Great Western Highway
Blackheath to Little Hartley

Chapter 9
Air quality

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9 Air quality

This chapter summarises the air quality assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full air quality assessment is provided in Appendix E (Technical report – Air quality).

9.1 Key air quality issues for the project

Pollutants of interest from the project include those generated from both the combustion of fossil fuels and from non-combustion sources such as the generation of dust from the disturbance of soil during construction. The effect of these pollutants on human health and the environment is discussed in Chapter 10 (Human health) and Appendix E (Technical report – Air quality). The pollutants of interest assessed are:

- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- particulate matter less than 10 microns in diameter (PM_{10})
- particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)
- volatile organic compounds (VOCs) including:
    - benzene
    - formaldehyde
    - toluene
    - acetaldehyde
    - ethylbenzene
    - xylene
    - 1,3 butadiene
- polycyclic aromatic hydrocarbons (PAHs).

The potential main sources of air emissions from the project addressed in this report are as follows:

- construction dust from demolition, earthworks, the concrete batching plant, the movement of vehicles on the construction site and spoil handling
- construction plant engine exhaust emissions
- odour emissions from earthworks during construction
- vehicle emissions from the operation of the project in relation to:
    - surface road emissions
    - in-tunnel emissions
    - the preferred tunnel ventilation design (ventilation outlet emissions or portal emissions) as discussed in Section 4.5 of Chapter 4 (Project description).

9.2 Air quality legislation, guidance and assessment criteria

9.2.1 Air quality legislation and guidelines

The relevant legislation and guidance documents for the regulation and assessment of air quality in NSW are:

- *National Environment Protection Council Act 1994* (Cth) which provides the relevant National Environment Protection Measures (NEPMs) relevant to air quality:
  - National Environment Protection (Ambient Air Quality) Measure (National Environmental Protection Council, 2021)
  - National Environment Protection (Air Toxics) Measure (National Environmental Protection Council, 2004)
- *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) supported by the following regulations and guidance documents:
  - Protection of the Environment Operations (Clean Air) Regulation 2021
  - Approved Methods for the Modelling and Assessment of Air pollutants in NSW (Approved Methods) (NSW Environment Protection Authority (EPA), 2022a)
  - Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (NSW EPA, 2022b).

Further detail of these documents is provided in Section 3 of Appendix E (Technical report – Air quality).

Ventilation outlets are regulated by the EPA as a scheduled activity under the POEO Act. The project is not currently a listed road tunnel, but it is anticipated that the EPA would consider listing the project if it is approved and if the ventilation outlet option is pursued as the preferred ventilation option.

9.2.2 Air quality criteria and standards

An evaluation approach using multiple sets of assessment criteria has been used to assess the air quality impacts of the project. Since the project passes through areas with high ecological values, environmental impact criteria have been included in the assessment criteria. Neither the Approved Methods nor the NEPMs include environmental criteria for the assessment of impacts on ecological receptors, except for hydrogen fluoride. However, the EPA Victoria Guideline (EPA VIC, 2022) sets environmental criteria based on World Health Organisation standards and these have been adopted for the project.

Two ventilation options, emissions via ventilation outlets or portals (Chapter 4 (Project description)) have been assessed. Project impact descriptors for the assessment of portal emissions were developed and endorsed by Advisory Committee on Tunnel Air Quality (ACTAQ) (EMM Consulting, 2022). The methodology for the application of these descriptors is described in Section 3 of Appendix E (Technical report – Air quality).

In summary, four sets of assessment criteria were used for the assessment of air quality impacts from the project:

- air quality criteria prescribed in the Approved Methods, used to assess ground level concentrations (Table 9-1)
- project impact assessment descriptors endorsed by the ACTAQ (EMM Consulting, 2022) used to assess annual average NO_2 and $PM_{2.5}$ emissions from both portals and ventilation outlets (Table 9-2 and Table 9-3)
- environmental assessment markers used to assess potential air quality impacts on ecological receptors for NO_2, toluene and $PM_{2.5}$ (Table 9-4)

- assessment of in-tunnel air quality based on in-tunnel air quality criteria for NO_2 and visibility as detailed in the ventilation analysis (Section 8.4 of Appendix E (Technical report – Air quality)) (Table 9-6).

Air quality standards are typically a concentration limit for a given averaging period to address long-term, e.g. annual average, or short-term exposure, e.g. 24 hour or one hour average (see Section 3.4 of Appendix E (Technical report – Air quality)). These criteria are among the most stringent worldwide (see Annexure B of Appendix E (Technical Report – Air quality). In meeting these in-tunnel and ambient air quality criteria, the comparison with national and international air quality standards show that this tunnel is designed and would be operated consistent with international best practice.

Ambient air quality criteria

The ambient air quality criteria prescribed in the Approved Methods, (NSW EPA, 2022a; NSW EPA 2022b) were applied as shown in Table 9-1. A comparison of international ambient air quality criteria is shown in Section 1.3 (Table B-1) of Annexure B of Appendix E (Technical report – Air quality). An ambient air quality criterion relates to the background concentration of an air pollutant in the outdoor air.

Table 9-1 Ambient air quality criteria applied to the project

Pollutant	Averaging period	Criteria ($\mu g/m^3$)
Particulate matter (PM_{10})	24 hour maximum	25
	Annual average	8
Particulate matter ($PM_{2.5}$)	24 hour maximum	25
	Annual average	8
Nitrogen dioxide	1 hour maximum	164
	Annual average	31
Carbon monoxide	1 hour maximum	30,000
	8 hour maximum	10,000
Benzene (C_6H_6)	99.9th percentile 1-hour average	29
Formaldehyde	99.9th percentile 1-hour average	20
1,3-butadiene	99.9th percentile 1-hour average	40
Toluene (C_7H_8)	99.9th percentile 1-hour average	360
Ethylbenzene (C_8H_{10})	99.9th percentile 1-hour average	8,000
Xylene (C_8H_{10})	99.9th percentile 1-hour average	190
PAHs (as Benzo(a)pyrene)	99th percentile 1 hour	0.04

Project impact assessment descriptors

These descriptors have been applied to the assessment of emissions for both ventilation outlets and portal emission options to enable a comparison of both options. The pollutant concentration range and overall impact level are shown in Table 9-2 and Table 9-3.

Table 9-2 Project impact descriptors for annual average NO_2 at individual receptors

Total concentration at receptor for a given averaging period	Absolute change in concentration relative to air quality criterion				
	<0.5% (<0.16 µg/m^3)	≥0.5% to <1.5% (≥0.16 to <0.47 µg/m^3)	≥1.5% to <5.5% (≥0.47 to <1.71 µg/m^3)	≥5.5% to <10.5% (≥1.71 to <3.26 µg/m^3)	≥10.5% (≥3.26 µg/m^3)
≤75% of Air Quality Criteria (AQC) (≤23.3 µg/m^3)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>23.3 to ≤29.5 µg/m^3)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<29.5 to ≤31.9 µg/m^3)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>31.9 to ≤34.1 µg/m^3)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥34.1 µg/m^3)	Negligible	Moderate	Substantial	Substantial	Substantial

Table 9-3 Project impact descriptors for annual average $PM_{2.5}$ at individual receptors

Total annual average concentration at receptor	Absolute change in concentration relative to air quality criterion				
	<0.5% (<0.04 µg/m^3)	≥0.5% to <1.5% (≥0.04 to <0.12 µg/m^3)	≥1.5% to <5.5% (≥0.12 to <0.44 µg/m^3)	≥5.5% to <10.5% (≥0.44 to <0.84 µg/m^3)	≥10.5% (≥0.84 µg/m^3)
≤75% of AQC (≤6.0 µg/m^3)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>6 to ≤7.6 µg/m^3)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<7.6 to ≤8.2 µg/m^3)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>8.2 to ≤8.8 µg/m^3)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥8.8 µg/m^3)	Negligible	Moderate	Substantial	Substantial	Substantial

Ecological impact assessment criteria

Ecological receptors for the project have been assessed against the NO_2 annual average in the Victoria EPA Guideline (EPA VIC, 2022) for terrestrial vegetation as shown in Table 9-4. The endpoint represents the receptor or issue that the environmental air quality impact assessment criteria is protective of, if the endpoint is not relevant to a site, then the criteria does not apply.

Table 9-4 Victoria EPA environmental air quality impact criteria

Pollutant	Averaging period	Ecological endpoint	Environmental criteria ($\mu g/m^3$)
NO_2	Annual	Terrestrial vegetation	30
Toluene	Maximum 30 min	Environmental aesthetics	1,100
$PM_{2.5}$	10 hour	Terrestrial vegetation	50

Particulate emissions from vehicle exhaust are largely fine particulates within the $PM_{2.5}$ fraction. The effects of fine particulates on photosynthesis of vegetation are not well understood; and there is not currently an established criteria for assessment of ecological receptors with regards to $PM_{2.5}$ concentrations. To assess the potential $PM_{2.5}$ impacts on ecological receptors, the findings of the study 'The Response of Plant Photosynthesis and Stomatal Conductance to Fine Particulate Matter ($PM_{2.5}$) based Leaf Factors Analysing' (Li et.al. 2019) were used to define the assessment methodology.

Based on the findings of the study the most conservative threshold to assess ecological impacts would be a $PM_{2.5}$ $\mu g/m^3$ concentration of 50 $\mu g/m^3$ where photosynthetic rate and stomatal conductance is expected to decrease. The benchmark value of 50 $\mu g/m^3$ over a maximum 10-hour averaging period was adopted to assess predicted $PM_{2.5}$ concentration at ecological receptors.

In-tunnel air quality

In February 2016, the ACTAQ issued a document entitled 'In-Tunnel Air Quality (Nitrogen Dioxide) Policy' (ACTAQ, 2016). That document further consolidated the approach taken earlier for the NorthConnex, WestConnex New M4 and New M5 projects. The policy wording requires tunnels to 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'. This criterion compares favourably to the international in-tunnel criteria, shown in Table 9-5, which range between 0.4 and 1.0 ppm. Examples of in-tunnel NO_2 values for ventilation control from other projects internationally and in Australia are summarised in Table 9-5.

The criteria adopted for assessment of in-tunnel air quality are shown in Table 9-6. The NO_2 is a rolling average over the length of the tunnel as described in the In-Tunnel Air Quality (Nitrogen Dioxide) Policy (ACTAQ, 2016). The visibility criterion is a measurement of the scattering (extinction) of light by particles in the air, leading to low visibility in tunnels. The desired outcome for this criterion is to maintain clear air for good visibility within the tunnel.

Table 9-5 Comparative in-tunnel NO_2 limits (ACTAQ, 2016)

Jurisdiction/project	In-tunnel NO2 criteria	Design or compliance	Averaging period
NSW/NorthConnex[1]	0.5 ppm tunnel route average	Design and compliance	15-minutes
Brisbane City Council/Clem 7 (2007/Legacy Way (2010) tunnels	1 ppm average	Design and compliance	None given
Permanent International Association of Road Congresses	1 ppm tunnel average	Design only	None given
New Zealand	1 ppm	Design only	15-minutes
Hong Kong	1 ppm	Design only	5-minutes

Table notes:

1. Other projects have used these criteria including WestConnex projects (New M4, M4-M5, M8) and Western Harbour Tunnel.

Table 9-6 In-tunnel air quality criteria adopted for the assessment

Pollutant	Averaging period	Criteria
NO_2	15-min rolling average	0.5 ppm
Visibility (extinction co-efficient limit)	15-min rolling average	0.005 m^{-1}

9.3 Assessment approach

9.3.1 Construction assessment methodology

Dust emissions

A qualitative risk-based methodology was used to assess the impacts of dust given it is not possible to predict weather conditions during construction activities in future years. The majority of the works would be underground. The assessment follows the UK Institute of Air Quality Management's (IAQM) Guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2014)[1]. The methodology is shown in Figure 9-1 and included:

- step 1: an initial screening to identify where there is a risk of significant construction dust impacts, including a review of the proposed work, plant and equipment, and potential emission sources and levels
- step 2A: categorise dust generating activities required for the project to reflect their potential impacts including demolition, earthworks, construction, tunnelling and track-out work
- step 2B: assess the risk of dust impacts during project construction through defining the potential magnitude of dust created by the activity, and the sensitivity of the area
- step 3: identification of mitigation measures for the potential impacts identified
- step 4: determine whether there are residual significant impacts after mitigation
- step 5: produce a dust assessment report that captured the approach, risks identified, mitigations required and significance of impacts.

[1] This assessment criteria has been adapted for use in NSW regarding ambient PM_{10} concentrations (being particulate matter less than or equal to 10 micrometres in diameter)

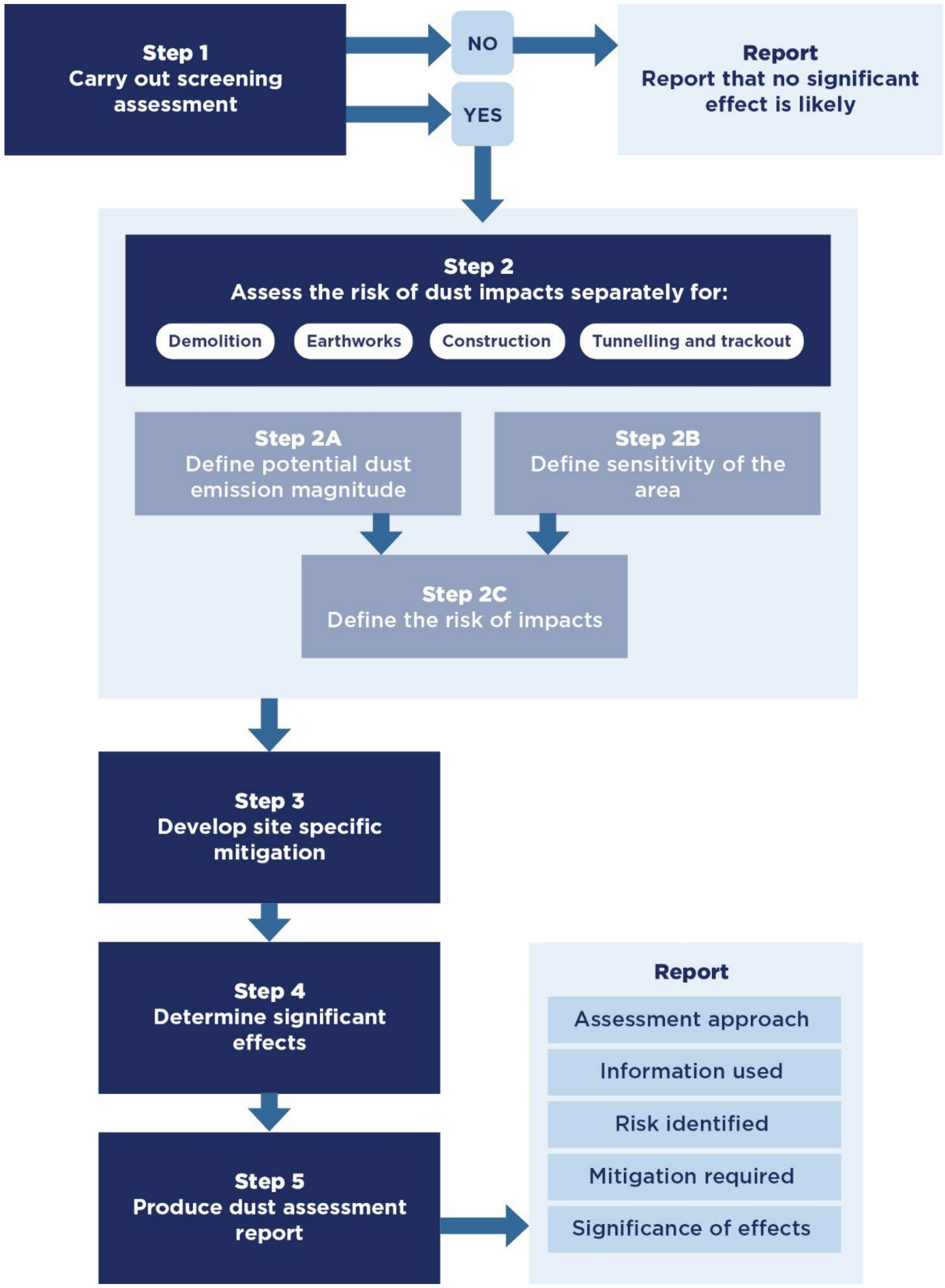

Figure 9-1 Construction dust assessment methodology

Exhaust emissions

Previous experience of assessing the exhaust emissions from onsite mobile and stationary equipment as well as construction traffic indicates that these emissions are unlikely to make a significant impact on local air quality (IAQM, 2014). Potential impacts from exhaust emissions from construction of the project were qualitatively assessed.

Assessment of odours

Potential sources of odour during construction would primarily be due to:

- the disturbance of acid sulfate soils or acid sulfate rock (ASR)
- contaminated soils during earthworks.

Acid sulfate occurs naturally in soils and rock that contains iron sulfides. When exposed to air, odorous compounds can be generated. The likelihood of encountering acid sulfate soils within the project area is low (see Chapter 15 (Soils and contamination)).

ASR is unweathered rock (i.e., rock that has not been exposed to water, wind, ice, plants, or changes in temperatures) which contains metal sulfide minerals. When exposed to either oxygen or water, oxidation of the sulphide within the ASR leads to the formation of iron oxides, sulfuric acid, sulfates, and salts.

Potential ASR deposits have been identified around the western half of the project alignment within Illawarra Coal Measures and Shoalhaven geological formations (see Chapter 13 (Groundwater and geology)). ASR may be exposed during tunnel excavation. An acid sulfate rock management plan would be implemented during construction.

Another potential minor source of odour emissions would be from asphalt during road pavement construction. Odour emissions from the laying of asphalt are from a complex mixture of hydrocarbons and VOCs. Potential odour impacts from this source would be minor and transitory in nature provided appropriate management measures for the project are applied as discussed in Section 9.7.

Given the low probability of odours occurring during earthworks and the transient nature of odours from the short lengths of surface roads on which pavement construction would occur, odours would be adequately managed by the measures in Section 9.7.

9.3.2 Operational assessment methodology

A quantitative assessment of operational air quality impacts was undertaken to determine the changes in air quality as a result of the project. The assessment process is outlined in Figure 9-2.

