Appendix F

Air Quality Impact Assessment

Prepared for
Transport for NSW
ABN: 18 804 239 602

AECOM

Air Quality Impact Assessment

Technical Report

18-Jul-2022
Westlink M7 Widening

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Air Quality Impact Assessment

Client: Transport for NSW

ABN: 18 804 239 602

Prepared by

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Quality Information

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Reviewed by David Rollings David Rollings

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	24-Jun-2022	For Client Review	David Rollings Associate Director – Air Quality	
1	14-Jul-2022	Updated draft for review	David Rollings Associate Director - Air Quality	
2	18-Jul-2022	Final Report	David Rollings Associate Director - Air Quality	

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Glossary and abbreviations

Key terms	Description
Approved project	The Westlink M7 (previously referred to as Western Sydney Orbital) is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, the Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek.
Conditions of Approval (CoA)	These are the current conditions that apply to the approved project. Found here: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-663-MOD-5%2120190718T013836.398%20GMT
Construction footprint	The area required for construction of the Proposed Modification
Modification	Proposed changes to be made to the conditions of approval for the approved project.
Operational footprint	The area required for operation of the Proposed Modification
Proposed Modification	The addition of a trafficable lane in both directions within the existing median of the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to the Westlink M7 Bridge at Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 (Light Horse) Interchange.
Receptor	Location where a modelling prediction is made. This may represent an actual location on the ground (such as residential premises or industrial development) or may represent an arbitrary point in space used to generate concentration contours.
Risk	The likelihood of an adverse event occurring
Trackout	Trackout refers to the transport of dust from the construction site onto the public road network where it can be deposited and resuspended by vehicles using the network.
Westlink M7	M7 Motorway or formerly known as Western Sydney Orbital.
Transport for NSW	The proponent seeking approval for the modification.

Acronym	Definition
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AEI	NSW EPA Air Emissions Inventory
ART	Articulated truck
ASS	Acid Sulfate Soils
BoM	Bureau of Meteorology
BUSD	Diesel bus
CASANZ	Clean Air Society of Australia and New Zealand
CALMET	The CALMET meteorological model
CEMP	Construction Environmental Management Plan – A site specific plan developed for the construction phase to ensure that all contractors and sub-contractors comply with the environmental conditions of approval and that the environmental risks are properly managed.
CO	Carbon monoxide
CORINE	Coordination on Information for the Environment land cover codes
DLCV	Diesel light commercial vehicle
DPE	NSW Department of Planning and Environment
DPV	Diesel passenger vehicle
EIS	Environmental Impact Statement
EMS	Environmental management system
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EP&A Regulation	*Environmental Planning and Assessment Regulation 2021* (NSW)
EPA	NSW Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Act 1999* (Commonwealth)
EPL	Environment protection licence
GIS	Graphical Information System
GMR	Greater metropolitan region (Sydney)
GPG	Good Practice Guide
GRAL	Graz Lagrangian Model
GRAMM	Graz Mesoscale Model
HDV	Heavy duty vehicles
IAQM	Institute of Air Quality Management (United Kingdom)
IRSD	Index of Relative Socio-economic Disadvantage
km	kilometres
LDV	Light duty vehicles
LEP	Local Environmental Plan

Acronym	Definition
LGA	Local Government Area
m	metres
m^3	Cubic metre
MTO	Match To Observations
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
OEH	NSW Office of Environment and Heritage
PLCV	Petrol light commercial vehicle
$PM_{2.5}$	Particulate matter equal to or less than 2.5 microns in diameter
PM_{10}	Particulate matter equal to or less than 10 microns in diameter
POEO	Protection of the Environment Operations (Act)
PPV	Petrol passenger vehicle
RIG	Rigid truck
SA1	Statical Area Level 1
SA2	Statical Area Level 2
SCF	Speed correction factor
SMZ	Selected material zone
SO_2	Sulphur dioxide
SSI	State Significant Infrastructure
TfNSW	Transport for NSW
TRAQ	Tool for Roadside Air Quality
TVOC	Total volatile organic compounds
VOCs	Volatile organic compounds
WSO Co	WSO Co Pty Limited
$\Delta PM_{2.5}$	Incremental increase in annual ground level $PM_{2.5}$ concentration.
µg	micrograms

Executive Summary

Introduction

The Westlink M7 is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, The Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek ('the approved project'). Transport for NSW (Transport) is seeking a modification to the approved project to widen part of the Westlink M7 in response to current and forecast traffic growth, and to improve motorway efficiency, travel time performance and safety. The Proposed Modification would permit the addition of a trafficable lane in both directions within the existing median of the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 Motorway (Light Horse) Interchange.

Transport as the proponent for the Proposed Modification, is requesting that the Minister of Planning and Homes modify the planning approval for the Western Sydney Orbital (now referred to as Westlink M7) under section 5.25 of the *Environmental Planning and Assessment Act 1979* (NSW). This air quality assessment has been prepared to support the modification report and to address the relevant Secretary's Environmental Assessment Requirements (SEARs) issued for the Proposed Modification. Specifically, this report has been prepared to assess the potential impacts of construction and operation of the Proposed Modification on ground level air quality concentrations at nearby sensitive receptors and to identify appropriate mitigation and management measures to address the impacts identified.

