes. Testing is limited to the daytime period only. Three receivers are selected for assessment, one nearest the substation building (40-42 Bridge Street), and two receivers to the east in Bulleen Road and Elizabeth Street.
- At the northern portal: the ambient levels to the west of Greensborough Road are unlikely to significantly change with increased distance; whereas the noise from the fan decreases as a point source (6dB/doubling of distance). The location in Hester Walk is considered an optimum assessment location.

The following locations were selected for assessment:

Table 4.1 Assessment Locations

Project Area	Address
Northern Portal	5 Hester Walk
	183 Greensborough Road
Manningham Interchange	218 Bulleen Road
	1a Elizabeth Street
	40 – 42 Bridge Street
Southern Interchange	11 Ben Nevis Grove

It is noted that during detailed design, these locations will be reviewed, and additional surveys undertaken if considered appropriate.

5 Background Noise survey

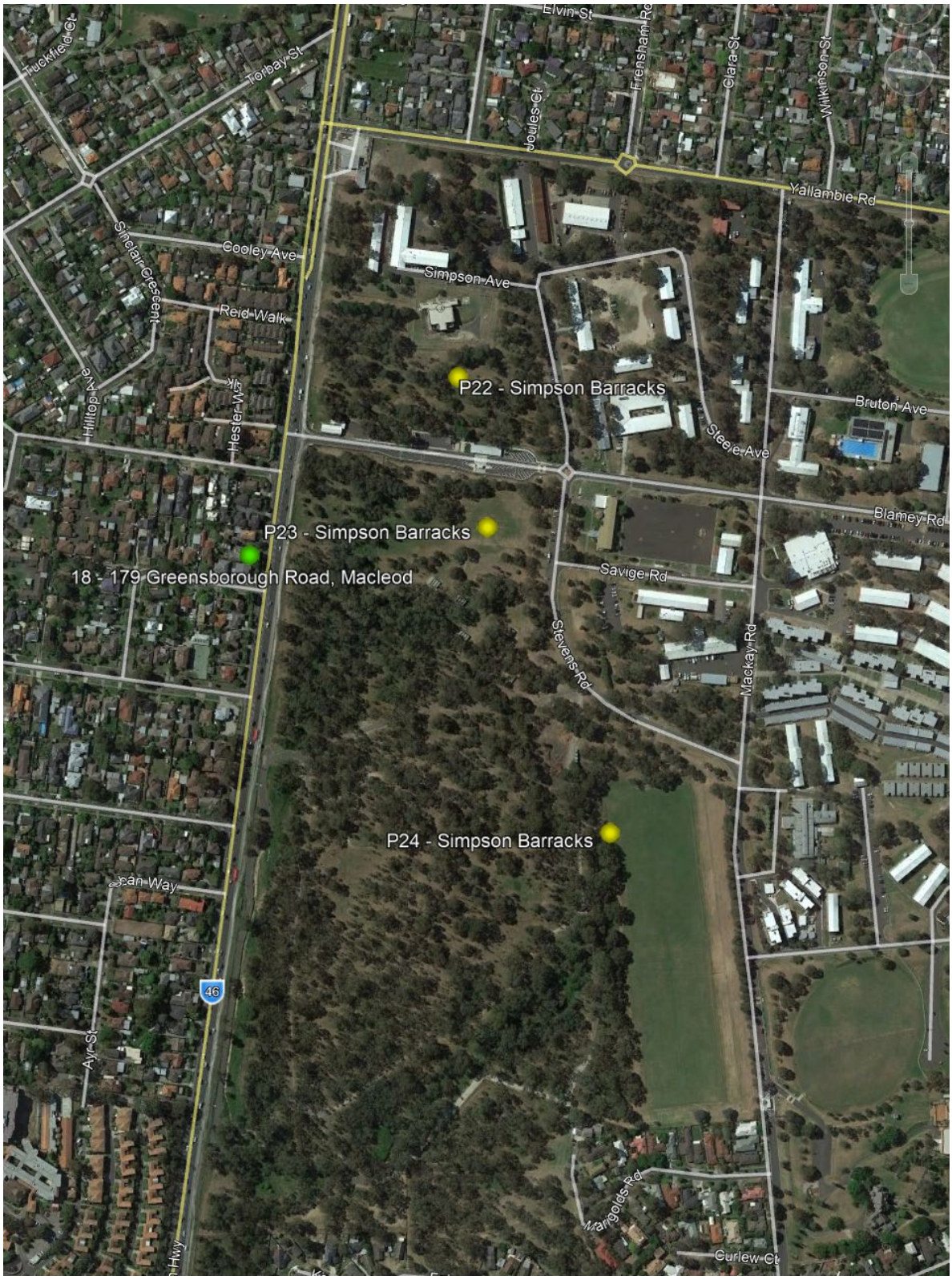
5.1 Average background noise levels (L_{A90})

Attended and unattended noise monitoring was undertaken to qualify and qualify the current noise environment.

Unattended measurements of existing noise environment forms part of the Existing Conditions assessment for the North East Link. This monitoring shows a snap-shot of the noise environment and helps to qualify the nature of the noise environment. The results of the unattended monitoring are presented in **Table 5.1**, with the monitoring positions shown in **Figure 4**.

Table 5.1 Ambient noise – attended short-term noise monitoring

Attended Short-Term Measurements								
Site ID	Name of open space	Start time of measurement	Measured Noise Level, dBA				Observation of noise sources	
			L_{Aeq}	L_{A90}	L_{A10}	L_{max}	Local environment	Traffic noise source (road)
P22	Simpson Barracks between Blamey Road and Simpson Ave	6/06/2018 9:15	54	52	56	69	Dominant road traffic noise, birds. Occasional passing cars on main road.	Greensborough Road
P23	Simpson Barracks on grass area cnr Blamey Road and Stevens Road	6/06/2018 7:37	58	56	60	67	Ambient road traffic noise. Bird noise and passing aircraft. Site is south of the base entrance, so experiences stationary and slow passing car noise at peak hour.	Greensborough Road
P24	Simpson Barracks on sports field off Mackay Road	6/06/2018 8:20	52	49	54	67	Ambient road traffic noise, birds. Occasional passing aircraft and cars on main road.	Greensborough Road



Green dot: unattended monitoring, Yellow dots: short-term attended monitoring

Figure 4 Unattended and attended noise monitoring locations near Simpson Barracks

Unattended monitoring qualified the longer-term noise environment and is used to set the SEPP N-1 noise criteria for the fixed plant and equipment at the locations where baseline monitoring was undertaken. These monitoring results are summarised in **Table 5.2**. In accordance with the SEPP N-1, an adjustment of -2 dB has been applied to the measured noise levels as the microphone was positioned one metre from an acoustically reflecting surface (wall or building).

For the purposes of this assessment, the background noise levels at residential areas further away from a main road are assumed to be 5 dBA lower than the nearest monitoring position. Road traffic noise modelling conducted as part of the *North East Link* EES, indicated that, for 2037 the highest decrease along any road in the modelling area was determined to be -1.4 dBA (with/without the project), a value of -2 dBA has been used in all locations.

The measured unattended noise levels can be used to determine the applicable SEPP N-1 noise limits for receivers potentially impacted by noise from the various fixed plant.

Table 5.2 Adjusted ambient noise monitoring results

Nearest Site	Assessment Location	Basis of background noise	Measured Average Measured L_{A90} Noise Level, dB(A)		
			Daytime	Evening	Night-time
Northern Portal	183 Greensborough Road, Watsonia	179 Greensborough Road, Watsonia	59	56	44
	5 Hester Walk, Watsonia	179 Greensborough Road, Watsonia minus 5dBA	54	51	39
Manningham Interchange	218 Bulleen Road, Bulleen	218 Bulleen Road, Bulleen	53	51	46
	1a Elizabeth Street, Bulleen	218 Bulleen Road, Bulleen minus 5 dBA	48	46	41
	40 – 42 Bridge Street	218 Bulleen Road, Bulleen minus 5 dBA	48	46	41
Southern Portal	11 Ben Nevis Grove, Bulleen	8 Ben Nevis Grove	46	48	43

Note 1: Measured background minus 2dBA for façade reflection and -2dBA for reduced future background noise level, as predicted in the Project wide noise modelling undertaken for the EES

Note 2: Measured background minus 5dBA for lower background environment (compared to monitoring position), -2dBA for façade reflection and -2dBA for reduced future background noise level

6 Noise Limits

Zoning levels for the nearest residential receivers nearest for each of the ventilation structure have been calculated in accordance with SEPP N-1. Refer to **Figure 5** to **Figure 7** for zone maps showing land use zoning surrounding the residences. The land use classification of areas inside the SEPP N-1 'zoning circles' are considered in the derivation of zoning levels.

The fans will operate day and night, though for most of the night at a lower setting. This assessment however, assumes that the fans could be operational at full capacity for some period during the night period, though this may be revised during detailed design.

6.1 Northern Portal

For the two receivers selected for assessment near the northern portal, using the ratios of the Type 2/Type 3 land within the zoning circles, and the average of the measured background noise levels, the appropriate noise limits were determined for day, evening, and night periods using the procedure prescribed by SEPP N-1. These limits are presented in **Table 6.1.**

The Commonwealth land has a planning zone CA, which is not in the Banyule Planning Scheme. For this assessment, the Commonwealth land is conservatively taken as general residential.

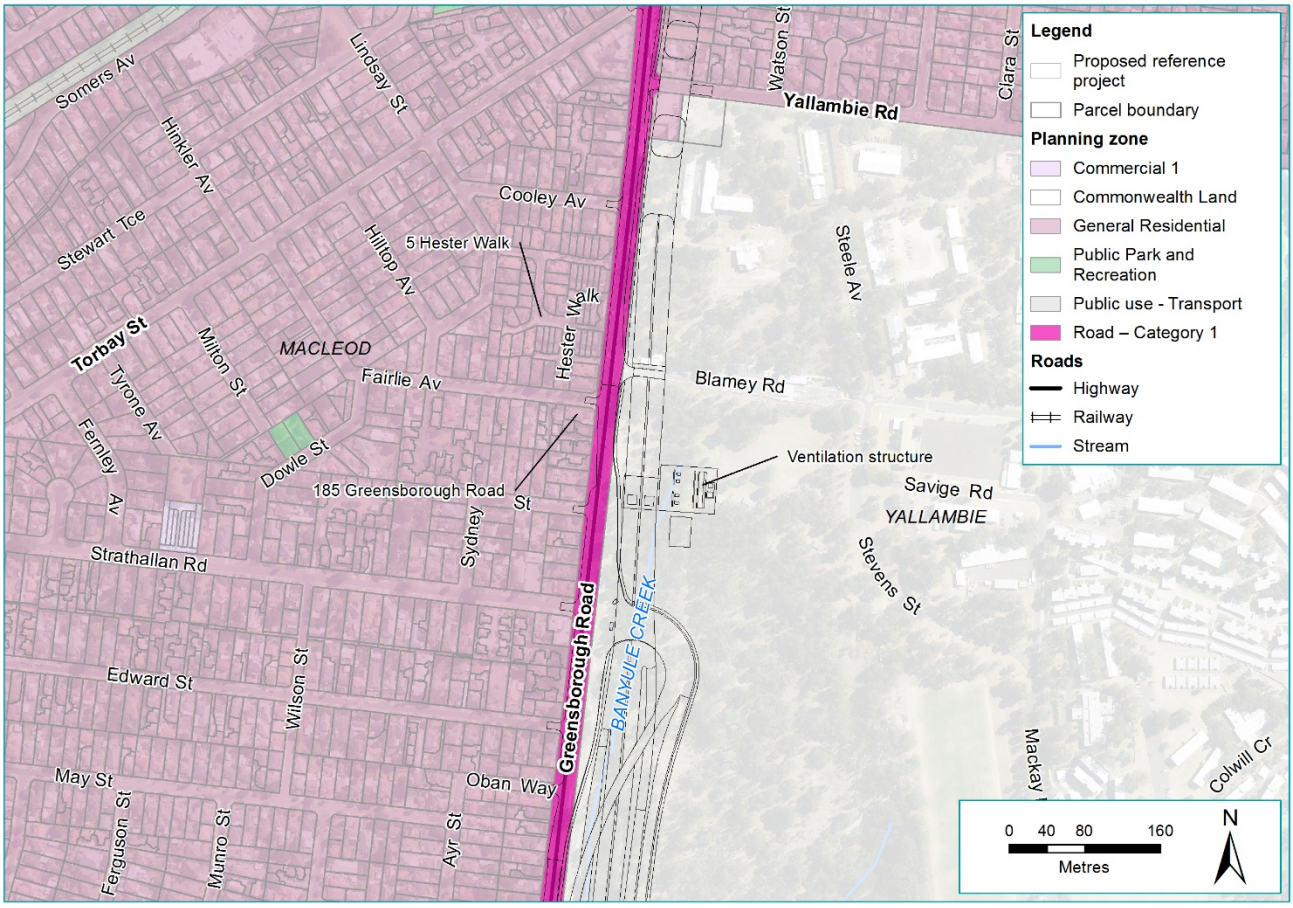


Figure 5 Zoning map - Northern portal

Table 6.1 SEPP N-1 Noise Limits – Northern Portal

	Day	Evening	Night
183 Greensborough Road, Watsonia			
Zoning Level, dBA	53	46	41
Background Noise Level, dBA L90 [1]	59	56	44
Background classification	Neutral	High	Neutral
Noise Limit, calculation	Neutral	Background + 3	Neutral
Noise Limit, dBA Leq	53	47	41
5 Hester Walk, Watsonia			
Zoning Level, dBA	51	45	40
Background Noise Level, dBA L90 [2]	55	52	40
Background classification	Neutral	High	Neutral
Noise Limit, calculation	Neutral	Background + 3	Neutral
Noise Limit, dBA Leq	51	47	40

Note 1: Measured background minus 2dBA for façade reflection and -2dBA for reduced future background noise level, as predicted in the Project wide noise modelling undertaken for the EES

Note 2: Measured background minus 5dBA for lower background environment (compared to monitoring position), -2dBA for façade reflection and -2dBA for reduced future background noise level

It is envisaged that these noise limits would be revised and refined during detailed design phase of the project.