The first stage of an air quality impact assessment is the collection of a wide array of data, which is combined to make pollutant predictions using a dispersion model. The predicted pollutant concentrations are then assessed against the relevant air quality criteria (Section 9.2.2 and Section 9.6) and health criteria (see Chapter 10 (Human health)).

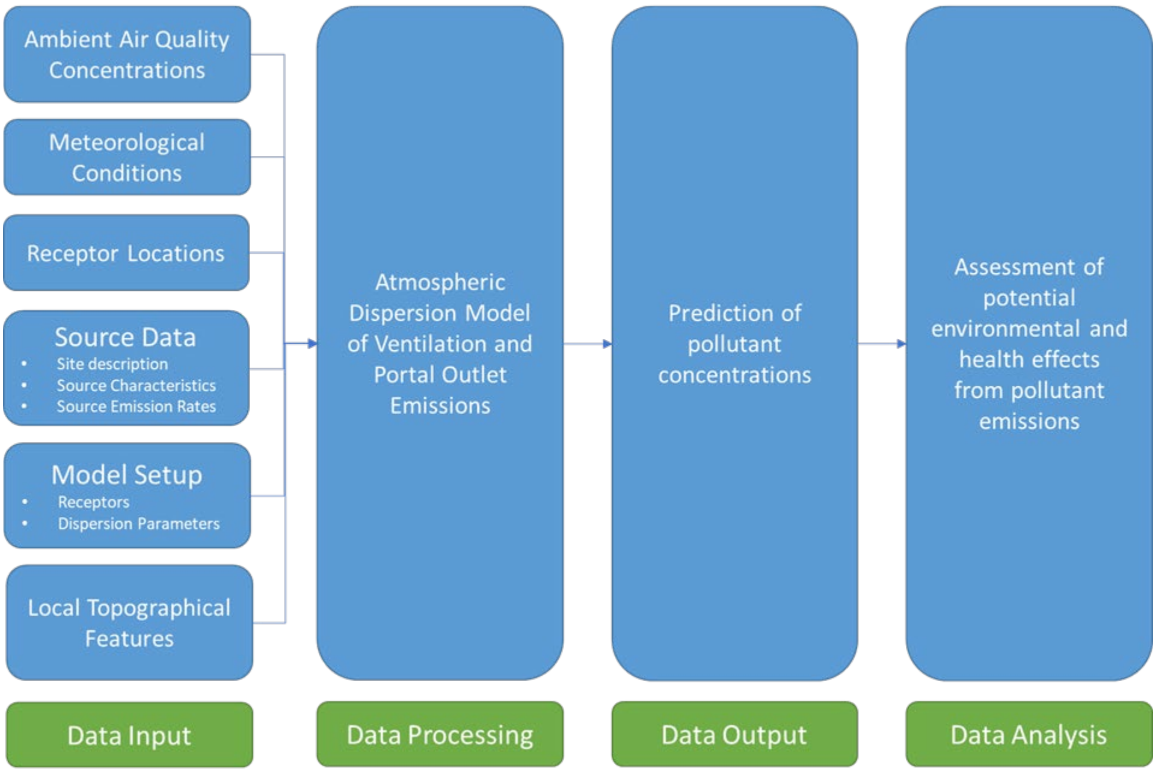

Figure 9-2 Stages of an air quality assessment

This assessment was carried in accordance with the Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales, NSW Environment and Protection Authority (NSW EPA, 2022a) and other guidance documents as detailed in the Secretary's environmental assessment requirements and in Section 3 of Appendix E (Technical report – Air quality).

The future air quality in the year of project opening (2030) and ten years after project opening (2040) was predicted by modelling based on:

- forecast traffic volumes and type of vehicles for each of those years (see Chapter 8 (Transport and traffic))
- emissions from that traffic calculated based on known vehicle fleet emissions and future emissions standards (see Section 6.7 of Appendix E (Technical report – Air quality))
- existing air quality and meteorology of the project area
- the terrain, or topography of the project area and any buildings which may affect dispersion of emissions from the project.

Using the meteorological and dispersion models, pollutant concentrations are predicted at specific locations. These locations may be sensitive receptor locations or a point on a spatial grid within the modelled area used to produce contour plots of pollutant concentrations. The consideration of ecological receptors in this assessment recognises the values of the Blue Mountains National Park adjacent to the project area and the Greater Blue Mountains World Heritage Area.

The predicted concentrations of pollutants were then compared to the relevant criteria or impact descriptors. Further detail of the assessment process is provided in Section 5 and 6 of Appendix E (Technical report – Air quality).

Study area

The area of interest for the project spans a 13-kilometre-long section of surface road connecting the upgraded Great Western Highway between Blackheath and Little Hartley.

The project corridor was divided into five modelling domains as shown in Figure 9-3. A more detailed description of each domain has been provided in Annexure J of Appendix E (Technical report – Air quality). The domains include:

- the practical extent of the expected emission plumes around the tunnel outlets – preliminary modelling of the ventilation outlet and portal emissions options was used to test the extent of the modelling domains. The aim of the preliminary modelling was to ensure the peak concentration was identified and the closest relevant receptors were considered
- location of the receptors in proximity to the ventilation outlets
- project footprint – the domains need to cover the extent of the project footprint
- dispersion modelling grid size – as the project needs to consider complex topographical changes as part of the portal outlet modelling, fine scale modelling grid is required. A two metre resolution modelling grid was adopted to ensure the changes close to the portals were adequately characterised.

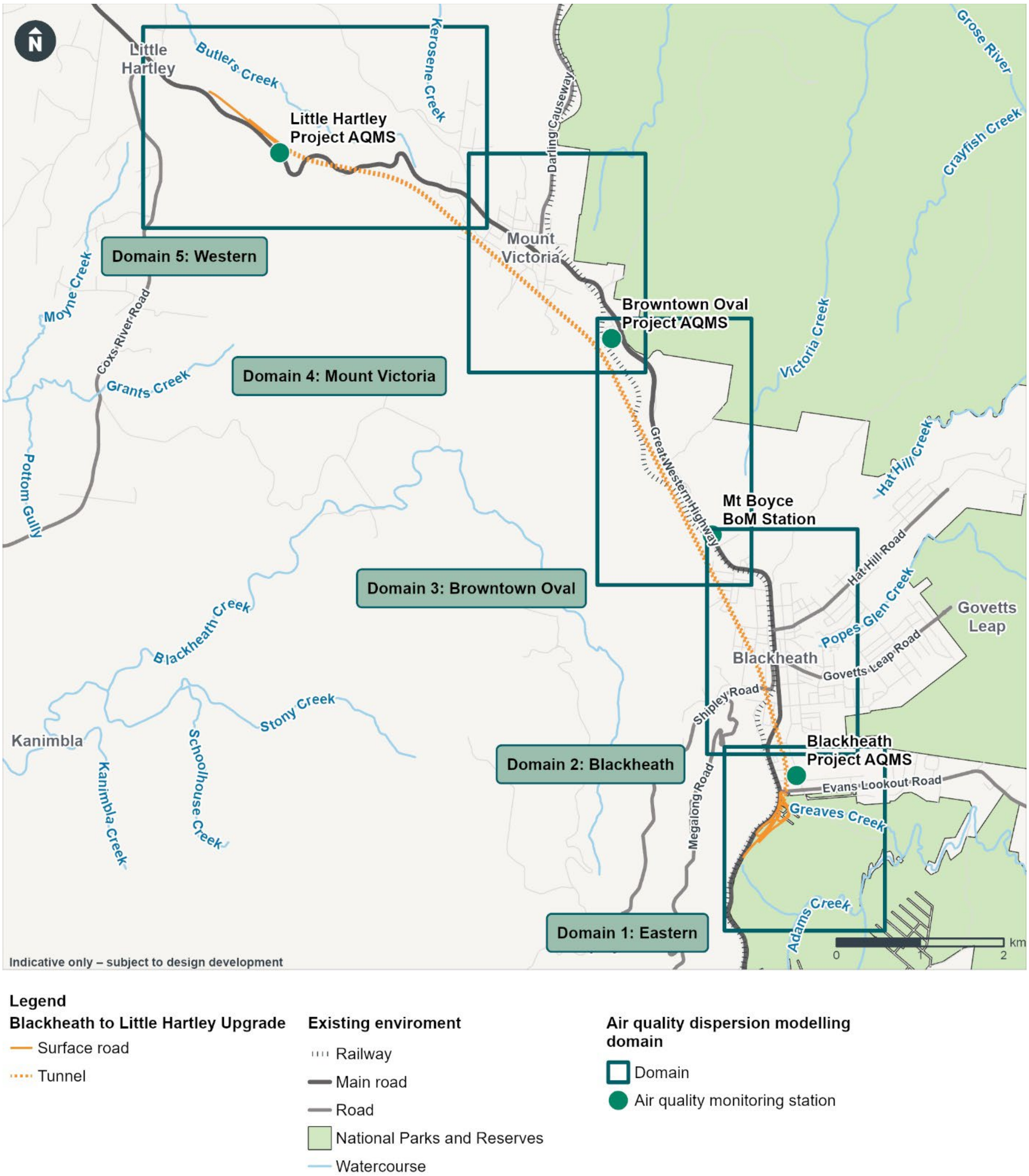

Figure 9-3 Dispersion modelling domains

Air quality modelling scenarios

Dispersion modelling scenarios define how emissions from surface roads, ventilation outlets or portals are combined for use in a dispersion model. Scenarios were developed considering three daily traffic emission profiles, expected from the tunnel including:

- typical daily traffic profile – the typical daily traffic profile reflects the expected hourly traffic numbers using the tunnel on a normal day (excluding peak traffic days such as Christmas, Easter, long weekend holidays and during special events such the Bathurst Super Car event). This profile is considered to provide the best indication of long-term impacts from the tunnel operations

- maximum daily traffic profile – the maximum daily traffic profile reflects traffic conditions that are only expected to occur for a small number of days per year e.g., during the Bathurst race weekend or at Christmas with high tourist numbers. As this is not expected to occur across many days per year, only short-term pollutant averaging periods have been considered for the assessment. This scenario best represents the tunnels worst-case short-term traffic conditions with the highest number of vehicles in the tunnel at any point in time, although with the mix of vehicles dominated by light (passenger) vehicles and lower numbers of heavy vehicles
- regulatory worst-case emissions profile – this reflects the theoretical maximum emissions concentrations modelled for every hour of one year. The tunnel emissions are equal to the emission concentrations that may be included in the tunnel environment protection licence (EPL), based on previous tunnel licences. Although licence conditions are not currently applicable to portal emissions, both ventilation outlet and portal emission options have been considered for the regulatory worst-case scenario.

In addition to the different operational emissions profiles outlined above, the assessment scenarios consider emissions from two different ventilation options. The two ventilation options consist of the ventilation outlet option and the portal emissions option, described in Section 4.5 of Chapter 4 (Project description).

The traffic scenarios considered future changes in the composition and performance of the vehicle fleet, as well as predicted traffic speeds, traffic volumes and the distribution of traffic on the road network (described in Chapter 8 (Transport and traffic)). For each expected traffic scenario, a spatial emissions inventory (emissions model) was developed. Greater uptake of alternate fuelled vehicles, in particular electric vehicles, are expected to reduce the NSW vehicle fleet emissions into the future. This expected reduction is difficult to quantify and is not included in the emissions inventory and model. Hence the vehicle emissions used are conservative for the future years 2030 and 2040.

The scenarios that were modelled are summarised in Table 9-7 and based on the traffic and transport modelling that include other components of the Great Western Highway Upgrade Program (Upgrade Program). Further detail on the traffic scenarios is provided in Section 8.1 of Chapter 8 (Transport and traffic). In the air quality assessment model, the following components were treated separately to take potential changes in traffic emissions across the road network into account:

- emissions from ventilation outlets
- emissions from exit portals
- emissions from the traffic on the existing surface road network, and new surface roads associated with the project.

Two traffic conditions were used to understand in-tunnel air quality conditions:

- typical traffic
- worst-case traffic.

Table 9-7 Modelled air quality scenarios for operation of the project

Ventilation option	Traffic scenario modelled (year)	Emission profile			
		Upgrade Program inclusion	Typical daily traffic	Maximum daily traffic	Regulatory worst case
None	Base year scenario (2018[1])	No	✔	✔	x
	Operational year scenario (2030) without the project	No	✔	✔	x

Ventilation option	Traffic scenario modelled (year)	Emission profile			
		Upgrade Program inclusion	Typical daily traffic	Maximum daily traffic	Regulatory worst case
	Operational year scenario (10 years after opening) (2040) without the project	No	✔	✔	x
Ventilation outlet option	Operational year scenario (2030) (at project opening)	All Upgrade Program components[2]	✔	✔	✔
	Operational year scenario (2040) (10 years after opening)	All Upgrade Program components[2]	✔	✔	✔
Portal emissions option	Operational year scenario (2030) (at project opening)	All Upgrade Program components[2]	✔	✔	✔
	Operational year scenario (2040) (10 years after opening)	All Upgrade Program components[2]	✔	✔	✔

Table notes:

1. 2018 was selected as the base year scenario given the impacts of the COVID-19 pandemic on travel patterns between 2020-2022.
2. Assumes the Katoomba to Blackheath Upgrade, the Medlow Bath Upgrade and the Little Hartley to Lithgow Upgrade are all operational.

GRAMM/GRAL modelling system

The atmosphere is a complex physical system, and the movement of air in a given location is dependent on a number of variables, including temperature, topography and land use, as well as larger-scale weather patterns. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations.

The operational assessment methodology involved combining the use of a meteorological model (Graz Mesoscale Model (GRAMM)) and a dispersion model (Graz Lagrangian Model (GRAL)) as illustrated in Figure 9-4. The GRAMM/GRAL models have been used on all recent Sydney road tunnel environmental impact assessments. Further detail of the GRAMM/GRAL modelling system is presented in Section 6.5 of Appendix E (Technical report – Air quality).

The GRAL dispersion model predicts potential ground-level pollutant concentrations by simulating the movement of individual ‘particles’ of a pollutant emitted from an emission source in a three dimensional wind field. The main project-specific inputs to the GRAL model are shown in Figure 9-4.

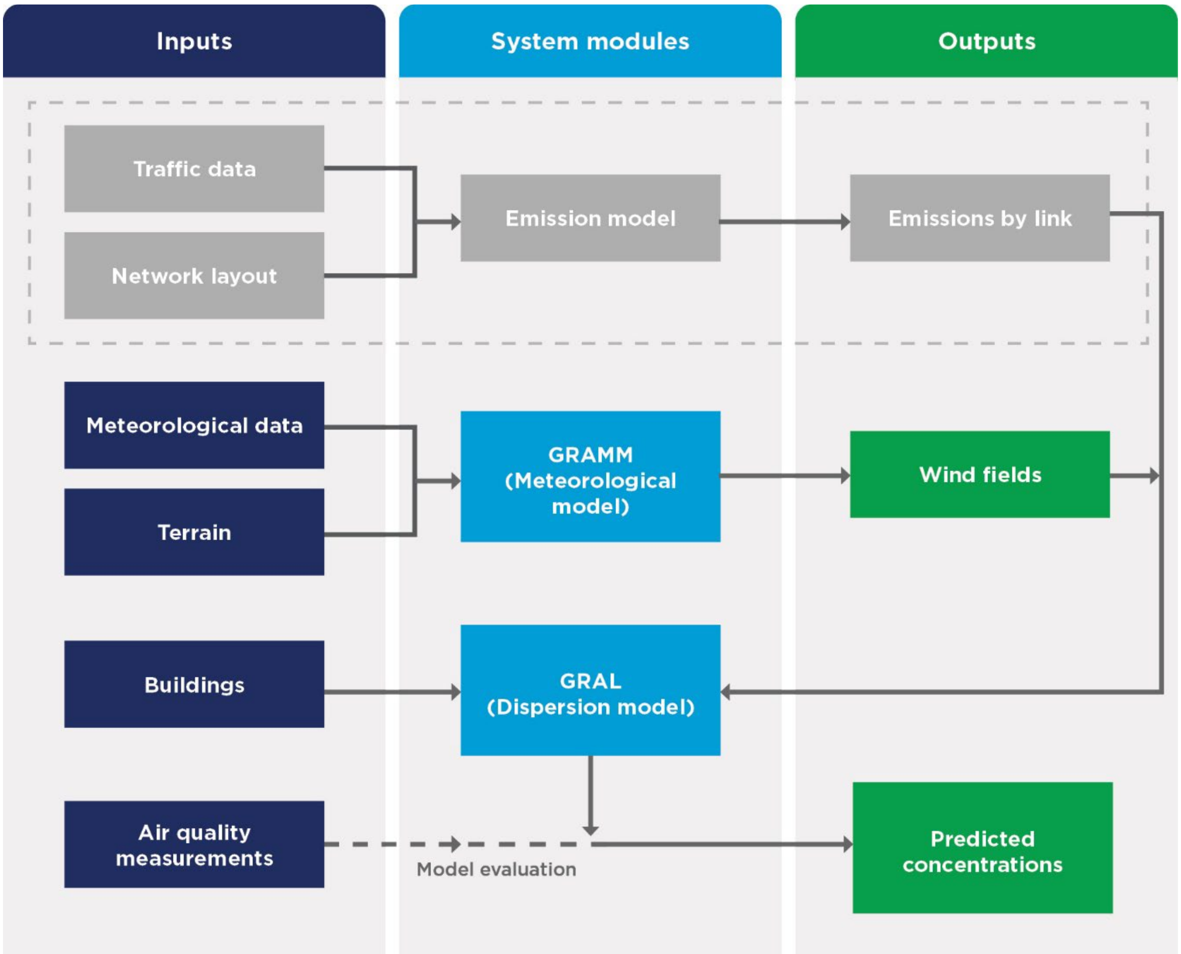

Figure 9-4 Overview of the operational air quality model

Air quality concentrations

The concentration of a pollutant at a given location includes contributions from various sources. The following sources were used to describe the concentration of a pollutant at a specific location or receiver (as depicted in Figure 9-5).