Air Pollutants and Emission Sources

Pollutants of interest from the Proposed Modification would include those generated from both the combustion of fossil fuels and from non-exhaust emission sources such as the disturbance of soil generating dust and the generation of dust from the movement of vehicles themselves. The pollutants of interest for this project include:

- 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); and
- Polycyclic Aromatic Hydrocarbons (PAHs).

Assessment Methodology

The assessment of the construction and operational impact associated with the Proposed Modification have been separated into two distinct assessment methodologies as follows:

- Qualitative construction impact assessment
- Quantitative operational impact assessment.

Potential impacts from dust generation during construction have been assessed using the UK Institute of Air Quality Management (IAQM), 2014 *Guidance on the assessment of dust from demolition and construction*. This document provides a qualitative risk assessment process for the potential unmitigated impact of dust generated from demolition, earthmoving and construction activities. The assessment provides a classification of the risk of dust impacts which then allows the identification of appropriate mitigation measures commensurate with the level of risk. Qualitative assessment of combustion emissions from construction vehicles and mobile and stationary plant equipment and odour emissions from earthworks was also undertaken.

Operational impacts have been assessed quantitatively through the adoption of a dispersion modelling methodology which uses a dispersion model to make predictions of expected pollutant levels at receptors surrounding the Proposed Modification. The operational assessment has been undertaken in accordance with the NSW EPA Approved Methods for Modelling using the dispersion model GRAL and is consistent with recent large scale road assessment projects undertaken in NSW.

The scenarios modelled in this assessment were based on existing roadway emissions (based on 2021) and future roadway emissions (based on 2026 and 2036 both with and without the Proposed Modification). These scenarios were aimed at providing an estimate of the existing and future air quality concentrations for the Westlink M7 and provide sufficient information to satisfy relevant regulators that the Proposed Modification is not causing an unacceptable change to the environment. Projected traffic volumes both with and without the project have accounted for approved projects at major intersections that would influence traffic volumes on the Westlink M7 including the future M12.

Five modelling scenarios were investigated for the Proposed Modification to determine the potential impacts of the Proposed Modification from an air quality perspective and included:

1. Baseline model using existing 2021 traffic volumes, fleet mix and alignment
2. 'Do-Nothing – Design Opening Year' using projected 2026 traffic volumes and fleet mix on the existing road alignment
3. 'Proposed Modification – Design Opening Year'' using projected 2026 traffic volumes and fleet mix on the proposed road alignment
4. 'Do-Nothing – 10 Years after Opening" using projected 2036 traffic volumes and fleet mix on the existing road alignment
5. 'Proposed Modification – 10 Years after Opening' using projected 2036 traffic volumes and fleet mix on the proposed road alignment.

As part of the assessment methodology, a review of approved and proposed developments within the study area including for road projects that intersect with Westlink M7 and other nearby or adjoining major developments was undertaken to identify construction and operation cumulative impacts.

Existing Environment

The existing environment has been examined in terms of the regional meteorology, existing pollutant levels, terrain features in the modelling domain, land use characteristics in the modelling domain and the receptors close to the Westlink M7.

Meteorological analysis focused on the Horsley Park Bureau of Meteorology station given its central location to the overall project, its proximity to the M7 motorway and its wind speed and direction having characteristics similar to observations across the south-western Sydney basin area. Meteorology showed a predominance of south-westerly and south-easterly winds with lower proportion of winds from all other directions. Calm conditions were high with average calms of 17.8% observed between 2010 and 2019 and average wind speeds were 2.2m/s. Seasonal winds showed minor variation with summer wind patterns being the only season where significant changes were observed from the annual wind patterns (absence of south-westerly winds in summer). Meteorology used for the assessment is considered representative of the regional conditions and is considered acceptable for use in the dispersion modelling.

When compared with existing NSW EPA standards, NO_2 and CO concentrations were well below their respective standards at all stations examined. PM_{10} concentrations (apart from the 2019 / 2020 bushfire period) showed a small number of exceedances across the monitoring period between 2015 and 2020. These exceedances were largely due to unusual events like dust-storms, backburning or bushfires. $PM_{2.5}$ concentrations generally exhibited the same pattern as PM_{10} with minor exceedances noted across the monitoring periods. Annual average $PM_{2.5}$ concentrations were shown to approach or exceed the annual average $PM_{2.5}$ EPA criteria at all monitoring station locations examined by the study. The exceedance of the 24-hour PM_{10} and $PM_{2.5}$ criteria and the exceedance of the $PM_{2.5}$ annual average criteria have been discussed further in the cumulative impact assessment section and the results section of the report.