6.2 Manningham Interchange

For the two receivers selected for assessment near the Manningham Interchange, using the ratios of the Type 2/Type 3 land within the zoning circles, and the average of the measured background noise levels, the appropriate noise limits were determined for day, evening, and night periods using the procedure prescribed by SEPP N-1. These limits are presented in **Table 6.2**.

The smoke exhaust fans at the Manningham Interchange will only be used in an emergency situation but will be tested routinely - maybe every three to six months. Testing would be expected to last for approximately an hour or two on each occasion, however it is reasonable to assume testing can be limited to the daytime period only. Consequently, this assessment is based on daytime operation of the fans, with the evening and night-time periods included for completeness.

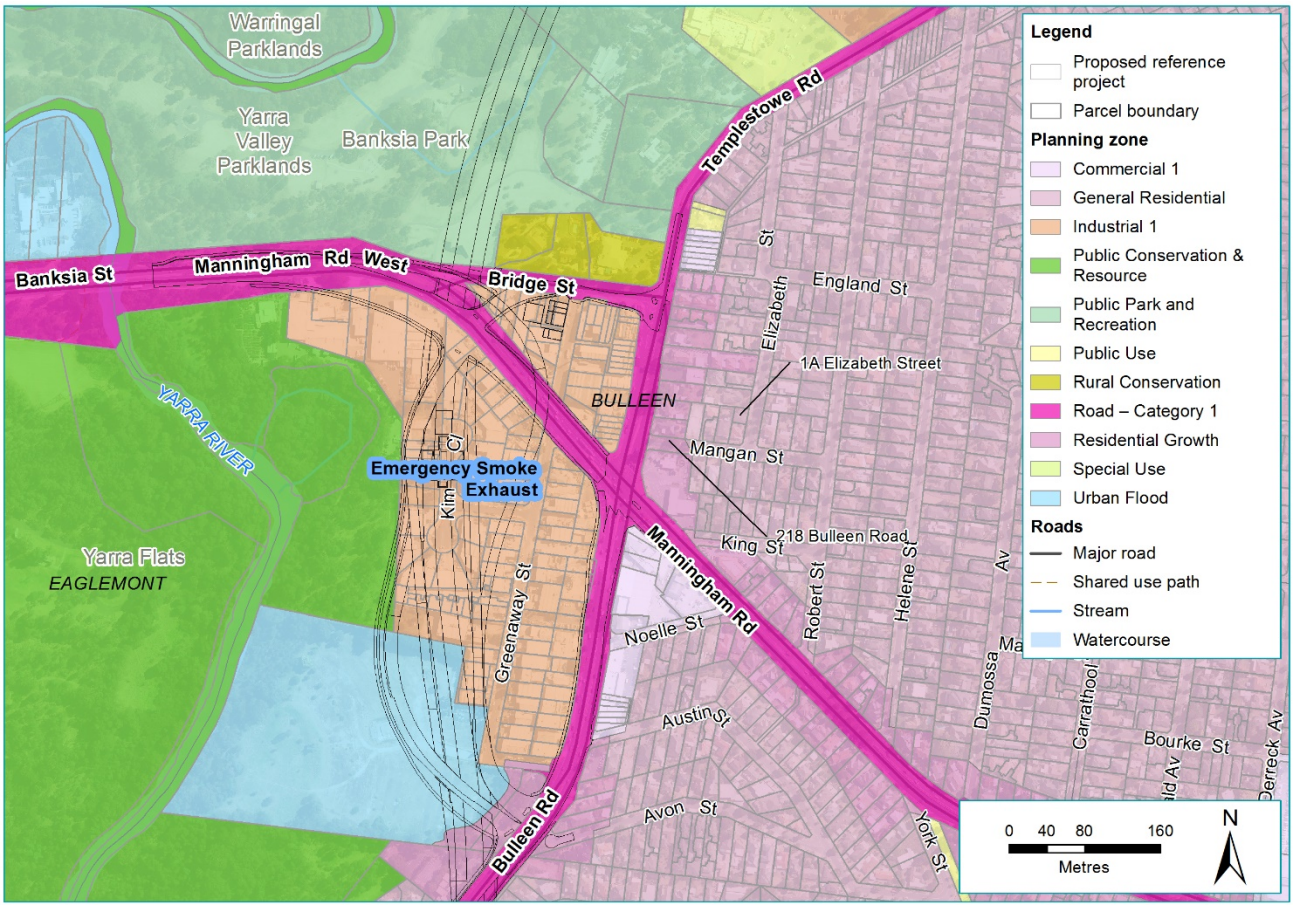


Figure 6 Zoning Map - Manningham Interchange

Table 6.2 SEPP N-1 Noise Limits, Manningham Interchange

	Day	Evening	Night
218 Bulleen Road			
Zoning Level, dBA	57	51	46
Background Noise Level, dBA L90 [1]	53	51	46
Background classification	Low	Neutral	Neutral
Noise Limit, calculation	Background +13	Neutral	Neutral
Noise Limit, dBA Leq	55	51	46
1A Elizabeth Street and 40 – 42 Bridge Street			
Zoning Level, dBA	53	46	41
Background Noise Level, dBA L90 [2]	48	46	41
Background classification	Neutral	Neutral	Neutral
Noise Limit, calculation	Neutral	Neutral	Neutral
Noise Limit, dBA Leq	53	46	41

Note 1: Measured background minus 2dBA for façade reflection and -2dBA for reduced future background noise level, as predicted in the Project wide noise modelling undertaken for the EES

Note 2: Measured background minus 5dBA for lower background environment (compared to monitoring position), -2dBA for façade reflection and -2dBA for reduced future background noise level

There was no significant contribution of industrial/commercial noise in the noise environment measurements taken at the measurement sites. The non-residential buildings west of Bulleen Road (south of Bridge Street) will be demolished as part of the project. No firm decision has been made as the future use of the land. The derived noise limits have been adjusted 3 dBA downwards to allow for the possible future contribution from commercial developments (should that eventuate). The adjusted noise limits are detailed in **Table 6.3**.

Table 6.3 SEPP N-1 Adjusted Noise Limits, Manningham Interchange

	Day	Evening	Night
218 Bulleen Road			
Noise Limit, dBA LAeq	52	48	43
1A Elizabeth Street and 40 – 42 Bridge Street			
Noise Limit, dBA LAeq	50	43	38

During the operational phase of the project, the electrical substations used for the emergency smoke exhaust fans at Manningham Interchange will be located within a dedicated acoustically treated building. Though the noise from the substation has been modelled, it can considered to have a negligible contribution to the overall noise environment.

It is envisaged that these noise limits would be revised and refined during detailed design phased of the project.

6.3 Southern Portal

The nearest assessment point was taken to be the residences at 11 Ben Nevis Grove, with the assessment based on the ambient environment at 8 Ben Nevis Grove, which can be considered representative of residences in the immediate surrounding area.

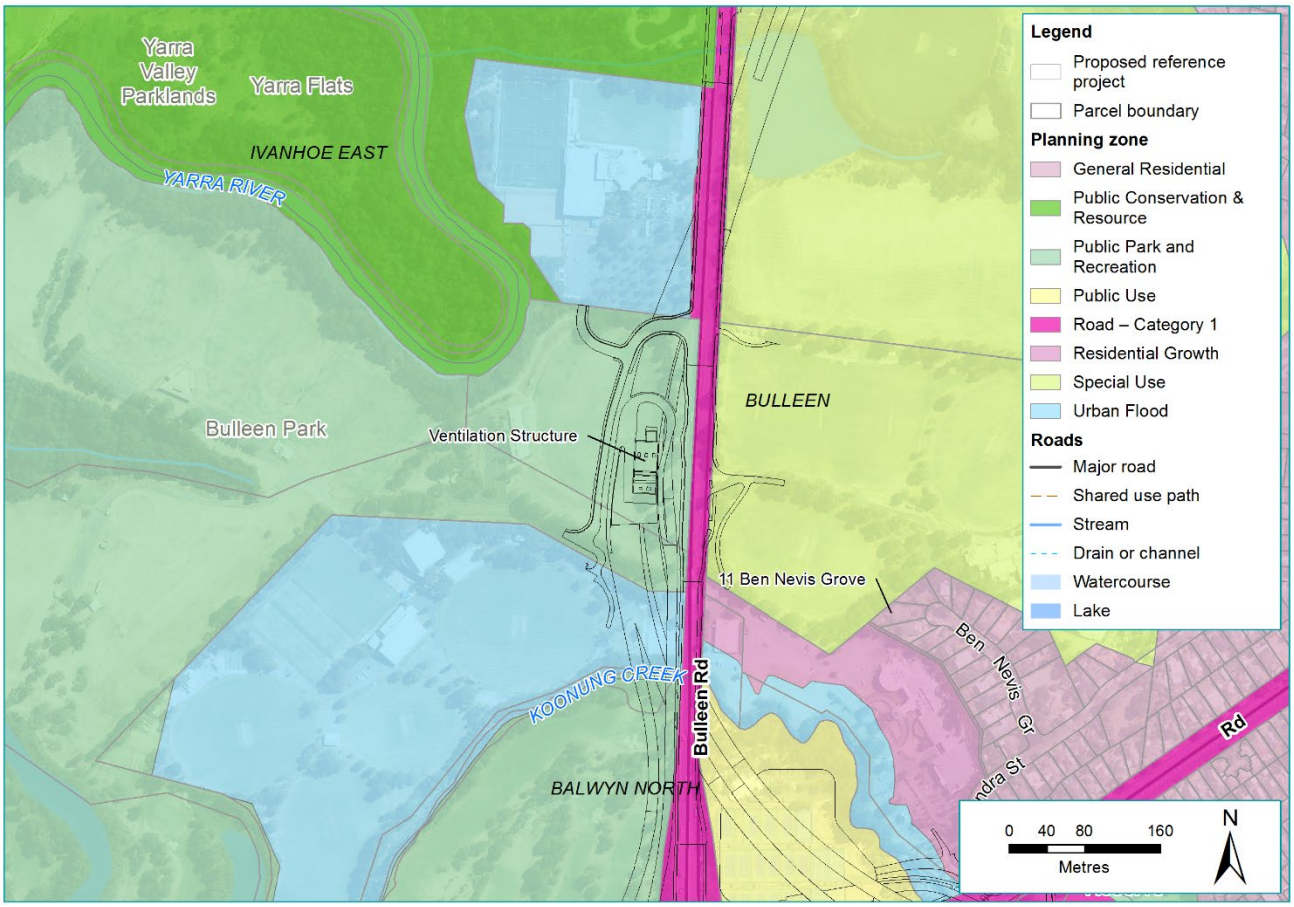


Figure 7 Zoning Map – Southern portal

Using the measured background noise levels, for the day, evening and night-time periods, the appropriate noise limits were determined using the procedure prescribed by SEPP N-1. These limits are presented in **Table 6.4**.