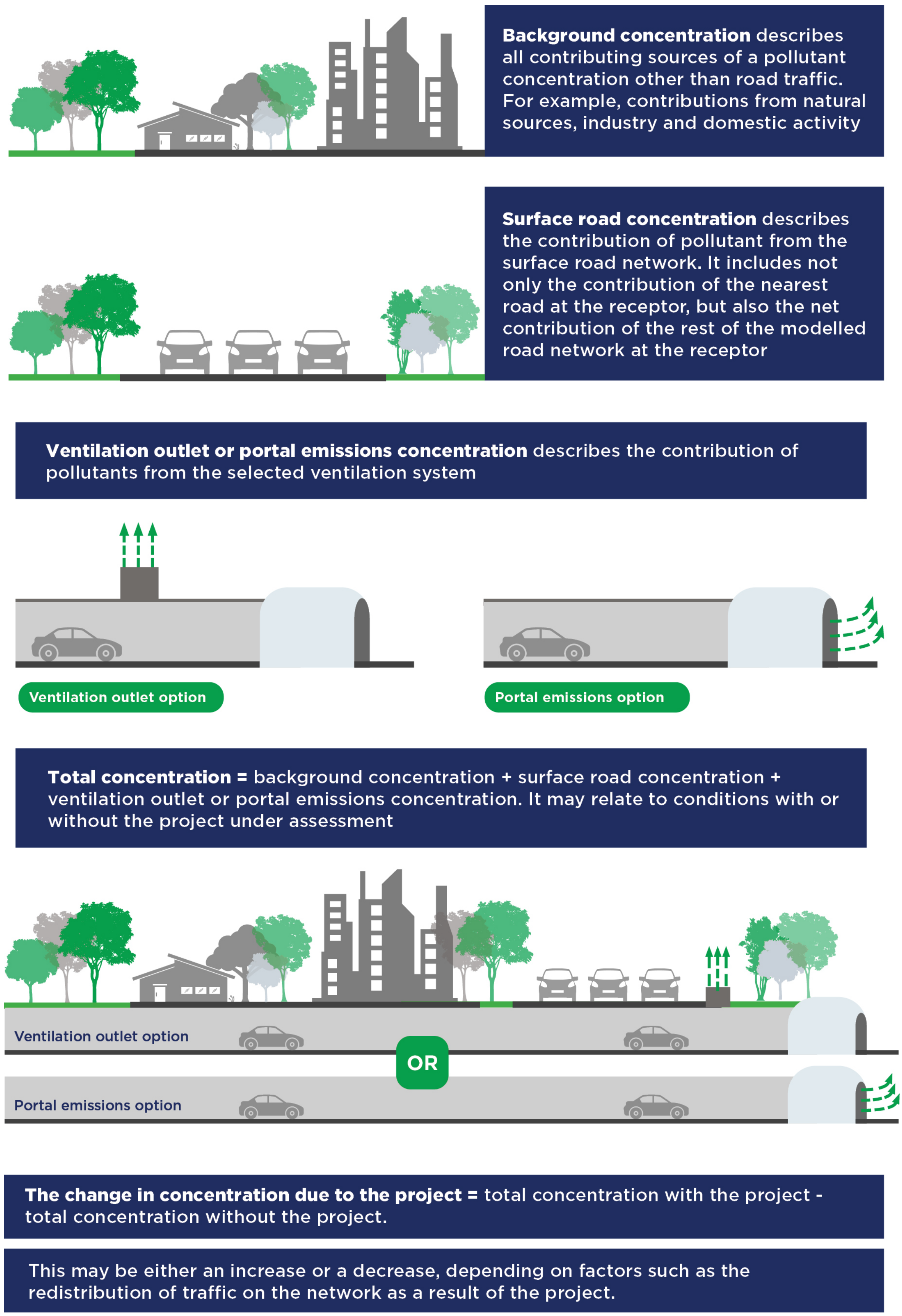

Figure 9-5 Components of air quality concentrations

In-tunnel air quality

In-tunnel air quality modelling was carried out using IDA Tunnel software which has been used on previous Sydney road tunnel assessments. The modelling considered traffic volumes and speeds, tunnel air flow, vehicle emission levels and temperature in the following scenarios:

- typical traffic – 24-hour operation of the project ventilation system under day-to-day conditions of expected traffic demand in 2030 and 2040
- worst-case traffic – the most onerous traffic conditions for the ventilation system (refer below).

The operational worst-case traffic scenarios represent the theoretical maximum pollutant concentrations for all potential traffic operations in the tunnel as well as vehicle breakdown situations. The operational worst-case scenarios are very conservative and would result in pollutant emission concentrations that are much higher than those that could occur under foreseeable operational conditions in the tunnel. Two scenarios were considered, including:

- the worst-case for traffic variable speeds
- the worst-case in the event of a breakdown or major incident.

The worst-case (variable speed) traffic operation scenario represents the upper limit of daily ventilation system operations in the tunnels, regardless of the year of operation, and is based on the traffic flows for the predicted traffic peak periods with the mainline tunnels reaching a theoretical maximum lane capacity traffic flow. The worst-case scenario was considered for average speeds for lane capacity for 20 to 80 kilometres per hour.

At an average traffic speed of 20 kilometres per hour through the tunnel jet fans would be operated to assist the longitudinal flow of air through the tunnel as the piston effect would be reduced by the slow-moving traffic and the volume of traffic passing through the tunnel is reduced. The likelihood of average traffic speed throughout the tunnel being less than 20 kilometres per hour is very small, likely less than one per cent, based on monitoring of traffic through the M5 East tunnel (see Annexure D of Appendix E (Technical report – Air quality)).

Traffic management plans would be developed during design development to provide capability to further reduce the likelihood of slow-moving traffic. Maintaining the traffic speed above 20 kilometres per hour in any section of the tunnel is also a safety measure to minimise the chance of rear end crashes at the end of a line of stopped or slow-moving traffic, which could result in a fire, and to allow vehicles in front of a fire to drive out of the tunnel without being over-run by smoke.

At an average speed of 80 kilometres per hour the traffic is free flowing with twice the volume of vehicles passing through the tunnel and no jet fans are required to assist the air flow through the tunnel.

The worst-case (breakdown or major incident) operation scenario assesses the most onerous traffic case, where congestion that occurs as a result of a breakdown affects the longest possible queue length within the tunnel. The air flow would be reliant on jet fans.

9.4 Existing environment

9.4.1 Terrain features

Terrain features include both the topographical changes and land use characteristics within a study area.

Topography along the project corridor is dominated by the western escarpment of the Blue Mountains plateau and the lower elevations in the Little Hartley valley. The majority of the Great Western Highway within the project corridor is situated along the Blue Mountains plateau at an elevation of about 1,025 to 1,091 metres above sea level. The elevation drops significantly as the Great Western Highway moves from Mount Victoria to Little Hartley valley, dropping from about 1,075 metres at Mount Victoria to about 830 metres in Little Hartley. The topographical changes observed between Mount Victoria and Little Hartley would be expected to affect the local meteorological conditions and, being close to the location of the western end of the tunnel, would affect the dispersion pattern for emissions from the tunnel.

Terrain changes are minor in the vicinity of the Blackheath portal and as such terrain is likely to have a limited effect on plume dispersion.

Detailed analysis of the terrain is provided in Section 4 of Appendix E (Technical report – Air quality).

9.4.2 Land use

Land use is a semi-rural to rural environment that includes some urban residential development scattered between areas of natural vegetation and rural communities. The natural vegetation in the area consists of several reserves as well as the Blue Mountains National Park. Areas of urban development occur at Blackheath and Mount Victoria.

Blackheath includes a mix of low to medium density residential and tourist accommodation, with a small commercial town centre and several public recreational areas including a golf course close to the Blackheath portal. On the outskirts of Blackheath are areas zoned for environmental living as well as several recreational reserves.

Mount Victoria has a small commercial town centre surrounded by low density residential and some public recreational areas. The land use surrounding the Mount Victoria township consists of areas zoned for environmental living as well as several recreational reserves and conservation areas.

The Little Hartley valley is rural residential, agricultural, and low-density residential land surrounded by areas of native vegetation.

These land use patterns have been included in the dispersion model.

9.4.3 Existing ambient air quality

Background air pollution in NSW is typically characterised by either ambient monitoring data collected from a project specific monitoring program or through the use of data measured at DPE monitoring locations throughout NSW. A full year of data from all seasons is typically considered the minimum amount of data needed to enable the thorough analysis of all likely existing pollutant concentrations, although having several years of data is also useful to understand longer term changes in pollutant concentrations.

For the purposes of dispersion modelling and impact assessment, ambient monitoring data needs to be from the same 12 month period as the meteorological data used for the dispersion modelling, in accordance with the Approved Methods (NSW EPA, 2022b). The meteorological year used for the dispersion modelling was 2018[2], hence an ambient air pollutant data set for 2018 was required.

Ambient air quality monitoring locations within the Blue Mountains region were reviewed, firstly to establish whether there were relevant monitoring stations close enough to the project area that could be used to characterise background air pollution levels and secondly, whether sufficient data is available to enable a seasonal pollutant analysis and contemporaneous meteorological analysis. All stations considered are discussed in Section 4 of Appendix E (Technical report – Air quality). Of these, the Katoomba DPE monitoring data provided some data that was representative of the background air quality. However, once the data from the 2019-2020 'Black Summer' bushfires was removed, there was insufficient data for a full 12 month data set. To overcome this limitation, three project specific monitoring stations were commissioned by Transport within the project corridor. Further information based on 12 months of monitoring data would be provided in future planning stages for the project.

[2] Existing year of 2018 was selected due to that year being the most recent full calendar year unaffected by either COVID travel restrictions conditions or the black summer bushfires in 2019. Traffic data was also available for that calendar year.

Project monitoring data

Three project specific monitoring stations have been installed at the following locations:

- Little Hartley adjacent to the Great Western Highway (operational since February 2022)
- Browntown Oval (operational since October 2021)
- Blackheath (operational since September 2021).

A summary of the data compared to the NSW EPA ambient air quality criteria is shown in Table 9-8.

Table 9-8 Project air pollutant monitoring station data summary

Pollutant	Averaging period	Units	Katoomba (Apr19-Jun20)	Blackheath (Nov21-Jun22)	Browntown Oval (Nov21-Jun22)	Little Hartley (Feb22-Jun22)	Synthetic data (Jan18-Dec18)	Criteria
NO_X	1 hour max	µg/m³	58.9	106.5	114.0	211.6	159.9	-
	All hours average[1]	µg/m³	3.8	9.1	7.1	23.4	11.2	-
NO_2	1 hour max	µg/m³	56.4	27.1	26.0	29.3	49.8	164
	All hours average[1]	µg/m³	2.7	3.3	1.9	5.5	6.3	31[2]
CO	1 hour max	µg/m³	1035	2114	1182	1333	1392	30000
	8 hour max	µg/m³	1021	1559	1099	1282	721	10000
PM_{10}	24 hour max	µg/m³	45.0	22.3	16.1	22.5	24.4	50
	All hours average[1]	µg/m³	6.7	6.8	6.3	6.7	8.4	25[2]
	No. exceedances	-	0	0	0	0	0	NA
$PM_{2.5}$	24 hour max	µg/m³	38.2	22.2	19.6	11.8	17.8	25
	All hours average[1]	µg/m³	3.8	3.9	3.7	3.5	5.2	8[2]
	No. exceedances	-	1	0	0	0	0	NA

Table notes:

1. Annual average cannot be calculated as less than 12 months of data was collected. All hours average has been used as a proxy for annual average
2. Criteria for annual average has been included for reference only as less than 12 months of data has been collected for each calendar year
3. This is not a criterion, more of an expectation for good airshed air quality

Unified monitoring data

The limited data availability prevented the use of a single representative observational data set for the background pollutant levels for the project corridor. To address this issue a unified monitoring data set was developed using observed data from the project monitoring stations and historical data from the Katoomba station. The methodology used to develop the unified monitoring data set is provided in Section 4.3 of Appendix E (Technical report – Air quality).

A comparison between the final unified data set, the project monitoring data and the Katoomba monitoring station data set is provided in Section 4.3 of Appendix E (Technical report – Air quality) with a summary of the unified data. The comparison showed a good correlation between the observed data while generally remaining conservative. On this basis the unified data set was considered appropriate for use when calculating the impacts of the project.

9.4.4 Meteorology

The dispersion model uses regional meteorological data to predict the direction of travel and degree of dispersion for a pollutant from the point of emission, whether that be the road, a ventilation outlet or a portal. Analysis of the meteorological data also considers how representative the dispersion modelling meteorology is of the local conditions. This is particularly relevant given the elevation difference between Blackheath and Little Hartley. Meteorological monitoring data was available from Lithgow, Wallerawang, Katoomba and Mount Boyce.

An analysis of the data available from these stations was undertaken, with the focus on data representativeness, quality and availability. The monitoring station data evaluation showed that only the Mount Boyce station was considered acceptable for use in the project (despite it being representative of the Blackheath to Mount Victoria area only)[3]. Monitoring data from the project stations located at Blackheath, Browntown Oval and Little Hartley did not have a full 12 months of data that could be used for the dispersion meteorology but have been used for verification purposes as discussed in Annexure E of Appendix E (Technical report – Air quality).

Given the limited data availability across the project corridor, the Mount Boyce meteorological data was used along with detailed topographical information and land use data to produce a refined GRAMM 'Match To Observation' meteorological data file for use in GRAL dispersion modelling.

The GRAMM model considers variable topographical and land use features across a modelling domain which enables the model to account for the expected differences between the Blackheath and Mount Victoria areas and the Little Hartley valley. This characteristic of the model means that although the Mount Boyce observation data is not representative of Little Hartley, the refined 'Match To Observation' GRAMM flow field data will take into account the significant differences between the top and bottom of the Blue Mountains and produce meteorology that is more reflective of conditions in the Little Hartley valley. The modelled data showed that calm (low wind speed conditions) percentages at Little Hartley were 10.6 per cent higher than calms observed at the top of the Blue Mountains, which is consistent with expectations for the region and consistent with limited observations undertaken at Little Hartley to date (additional detail on the Little Hartley measured data comparison is provided in Appendix E (Technical report – Air quality)).

Several additional verification analyses have been presented in Annexure E of Appendix E (Technical report – Air quality). All analyses show that the dispersion meteorology produced by GRAMM provides a good representation of the expected conditions in Little Hartley and at Blackheath and that the GRAMM data is acceptable for use in the assessment.

A detailed outline of the dispersion meteorology and discussion of its representativeness has been provided in Section 6.5 of Appendix E (Technical report – Air quality).

9.4.5 Sensitive receptors

The term "receptor" refers to a location where pollutant predictions are calculated by a dispersion model. Receptors can be either "sensitive" receptor locations or "gridded" receptors, which are locations on a spatial grid primarily used to generate pollutant concentration contours. Sensitive receptors are defined as "A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area." (NSW EPA, 2022a).

The eastern and western modelling domains (corresponding to the southern Blackheath residential area and the Little Hartley and western Mount Victoria areas), included sensitive receptor locations at all identified residential dwellings and commercial developments. Sensitive receptor locations were also placed at all residential and commercial developments within about 200 metres of the Great Western Highway between the Blackheath and Mount Victoria townships and in Little Hartley. These are the areas in which most development occurs and would be influenced by changes in air quality due to the project.

[3] Noting that Mount Boyce is considered representative of the project corridor meteorology at the top of the Blue Mountains. It is not considered representative of conditions at Little Hartley.

All sensitive receptor locations included in the dispersion model are shown in Figure 9-6.

No hospitals or retirement homes were identified for this assessment. Educational facilities (schools and pre-school) are shown in Table 9-9. Gridded receptors were included for all modelling domains at a two metre resolution. These receptors were used as the basis for the generation of concentration contours along the Great Western Highway and around the tunnel portals.

Table 9-9 Educational facilities in the project area

Receptor name	Address
Kookaburra Kindergarten	9/11 Park Ave, Blackheath
Blue Gum Montessori	95 Wentworth St, Blackheath
Blackheath Public School	Leichhardt St, Blackheath
Blue Mountains Christian School	60 Thirroul Ave, Blackheath
Possum's Patch Childcare Centre	107 Great Western Hwy, Mount Victoria
Mount Victoria Public School	105-107 Great Western Hwy, Mount Victoria
One School Global NSW	84 Great Western Hwy, Mount Victoria

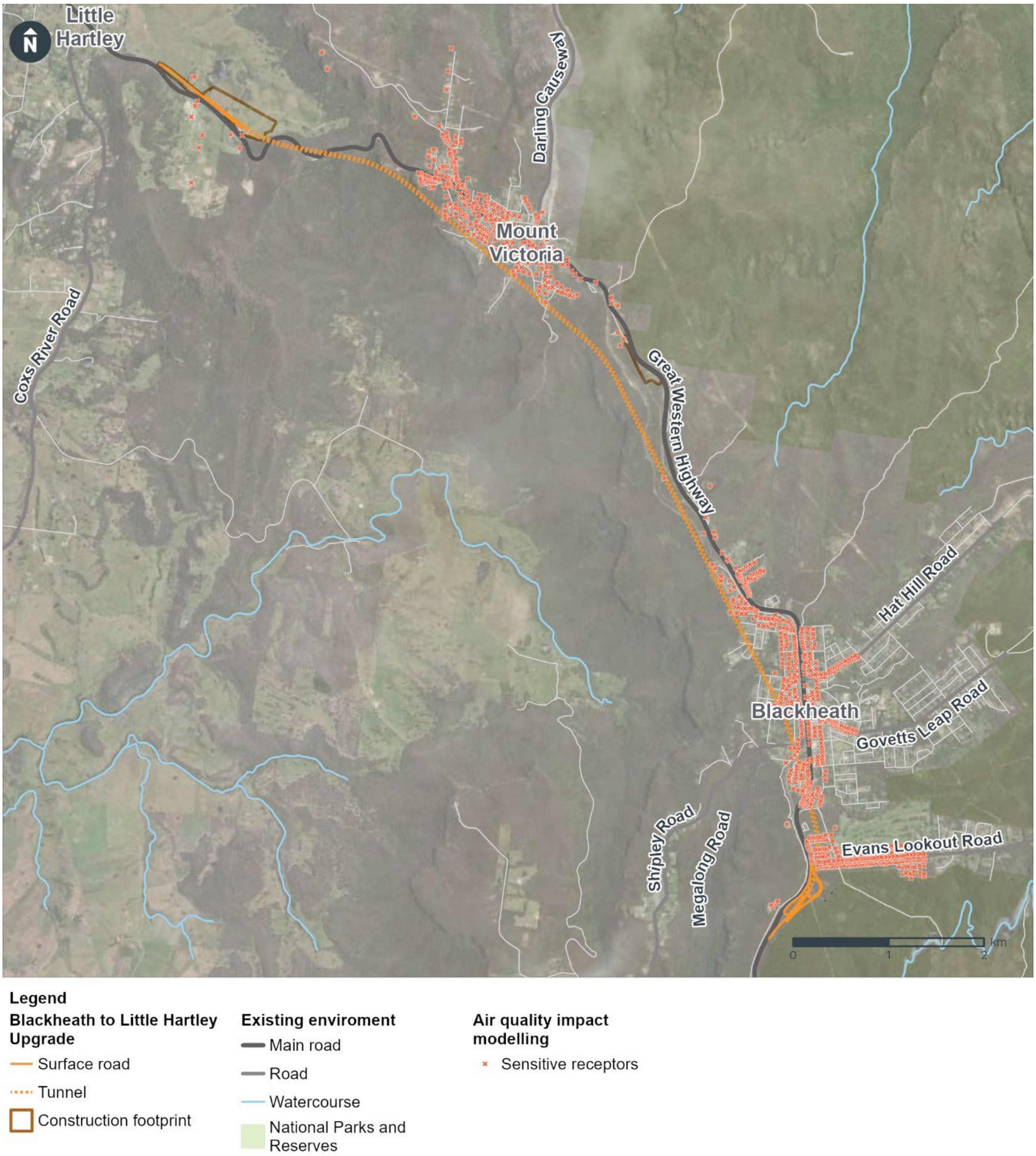

Figure 9-6 Sensitive receptor locations

9.4.6 Ecological receptors

Ecological receptors are areas of ecological significance. This can include areas such as national parks, state conservation areas, nature reserves and endangered ecological communities or species. Ecological receptors can also include agricultural activities that might be vulnerable to air emissions such as fruit and vegetable farms, flower farms or vineyards.