Terrain around the Proposed Modification is best categorised as coastal hinterland with rolling hills with a minor valley extending from the west of the southern end of the current Westlink M7 to around the St Marys region. There may be a minor effect of the terrain on the plume dispersion under specific meteorological conditions, but overall, the terrain is only expected have a limited influence on the plume dispersion.

Land use along the existing Westlink M7 is a mixture of urban residential, general industrial, waste management, parklands, low density residential, rural residential, agriculture and horticulture, recreational land and environmental conservation areas and remnant native vegetation. The land use patterns vary significantly along the length of the motorway which has been utilised in the dispersion model setup to ensure it has been accounted for in the results.

Construction Impact Assessment

A qualitative assessment of construction impacts from the project was undertaken to assess potential impacts from construction dust, combustion emissions and odour. The qualitative dust risk assessment undertaken in accordance with the IAQM UK 2014 methodology found that unmitigated dust risks at different points along the Westlink M7 for demolition, earthworks, construction and track out were rated as medium to high for dust soiling and human health and negligible to high for ecological risks. Specific activity-based dust mitigation measures recommended to reduce dust generation should be incorporated into the construction environmental management plans. Residual dust impacts are not anticipated to be significant with the application of mitigation measures.

Qualitative assessment of combustion emissions from the projects found that given the typically transitory nature of construction traffic, as well as use of mobile and stationary plant equipment exhaust emissions it is unlikely to make a significant impact on local air quality. Typical mitigation measures for maintenance and minimising combustion emissions from construction vehicles is also recommended as part of the construction environmental management plans. A qualitative assessment of odour impacts from earthworks found that the potential for odour impacts from construction would not be significant due to the low probability of encountering acid sulphate soils.

A cumulative assessment of construction impacts with several nearby approved projects was undertaken. The assessment found that most projects are located at a distance far enough away from the Proposed Modification construction footprint that potential cumulative impacts are expected to be negligible. Projects where there is the potential for cumulative air quality impacts include road construction works that intersect with the Westlink M7 Proposed Modification and developments adjoining the construction of commercial and industrial business parks and a primary school. Scheduled construction work for these developments may coincide with construction work for the proposed modification. Provided potential construction air quality impacts from the Proposed Modification are appropriately managed in accordance with recommend mitigation measures no significant cumulative impacts are anticipated.

Operational Impact Assessment

Analysis of the modelled results found that for the baseline scenario, predicted existing incremental and/or cumulative ground level concentrations at some sensitive receptors were elevated for some pollutants and in some instances exceeding the EPA criterion. Elevated pollutant concentrations included existing predicted 1-hour maximum and annual average NO_2, 24-hour maximum and annual average PM_{10} and $PM_{2.5}$ concentrations, with the highest predicted levels generally observed at the northern end of the alignment, particularly close to urban residential premises in Oakhurst and Glendenning. Existing predicted ground level concentrations for all other pollutants and averaging periods were below relevant EPA criterion.

Given that this assessment examines an upgrade to an existing roadway, the assessment of the Proposed modification was assessed within the context of:

a. Distinguishing between existing and future changes in ground level pollution concentrations that are not directly tied to the Proposed Modification but are a direct result of changing emission standards.

b. Distinguishing between predicted ground level pollution concentrations for 2026 and 2036 with and without the Proposed Modification; to understand the potential impacts directly associated with the Proposed Modification.

When compared with the baseline scenario results for both the ‘Do-Nothing’ and Proposed modification for 2026 and 2036 were lower than existing ground level concentrations at receptors for all pollutants. These predicted reductions in ground level concertation were generally greater for the 2036 modelled scenarios. This overall reduction is due to the anticipated changes in vehicle fleet mix with an expected increased proportion of vehicles with more stringent emission standards and reduced number of aging vehicles with lower emission standards. Where there are predicted exceedances in ground level concentrations for the Proposed Modification, they only occurred for NO_2, PM_{10} and $PM_{2.5}$ at locations where the existing ground level concentrations are already likely to exceed.

Analysis of changes in contribution of pollutant concentrations indicate that the Proposed Modification may result in higher concentrations at sensitive receptor locations than without the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential premises in Oakhurst and Glendenning. In general, however, observable changes between with and without project scenarios were relatively small when compared to the EPA criteria. Specifically,, for predicted change in annual $PM_{2.5}$ concentrations ($\Delta PM_{2.5}$) which can be used as a guidance for assessing changes in potential health risk was found to be relatively small at all receptors when comparing the with and without Proposed Modification Scenarios. All $\Delta PM_{2.5}$ were well below 1.8µg/m^3 the recommended threshold for determining intolerable risk; with the highest $\Delta PM_{2.5}$ values at sensitive receptors at the lower end of ‘tolerable risk’ category at less than 0.4 µg/m^3. Most receptors were found to lie within the ‘acceptable’ or ‘negligible’ risk category.