Table 6.4 SEPP N-1 Noise Limits, 11 Ben Nevis Grove – Southern Interchange

	Day	Evening	Night
11 Ben Nevis Grove			
Zoning Level, dBA	50	44	39
Background Noise Level, dBA L90 [1]	46	48	43
Background classification	Neutral	High	High
Noise Limit, calculation	Neutral	Background + 3	Background + 3
Noise Limit, dBA Leq	50	48	43

Note 1: Measured background minus 2dBA for façade reflection and -2dBA for reduced future background noise level, as predicted in the Project wide noise modelling undertaken for the EES

It is envisaged that these noise limits would be revised and refined during detailed design phased of the project.

6.4 Assessment

The assessment considers the combined noise from the fans and substation, to the nearest residences.

6.4.1 Noise modelling

A computer noise model of the proposed fixed structures has been undertaken to predict the potential break-out noise impact at the nearest sensitive receivers in reference to the relevant Project derived SEPP N-1 noise limits.

The following sections detail the modelling software and the methodology that was adopted, and lists the assumptions and parameters used for the calculations.

The general noise model used for road traffic predictions was adapted for to determine the noise from the proposed ventilation system and substation. All calculations were conducted using the ISO 9613- 2:1996 prediction method. The ISO 9613- 2:1996 Standard provides a method of calculating environmental noise from fixed plant items, as distinct from the CoRTN method, used the prediction of road traffic noise.

The noise model was created adopting the following assumptions:

- Topographical data within the study area.
- Digitised houses in the calculation areas.
- Design layouts and drawings of the ventilation structures.
- Assumed sound power level information for the various noise-emitting plant and equipment items proposed to be installed as part of the Project.
- Calculations were undertaken using ISO 9613- 2:1996. This model includes down-wind (noise enhancement) propagation of the noise to each of the calculation points.
- Whilst no specific directionality was added to the propagation of noise from the top of the discharge, the fans were located five meters below the top of the ventilation structure, as schematically shown in **Figure 8**.
- No insulation is included within the ventilation structure (though space exists).
- Aerial photography was used to determine the locations of the residential receivers.
- Noise from audible warning devices is not assessed under SEPP N-1 and has not been included within the noise model.
- Noise mitigation requirements are based on the predicted noise levels at noise sensitive receivers and the required noise reductions to meet the noise limits.
- During the detailed design phase, the calculations shall be revised considering the noise emission data from the selected fans
- Baseline noise monitoring was conducted under neutral atmospheric conditions, wind less than three metres per second and during periods of no rain.

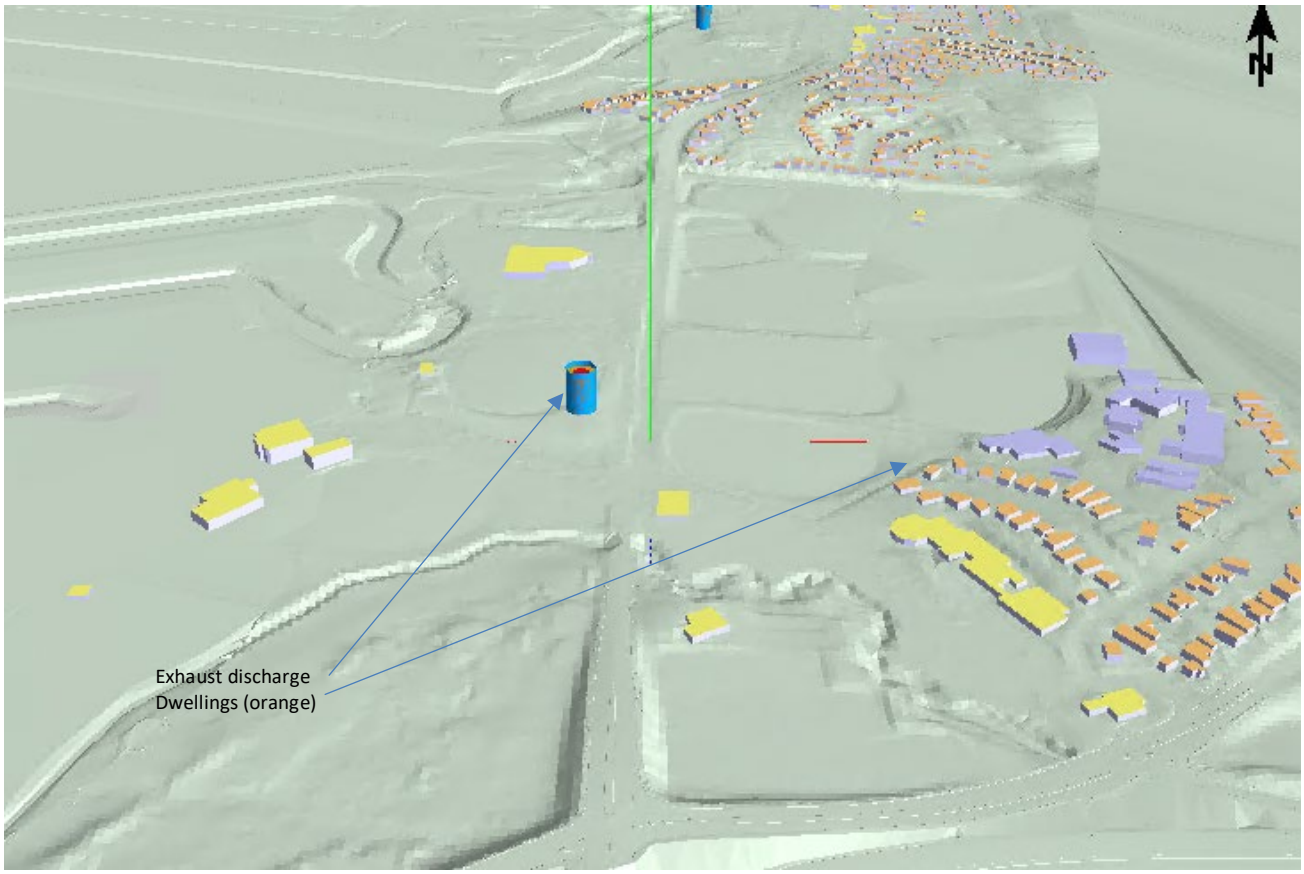


Figure 8 Schematic model showing ventilation discharge (southern portal)

Note that a works approval under the Victorian *Environmental Protection Act 1970* is required for industrial and waste management activities which have the potential for significant environmental impact such as road tunnels and associated ventilation systems.

Potential noise impacts associated with Project operations primarily relate to noise emanating from:

- Road tunnel ventilation structure exhaust fans (northern portal).
- Road tunnel jet fans located near the tunnel portals (northern and southern portal).
- Emergency smoke removal fans (Manningham Interchange).

Noise contours showing the dispersion of noise from the ventilation fans and substations are shown in the following images.

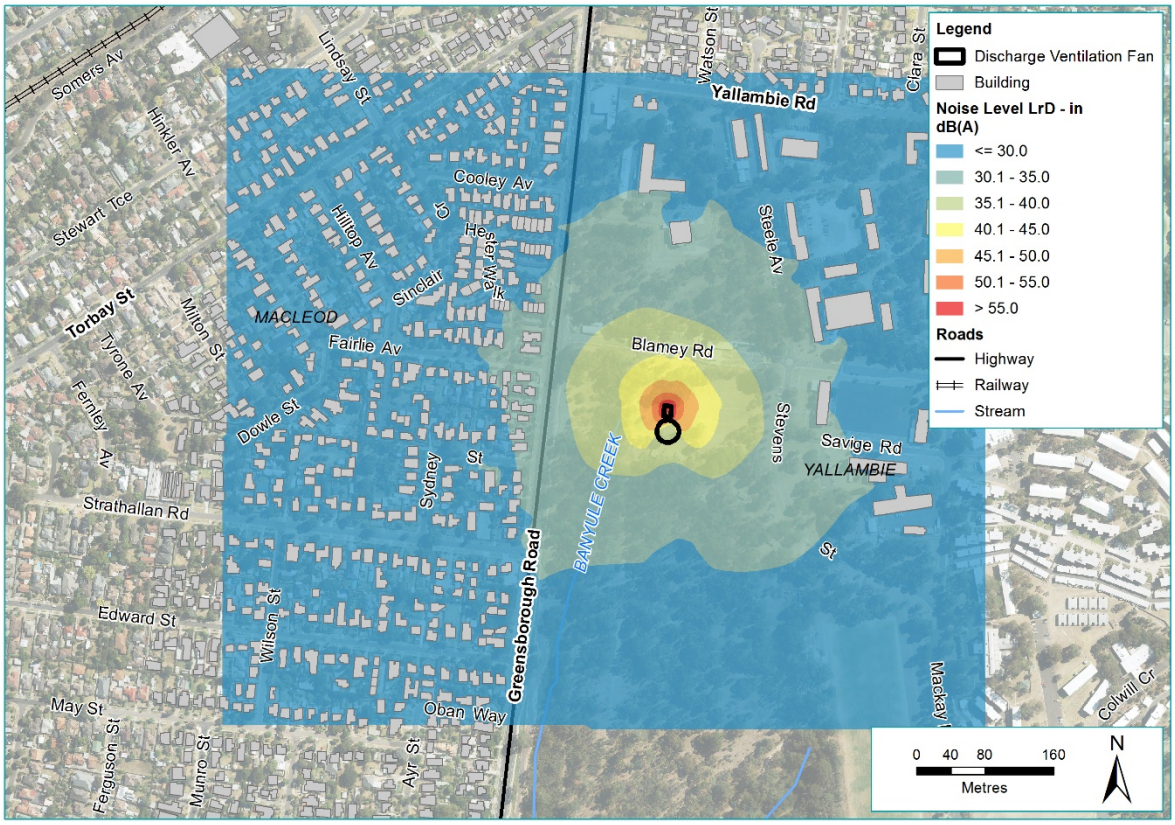


Figure 9 Noise contours from fan ventilation discharge at Northern Portal

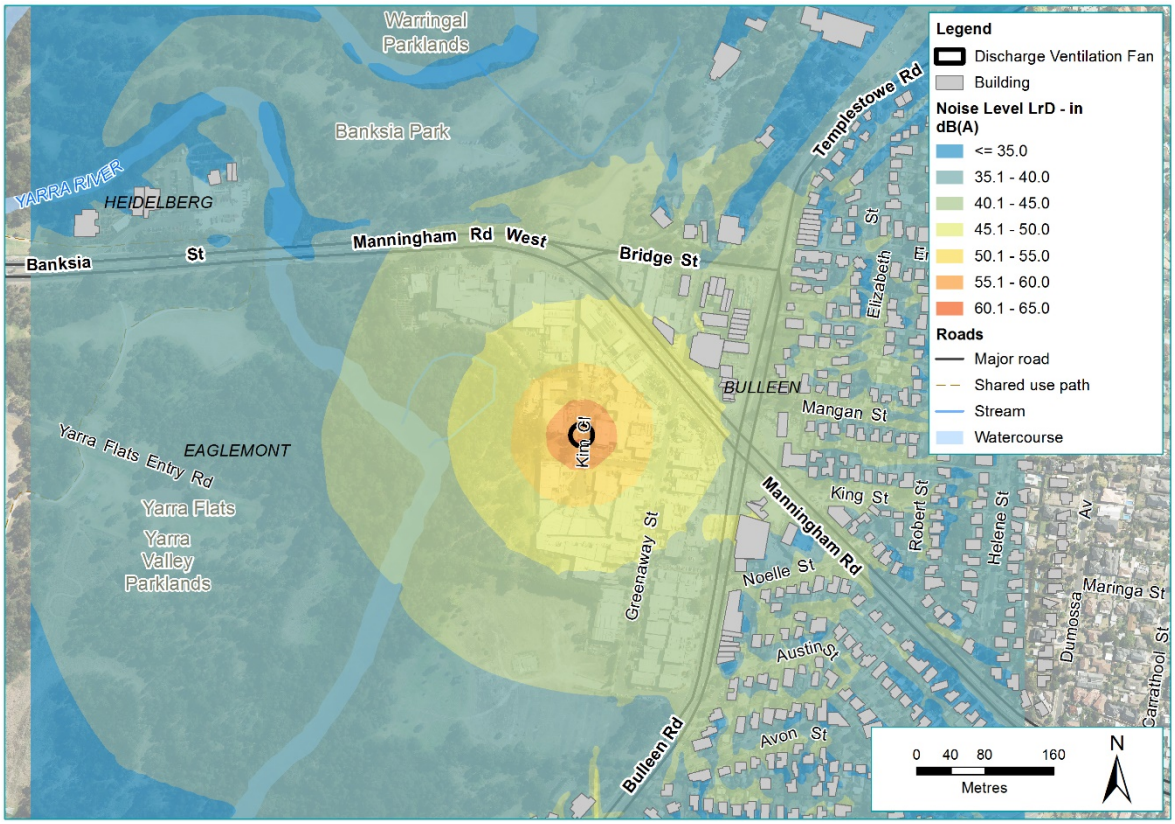


Figure 10 Noise contours from fan ventilation discharge at Manningham Interchange