Increased concentrations of atmospheric pollutants have the potential to affect sensitive habitats and plant communities. For example:

- high levels of prolonged dust deposition may lead to plant physical stress, reduced photosynthesis, respiration, and transpiration through smothering

- chemical changes to soils or watercourses may lead to a loss of plants or animals, for example via changes in acidity
- exposure to elevated NO_2 concentrations may result in changes to leaf chlorophyl and mineral ion content and changes to essential enzyme activity in vegetation
- physiological changes to vegetation because of increased pollutant concentrations may also have indirect effects such as increased susceptibility to stresses such as pathogens.

The assessment of ecological impacts associated with the project is provided in Chapter 12 (Biodiversity). Due to the ecological significance of the area surrounding the project, both construction and operational air quality impacts from the project were assessed.

9.5 Potential impacts – construction

9.5.1 Dust impact assessment

Construction of the project is anticipated to take around eight years. Potential dust impacts during the construction period have been determined based on the IAQM construction dust assessment guidance and the expected scale of the of construction activities outlined in Section 9.3.1.

Stage 1: screening stage assessment

An initial screening assessment was undertaken in line with the IAQM construction dust assessment guidance for each of the three construction sites defined in Chapter 5 (Construction) to identify whether there are any:

- human receptors within 350 metres of the construction sites
- ecological receptors within 50 metres of the construction sites
- human or ecological receptors within 50 metres of the construction haul route on public roads up to 500 metres from the construction sites.

Screening lines of 50 metres and 350 metres were drawn around the construction sites as shown in Figure 9-7 to Figure 9-9. The figures show that there are both human and ecological receptors within 350 metres and 50 metres respectively from the construction sites which trigger the requirement for a Stage 2 assessment.

In addition to the 50 metres and 350 metres screening lines, Figure 9-7 to Figure 9-9 show additional buffer zones of 20 metres, 100 metres and 200 metres. These distances have been used to estimate receptor sensitivity for the Stage 2 assessment.

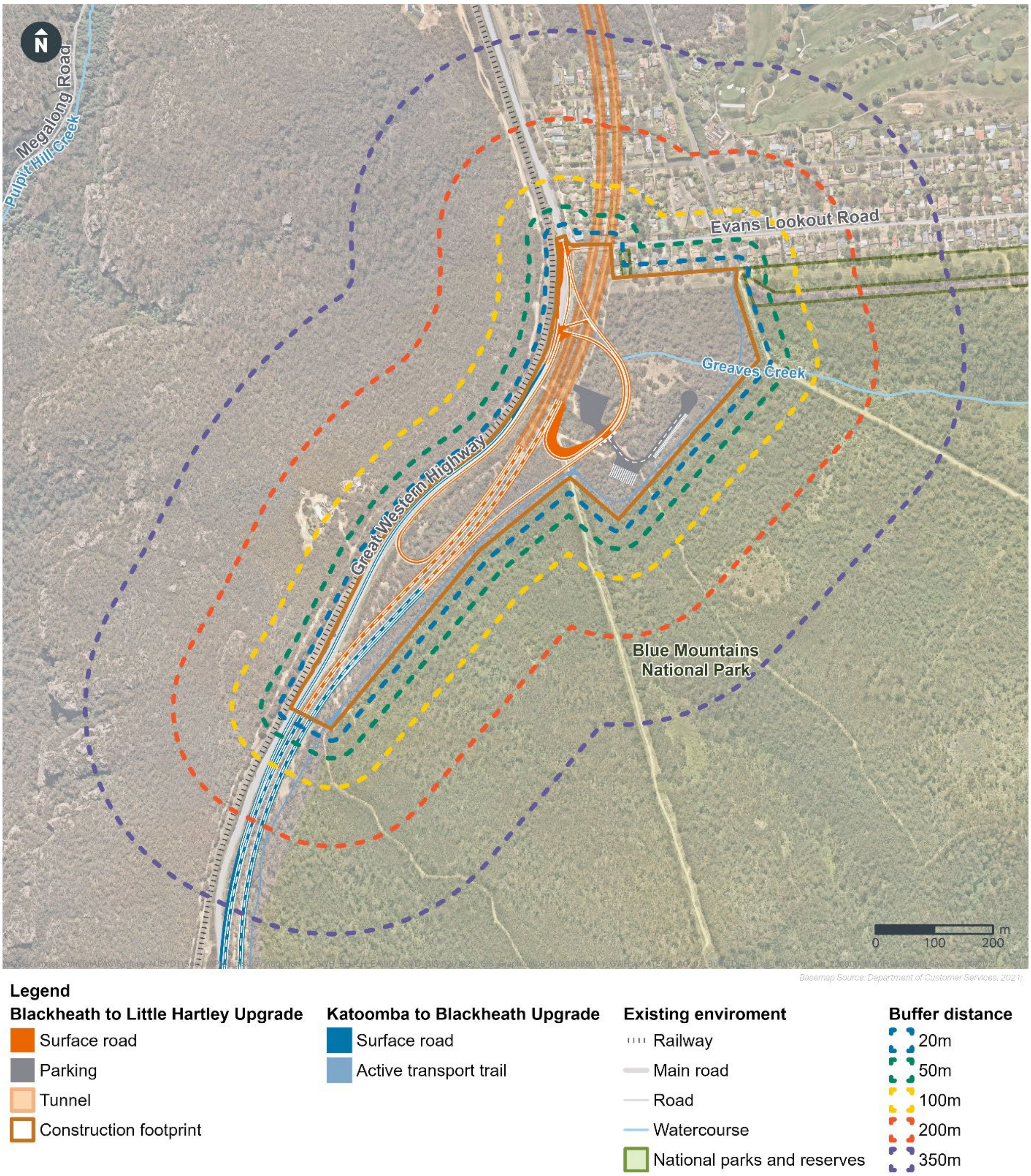

Figure 9-7 Buffer distances for Blackheath construction site

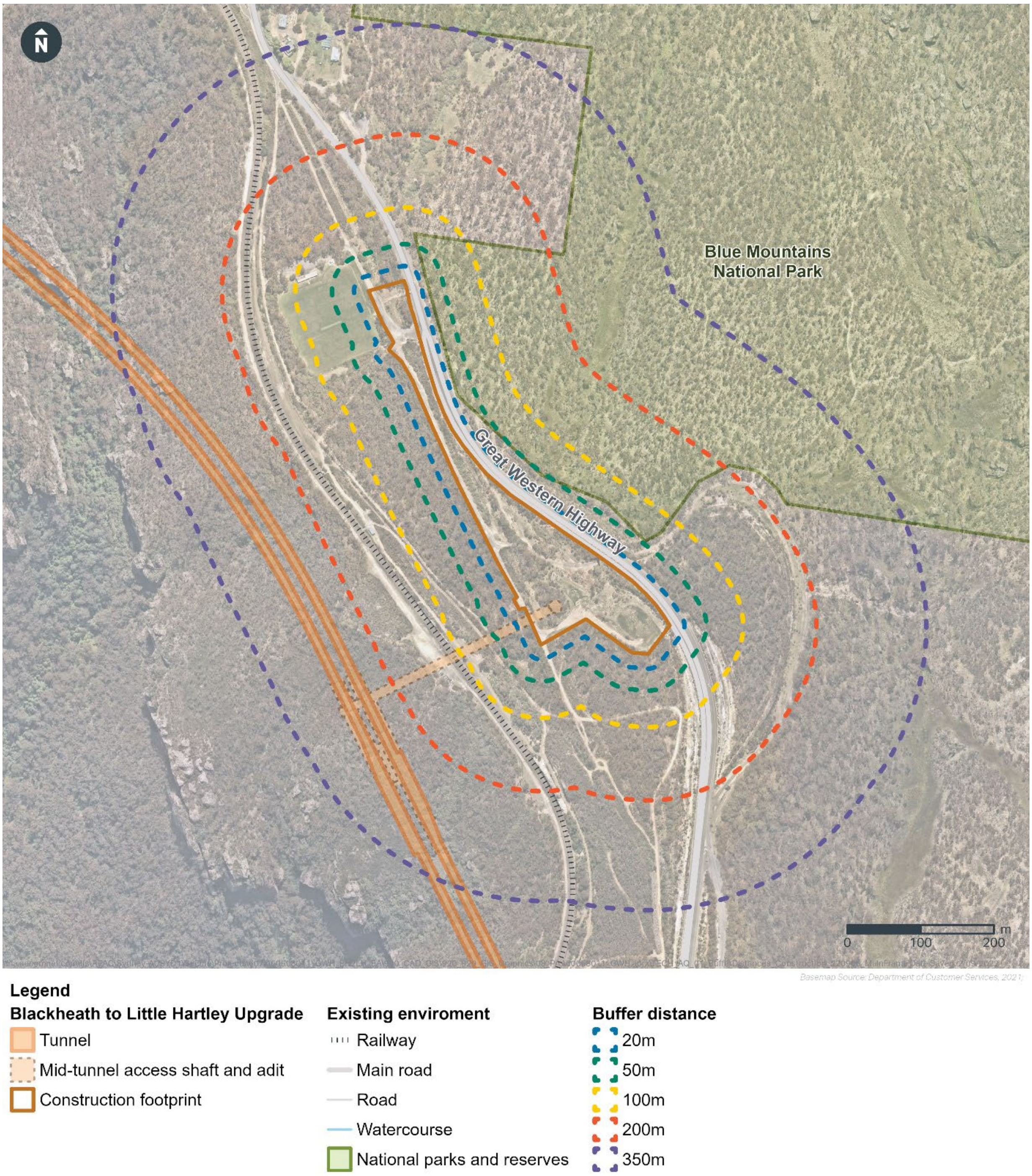

Figure 9-8 Buffer distances for Soldiers Pinch construction site

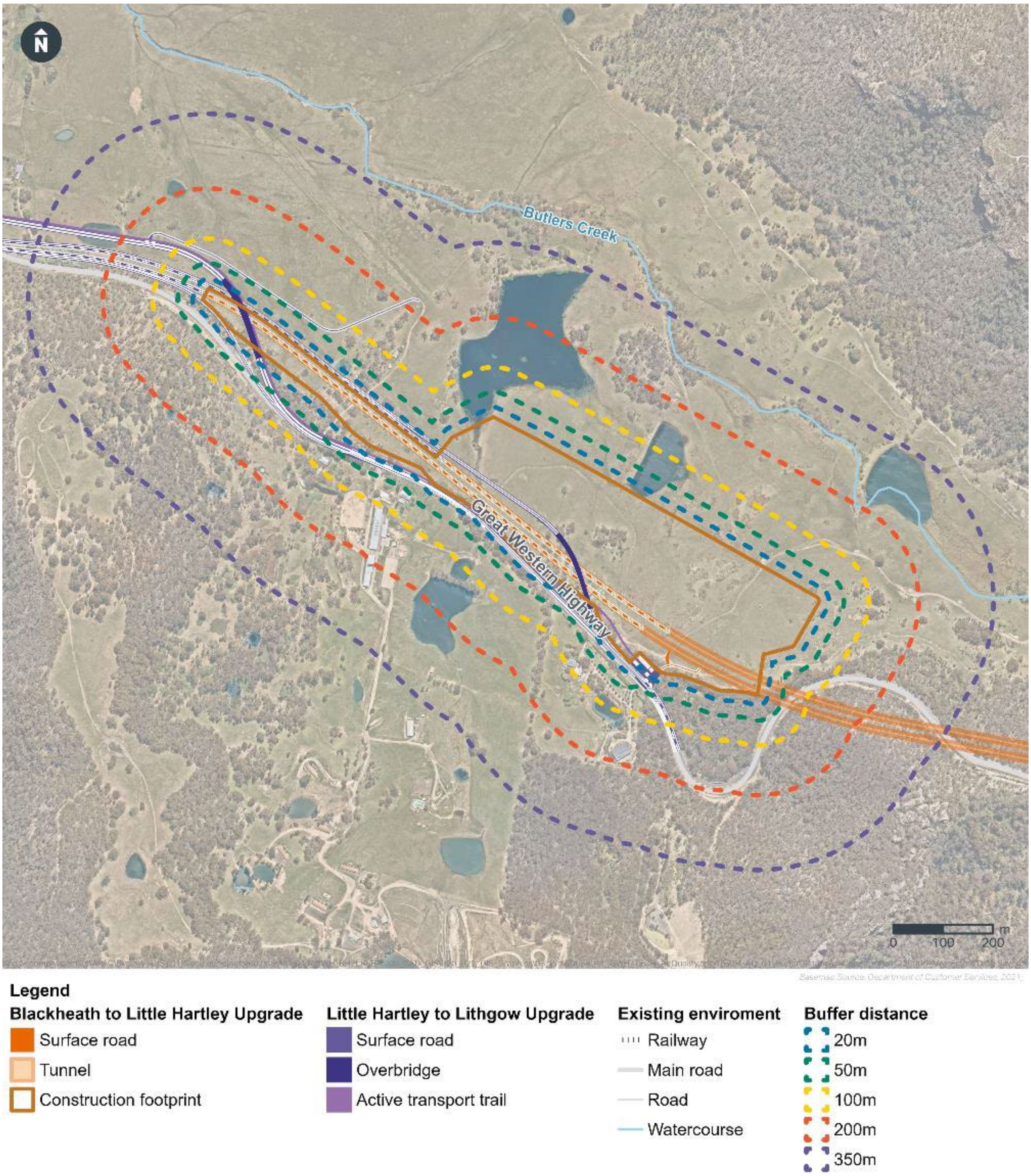

Figure 9-9 Buffer distances for Little Hartley construction site

Stage 2: Dust impact assessment by construction activity

Step 2A: Magnitude of construction activity

The magnitude of construction activity at each construction site is described in Chapter 5 (Construction) and assessed in relation to potential for generation of dust, as described in Section 5 of Appendix E (Technical report – Air quality). A summary of the assessment is presented in Table 9-10.

Table 9-10 Stage 2: IAQM screening assessment for construction zones

Construction site	Construction activity magnitudes			
	Demolition	Earthworks	Construction	Track-out
Blackheath	Medium	Large	Large	Large
Soldiers Pinch	Small	Large	Large	Large
Little Hartley	Medium	Large	Large	Large

Step 2B: Sensitivity to dust

The sensitivity of receptors to dust has been examined for each of the construction buffer zones and are shown in Table 9-11. Dust risk ratings are determined by the highest risk rating attributed to a construction buffer zone and have been estimated based on IAQM guidance and surrounding land use as discussed in Section 9.3.1.

Table 9-11 shows that:

- at Blackheath the risk of dust is high due to the proximity of highly sensitive residential receptors on the border of the construction footprint
- at Soldiers Pinch the risk of dust is low due to the presence of a single low sensitivity recreational receptor
- at Little Hartley the risk of dust is low due to limited proximity of highly sensitive rural receptors.

Table 9-11 Assessment of sensitivity of the areas in construction buffer zones to dust

Construction site	Receptor sensitivity	Distance from construction site boundary			
		< 20 m	< 50 m	< 100 m	< 350 m
Blackheath	High	10-100 (High)	10-100 (Medium)	10-100 (Low)	>100 (Low)
	Medium	>1 (Medium)	>1 (Low)	>1 (Low)	>1 (Low)
	Low	>1 (Low)	>1 (Low)	>1 (Low)	>1 (Low)
Soldiers Pinch	High	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	>1 (Low)	>1 (Low)
Little Hartley	High	No receptors identified	No receptors identified	1-10 (Low)	1-10 (Low)
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	No receptors identified	No receptors identified

Sensitivity to exposure to dust for human receptors

Sensitivity to dust (as PM_{10}) for human receptors has been assessed for each of the construction sites. Results of the analysis are detailed in Table 9-12. Dust health impacts ratings for human receptors are determined by the highest sensitivity rating attributed to a construction buffer zone and have been estimated based on IAQM guidance, using the background annual average PM_{10} of less than 8.4 μg/m^3 (see Table 9-8) and surrounding land use.

An assessment of potential human health risks from construction dust is provided in Chapter 10 (Human health).

From the results in Table 9-12 it was concluded that the risk of health impacts from PM_{10} emissions is low at all construction sites due to the low PM_{10} background concentrations and the limited number of sensitive receptors at Little Hartley and Soldiers Pinch.