Differences in the baseline and future scenarios greatly outweigh any difference between 2026 and 2036 with and without project scenarios due to anticipated changes in vehicle fleets. This is also evident between 2026 and 2036 modelled scenarios with a smaller difference in predicted ground level concentrations between the Proposed Modification and ‘do nothing’ scenario due to the weighting of emission factors on the results.

The Proposed Elizabeth Drive Upgrade which intersects with the Westlink M7 may also result in potential cumulative impacts from vehicle emissions. Assessment of cumulative impacts from the Proposed Elizabeth Drive Upgrade would need to be included as part of the EIS for Elizabeth Drive as lodgement of the development application for this project is expected to occur after the Westlink M7 Proposed Modification goes on exhibition. Both the Proposed Modification of Westlink M7 and the Proposed Upgrade to Elizabeth Drive are aimed at about improving traffic efficiency across the wider network.

Conclusion

Potential air quality impacts from the Proposed Modification are considered to be minor when predicted pollutant ground level concentrations are compared with and without the Proposed Modification in 2026 and 2036. Potential impacts from construction; including cumulative impacts with construction work at adjoining intersections can also be appropriately managed though standard mitigation measures are not expected to result in significant impacts. In conclusion, construction and operational air quality impacts from the Proposed Modification of Westlink M7 are unlikely to have a significant impact of ground level air quality concentrations.

1.0 Introduction

The Westlink M7 is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, The Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek ('the approved project'). Transport for NSW (Transport) is seeking a modification to the approved project to widen part of the Westlink M7 in response to current and forecast traffic growth, and to improve motorway efficiency, travel time performance and safety.

1.1 Overview of Proposed Modification

Transport, as the proponent for the Proposed Modification, is requesting that the Minister for Planning and Homes modify the planning approval for the Western Sydney Orbital (now referred to as Westlink M7) under section 5.25 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The original approval (DPE reference number SSI-663) was for the construction and operation of the four-traffic lane motorway. The Proposed Modification would permit the addition of a trafficable lane in both directions within the existing median of the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 Motorway (Light Horse) Interchange as shown in **Figure 1-1**.

This technical assessment has been prepared to support the application for the Proposed Modification.