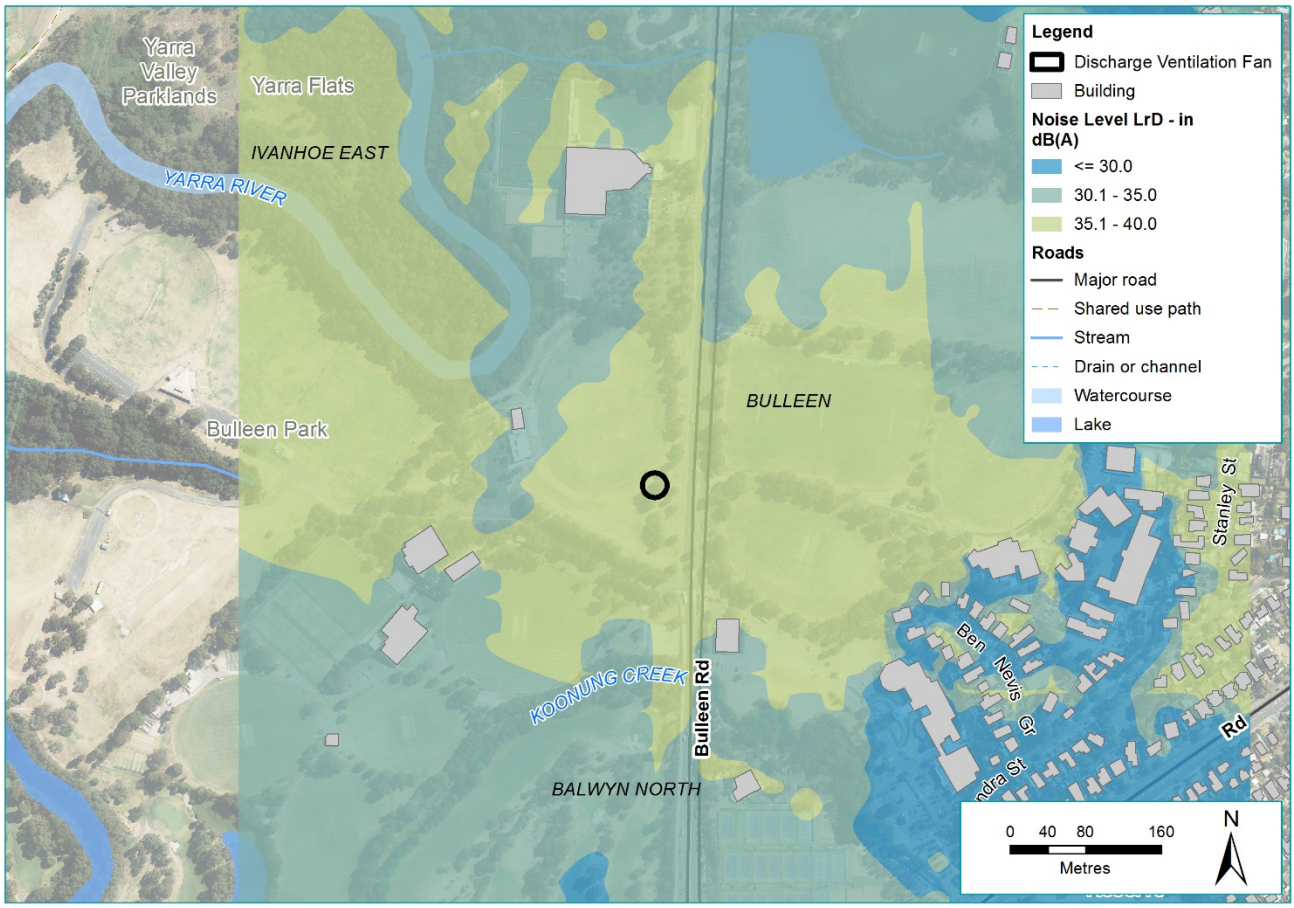


Figure 11 Noise contours from fan ventilation discharge at Southern Portal

6.4.2 Electrical substation (northern and southern portal)

- Mitigation incorporated within the design

Calculations, based on the initial design identified that noise mitigation would be required for the fans to achieve compliance, with the external noise criteria.

The following in-principle mitigation requirements have been identified for the SEPP-N1 analysis.

Ventilation and smoke fans

The exhaust fans are configured so the intake draws air from within the tunnel, though all fans are designed to be unidirectional. The noise from the fans is dependent on the ratings of the fans, the path the noise travels between the fan and the tunnels/outside space, including the nature of any intervening noise mitigation. During the detailed design, the complete noise path must be considered with respect to noise breakout to the wider community and to noise within the tunnel.

Noise sources in the tunnel including the jet fan noise and road traffic noise could also travel through the intake path to the outside environment. Though the inherent in-line mitigation (required to reduce fan noise) would most likely address this, it must be considered during detailed design on the basis of the finalised equipment selection.

Calculations of the in-tunnel fan jet noise was undertaken using measured field data and ISO 9613 propagation algorithms. To the north of the northern portal a small allowance for the potential reverberant build-up within the depressed roadway.

Calculations include an assumption that the character of the noise will be not be tonal, and no tonality correction has not been applied. The results in **Table 6.5** indicate that for the selected ventilation fans, no additional mitigation would be required to achieve the SEPP N-1 noise limits, detailed in **Table 2.1**. to **Table 2.2**. Notwithstanding, the detailed design should examine opportunities to further minimise noise from the fixe plant.

The predictions include the contribution from the in-tunnel exhaust fans, for which no additional mitigation is required.

Table 6.5 Assessment of noise emissions from ventilation system

Location	SEPP N1 criteria (dBA)	Predicted emissions (dBA) (1st floor level)	Margin Below criteria (dBA)	Statement of compliance
Northern portal				
183 Greensborough Road	53 (daytime)	33 (fan + substation)	20	Complies with SEPP N-1
	47 (evening)	33 (fan + substation)	14	Complies with SEPP N-1
	41 (night-time)	33 (fan + substation)	8	Complies with SEPP N-1
5 Hester Walk	51 (daytime)	28 (fan + substation)	23	Complies with SEPP N-1
	47 (evening)	28 (fan + substation)	19	Complies with SEPP N-1
	40 (night-time)	28 (fan + substation)	12	Complies with SEPP N-1
Manningham Interchange				
218 Bulleen Road	52 (daytime)	49 (fan + substation)	3	Complies with SEPP N-1
	48 (evening)	19 (substation only)	29	Complies with SEPP N-1
	43 (night-time)	19 (substation only)	24	Complies with SEPP N-1
1A Elizabeth Street	50 (daytime)	46 (fan + substation)	4	Complies with SEPP N-1
	43 (evening)	16 (substation only)	27	Complies with SEPP N-1
	38 (evening)	16 (substation only)	22	Complies with SEPP N-1
40 – 42 Bridge Street	50 (daytime)	48 (fan + substation)	2	Complies with SEPP N-1
	43 (evening)	26 (substation only)	17	Complies with SEPP N-1
	38 (evening)	26 (substation only)	12	Complies with SEPP N-1
Southern portal				
11 Ben Nevis Grove	50 (daytime)	36 (fan only)	14	Complies with SEPP N-1
	48 (evening)	36 (fan only)	12	Complies with SEPP N-1
	43 (night-time)	36 (fan only)	7	Complies with SEPP N-1

During detailed design, the proposed silencers (and other forms of noise mitigation) shall be selected to provide an overall insertion loss (under expected operating conditions) considering flow noise due to the movement of air through splitters of the silencers, on the intake and discharge side of each of the fans. The preliminarily identified silencers will need be re-verified during detailed design, having consideration of the design of the building and the frequency dependent noise spectra of the selected fans.

6.4.3 Acoustic design considerations

During detailed design, the selected plant will require re-assessment; having consideration of the final noise levels and location of the plant. At that time the following tasks will need to be considered to further enhance the prediction process:

- The contractor chosen to build the tunnel ventilation system would also be responsible for its ongoing operation. This responsibility would be implemented through contractual documents and the North East Link Environmental Performance Requirements (EPR)s. EPR NV6 gives the contractor responsibility for ensuring the tunnel ventilation system's compliance with all aspects of SEPP N-1, which includes the principle of the application of best practice, at the point of initial operation and on an ongoing basis. EPR NV7 gives the contractor responsibility to monitor noise emissions from the tunnel ventilation system on commencing road operation and post opening to verify compliance with the SEPP N-1. Compliance with these EPRs would be achieved through a potential combination of appropriate initial design choices to be specified during the detailed design process, ongoing noise monitoring and appropriate maintenance, replacement of parts or the addition of extra attenuation as required. It is anticipated that EPA will require the contractor to submit detailed design documentation and updated noise modelling to EPA, that demonstrates that the to be built tunnel ventilation system can achieve compliance with SEPP N-1 at the point of construction and for future operation. This is consistent with EPA's approach taken in West Gate Tunnel Works Approval.
- It is envisaged that the contractor would review current best practices relating to the tunnel ventilation system and justify the design with respect to best practice, as part of the detailed design.
- As set out in the Project's Environmental Management Framework, an independent auditor will undertake audits during construction and operation to confirm compliance with and implementation of the EPRs.
- Silencer insertion-loss data should be based on dynamic testing of the product under similar conditions to the operation conditions, where this is feasible. This is to also address flow noise, across the face of the silencer.
- When selecting silencers or other forms of noise mitigation, consideration must be given to the acoustic performance throughout the life of the product. The report shall detail how the potential for acoustic degradation in the performance equipment (such as silencers) through wear, dust build-up etc will be addressed.
- The detailed design shall consider and justify the need for adjustments to the predicted levels, having consideration of the character of the noise (tonal, impulsive or low frequency).
- The current design does not include any silencer for the Manningham emergency smoke discharge fans. Consideration of reducing noise emissions is required under the SEPP, and will need to be undertaken for noise from the smoke discharge fans, noting that silencers can impede the performance of the fan.
- Detailed design should document the design uncertainties and ensure that required noise targets (or better) are achieved, by means of:-
    - safety factors (i.e. design to lower targets);

  - minimising noise emissions, consistently with the implementation of best practice noise control measures.

- As a contingency, (but not a direct for of mitigation), noise from the tunnel ventilation system should be measured on commencing road operation and noise from the Tunnel ventilation system monitored as agreed with EPA Victoria to verify compliance with SEPP N-1. Rectification measures will be implemented if noise level criteria are not met. The type and form of possible additional mitigation cannot be determined at this stage (if any), but may include consideration of the some of the following (or other) in-principle measures; the incorporation of acoustic insulation in the duct system , optimisation of turning vanes, removal of possible obstacles in the air flow path, optimisation /lengthening of silencers, incorporation of attenuation in bends, optimisation of the fan speed etc. It is understood that the design of the mechanical services system has allowed some additional space for supplementary noise attenuation, should it be required.

6.5 Statement of Compliance

With the development and incorporation of the proposed noise mitigation, the predicted noise levels at the potentially most impacted noise sensitive buildings identified for assessment, are predicted to comply with the relevant SEPP N-1 noise limits, based on the assumptions detailed in this report.

The reference design includes a number of potential uncertainties associated with the assessment. These may include the dynamic attenuation of the silencer (compared to the static test results), the potential for regenerated noise across the face of the silencer, the degradation of the silencer due to dust build-up (assuming yearly cleaning and appropriate maintenance) etc. The modelling however, contains some conservatism; the fans are positioned at the base of the discharge within a fan room whereas they were modelled near the top of the ventilation structure, the acoustical losses at bends of ductwork, acoustic losses along the air-path, end reflection loss at the point of discharge, or specific directionality of the noise etc are not included in the modelling and will act to lower the predicted emissions. Having considered the balance of uncertainties and the conservatism within the modelling, and the degree to which the predictions are below the criteria; it is considered that the conservatism within the model is sufficient to offset the possible uncertainty.