Table 9-12 Assessment of sensitivity of the area to human health impacts from PM_{10}

Construction site	Receptor sensitivity	Distance from construction site boundary				
		< 20 m	< 50 m	< 100 m	< 200m	< 350 m
Blackheath	High	10-100 (Low)	10-100 (Low)	10-100 (Low)	10-100 (Low)	10-100 (Low)
	Medium	1-10 (Low)	>10 (Low)	>10 (Low)	>10 (Low)	>10 (Low)
	Low	≥1 (Low)	≥1 (Low)	≥1 (Low)	≥1 (Low)	≥1 (Low)
Soldiers Pinch	High	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	≥1 (Low)	≥1 (Low)	≥1 (Low)
Little Hartley	High	No receptors identified	No receptors identified	1-10 (Low)	1-10 (Low)	1-10 (Low)
	Medium	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified	No receptors identified	No receptors identified	No receptors identified

Sensitivity to exposure to dust for ecological receptors

The sensitivity of ecological receptors to dust have been examined for each of the construction sites and are reported in Table 9-13. Dust risk ratings for ecological receptors are determined by the highest risk rating attributed to a construction footprint area and have been estimated based on IAQM guidance and the ecological value of the land around the construction sites.

Results in Table 9-13 show the following:

- Blackheath and Soldiers Pinch construction sites are considered to have a high sensitivity to dust due to their proximity to the Blue Mountains National Park; regarded as a highly sensitive ecological receptor due to its World Heritage and National Heritage listings
- the Little Hartley construction site is surrounded primarily by agricultural land of low ecological sensitivity but does contain some adjacent remnant native vegetation and is therefore considered of medium sensitivity.

Table 9-13 Assessment of sensitivity of the area to ecological impacts

Construction site	Receptor sensitivity	Distance from construction site boundary	
		< 20 m	20 - 50 m
Blackheath	High	High sensitivity	Medium sensitivity
	Medium	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified
Soldiers Pinch	High	High sensitivity	Medium sensitivity
	Medium	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified
Little Hartley	High	No receptors identified	No receptors identified
	Medium	Medium sensitivity	Low sensitivity
	Low	Low sensitivity	Low sensitivity

Step 2C: Overall dust risk ratings

The potential risks for the overall project were found to range from negligible to high, as summarised in Table 9-14.

Specifically, for human receptors the risk of unmitigated dust was medium to high at Blackheath due to the proximity of sensitive receptors to the north, while dust risks at Soldiers Pinch and Little Hartley were low. Unmitigated dust human health risks were considered low across all sites, largely attributed to the low existing PM_{10} background levels as well as low density of sensitive receptors.

The unmitigated risks of dust impacts to ecological receptors at Blackheath and Soldiers Pinch were largely considered high risk due to the proximity of the Blue Mountains National Park and its high ecological sensitivity. Unmitigated ecological risks at Little Hartley were rated medium risk.

Table 9-14 Assessment of unmitigated dust risks for construction activities

Construction area	Activity	Step 2A: Potential for dust emissions	Step 2B: Sensitivity of area			Step 2C: Risk of unmitigated dust impacts		
			Dust	Human health	Ecology	Dust	Human health	Ecology
Blackheath	Demolition	Medium	High	Low	High	Medium	Low	Medium
	Earthworks	Large	High	Low	High	High	Low	High
	Construction	Large	High	Low	High	High	Low	High
	Trackout	Large	High	Low	High	High	Low	High
Soldiers Pinch	Demolition	Small	Low	Low	High	Negligible	Negligible	Medium
	Earthworks	Large	Low	Low	High	Low	Low	High
	Construction	Large	Low	Low	High	Low	Low	High
	Trackout	Large	Low	Low	High	Low	Low	High
Little Hartley	Demolition	Medium	Low	Low	Medium	Low	Low	Medium
	Earthworks	Large	Low	Low	Medium	Low	Low	Medium
	Construction	Large	Low	Low	Medium	Low	Low	Medium
	Trackout	Large	Low	Low	Medium	Low	Low	Medium

Given the unmitigated risk ratings which range from negligible to high for the project, specific activity-based mitigation measures would be implemented to reduce the likelihood of dust being generated. These mitigation measures are outlined in Section 9.7 and would be implemented throughout construction works.

9.5.2 Assessment of impacts of combustion emissions

The source of combustion emissions during the project construction phase would be from combustion of petrol and diesel fuel by light and heavy vehicles travelling to and from site as well as onsite, mobile construction equipment and stationary equipment such as diesel generators.

Construction access is expected to primarily occur from the existing Great Western Highway with access routes shown in Chapter 5 (Construction). Given the existing volume of traffic using the Great Western Highway, combustion emissions from construction traffic on the Great Western Highway are unlikely to result in a notable deterioration in ambient air quality at nearby sensitive receptors.

Combustion emissions from diesel operated mobile equipment as listed in Chapter 5 (Construction) would also result in air pollutant emissions. Stationary diesel generators may be used to provide onsite power to construction ancillary facilities and equipment where access to the electricity grid may not be readily available.

Given the existing volume of traffic utilising the Great Western Highway, it is unlikely that emissions from construction traffic and use of mobile and stationary plant would make a significant impact on local air quality. Typical mitigation and maintenance measures for operation of construction vehicles and plant equipment would be included in the Construction Environmental Management Plan (CEMP) and when applied, adverse air quality impacts from the operation of construction vehicles and plant equipment are expected to be minimal.

9.5.3 Odour emission impact assessment

Potential odour impacts from the site during construction would be temporary in nature. Potential sources of odour would primarily occur from the disturbance of acid sulfate soils or ASR or contaminated soils during earthworks.

Given the extremely low to low probability for intercepting acid sulfate soils across the study area, potential odour risks associated with the project are not considered significant. In the event ASR is encountered during excavation works, measures outlined in the ASR management plan would be implemented. Potential impacts and management measures for ASR are further discussed in Chapter 15 (Soils and contamination).

During tunnel construction between Mount Victoria and Little Hartley coal seam gas or methane gas, which is an odorous gas, may be encountered. See Chapter 13 (Groundwater and geology) for a further discussion on the presence of coal seams in the surrounding geology. Mitigation measures for prevention of gas build-up in the event that coal seam or methane gas is present is discussed in Chapter 13 (Groundwater and geology). The requirement for installation of gas drainage wells would be confirmed during ongoing design development and during construction as tunnelling occurs. Another potential minor source of odour emissions would be from volatile organic compounds (VOCs) released during road pavement construction. Odour emissions from the laying of asphalt are from a complex mixture of hydrocarbons and VOCs and are anticipated to be minor in nature provided appropriate management measures outlined in the CEMP for the project are applied.

9.6 Potential impacts – operation

The ground level concentrations of pollutants from both the ventilation outlet option and the portal emissions option were modelled separately to provide a clear comparison of their respective impacts on local air quality. The emissions from each of these sources was also combined with the background (existing) pollution levels and the emissions from traffic on surface roads to predict total pollutant concentrations and the total change in pollutant concentrations with and without the project.

9.6.1 Assessment of operational impacts of ventilation outlets

NSW EPA criteria

A summary of highest predicted air pollutant ground level concentrations for the ‘with project’ and ‘without project’ scenarios and for the 2018 base year is shown in Table 9-15. Results are compared with NSW EPA criteria from the Approved Methods (NSW EPA, 2022a; NSW EPA, 2022b).

Predicted contributions from the ventilation outlets and total concentrations (project contribution and background) for NO_2 and $PM_{2.5}$ for the project in 2030 and 2040 were below the EPA criteria. There were some exceedances of the EPA maximum one-hour and annual average NO_2 criteria for the base year 2018 scenario and the ‘without project’ scenarios in 2030 and 2040. The results of the modelling indicate a reduction in ground level pollutant concentrations from the project in 2030 as shown in Figure 9-10 to Figure 9-13. This improvement in air quality would be due to the improved traffic flow and reduced traffic volumes along the existing Great Western Highway as a result of traffic diverting to the tunnel, and the reduced gradient in the tunnel compared to the existing Victoria Pass, as well as improved emissions standards.

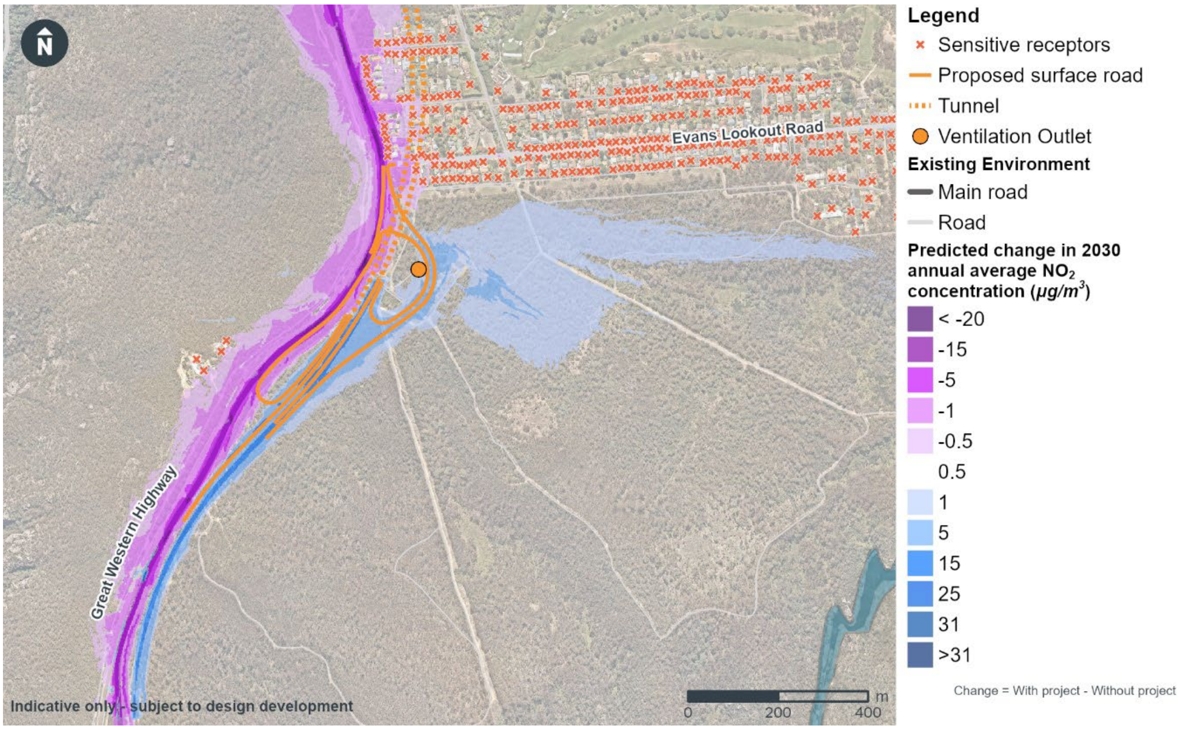

Figure 9-10 Annual average NO_2 concentration change contour for ventilation outlet option in 2030 at Blackheath

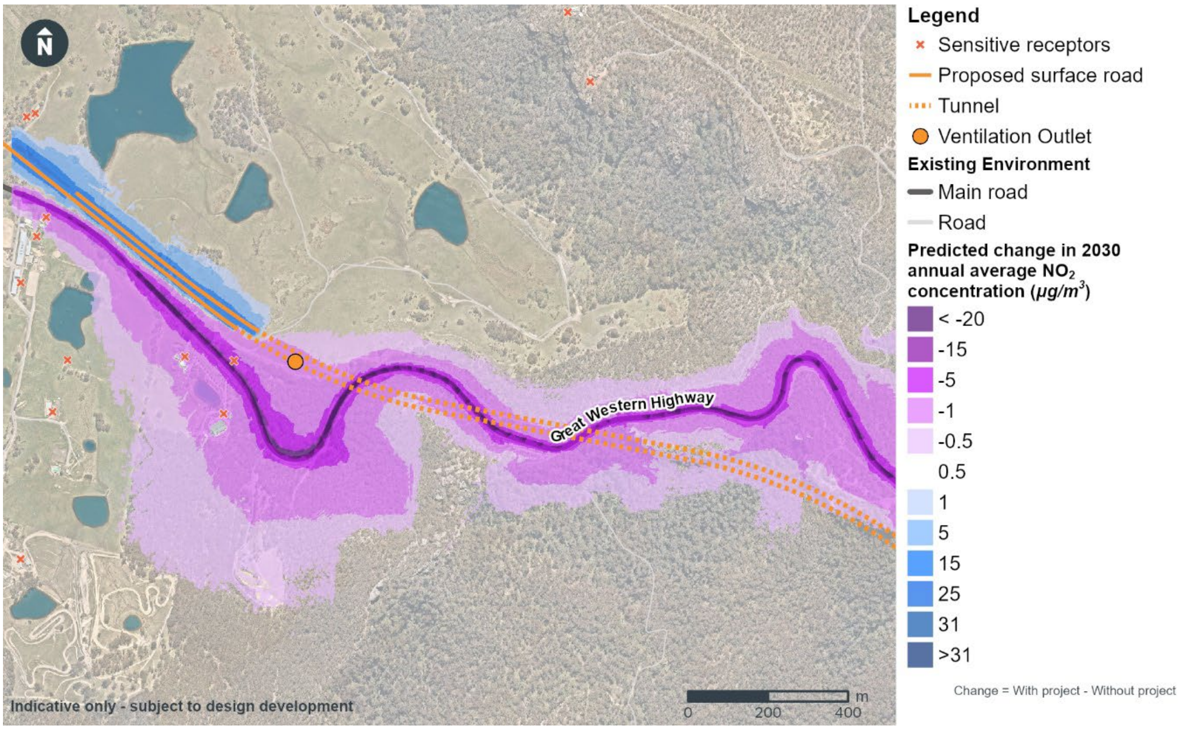

Figure 9-11 Annual average NO_2 concentration change contour for ventilation outlet option in 2030 at Little Hartley

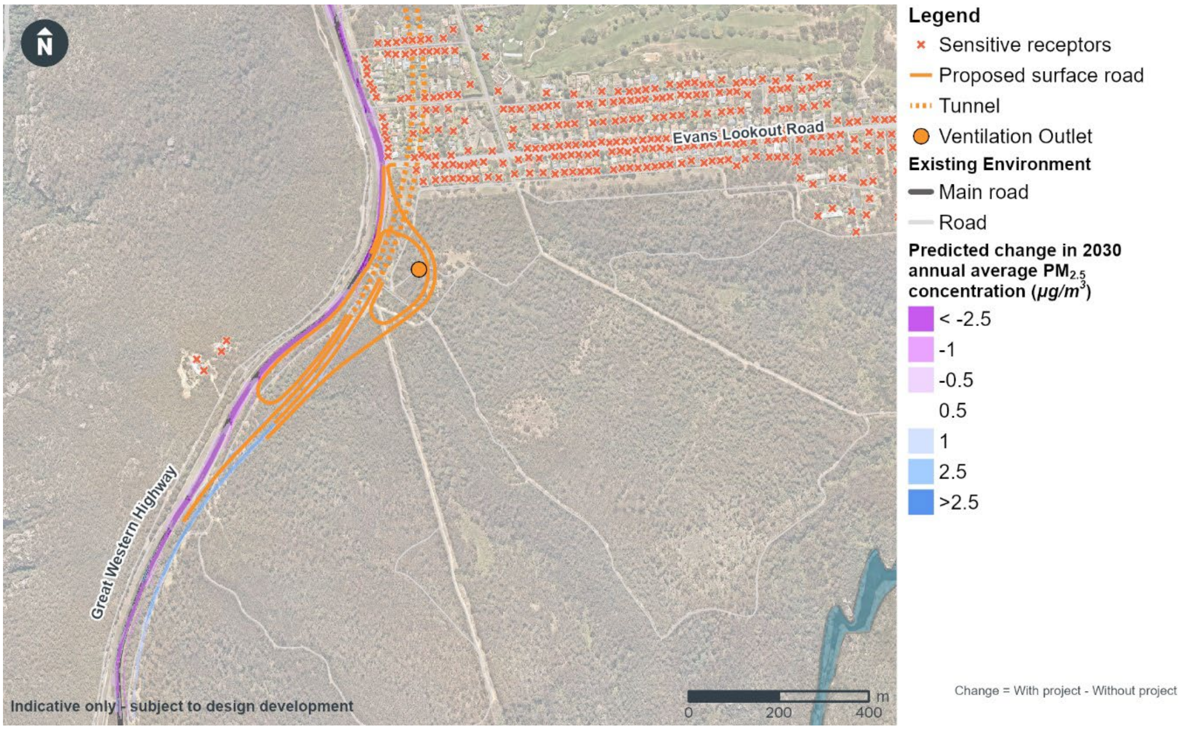

Figure 9-12 Annual average $PM_{2.5}$ concentration change contour for ventilation outlet option in 2030 at Blackheath

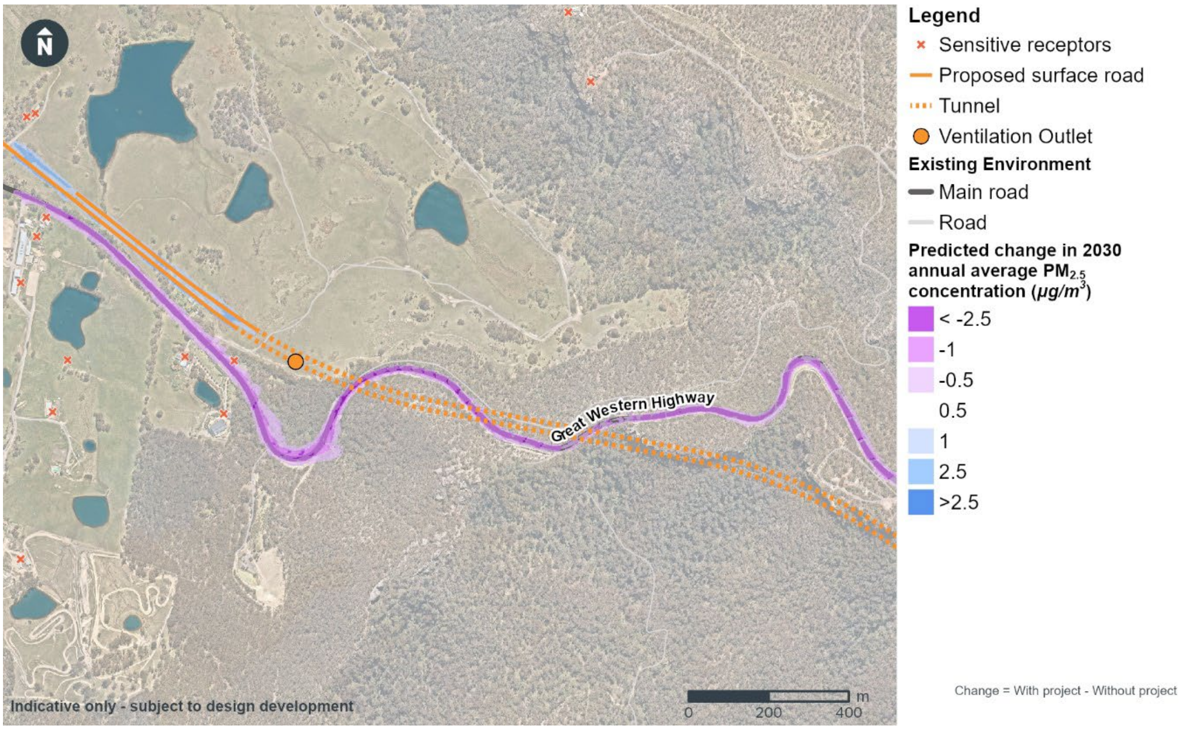

Figure 9-13 Annual average $PM_{2.5}$ concentration change contour for ventilation outlet option in 2030 at Little Hartley

Table 9-15 shows the highest predicted $N0_2$ and $PM_{2.5}$ ground level concentrations for the ventilation outlet option. Both the 2030 and 2040 'without project' scenarios concentrations were lower than the 2018 base year. The difference in concentrations between the base year and future 'without project' scenarios is largely attributed to improved emission standards for vehicles between 2018 and 2030 and between 2030 and 2040. Increased uptake of electric vehicles would further reduce emissions although the future percentage of electric vehicles in the NSW vehicle fleet cannot be reliably predicted at this time and is not included in the emission modelling, hence the results presented are conservative. In 2020, the percentage of electric vehicle new car sales in the NSW was 0.68 per cent (NSW Government, 2021c). The NSW Government has developed an Electric Vehicle Strategy to increase the number of electric vehicles in NSW which are projected to make up 52 per cent of new car sales in 2030-31 (NSW Government, 2021c).