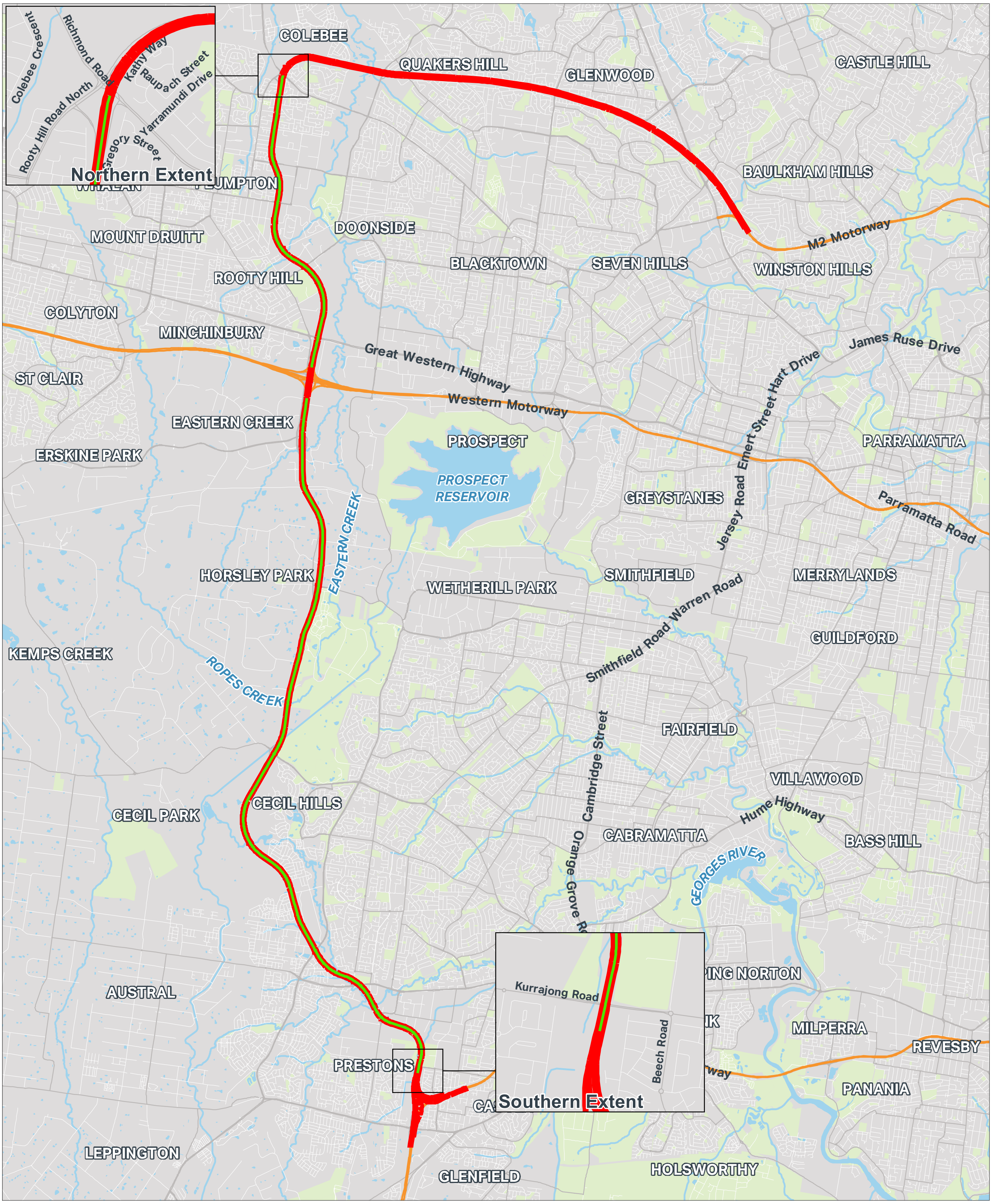


FIGURE 1-1: EXTENT OF THE APPROVED PROJECT AND THE PROPOSED MODIFICATION

N

0 2 4 km

Legend

- Proposed modification
- Approved project
- Motorway
- Primary road

Source:

1.2 Purpose of this technical report

This technical report provides an air quality assessment of the Proposed Modification to the Westlink M7 and has been prepared to inform the modification report. The aim of this air quality report is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) for the modification, provided by the NSW Department of Planning and Environment (DPE) (Application number SSI 663) dated 10 June 2022.

The relevant air quality SEARs applicable to this project are presented in **Table 1-1**. Where each of the SEARs have been addressed in the report have also been included in the table.

Table 1-1 SEARs – Air Quality

Desired Performance Outcome	SEAR	Where addressed within this report
Other Issues	1. An assessment of the following issues must be undertaken in accordance with the commitments in Attachment 2 of the M7 Motorway (SSI 663) – Project Modification letter submitted 9 May 2022 (via Major Projects Portal): • Air Quality Extract from Attachment 2 of the M7 Motorway (SSI 663) – Project Modification letter submitted 9 May 2022). *Air quality impact assessment (AQIA) for construction and operation of the Proposed Modification in accordance with the current guidelines. This will include:*	
	• *an analysis of relevant regional characteristics including existing air pollutant concentrations in the area, meteorological modelling, identification of sensitive receptors, and identification of obstacles to air dispersion*	**Section 4.2.4, Section 5.0**. **Appendix C** and **Appendix D**.
	• *a qualitative risk assessment of construction impacts*	**Section 4.1** and **Section 6.0**
	• *dispersion modelling for operational impacts. This will compare existing motorway pollutant concentrations; do-nothing (two lane carriageway plus M12/M7 intersection) (year of opening and design year) and the cumulative do-something (motorway widening plus M12/M7 intersection) (year of opening and design year) scenarios.*	**Section 4.2**[1]. **Section 7.0**, **Appendix H** and **Appendix I**
	• *qualitative cumulative impact assessment with the Elizabeth Drive project.*	**Section 6.5** and **Section 7.2**

[1] Modelling scenarios are described in Section 4.2 of this report. Baseline modelling was undertaken using recently available 2021 data which is consistent with the data used in the Westlink M7 Traffic Assessment. All future modelling scenarios account for M12 with regard to assumed future traffic numbers and includes modelling of on and off ramps at M7/M12 intersection.

1.3 Structure of this technical report

This technical report is structured as follows:

- **Section 1.0 – Introduction**: This section introduces the background and planning context for the Proposed Modification.
- **Section 2.0– Proposed Modification**: This section provides a description of the Proposed Modification from an air quality perspective including construction and operational activities.
- **Section 3.0 – Air quality legislation, strategies, guidance and criteria overview**: This section provides a high-level overview of the applicable legislation and guidance documents applicable to the Proposed Modification.
- **Section 4.0 – Assessment methodology:** This section outlines the methods used to assess changes to air quality for the Proposed Modification. This includes both the construction and operation of the roadway.
- **Section 5.0 – Existing environment**: This section describes the existing environment as it relates to air quality. This includes an analysis of meteorology, existing ambient pollutant levels and existing environment aspects that affect plume dispersion e.g., terrain.
- **Section 6.0 – Construction impact assessment:** This section assesses the air quality impacts of the Proposed Modification during the construction stage of the Proposed Modification.
- **Section 7.0 – Operational impact assessment:** This section assesses the air quality impacts of the Proposed Modification during operation. This considers current road conditions in 2021 and projected future road conditions in 2026 and 2036.
- **Section 8.0 – Mitigation and management measures:** This section documents environmental management measures that are proposed to mitigate the identified impacts of the Proposed Modification (taking into account the existing Conditions of Approval for the approved project).
- **Section 9.0 – Conclusion:** This section summarises the construction and operational air quality impacts of the Proposed Modification and briefly describes the recommended mitigation and management measures.