7 Sensitivity Analysis

It is plausible that the final location of the ventilation structure may be subject to some refinement during the detailed design phase of the project. The following comments are intended to provide some high-level guidance on the impacts associated with possible changes to the location of the buildings. It is noted that re-evaluation of the assessment due to final plant selection, with measurements of the ambient noise at the selected receivers, is still required.

If the location of the ventilation system at northern portal were to change between the locations shown in **Figure 12**, reassessment of the noise impacts would not be considered warranted if the position were to change from the proposed position to Location 3 or Location 5, but would be required for a change to Location 2 or Location 4.



Figure 12 Sensitivity of location for the ventilation structure at the northern portal

Based on the predicted emissions and the margin of compliance, the possible relocation of the ventilation system at southern portal would not require re-assessment should the position of the ventilation system change to Location 2 or Location 4, as shown in **Figure 13.** Should the structure be relocated to locations 3 or 5, then a re-evaluation may be required.

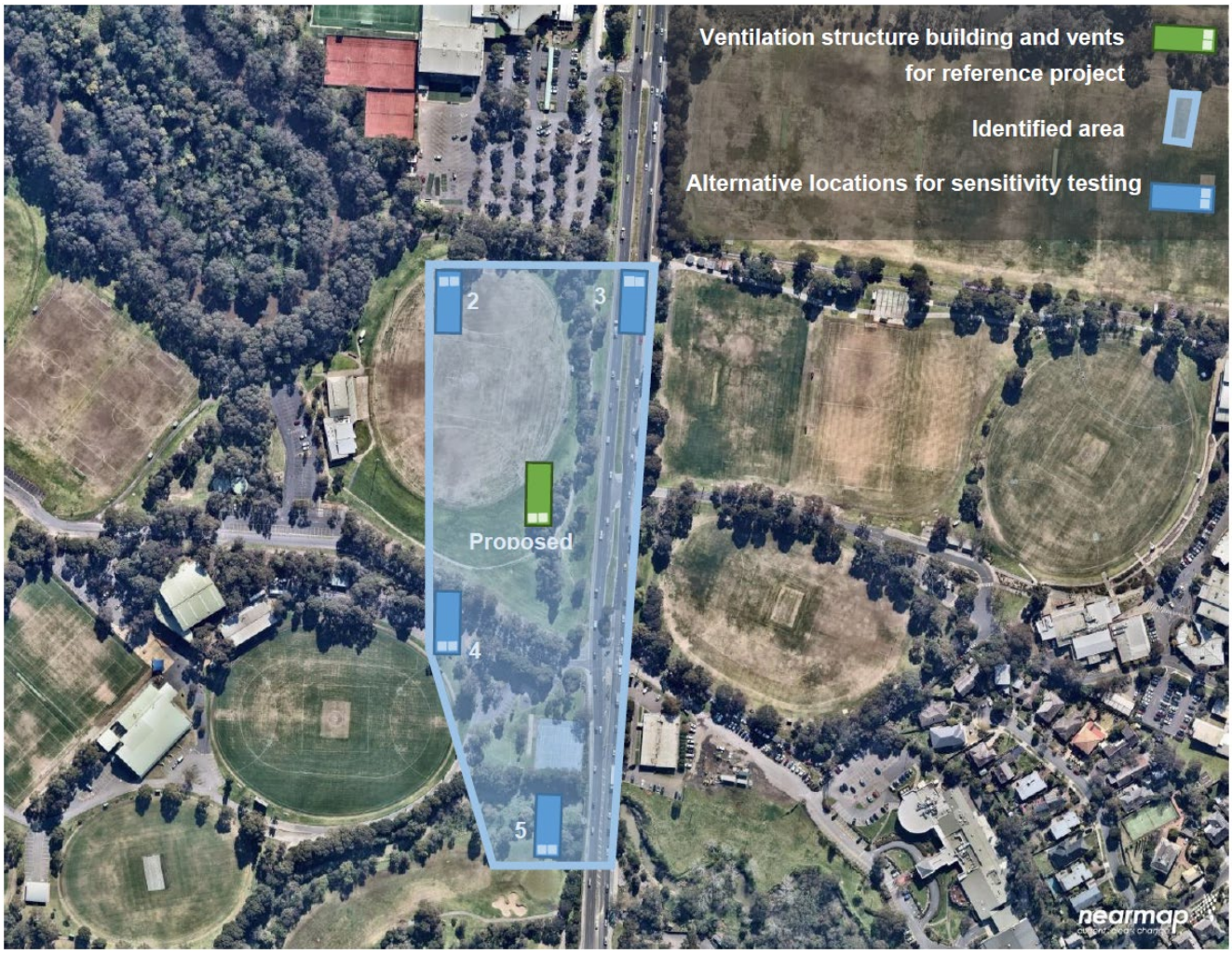


Figure 13 Sensitivity of location for the ventilation structure at the southern portal

8 Conclusion

This assessment assessed the combined noise from the ventilation system and associated surface substation buildings to the surrounding community. It is predicted that the noise emissions (with the proposed silencers and other forms of noise mitigation) is expected to readily comply with the requirements of SEPP N-1, when the plant is operational.

The reference design includes a number of potential uncertainties associated with the assessment. The modelling contains some conservatism. Having considered the balance of uncertainties and the conservatism within the modelling, and the degree to which the predictions are below the criteria; it is considered that the conservatism within the model is sufficient to offset the possible uncertainty.

The assessment will need to be reviewed during the detailed design to ensure the assessment locations selected remain representative, the assessment reflects the plant (and mitigation) finally selected for installation, and consideration is given to the layout of the structure (including the noise path between the fan and the point of discharge). Revisions to the prevailing background noise levels and consequently reconfirmation of the noise targets, may be warranted.

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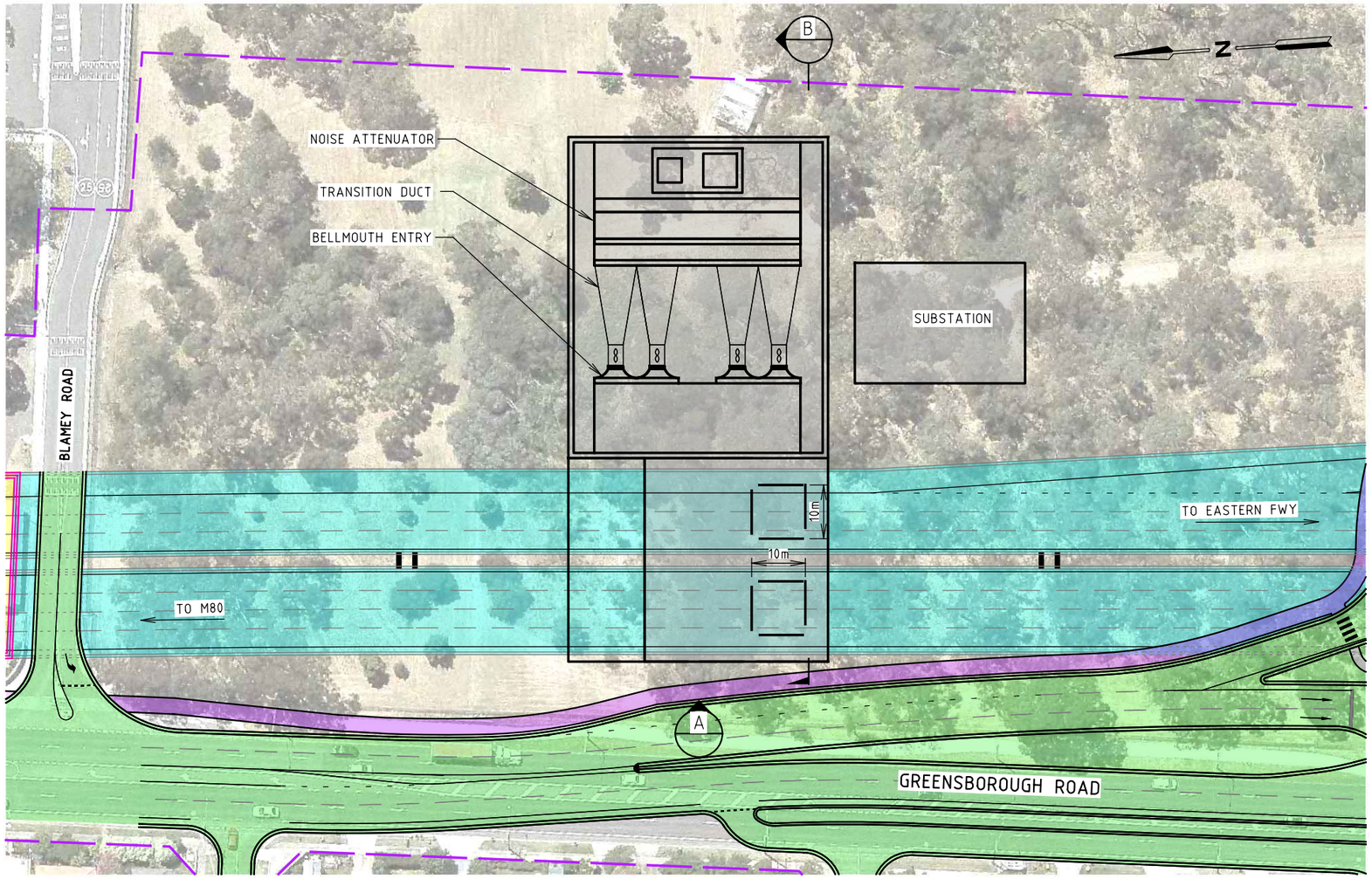
TOWNSVILLE
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NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695

Appendix D Design drawings and site layout plans



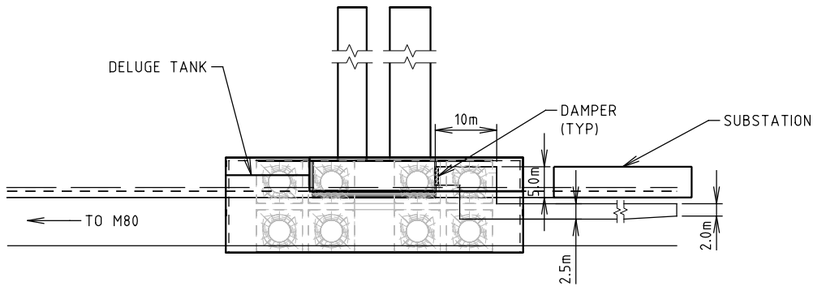
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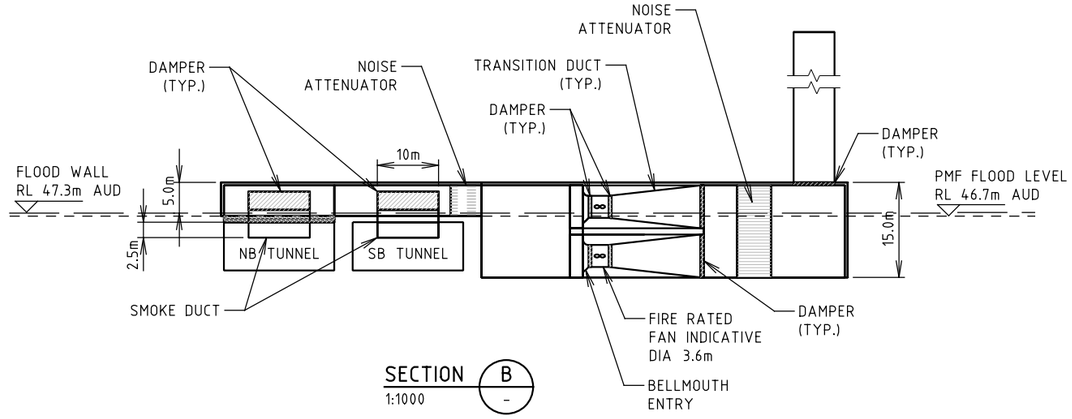
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- CUT AND COVER
- NEW SURFACE (SHARED USE PATH)

NOTES:

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2. ADDITIONAL FAN SPACE PROVISIONING FOR UNDER ROAD DECK VENTILATION TBD.
3. DESIGN BASED ON ASSUMPTION THAT SEPARATE SMOKE SYSTEM FANS ARE NOT REQUIRED.