Table 9-15 Highest predicted NO_2 and $PM_{2.5}$ ground level concentrations for the ventilation outlet option

Pollutant	Averaging period	Background concentration (µg/m³)	Baseline (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)		Criteria (µg/m³)*
			Without Project	Without project	With Project	Without project	With Project	
Project only concentrations – ventilation outlet and surface road contribution without background concentrations								
NO_2	Annual Average	NA	19.6	19.5	5.9	12.1	4.7	31
$PM_{2.5}$	24 Hour Maximum	NA	5.8	4.3	0.9	3.5	0.9	25 (20)
	Annual Average	NA	1.9	1.4	0.2	1.1	0.2	8 (7)
Total pollutant concentrations – ventilation outlet and surface road contribution with background concentrations								
NO_2	1 Hour Maximum	49.8	144.5	144.5	136.6	144.5	130.9	164
	Annual Average	6.3	25.9	25.8	12.1	18.4	11.0	31
$PM_{2.5}$	24 Hour Maximum	17.8	21.8	20.7	18.1	20.1	18.1	25 (20)
	Annual Average	5.2	7.1	6.6	5.4	6.3	5.4	8 (7)

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average 2025 $PM_{2.5}$ NEPM goal

In addition to the predicted highest ground level concentrations at a receptor reported above, Table 9-16 provides a summary of predicted cumulative NO_2 and $PM_{2.5}$ concentrations at SHR receptors. Predicted total annual average NO_2 and $PM_{2.5}$ concentrations were below the EPA criteria (and below the 2025 annual average NEPM goal for $PM_{2.5}$) for all modelled scenarios.

About 79 per cent of receptors would experience a decrease in concentration of annual average NO_2 and about 76 per cent of all receptors would experience a decrease in annual average $PM_{2.5.}$

In 2030, less than 21 per cent of the 1,092 receptors would experience a very minor increase of up to 0.5 µg/m³ in annual average NO_2 and up to 0.1 µg/m³ in annual average $PM_{2.5.}$ These changes in concentration are unlikely to be discernible from measured background concentrations.

As such no significant air quality impacts are predicted for the project for the ventilation outlet option.

Table 9-16 Predicted total annual NO_2 and $PM_{2.5}$ concentrations at local educational facilities for the ventilation outlet option

Sensitive receptor	Base year (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)	
		Without project	Project	Without project	Project
Predicted total annual average NO_2 concentrations					
Kookaburra Kindergarten	9.7	9.7	9.3	9.4	9.3
Blue Gum Montessori	9.6	9.5	9.5	9.4	9.4
Blackheath Public School	9.2	9.2	9.3	9.2	9.2
Blue Mountains Christian School	9.2	9.2	9.4	9.2	9.2
Possum's Patch Childcare Centre	10.1	10.1	9.4	9.6	9.3
Mount Victoria Public School	12.6	12.4	10.0	10.8	9.7
One School Global NSW	9.8	9.7	9.3	9.4	9.2
Criteria (µg/m³)	31				
Predicted total annual average $PM_{2.5}$ concentrations					
Kookaburra Kindergarten	5.2	5.2	5.2	5.2	5.2
Blue Gum Montessori	5.2	5.2	5.2	5.2	5.2
Blackheath Public School	5.2	5.2	5.2	5.2	5.2
Blue Mountains Christian School	5.2	5.2	5.2	5.2	5.2
Possum's Patch Childcare Centre	5.3	5.3	5.2	5.2	5.2
Mount Victoria Public School	5.5	5.4	5.3	5.4	5.3
One School Global NSW	5.2	5.2	5.2	5.2	5.2
Criteria (µg/m³)	8 (7)				

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average PM2.5 2025 NEPM standard

Figure 9-14 and Figure 9-15 illustrate the spatial distribution of the plume under the ventilation outlet option at Blackheath and Little Hartley respectively, for typical daily traffic in 2030. The shading represents the concentrations resulting from the ventilation outlet contribution to the annual average $PM_{2.5}$ ground level concentrations.

Modelled results for other pollutants compared against the NSW EPA criteria, including results for maximum daily traffic and regulatory worst case ventilation emission profiles are reported in Section 8 of Appendix E (Technical report – Air quality).

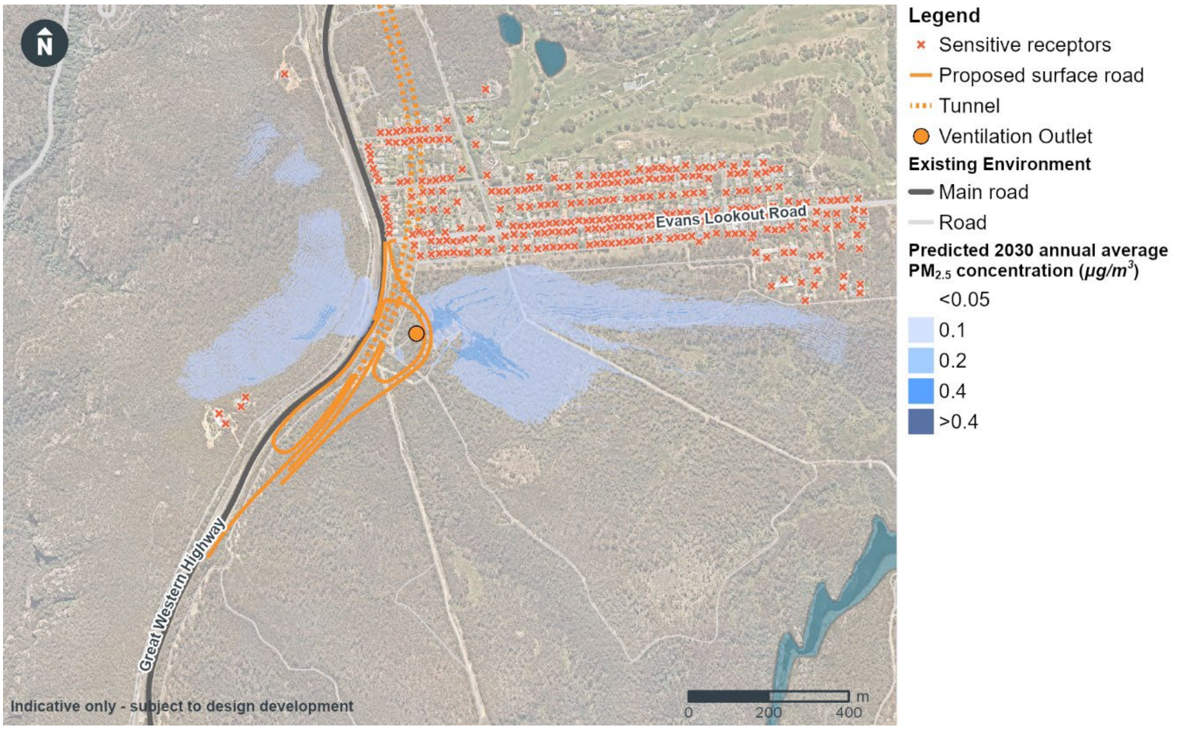

Figure 9-14 Contribution to annual average $PM_{2.5}$ concentrations at Blackheath for the ventilation outlet option (typical daily traffic in 2030)

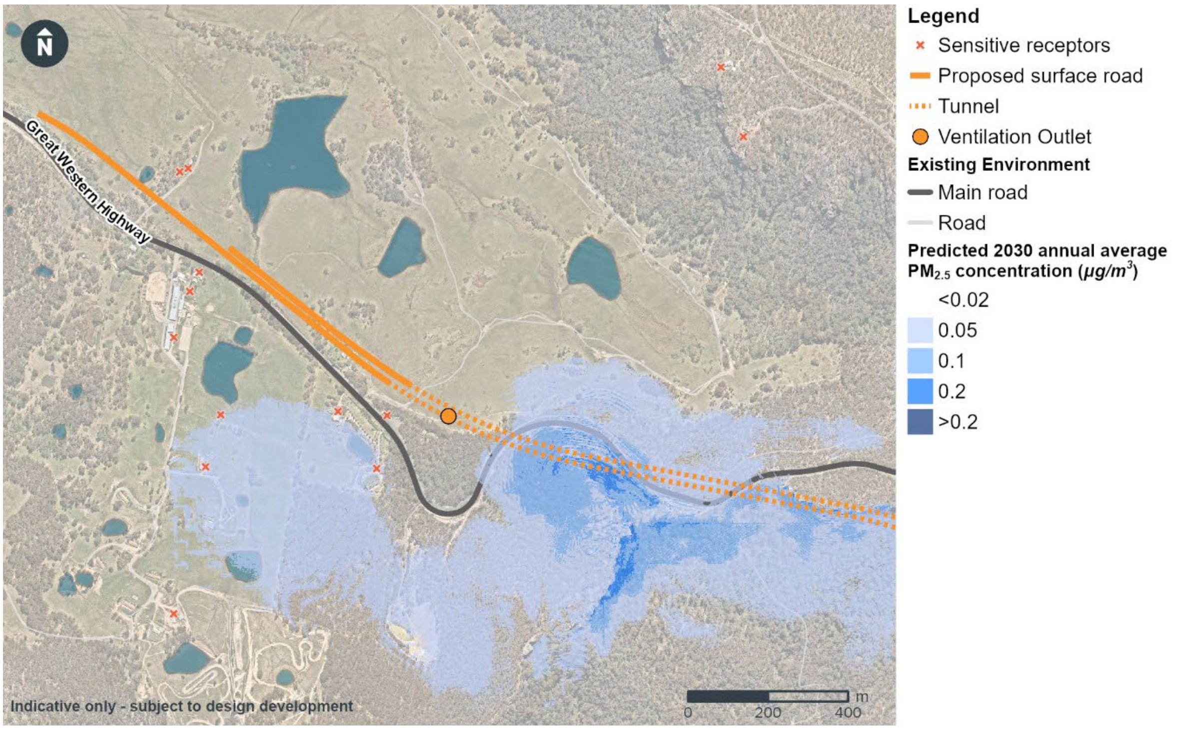

Figure 9-15 Contribution to annual average $PM_{2.5}$ concentrations at Little Hartley for the ventilation outlet option (typical daily traffic in 2030)

Modelled results for other pollutants compared against the NSW EPA criteria, are reported in Section 8 of Appendix E (Technical report – Air quality).

9.6.2 Assessment of operational impacts from portal emissions

The predicted modelling results for portal emissions indicate a reduction in ground level pollutant concentrations from the project as shown in Figure 9-16 to Figure 9-19. This improvement in air quality would be due to the improved traffic flow and reduced traffic volumes along the existing Great Western Highway as a result of traffic diverting to the tunnel, and the reduced gradient in the tunnel compared to the existing Victoria Pass, as well as improved emissions standards.

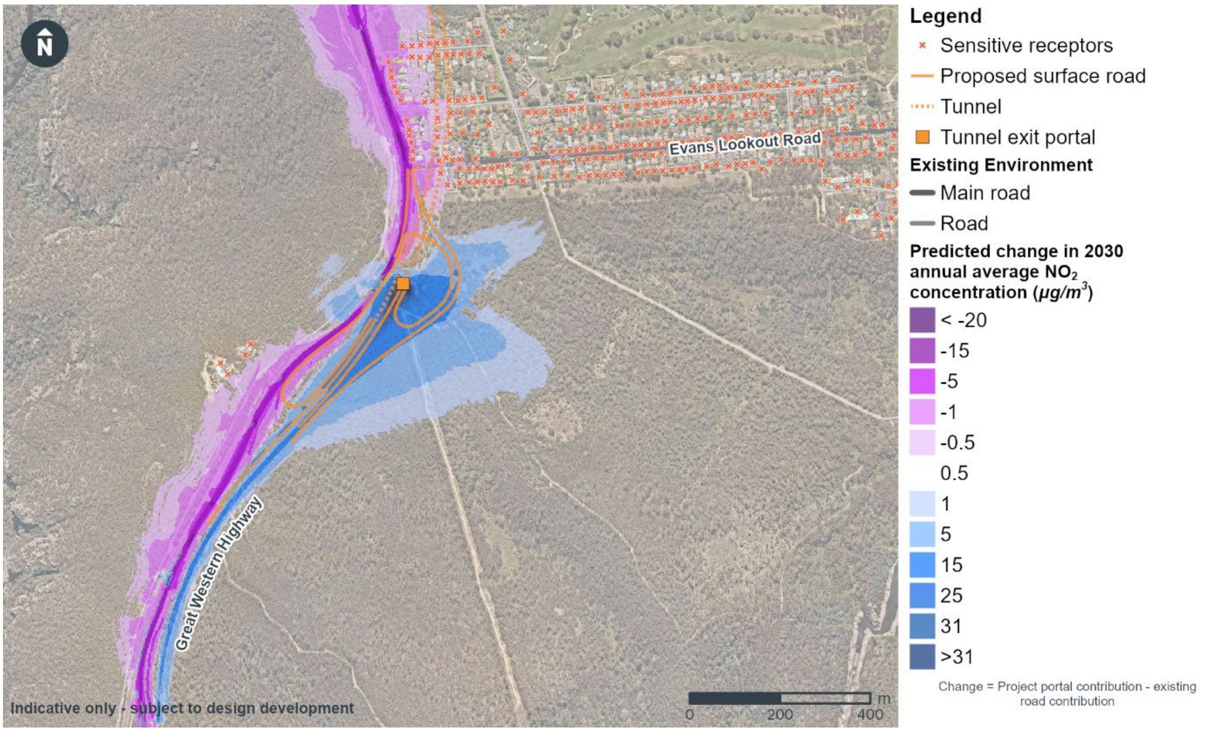

Figure 9-16 Annual average NO_2 concentration change contour for portal emissions option in 2030 at Blackheath

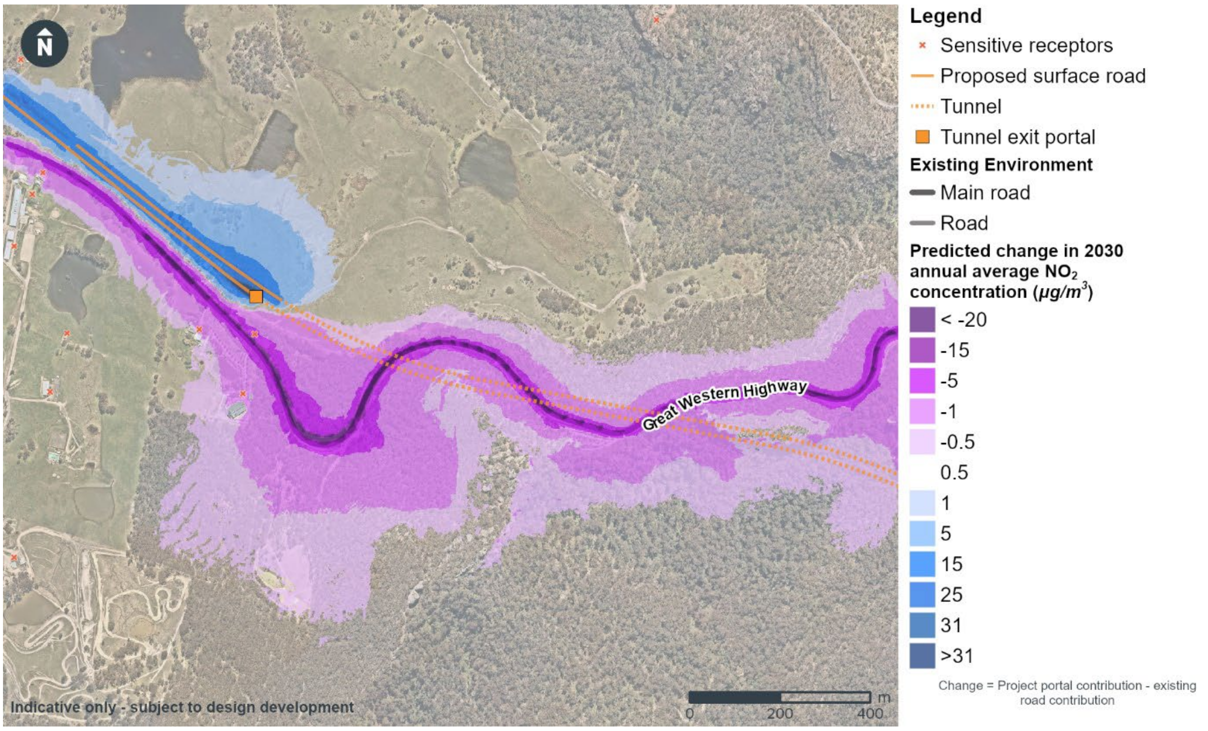

Figure 9-17 Annual average NO_2 concentration change contour for portal emissions option in 2030 at Little Hartley