2.0 Proposed Modification

2.1 Overview

The Proposed Modification would permit the addition of a trafficable lane in both directions within the existing median of the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to at Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 (Light Horse) Interchange. An overview of the Proposed Modification is provided in **Figure 1-1**.

A full description of the construction activities and operational features associated with the Proposed Modification are provided in detailed in Chapter 4 (Proposed modification) of the modification report.

The Proposed Modification to the approval for the Westlink M7 would include the following key operational components:

- Widening of the motorway into the existing median for a length of about 26 kilometres along the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to Richmond Road interchange in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7(Light Horse) Interchange
- Widening the exit from the Westlink M7 northbound onto the M4 Motorway westbound from one lane to two lanes
- Widening of 43 existing northbound and southbound bridges on the Westlink M7 at 23 locations within the centre median, and widening on the outside of the bridges on the approach to the M4 Motorway from Old Wallgrove Road
- Upgrades, additions and modifications to noise walls
- Utility works and upgrades to drainage
- Intelligent Transport System (ITS) installations, adjustments and relocations to cover the new lane configurations.

Existing operational features impacted by the Proposed Modification would include:

- Main road alignment, including median and bridge areas
- Interchanges, tie-ins and entry/exit ramps
- Fill embankments and cuttings
- Culverts and drainage structures
- Water quality control measures, including basins
- Landscaping
- Existing public art and landscaping at the M4 Motorway/Westlink M7 (Light Horse) Interchange
- Maintenance access
- Security fencing
- Noise barriers
- Shared path
- Other associated elements required during operation (for example, intelligent transport systems (ITS), utilities and variable message signs (VMS)).

The following activities would be required to facilitate construction of the Proposed Modification:

- Establishment of several construction ancillary facilities within and adjacent to the Westlink M7 and the M12 Motorway construction area. These would be used for stockpiling, construction support at bridge and median widening locations, project offices and compounds. The precise number and location of construction ancillary facilities would be determined by the construction contractor in accordance with the environmental approval

- Vegetation clearing within the widening areas and construction ancillary facilities (including construction accesses)
- Demolition of existing structures and infrastructure within the widening areas
- Provision of temporary water management infrastructure including the maintenance of stormwater drainage and establishment of waterway crossings and diversions
- Utility works within Westlink M7 and adjoining roads, particularly around existing motorway bridge substructures
- Earthworks for bridge and road widening within the existing median, and placement and compaction of fill material likely to result in a net amount of cut material
- Bridge widening works to existing structures including establishment of substructures including piles, abutments, piers and headstocks and superstructures including beams, girders, decks and barriers
- Pavement widening works within the road median
- Finishing works including asphalting the carriageway surface, line marking, signage, permanent barriers and median infill, adjustments to noise walls, installation of communications infrastructure and landscaping treatments.

During construction temporary road network changes would be required including a reduction in speed limits along the Westlink M7, temporary traffic diversions and lane closures. Two lanes in each direction on the Westlink M7 would be maintained during peak traffic periods. Temporary lane and full local road closures as well as temporary off-motorway detour routes would be required to support the bridge widening construction activities. Construction access and haulage of materials would primarily be from within Westlink M7, however would also include roads adjacent to the Westlink M7. Construction of the Proposed Modification would also require temporary closures to sections of the existing Westlink M7 shared path, however appropriate detours would be in place for this facility.

Construction would likely commence in 2023 and continue through to the end of 2025. The construction program for the M12 Motorway interface has been considered in the development of this program. It is proposed to undertake the Proposed Modification at this interchange at the same time as the M12 Motorway project works to minimise disruption and achieve efficiencies during construction.