FRONT VIEW A
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SECTION B
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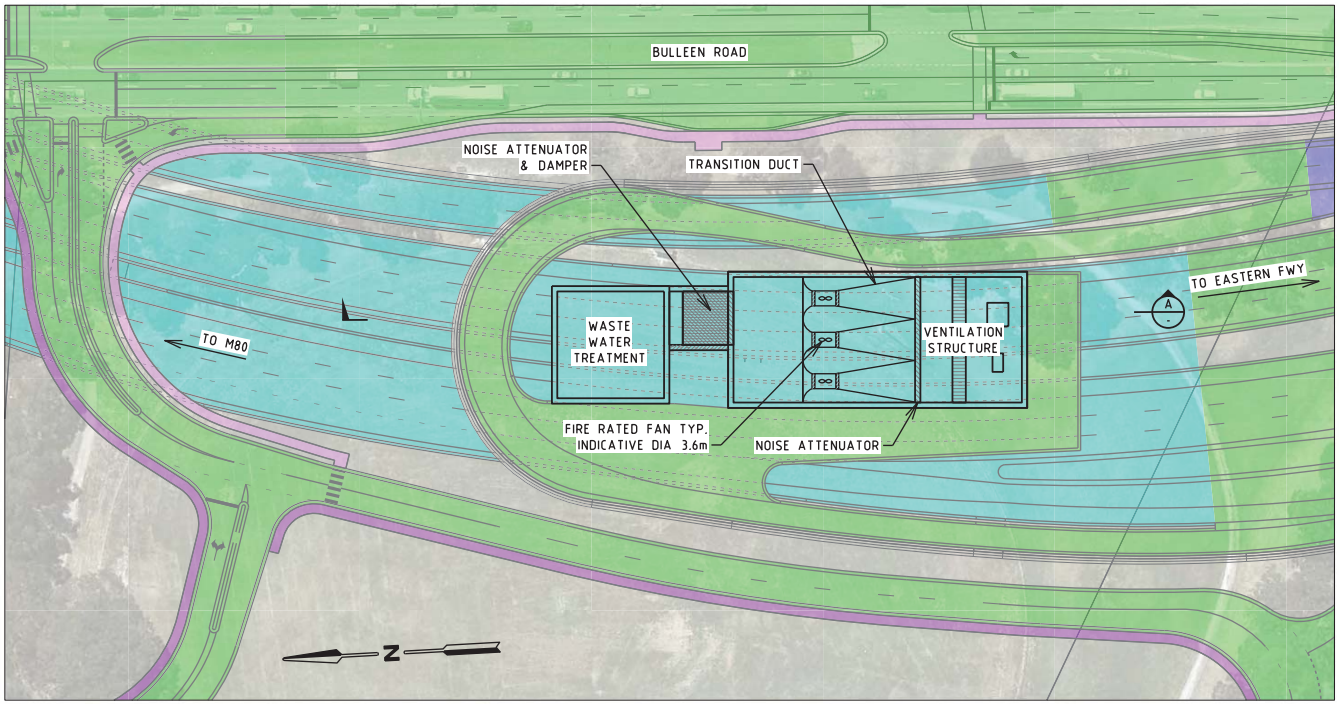
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Drawn	Designer
Drafting Check	Design Check
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Client NORTH EAST LINK PROJECT
Project NORTH EAST LINK
Title VENTILATION, FLS AND M&E
NORTHERN PORTAL - GENERAL ARRANGEMENT

Drg No: 3135006-RD-SKT-W00-01-TU-11001 Rev: 0

Plot Date: 6/03/2019 Cad File No: 3135006-RD-SKT-W00-01-TU-11001



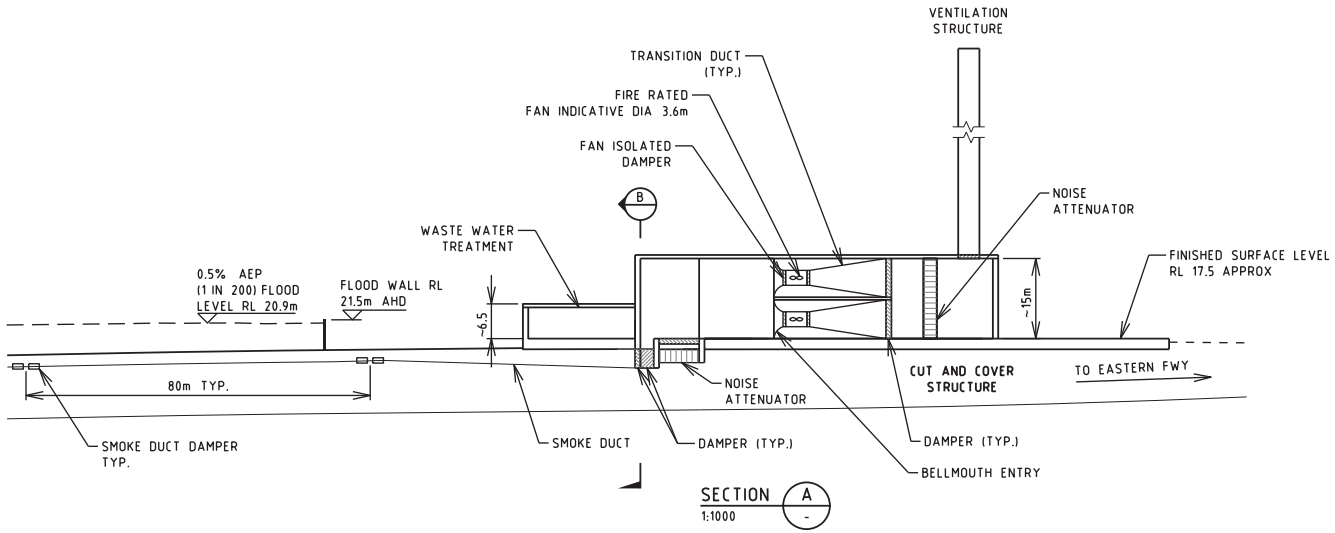
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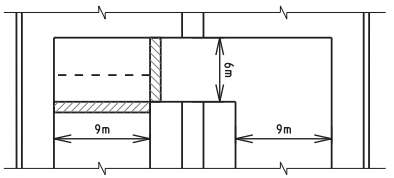
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- SURFACE
- CUT AND COVER
- REINSTATED SURFACE (SHARED USE PATH)
- NEW SURFACE (SHARED USE PATH)

NOTES:

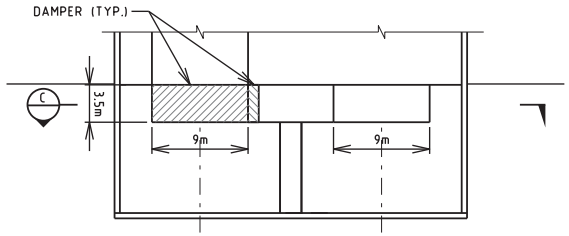
1. WASTEWATER TREATMENT PLANT SHALL NOMINALLY BE MODULAR AND CONSIST OF:
   a. INLET BUFFER TANK TO LIMIT THE IMPACT OF PEAK FLOWS RESULTING FROM FIRE SUPPRESSION SYSTEM TESTING (OR EMERGENCY INCIDENTS).
   b. OIL-WATER SEPARATOR TO REMOVE FREE FLOATING HYDROCARBONS AND HEAVIER SUSPENDED SOLIDS.
   c. CHEMICAL DOSING, FLOCCULATION AND DISSOLVED AIR FLOTATION FOR THE REMOVAL OF SOLIDS AND IRON.
   d. SAND FILTRATION FOR FINAL POLISHING AS WELL AS PROVIDING AN ADDITIONAL BARRIER FOR REMOVAL OF CONTAMINANTS.
   e. PH CORRECTION TO LIMIT THE TREATED WATER PH TO WITHIN THE RANGE OF 7-8.5.
   f. SLUDGE HANDLING AND DEWATERING.
2. WASTEWATER TREATMENT PLANT SHALL BE SIZED TO TREAT 900m3 OF WASTE WATER IN 48 HRS.
3. WASTEWATER TREATMENT PLANT SHALL DISCHARGE TO SEWER UNDER A TRADE WASTE AGREEMENT IN ACCORDANCE WITH EPA VICTORIA REQUIREMENTS.
4. ADDITIONAL FAN SPACE PROVISIONING FOR UNDER ROAD DECK VENTILATION TBD.



SECTION A
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SECTION C
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SECTION B
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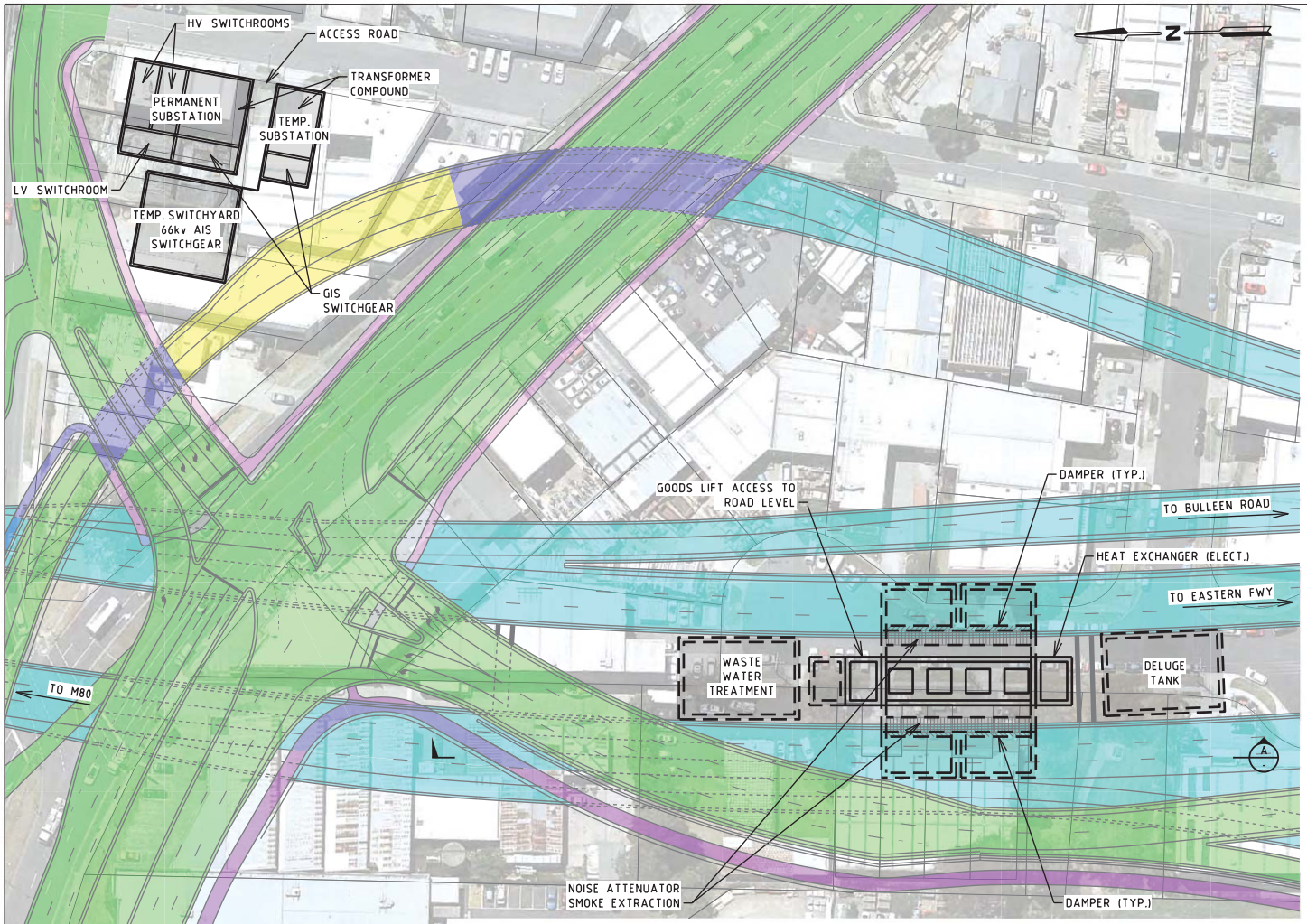
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SOUTHERN PORTAL - GENERAL ARRANGEMENT

Drg No:
Rev: 0

Plot Date: 19/10/2018
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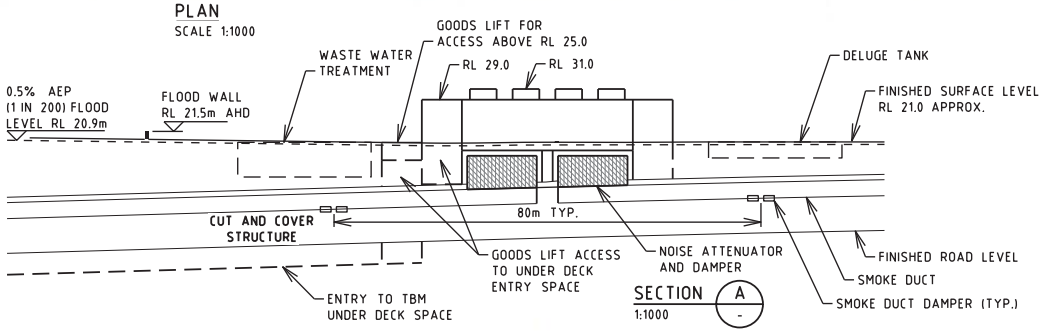
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- SURFACE
- OPEN CUT
- CUT AND COVER
- REINSTATED SURFACE (SHARED USE PATH)
- NEW SURFACE (SHARED USE PATH)

NOTES:

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5. ADDITIONAL FAN SPACE PROVISIONING FOR UNDER ROAD DECK VENTILATION TBD.