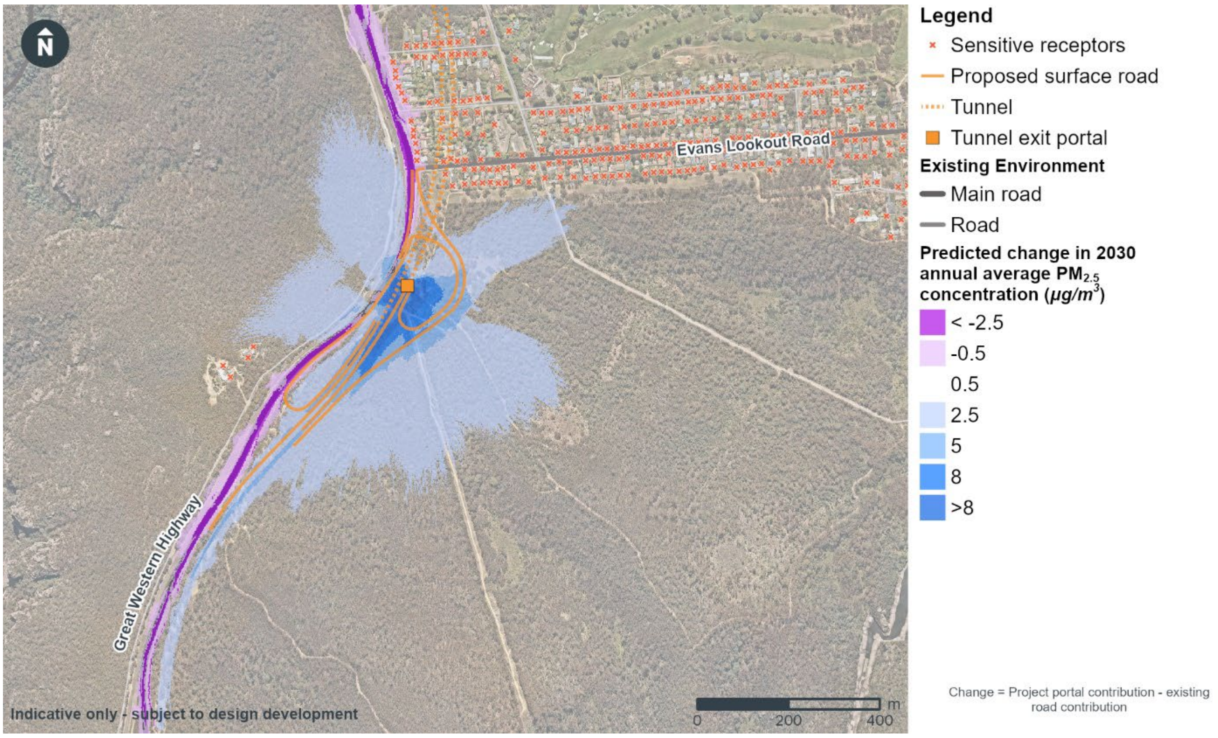

Figure 9-18 Annual average $PM_{2.5}$ concentration change contour for portal emissions option in 2030 at Blackheath

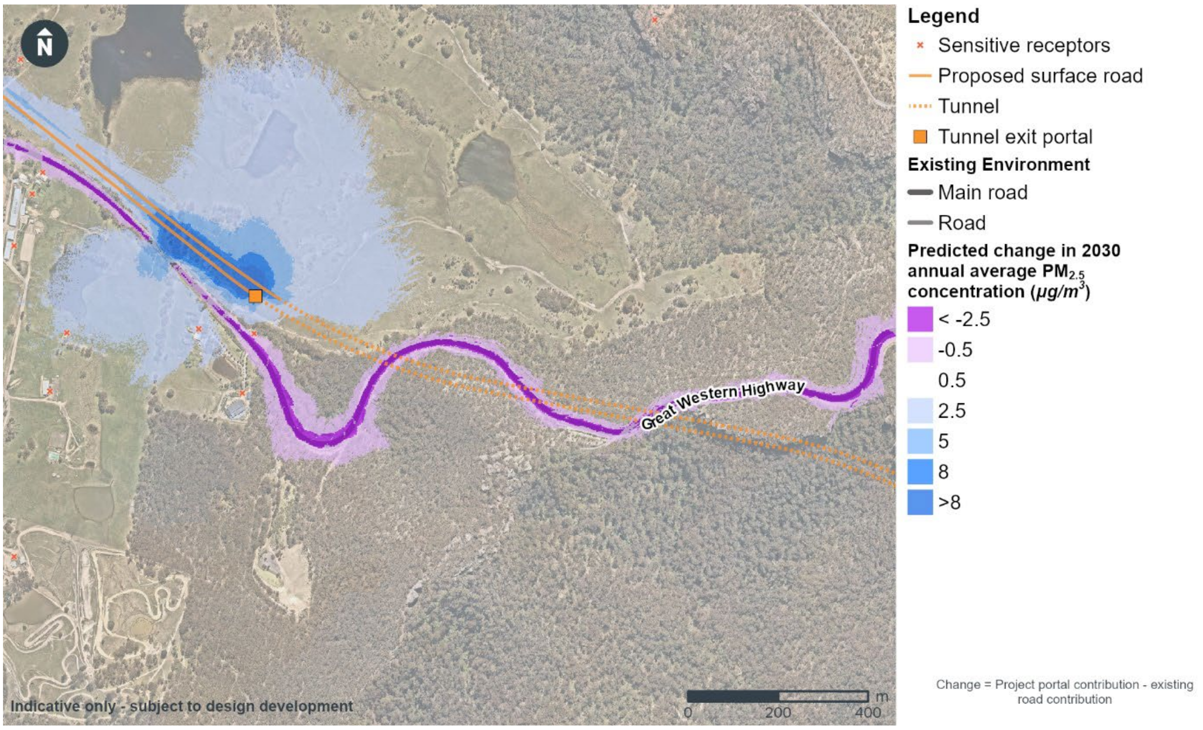

Figure 9-19 Annual average $PM_{2.5}$ concentration change contour for portal emissions option in 2030 at Little Hartley

NSW EPA criteria

A summary of the highest ground level pollutant concentrations from portal emissions for all traffic scenarios (Blackheath and Little Hartley receptors combined) is provided in Table 9-17.

Table 9-17 Predicted highest NO_2 and $PM_{2.5}$ concentrations for the portal emissions option

Pollutant	Averaging period	Background concentration	Base year 2018	2030 Without project	2030 Project	2040 Without project	2040 Project	Criteria
		(µg/m³)						
Project pollutant concentration – all project sources in isolation from background								
NO_2	Annual Average	NA	19.6	19.5	7.8	12.1	5.0	31
$PM_{2.5}$	24 Hour Maximum	NA	5.8	4.3	1.5	3.5	1.7	25 (20)
	Annual Average	NA	1.9	1.4	0.5	1.1	0.6	8 (7)
Total pollutant concentrations – all project sources including background								
NO_2	1 Hour Maximum	49.8	144.5	144.5	142.3	144.5	131.8	164
	Annual Average	6.3	25.9	25.8	14.1	18.4	11.3	31
$PM_{2.5}$	24 Hour Maximum	17.8	**21.8**	**20.7**	18.6	**20.1**	18.7	25 (20)
	Annual Average	5.2	**7.1**	6.6	5.7	6.3	5.8	8 (7)

Table notes:

1. Criteria in parenthesis represent the maximum 24 hour and annual average $PM_{2.5}$ NEPM goals proposed for 2025.
2. Bold entries denote exceedances of the proposed NEPM goal. Note the only exceedances are without the project.

In addition to the predicted highest ground level concentrations at a receptor reported above, Table 9-18 provides a summary of predicted total NO_2 and $PM_{2.5}$ concentrations at identified sensitive receptors. Predicted total annual average NO_2 and $PM_{2.5}$ concentrations were below the EPA criteria (and below the 2025 annual average NEPM goal for $PM_{2.5}$) for all modelled scenarios. As such no significant air quality impacts are predicted for the project under the portal emission option for the specific sensitive receptors.

Table 9-18 Predicted total annual NO_2 and $PM_{2.5}$ concentrations at local educational facilities for the portal emissions option

Sensitive Receptor	Base year (2018) (µg/m³)	Design opening year (2030) (µg/m³)		Ten years after opening (2040) (µg/m³)	
		Without project	Project	Without project	Project
Predicted total annual average NO_2 concentrations					
Kookaburra Kindergarten	9.7	9.7	9.3	9.4	9.3
Blue Gum Montessori	9.6	9.5	9.5	9.4	9.4
Blackheath Public School	9.2	9.2	9.2	9.2	9.2
Blue Mountains Christian School	9.2	9.2	9.2	9.2	9.2
Possum's Patch Childcare Centre	10.1	10.1	9.4	9.6	9.3
Mount Victoria Public School	12.6	12.4	10.0	10.8	9.7
One School Global NSW	9.8	9.7	9.3	9.4	9.2
Criteria (µg/m³)	31				
Predicted total annual average $PM_{2.5}$ concentrations					
Kookaburra Kindergarten	5.2	5.2	5.2	5.2	5.2
Blue Gum Montessori	5.2	5.2	5.2	5.2	5.2
Blackheath Public School	5.2	5.2	5.2	5.2	5.2
Blue Mountains Christian School	5.2	5.2	5.2	5.2	5.2
Possum's Patch Childcare Centre	5.3	5.3	5.2	5.2	5.2
Mount Victoria Public School	5.5	5.4	5.3	5.4	5.3
One School Global NSW	5.2	5.2	5.2	5.2	5.2
Criteria (µg/m³)	8 (7)				

Table notes:

1. Criteria in parenthesis represent maximum 24 hour and annual average PM2.5 NEPM standard that may be adopted by NSW EPA in the future.

Figure 9-20 and Figure 9-21 illustrate the spatial distribution of the plume from the portal emission option at Blackheath and Little Hartley respectively, for typical daily traffic in 2030. The shading represents the concentrations resulting from the ventilation outlet contribution to the annual average $PM_{2.5}$ ground level concentrations.

Modelled results for other pollutants compared against the NSW EPA criteria, are reported in Section 8 of Appendix E (Technical report – Air quality).

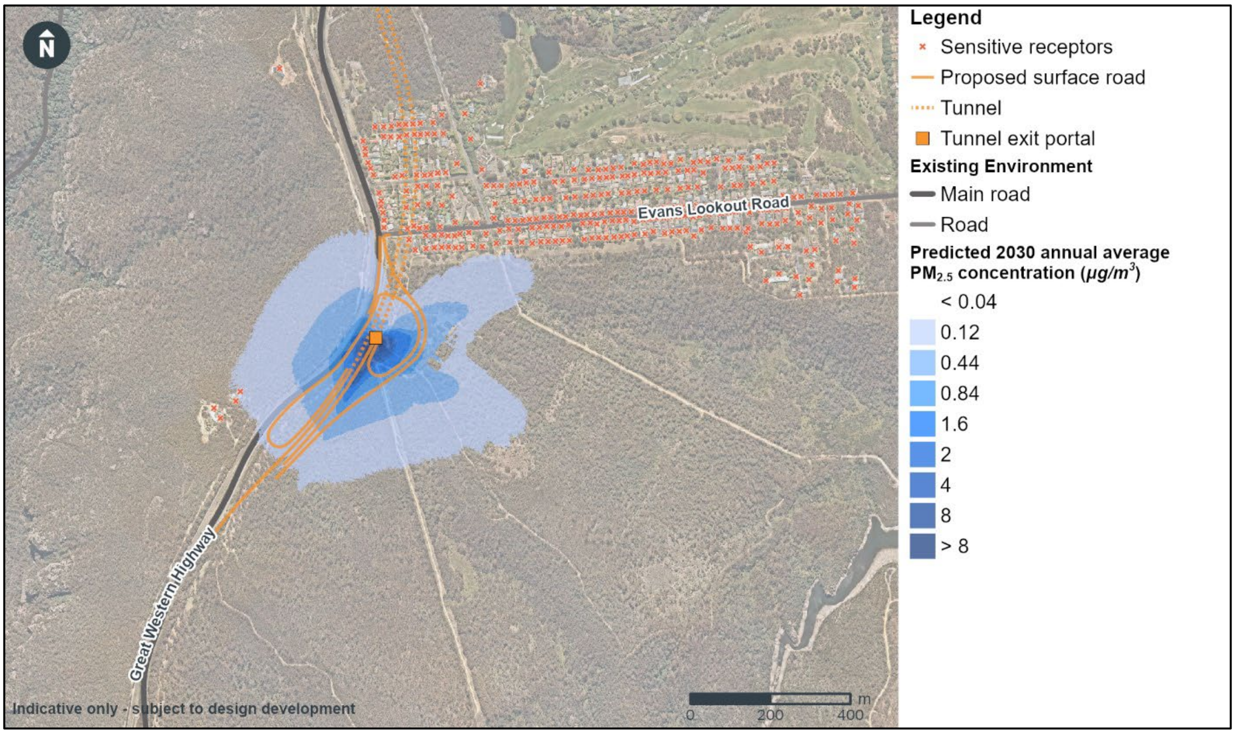

Figure 9-20 Contribution to annual average $PM_{2.5}$ concentrations at Blackheath for the portal emissions option (typical daily traffic in 2030)

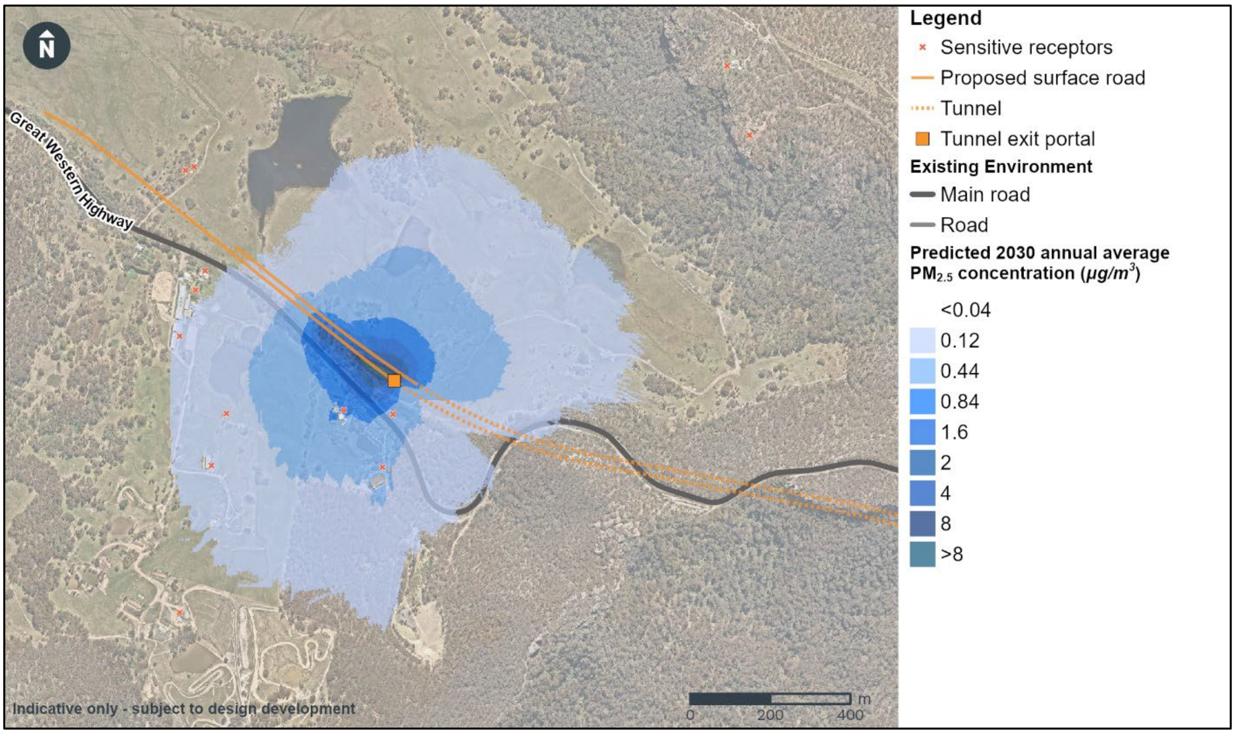

Figure 9-21 Contribution to annual average $PM_{2.5}$ concentrations at Little Hartley for the portal emissions option (typical daily traffic in 2030)

9.6.3 Comparison of ventilation options

This comparison is based on the typical daily traffic and for the annual average NO_2 and $PM_{2.5}$ for 2030 and 2040. Results for the maximum daily traffic and regulatory worst case are provided in Section 8 of Appendix E (Technical report – Air quality).

Figure 9-22 shows the incremental contributions of each ventilation option for NO_2 and $PM_{2.5}$ comparing the highest ground level concentrations for 2030 and 2040. The figure shows:

- for NO_2 in 2030 the maximum one-hour concentrations at the highest receptor concentration was around 16 per cent higher for the portal emissions option as a percentage of the EPA criteria and around 6.4 per cent higher for the annual average. The predicted one-hour maximum and annual average concentration at the receptor with the highest NO_2 concentration were within two per cent of each other for the ventilation options for 2040
- for $PM_{2.5}$ both the 24-hour maximum and annual average concentrations are slightly higher for the portal option. A difference of 2.1 to 2.8 per cent of the EPA criteria was predicted for the 24-hour maximum and 3.6 to 4.4 per cent of the EPA criteria was predicted for the annual average.

Both ventilation options meet the criteria for NO_2 and $PM_{2.5}$ under all averaging periods. Further comparison of operational air quality impacts associated with different ventilation options is provided in Section 8.4 of Appendix E (Technical report – Air quality).