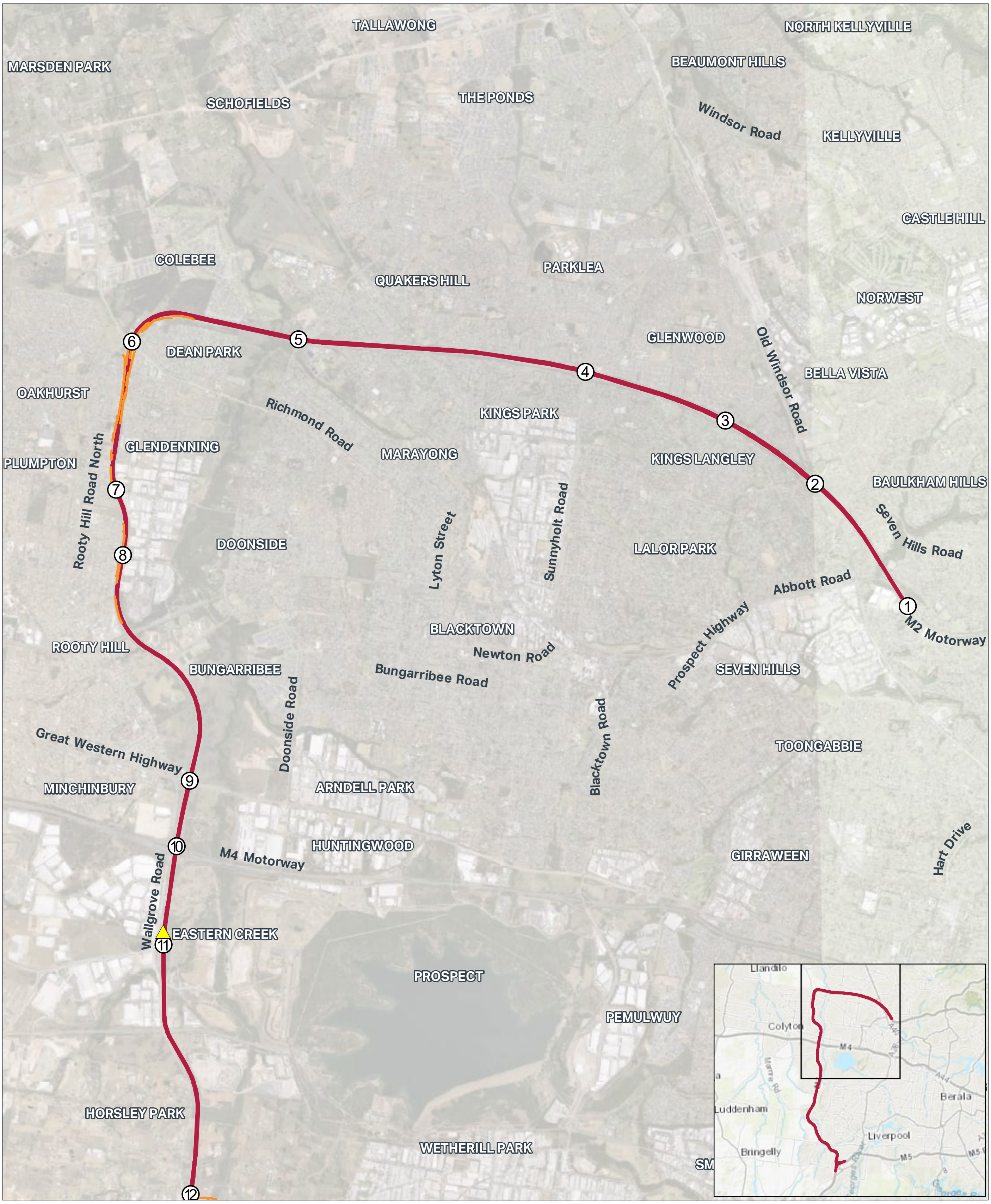


FIGURE 2-1: OVERVIEW OF APPROVED PROJECT (SHEET 1 OF 2)

Legend

- Westlink M7
- Eastern Creek Control Centre
- Existing noise wall

Interchanges

1. M2 Motorway
2. Old Windsor Road
3. Norwest Boulevard
4. Sunnyholt Road
5. Quakers Hill Parkway
6. Richmond Road
7. Power Street
8. Woodstock Avenue
9. Great Western Highway
10. M4 Motorway
11. Wallgrove Road at Old Wallgrove Road
12. The Horsley Drive