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SECTION A
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Project: NORTH EAST LINK
Title: VENTILATION, FLS AND M&E
MANNINGHAM INTERCHANGE - GENERAL ARRANGEMENT

Drg No:
Rev: 0

Plot Date: 18/10/2018 Cad File No:

Appendix E Title plans

Northern ventilation structure

Address	Title details	
	Vol	Fol
2 Yallambie Rd, Yallambie 3085	6700	806
	4451	O66



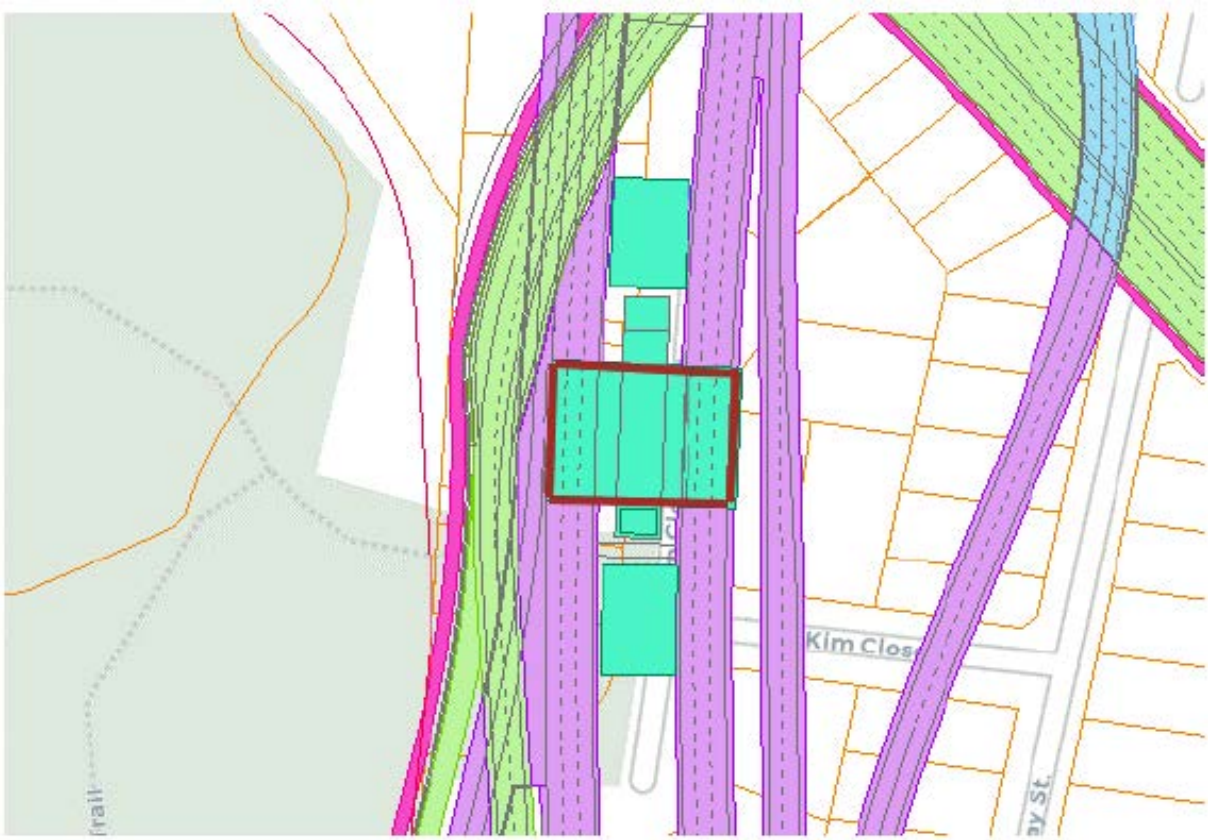
Southern ventilation structure

Address	Title details	
	Vol	Fol
175-189 Bulleen Rd Bulleen 3105	8808	757
175-189 Bulleen Rd Bulleen 3106	9176	498
169-173 Bulleen Rd Bulleen 3106	8873	904
167 Bulleen Rd, Bulleen 3106	8873	903
1 Musca St, Balwyn North 3104	11526	551



Emergency smoke discharge structure

Address	Title details	
	Vol	Fol
16 Kim Close Bulleen 3105	9147	719
15 Kim Close Bulleen 3105	9147	718
7a Kim Close Bulleen 3105	9335	297
1/8 Kim Close Bulleen 3105	9920	907
2/8 Kim Close Bulleen 3105	9920	908
3/8 Kim Close Bulleen 3105	9920	909
8 Kim Close Bulleen 3105	CM/SP33677	



Appendix F Climate change predictions

Greater Melbourne Climate Change Projections

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Viewbank[6] Latitude:37.74 Degrees South Longitude:145.10 Degrees East Elevation: 66 m			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Mean maximum daily temperature (°C) [1]	20.9	Absolute change	+0.8 (+0.6 to +1.2)	Very high model agreement on substantial increase	+1.6 (+1.1 to +2.1)	Very high model agreement on substantial increase	+3.5 (+2.5 to +4.3)	Very high model agreement on substantial increase
Mean minimum daily temperature (°C) [1]	9.9	Absolute change	+0.8 (+0.5 to +1.1)	Very high model agreement on substantial increase	+1.4 (+1 to +1.8)	Very high model agreement on substantial increase	+2.9 (+2.4 to +3.8)	Very high model agreement on substantial increase
Mean number Days above 35 °C (Melbourne)[2]	14.2	Absolute change	13 (12 to 15) (RCP 4.5)	n/a	+16 (+15 to +20)	Very high confidence that projected warming will result in more frequent, and hotter, hot days	+24 (+19 to +32)	Very high confidence that projected warming will result in more frequent, and hotter, hot days

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Viewbank[6] Latitude:37.74 Degrees South Longitude:145.10 Degrees East Elevation: 66 m			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Highest recorded temperature (°C) [3]	46.7 (7th of Feb 2009)	N/A	Very high confidence in a substantial increase in the temperature reach on the hottest days, the frequency of hot days and the duration of warm spells					
Severe fire danger days per year (FFDI > 50) (Melbourne)[4]	1.0 (1995 baseline)	Absolute change	1.2	There is high confidence that climate change will result in harsher fire weather in the future. Low confidence in the magnitude of the change to fire weather	1.4	There is high confidence that climate change will result in harsher fire weather in the future. Low confidence in the magnitude of the change to fire weather	2.1	There is high confidence that climate change will result in harsher fire weather in the future. Low confidence in the magnitude of the change to fire weather
Average number of frost risk days per year [2]	0.9 (1981-2010)	Absolute change	+0.6 (+0.8 to +0.4) (RCP 4.5)	High confidence in a decrease in the frequency of frost risk days	+0.2 (+0.3 to +0.1)	High confidence in a decrease in the frequency of frost risk days	0.0 (0.0 to 0.0)	High confidence in a decrease in the frequency of frost risk days
Rainfall (mm) [1]	656.3	Percentage change	-1 (-7 to +2)	High model agreement on little change	-3 (-10 to +3)	Low model agreement on the direction of change	-5 (-19 to +5)	Medium model agreement on decrease
Rainfall intensity [5]	N/A	N/A	High confidence that the intensity of heavy rainfall events will increase in the cluster, but magnitude of change, and the time when any change may be evident against natural fluctuations, cannot be reliably projected					

Variable	Annual historic trend	Climate change projections	RCP 8.5 2030 scenario		RCP 4.5 2090 Scenario		RCP 8.5 2090 scenario	
Weather station: Viewbank[6] Latitude:37.74 Degrees South Longitude:145.10 Degrees East Elevation: 66 m			Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence	Most likely – 50th percentile (10th- 90th percentile)	Degree of confidence
Evapotranspiration (%) [1]	N/A	Percentage change	+4.3 (+2.2 to +6.1)	Very high model agreement on substantial increase	+6.9 (+4.3 to +10.1)	Very high model agreement on substantial increase	+14.4 (+9.5 to +22.2)	Very high model agreement on substantial increase
Mean 9 am relative humidity (%) [1]	75	Percentage change	-0.5 (-1.1 to 0)	High model agreement on decrease	-0.9 (-1.7 to -0.1)	Medium model agreement on substantial decrease	-1.3 (-2.9 to +0.8)	High model agreement on substantial decrease
Mean 3 pm relative humidity (%) [1]	53	Percentage change						
Mean 9 am wind speed (km/h) [1]	11.3	Percentage change	+0.4 (-2.1 to +2.4)	Medium model agreement on little change	-0.6 (-2.1 to +1.5)	Medium model agreement on little change	+0.3 (-2.5 to +2.9)	Medium model agreement on little change
Mean 3 pm wind speed (km/h) [1]	17.2	Percentage change						
Solar radiation (%) [1]	N/A	Percentage change	+1.3 (+0.1 to +2.4	Medium model agreement on substantial increase	+1.9 (+0.1 to +3.5)	High model agreement on substantial increase	+3.1 (+0.3 to +6.8)	High model agreement on substantial increase
Soil moisture (%) [1]	N/A	Percentage change	-2.9 (-4.9 to -0.5)	High model agreement on substantial decrease	-3.6 (-5.9 to -0.7)	High model agreement on substantial decrease	-6.8 (-13.7 to -3.4)	High model agreement on substantial decrease

[1] Projection data obtained from Climate Change in Southern Slopes, CSIRO & BOM 2015. Figures obtained from Appendix, Table 1

[2] Projection data obtained from Climate Change in Australia Southern Slopes (projection for Melbourne), CSIRO & BOM 2015. Figures obtained from Box 4.3. Confidence statement sourced from pg. 4.

[3.] Qualitative projection analysis obtained from Climate Change in Australia Southern Slopes, CSIRO & BOM 2015 Introduction Hotter and more frequent hot days. Page 4

[4] Baseline and projection data obtained from Climate Change in Australia Southern Slopes Cluster Report, CSIRO & BOM 2015. Figures obtained from Table 4.10.1. Fire weather is estimated using the McArthur Forest Fire Danger Index (FFDI); where FFDI exceeds 50, fire weather is deemed 'severe'. Confidence statement sourced from p 6.

[5] Qualitative projection analysis obtained from Climate Change in Australia Southern Slopes, CSIRO & BOM 2015 sourced from p 4.