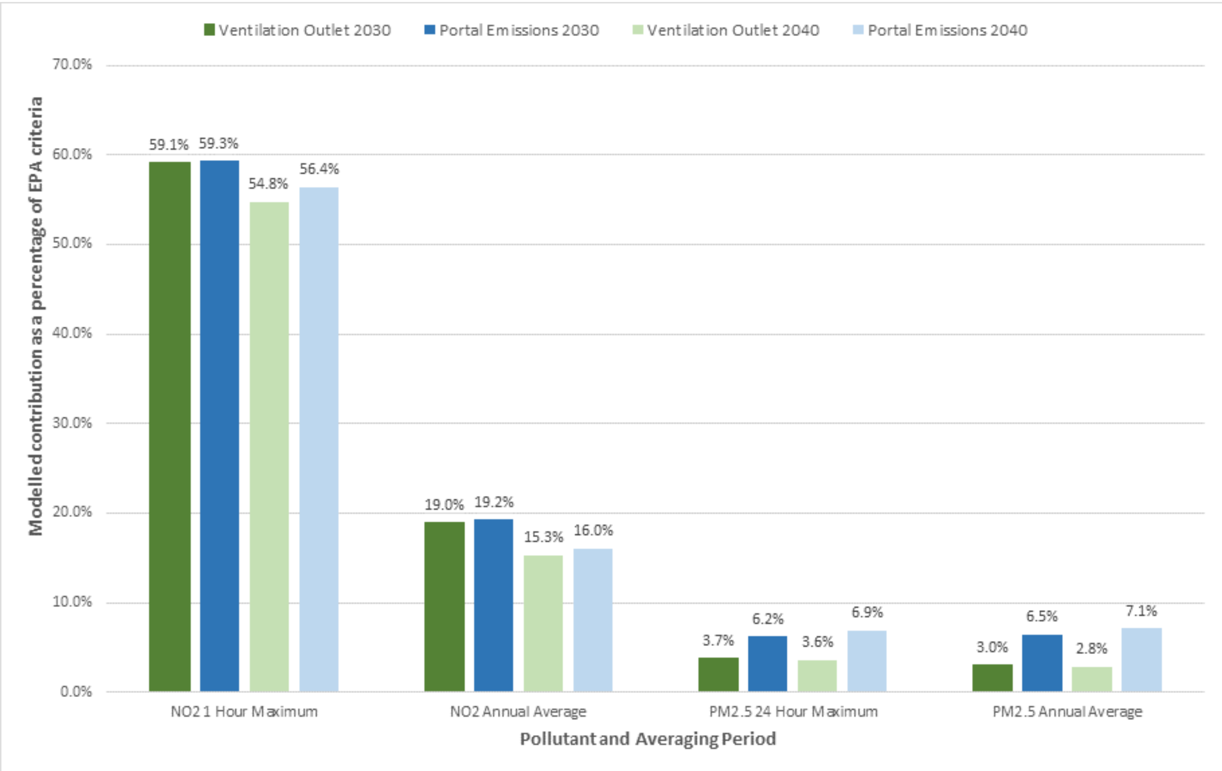

Figure 9-22 Comparison of highest NO_2 and $PM_{2.5}$ receptor concentrations (ventilation outlet and portal options only)

Annual average NO_2 concentrations

Predicted differences in annual average NO_2 concentrations between ventilation options are relatively small when compared to the EPA criteria of 31µg/m^3.

While slightly higher annual average NO_2 concentrations are generally predicted for the portal emissions option, the difference in predicted contributions for the ventilation option and portal emissions option at receptors are unlikely to be discernible from background air quality concentrations.

Annual average $PM_{2.5}$ concentrations

Predicted differences in annual average $PM_{2.5}$ concentrations between ventilation options are small when compared to the EPA criteria of 8µg/m^3.

Comparison of ventilation options using project impact descriptors

Ventilation options have been analysed against the specific project impact assessment descriptors endorsed by ACTAQ (EMM Consulting, 2022) for annual average NO_2 and $PM_{2.5}$ as discussed in Section 9.2.2.

Comparison of predicted annual average absolute changes in concentration and impact descriptors at sensitive receptors for NO_2 and $PM_{2.5}$ for 2030 and 2040 using typical daily traffic are summarised here and reported in more detail in Appendix E (Technical report – Air quality).

Given most receptors modelled along the Great Western Highway will experience a decrease in concentration (with vehicle numbers on the surface roads decreasing), the data has been compared showing whether there is an associated decrease or increase in concentration for each descriptor classification.

Annual average NO_2

Results of the comparison indicate that:

- there is no material difference in air quality outcomes for the two ventilation options, with predicted pollutant concentration increases at all receptors rated 'negligible' for each ventilation option
- slight, moderate, or substantial beneficial impacts are predicted at a similar number of receptors for each option.

Annual average $PM_{2.5}$

Results of the comparison indicate that:

- for both ventilation options, changes in concentrations are negligible; with all predicted adverse impacts assigned a negligible impact rating, with exception of one receptor at Little Hartley for the portal emissions option predicted to experience a slight adverse impact in 2030 and moderate adverse impact in 2040
- some slight to moderate beneficial impacts were observed for some receptors for both ventilation options. Differences between the number of sensitive receptors that were predicted to experience a slight or moderate decrease in annual average $PM_{2.5}$ for each ventilation option were very small.

Results of the comparison indicate there is no material difference in air quality outcomes for the two ventilation options; with predicted pollutant concentration increases at all receptors rated 'negligible' for each ventilation option. Slight to moderate beneficial impacts predicted at a similar number of receptors for each option.

Summary of operational air quality impacts for both ventilation options

Typical daily traffic

Comparison of predicted modelling results for the two ventilation options showed some differences in spatial distribution of pollutants, but no material difference in potential air quality impacts when all sensitive receptors are considered.

The results of the air quality impact assessment for both ventilation options show that for typical daily traffic:

- most (76-79 per cent) sensitive receptors would be expected to experience a decrease in pollutant concentrations. The largest decreases in ground level pollutant concentrations would be expected along the existing Great Western Highway due to the reduced traffic volumes as traffic would divert to the tunnel
- the total ground level concentrations for NO_2, CO, PM_{10} and $PM_{2.5}$ at all sensitive receptors were below the EPA criteria
- predicted contributions from both ventilation options were generally low when compared to existing background pollutant levels, the EPA criteria and NEPM goals

- predicted contributions from both ventilation options and surface roads were below the relevant EPA criteria for VOCs and PAHs at less than one per cent of the criteria. Based on the low-level concentrations for toluene, acetaldehyde and xylene, no odour impacts from vehicle exhausts are anticipated.

Maximum daily traffic

The maximum daily traffic profile reflects traffic conditions that are only expected to occur for a small number of days per year; identified as peak days where the total bi-directional traffic flow is above 1,300 vehicles per hour. Results of the modelling for the maximum daily traffic profile indicated that, for both the ventilation outlet and portal emissions options:

- there are no predicted exceedances of the EPA criteria for all pollutants under all averaging periods in 2030 and 2040
- predicted concentrations as a result of the project for all pollutants are higher for the 2030 modelled scenario than the 2040 scenario, which is consistent with observations made in relation to the typical daily traffic scenario and is a result of improved emissions from the vehicle fleet
- predicted ground level pollutant concentrations for all modelled scenarios were lower than the equivalent daily average traffic emission profile scenarios. This was attributed to the traffic mix being a higher proportion of light passenger vehicles with a much lower proportion of heavy vehicles expected on the small number of days characterised by the maximum daily traffic profile.

Regulatory worst case

The regulatory worst case emission profile reflects the potential emission concentrations that could theoretically occur when tunnel emissions are equal to the emission concentration limits set by the EPA under the EPL for the project. Predicted ground level concentrations at sensitive receptors for the regulatory worst-case scenarios for both ventilation options were found to be compliant with relevant EPA criteria for all pollutants examined. This indicates that operation of either the ventilation outlet option or the portal emissions option would operate under the proposed emission limits and within the limits of the EPA criteria. Further detail of assessment for all pollutants during operation is reported in Section 8 of Appendix E (Technical report – Air quality).

9.6.4 Assessment of odour impacts

The following provides an assessment of potential odour impacts from vehicle emissions associated with the project. Potential odour impacts have been assessed based on individual odorous air pollutants for VOCs ethylbenzene, toluene, acetaldehyde and xylene.

Table 9-19 provides a summary of one-hour 99.9th percentile ground level concentrations at the worst affected sensitive receptor for ethylbenzene, toluene, acetaldehyde, and xylene for all modelled scenarios for the typical daily traffic emission profile. Additional information for peak day and regulatory worst-case scenarios is discussed in Section 8 of Appendix E (Technical report – Air quality).

Predicted one-hour 99.9th percentile ground level concentrations at the worst affected receptors in Table 9-19 are well below the air quality assessment criteria for all pollutants at less than one per cent of the criteria, for all modelled scenarios. The change in concentration at the worst affected receptors was negligible for both ventilation outlet and portal emissions options for 2030 and 2040. The predicted minor reduction in VOC concentrations is the same for both options indicating the worst affected receptor was largely influenced by changes to surface road emissions.

Given the very low predicted ground level concentrations for individual odorous pollutants; and predicted changes in concentration with and without the project were less than one per cent of the relevant criteria, no noticeable odour impacts from vehicle emissions are anticipated from operation of the project.

Table 9-19 Predicted 1-hour 99.9th percentile concentrations for individual odours VOCs

Pollutant	1-hour 99.9th percentile concentration (µg/m³)					Criteria (µg/m³)	Change in concentration (µg/m³)	
	Existing	2030		2040			2030	2040
		Without project	With project	Without project	With project			
Ventilation outlet								
Ethylbenzene	0.2	0.06	0.01	0.03	0.01	8000	-0.04	-0.02
Toluene	1.08	0.32	0.08	0.17	0.04	360	-0.25	-0.13
Acetaldehyde	0.12	0.04	0.01	0.02	<0.01	42	-0.03	-0.01
Xylene	0.81	0.24	0.06	0.13	0.03	190	-0.18	-0.10
Portal emissions								
Ethylbenzene	0.20	0.06	0.02	0.03	0.01	8000	-0.04	-0.02
Toluene	1.08	0.32	0.09	0.17	0.04	360	-0.23	-0.13
Acetaldehyde	0.12	0.04	0.01	0.02	<0.01	42	-0.03	-0.01
Xylene	0.81	0.24	0.07	0.13	0.03	190	-0.17	-0.10

9.6.5 Assessment of ecological impacts

Assessment of ecological impacts has been undertaken for the project in 2030 and 2040 for the typical daily traffic emission profile and a summary of the assessment for both ventilation options is provided below. Evaluation of ecological impacts for both ventilation options was undertaken by visually examining predicted modelled contribution contours at ecological receptors and comparing the concentrations to the identified ecological impact assessment markers.

Predicted cumulative impacts (project contribution plus background concentrations) for both ventilation options were found to be below the environmental assessment markers for ecological receptors, with no material difference between the options. Predicted cumulative concentrations at ecological receptors are as follows:

- the modelled annual average NO_2 contribution when added to a background concentration of 6.3 µg/m³ and compared to the assessment criteria of 30 µg/m³ were:
  - below 9.7 µg/m³ for the ventilation outlet option
  - below 12.8 µ/m³ for portal emissions option
- for the maximum 30-minute toluene modelled contributions when compared to the assessment criteria of 1,100 µg/m³ were:
  - below 0.1 µg/m³ for the ventilation outlet option
  - below 0.1 µ/m³ for portal emissions option
- for the maximum 10-hour $PM_{2.5}$ modelled contributions when added to a background concentration[4] of 35.3 µg/m³ when compared to the assessment criteria of 50 µg/m³ were:
  - below 36.8 µg/m³ for the ventilation outlet option
  - below 45.3 µ/m³ for portal emissions option.

Based on the predicted cumulative concentrations for all examined pollutants, no significant air quality related ecological impacts are anticipated from the project for either ventilation option.

[4] The 10-hour maximum $PM_{2.5}$ background concentration was derived from the unified data set as described in Appendix E (Technical report – Air quality).

9.6.6 In-tunnel air quality

Figure 9-23 and Figure 9-24 show the predicted in tunnel air 15-minute average NO_2 concentrations and visibility (based on in-tunnel $PM_{2.5}$ emissions) for the project for 2030 and 2040. The results of the ventilation analysis show that both predicted NO_2 concentrations and visibility are well below the in-tunnel air quality criteria for eastbound and westbound typical daily traffic in 2030 and 2040.

The analysis and results for maximum daily expected traffic and worst case scenarios, are provided in Annexure D of Appendix E (Technical report – Air quality).

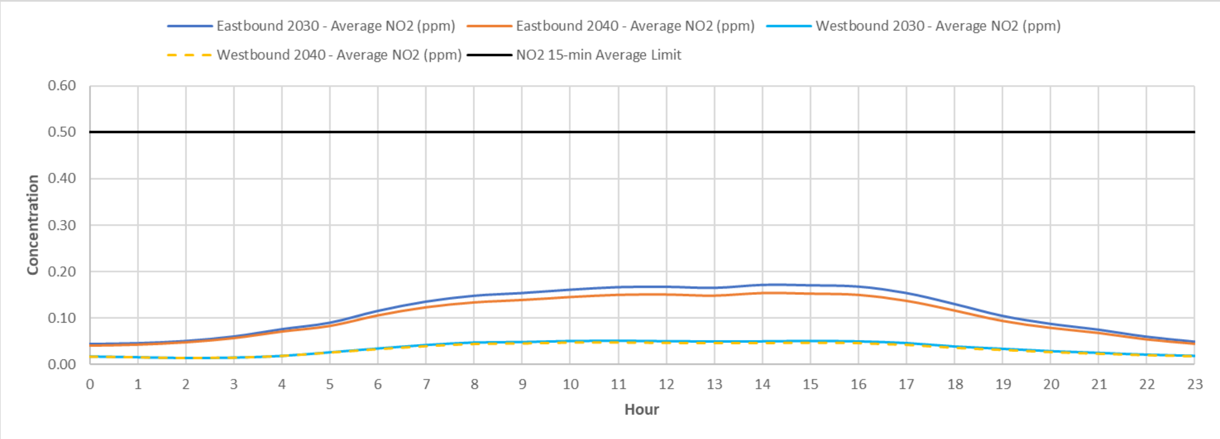

Figure 9-23 Predicted 15-min average NO_2 concentrations (ppm) for typical daily traffic operations for 2030 and 2040 (Stacey Agnew, 2022)

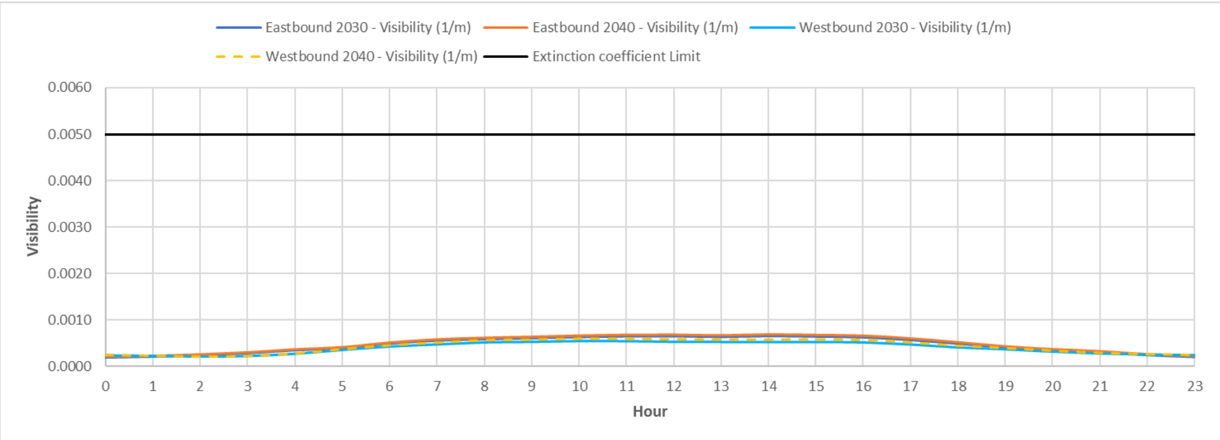

Figure 9-24 Predicted 15-min average visibility (1/m) for expected traffic operations for 2030 and 2040 (Stacey Agnew, 2022)

9.7 Environmental mitigation measures

9.7.1 Performance outcomes

Performance outcomes for the project in relation to air quality are listed in Table 9-20 and identify measurable performance-based standards for environmental management.

Table 9-20 Air quality performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed, constructed and operated in a manner that minimises air quality impacts (including nuisance dust and odour) to minimise risks to human health and the environment to the greatest extent practicable.	Design, construct and operate the project to achieve applicable amenity and human health based in-tunnel and ambient air quality criteria, including in relation to nuisance dust and odour.	Design, construction and operation

9.7.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential air quality impacts as a result of the project are outlined in Table 9-21. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 9-21 Environmental mitigation measures – air quality

ID	Mitigation measure	Timing
AQ1	Construction activities will be managed to minimise the emission of visible dust beyond the construction footprint. Measures to minimise the generation and emission of dust will be detailed in the Construction Environmental Management Plan (CEMP), and applied to relevant construction locations and construction activities. Dust mitigation measures for each location/ activity may include one or more of the following: • visual inspection of construction sites to identify sources of dust emissions, taking into account weather conditions (particularly dry and windy conditions) and the scale, nature and intensity of construction activities • scheduling of dust generating activities to minimise potential for elevated cumulative dust generation • location and management of dust generating stockpiles away from sensitive human and ecological receptors • application of measures to minimise dust generation from surfaces and stockpiles, such as sealing (or other treatment), application of water sprays, covers and enclosures, dust barriers or similar • progressive site rehabilitation or stabilisation to minimise the potential for and duration of dust generation from disturbed areas • implementation of speed limits on unsealed roads and other trafficked surfaces.	Construction
AQ2	Air emissions from construction plant and equipment will be minimised by: • using mains electricity or battery powered equipment instead of diesel- or petrol-powered generators where practicable • switching off vehicles, plant and equipment when not in use • using lower emissions plant and equipment where feasible and reasonable.	Construction

ID	Mitigation measure	Timing
AQ3	Dust emissions from construction vehicles travelling to or from the construction footprint will be minimised by: • covering dust generating loads where practicable • implementing a wheel washing system at relevant construction site access points (with rumble grids to dislodge accumulated dust and mud prior to leaving the site) where practicable • using water-assisted sweepers or similar on access roads around the construction footprint to remove any material tracked onto those roads by construction traffic.	Construction
AQ4	The existing air quality monitoring program will be reviewed in consultation with relevant stakeholders and updated and implemented to confirm the in-tunnel air quality and ambient air quality performance of the project during the first two years of operation.	Operation
AQ5	The tunnel walls will be cleaned as part of routine maintenance to reduce concentrations of small particles.	Operation
AQ6	If required, in-tunnel air quality will be managed by temporary in-tunnel traffic management measures. These temporary measures will be communicated to tunnel users using a range of methods including traffic lights, barriers, variable message signs, radio broadcasts and public address systems (used in emergencies).	Operation