[6] Annual historic trend data obtained from Viewbank Weather Station (Site number 086068). Data available at: http://www.bom.gov.au/climate/averages/tables/cw_086068.shtml Last accessed April 23 2018

Appendix G Community facilities identified in EES Social Impact Assessment

Facility name	Address
Greensborough bypass path	Adjacent to Greensborough bypass
Plenty River Linear Reserve and Plenty River Trail	Plenty River Drive
Greensborough Collendina Reserve	Cnr Collendina Crescent and Eastgate Drive, Greensborough
Metropolitan Ring Road Linear Reserve and Metropolitan Ring Road Path	Follows the Metropolitan Ring Road
Unnamed reserve	Off Callan Walk, Greensborough
Hughes Circuit Reserve	Hughes Circuit, Bundoora
Maroondah Aqueduct	Chappell Drive, Bundoora
Garvey Oval	Ambrose Treacy Drive
Gillingham Reserve	Gillingham Street, Watsonia North
Trist Street Reserve	24 Trist St, Watsonia North
Watsonia North Primary School	16 Sharpes Rd, Watsonia North
Greensborough Preschool	17-19 Ester Street, Greensborough
Abacus Child Care Centre	3 William Street, Greensborough
Kalparrin Early Intervention Centre child care	1 Kalparrin Avenue, Greensborough
Greensborough Road Surgery	520 Greensborough Rd, Greensborough
Diaverum Diamond Valley Dialysis Clinic	15 Grimshaw Street, Greensborough
Greensborough Maternal and Child Health	17 Ester St, Greensborough
St Mary's Church	204 Grimshaw Street, Greensborough
St Mary's School	210 Grimshaw Street, Greensborough
Greensborough College	Nell Street, Greensborough
Greensborough Primary School	130 Grimshaw Street, Greensborough
Kalparrin Gardens	Yando Street, Greensborough
Poulter Avenue Reserve	Poulter Avenue, Greensborough
Whatmough Park	Kalparrin Avenue, Greensborough

Facility name	Address
Fell Reserve	Access via Grimshaw Street and Lorimer Street, Greensborough
Plenty River Drive Reserve	73 Plenty River Drive, Greensborough
St Mary's Reserve	Cnr Greensborough Rd and Grimshaw Street, Greensborough
Banfield Terrace Reserve	2 Sophie Place, Greensborough
Greensborough Police Station	167-169 Grimshaw Street, Greensborough
Greensborough MFB Fire Station	141 Grimshaw Street, Greensborough
Watsonia Occasional Child Care Centre	58 Gabonia Ave, Watsonia
MS Society Retirement Village	303-311 Greensborough Rd, Greensborough
Watsonia Scout Hall	Grimshaw Street, Watsonia
Watsonia RSL	6 Morwell Avenue, Watsonia
North East Citizen Advocacy (NECA)	56 Gabonia Avenue, Watsonia
Watsonia Library	4 Ibbottson Street, Watsonia
Holy Spirit Anglican Church	Corner of Watsonia Road and Ibbottson Street, Watsonia
Grace Baptist Church	240 Nell Street West, Watsonia
Watsonia Uniting Church	71 Devonshire Road, Watsonia
Concord School	16 Meagher Street, Watsonia
Watsonia Primary School	240 Nell Street, Watsonia
AK Lines Reserve	Grimshaw Street, Watsonia
Elder Street Reserve	Elder Street, Watsonia
West Mayling Reserve	Mayling Court, Watsonia
Gabonia Avenue Reserve & Frensham Sec Reserve	56 Gabonia Avenue, Watsonia
Watsonia Station Carpark Reserve	Greensborough Road, Watsonia
Watsonia Road Reserve	Watsonia Road, Watsonia
Greensborough Road Early Learning and Kinder	51-53 Greensborough Road, Macleod
Macleod Recreation and Fitness Centre Child Care Centre	2 Somers Avenue, Macleod
Macleod Preschool	Birdwood Avenue, Macleod
Baptcare Strathalan Macleod	50 Braidhill Road, Macleod
Regis Macleod	118 Somers Avenue, Macleod
Macleod Maternal and Child Health	5 Birdwood Avenue, Macleod

Facility name	Address
IDV (Disability Service Provider)	88 McNamara Street, Macleod
Macleod YMCA Recreation and Fitness Centre (includes children's centre)	157 Wungun Street, Macleod
Nets Stadium Banyule	2 Somers Avenue, Macleod
Macleod Organic Community Garden	Somers Avenue, Macleod
Winsor Reserve	Somers Avenue, Macleod
Macleod College Oval	Adjoins Melrose Avenue and Somers Avenue
Harry Pottage Reserve	Glenmore Street, Macleod
Macleod Park	Aberdeen Road, Macleod
Macleod Tennis Club	Aberdeen Road, Macleod
Macleod Junior Football Club and Macleod Cricket Club	60-80 Chapman St, Macleod
Simpson Barracks	Steele Road
Coleen Street Reserve	Fahey Crescent
Borlase Reserve	Borlase Street
Melbourne Water easement	North of Lower Plenty Road and east of Greensborough Road
Goodstart Early Learning	93-97 Banyule Rd, Rosanna
Assisi Centre Aged Care	230 Rosanna Road, Rosanna
Japara Rosanna Views Nursing Home	269-271 Lower Plenty Road, Rosanna
St Martin of Tours Catholic Church	2 Silk Street, Rosanna
St Martin of Tours Catholic Primary School	2-12 Silk Street, Rosanna
Banyule Primary School	50 Banyule Road, Rosanna
Maleela Reserve	Maleela Grove, Rosanna
Mercedes Court Reserve	McCrae Road, Rosanna
River Gum Walk (Rosanna)	South of Banyule Road and parallel to Beverly Road
Creekbend Reserve	Running from Lower Plenty Road to Banyule Road
Rosanna Golf Links Primary School	Interlaken Parade, Rosanna
Viewbank College	1 Warren Road, Viewbank
Viewbank Family Medical Group	15-17 Martins Lane, Viewbank
Viewbank Podiatry	15 Martins Lane, Viewbank
Simla Close Reserve	Simla Close, Viewbank
Banyule Flats	Banyule Road, Viewbank

Facility name	Address
River Gum Walk (Heidelberg)	Candlebark Crescent, Heidelberg
Warringal Parklands	Beverley Road, Heidelberg
Banyule Tennis Club	Plymouth Court, Heidelberg
Heidelberg Park and Heidelberg cricket ground	Beverley Road, Heidelberg
Banyule Theatre Complex	10 Buckingham Drive, Heidelberg
Heidelberg Police Station	7 Jika St, Heidelberg
Austin Hospital Precinct	145 Studley Road, Heidelberg
Heidelberg Primary School	120 Cape Street, Heidelberg
Yarra Flats Park	Access via The Boulevard, East Ivanhoe
Creative Play Early Learning Centre	1 Templestowe Road, Bulleen
Kalker Montessori Centre	1-3 Estelle Street, Bulleen
Veneto Club	191 Bulleen Road, Bulleen
Heide Museum of Modern Art	7 Templestowe Road, Bulleen
Bulleen Art and Garden	6 Manningham Road West, Bulleen
Marcellin College	160 Bulleen Road, Bulleen
Trinity Grammar School Sporting Complex	Bulleen Road, Bulleen
Bolin Bolin Billabong	191 Bulleen Road, Bulleen
Carey Grammar Sports Complex	169 Bulleen Road, Bulleen
Yarra Valley Parklands – Banksia Park	Templestowe Road, Bulleen
Yarra Valley Parklands – Yarra Flats	
Sandra Street Reserve	Sandra Street, Bulleen
Bulleen Park	Bulleen Road, Bulleen
Koonung Reserve (also known as Koonung Park)	Corner Furneaux Grove and Balwyn Road, Bulleen
Koonung Creek Reserve (Bulleen)	Follows Koonung Creek and Eastern Freeway
Willow Bend Reserve	Willow Bend, Bulleen
Pipe Line Reserve	Estelle Street Bulleen
Yarra Valley Country Club	9 Templestowe Road, Bulleen
Bulleen Golf Driving Range	37 Templestowe Road, Bulleen
Wonderland Childcare and Kinder	6 High Street Doncaster
Applewood Residence	5 Grand Blvd, Doncaster
Tende Beck Scout Hall	5 High St, Doncaster

Facility name	Address
North Eastern Jewish Centre (Yeshurun Congregation)	6 High St, Doncaster
Birralee Primary School	8-26 Heyington Ave, Doncaster
Wilsons Road Reserve	107 Wilsons Rd, Doncaster
Katrina Street Reserve	Katrina Street
Davis Street Reserve	Davis Street Doncaster
Tram Road Reserve	Tram Rd and Whittens Lane
Koonung Creek Linear Park (Doncaster)	Windella Quadrant, Doncaster
Stanton Street Reserve	33 Stanton Street, Doncaster
Doncaster Park and Ride	412 Doncaster Road
Tino Ceberano Martial Arts Academy	Cnr Doncaster Rd and High St, Doncaster
Greythorn Bowling Club	7 Gregory Ct, Doncaster
Manningham Park Reserve (also known as Park Avenue Reserve)	40 Park Avenue
Koonung Creek Reserve (Doncaster East)	Cnr Eastern Freeway and Wetherby Rd, Doncaster East
Boronia Grove Reserve	Leeds Street, Doncaster East
Beverley Hills Primary School	2 Cassowary St, Doncaster East
Japara Sydney Williams Apartments	31 Blackburn Road, Doncaster East
Heatherwood School	370 Springvale Road, Donvale
State Vision Resource Centre	370 Springvale Road, Donvale
Koonung Creek Linear Park (Donvale)	Follows the Eastern Freeway. Accessible via Tunstall Rd
Donvale Primary School	Elata St, Donvale
Aranga Reserve	45 Aranga Crescent, Donvale (also accessible by Eastway Avenue)
Oxford Street Reserve	Oxford Street, Nunawading
Belle Vue Primary School	20 Highview Rd, Balwyn North
Boroondara Tennis Centre	150 Bulleen Rd, Balwyn North
Musca Street Reserve	31 Orion St, Balwyn North
Columba Street Reserve	47 Columba St, Balwyn North
Leonis Avenue Reserve	167 Bulleen Rd, Balwyn North
Koonung Creek Reserve (Balwyn North)	17 Carron St, Balwyn North
Winfield Road Reserve	120 Winfield Rd, Balwyn North

Facility name	Address
Yarra Flats Reserve	1244 Burke Rd, Balwyn North
Freeway Public Golf Course	47-49 Columba St, Balwyn North
Boroondara Park Primary School	40 Almond St, Balwyn North
Kew Golf Club	120 Belford Rd, East Kew
Hays Paddock/Reserve	Leason St, Kew East
Hyde Park	2 Kilby Rd, Kew East
Burke Rd Billabong Reserve	1585 Burke Rd, Kew East
Green Acres Golf Club	51 Elm Grove, Kew East
Willsmere-Chandler Park	Willow Grove, Kew East
Guide Dogs Victoria (National guide dog and mobility Centre)	2 Chandler Hwy, Kew
Royal Talbot Rehabilitation Centre	1 Yarra Blvd, Kew
Yarra Bend Park (Kew)	Follows Yarra River
Kate Campbell Reserve	Kellett Grove, Kew
Jack O'Toole Reserve	2-4 Kilby Rd, Kew
North Kew Tennis Club	177 Willsmere Rd, Kew
1st Kew Scout Group	177 Willsmere Rd, Kew
Elgar Park	653-661 Elgar Rd, Mont Albert North
Koonung Creek Wetlands	Follows Eastern Freeway
Koonung Creek Linear Park (Box Hill North)	Follows Eastern Freeway
Presbyterian Theological College	684 Elgar Rd, Box Hill North
Frank Sedgmen Reserve	Box Hill North
Bounce Inc.	22 Joseph St, Blackburn North
Melbourne Badminton Centre	6-16 Joseph St, Blackburn North
Eastern Freeway Linear Park (Blackburn North)	Follows Eastern Freeway
Koonung Creek Linear Park (Blackburn North)	Follows Eastern Freeway
Slater Reserve	11 Grosvenor St, Blackburn North
Warekila Preschool	Kett St, Nunawading
Eastern Freeway Linear Reserve (Nunawading)	Follows Eastern Freeway
Ronald E Gray Reserve	30 Outlook Drive, Nunawading
Koonung Creek Linear Park (Nunawading)	Follows Eastern Freeway
Alphington Park	View St, Alphington

Facility name	Address
Latrobe Golf Club	Farm Rd, Alphington
Thomas Embling Hospital	101 Yarra Bend Rd, Fairfield
Melbourne Polytechnic	Yarra Bend Rd, Fairfield
RMIT Surveying Field Station	201 Yarra Bend Rd, Fairfield
Victorian Indigenous Nurseries Co-Operative	Yarra Bend Road, Fairfield VIC 3078
Yarra Bend Park (Fairfield)	Yarra Bend Rd, Fairfield
Fairlea Reserve	Within Yarra Bend Park
Yarra Bend Public Golf Course	Yarra Bend Rd, Fairfield
Petit Early Learning Journey	372 Hoddle St, Clifton Hill
Gray Street Reserve	Cnr Gray St and Trenery Crescent
Ramsden Street Reserve	Cnr Ramsden St and Field St
Dights Falls Reserve	Trenerry Crescent, Abbotsford
Victoria Park	Abbot Street and Lulie Street, Abbotsford
Maugie Street Reserve	Maugie Street
Plenty Road Path	Bundoora
Unnamed open space area	22 Enterprise Drive, Bundoora
Unnamed reserve	40 Worcester Crescent, Bundoora
Apostolic Church	28/20 Enterprise Drive, Bundoora
Northpark Private Hospital	Greenhills Road, Bundoora