0 1 2 km

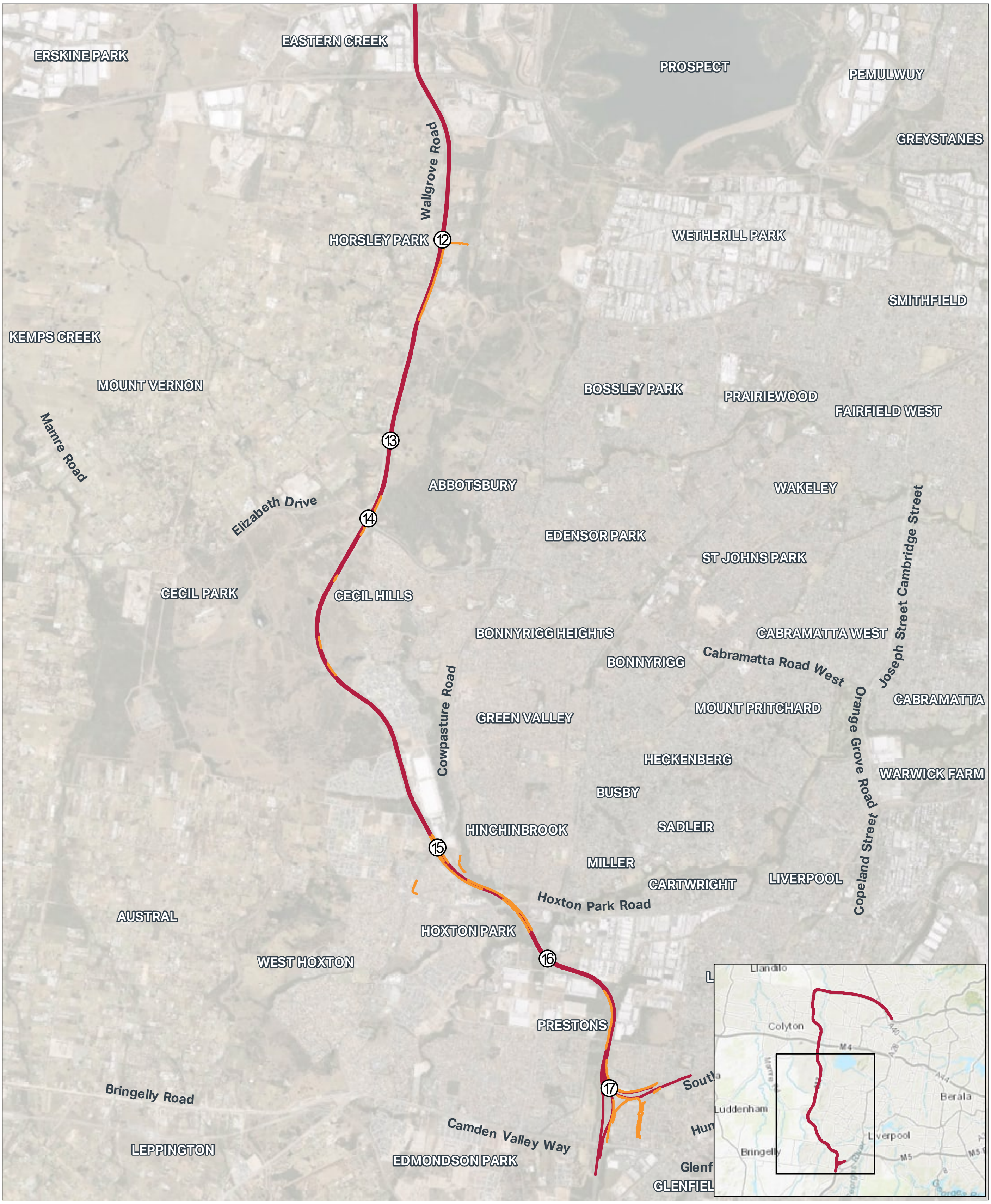


FIGURE 2-2: OVERVIEW OF APPROVED PROJECT (SHEET 2 OF 2)

Legend

- Westlink M7
- Existing noise wall

Interchanges

- 12 The Horsley Drive
- 13 Wallgrove Road near Villiers Road
- 14 Elizabeth Drive
- 15 Cowpasture Road
- 16 Bernera Road
- 17 M5 Motorway

N

0 1 2 km

AECOM

2.2 Key air quality issues for the Proposed Modification

2.2.1 Significance of road traffic pollution

Air pollution from road traffic is one of the major sources of air emissions in urban areas and can be associated with a wide range of health effects (see **Appendix A**). Traffic congestion increases vehicle emissions and degrades ambient air quality for individuals living near major roadways and within an airshed in general. It is therefore important to identify the key pollutants of interest associated with vehicle emissions and understand the potential air quality impacts associated with the Proposed Modification.

2.2.2 Pollutants of interest

Pollutants of interest from the Proposed Modification would include those generated from both the combustion of fossil fuels and from non-exhaust emission sources such as the disturbance of soil generating dust and the generation of dust from the movement of vehicles themselves. The pollutants of interest for this project include:

- 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
  - Xylene
  - 1,3 butadiene
- Polycyclic Aromatic Hydrocarbons (PAHs).

Sulphur dioxide (SO_2) concentrations from vehicle emissions attributed to operation of the Proposed Modification are anticipated to very low due to stringent diesel and petrol fuel quality standards in Australia that limit sulphur content[2]. On this basis, SO_2 has not been considered further by this assessment.

2.2.3 Potential sources of air emissions

Key potential sources of air emissions from the Proposed Modification addressed in this report are as follows:

- Construction dust from various different stages of work, including demolition, earthworks, construction activities and the movement of vehicles on the construction site;
- Construction plant engine exhaust emissions;
- Odour impacts from earthworks during construction and
- Vehicle emissions from the operation of the Proposed Modification.

[2] The quality of automotive fuels in Australia is regulated by the *Fuel Quality Standards Act 2000*, the *Fuel Quality Standards Regulations 2001* and the *Fuel Standard (Automotive Diesel) Determination 2001* (updated in 2019). The sulphur content in diesel fuel is limited to 10 ppm. The maximum sulphur content in fuel for petrol is currently 50ppm with a further reduction of the standard to 10ppm scheduled for 2027.

Construction dust

Sources of dust or particulate emissions (PM_{10} and $PM_{2.5}$) during construction can be largely divided into four main categories:

1. Demolition works including:
   - Removal of existing pavement and roadway
   - Demolition of bridge barriers and supports
   - Removal of retaining walls, noise walls and barriers
   - Relocation of utilities and drainage infrastructure
   - Windblown dust from exposed surfaces and stockpiles
2. Earthworks including:
   - Excavation activities and materials handling associated with associated with:
     - Topsoil stripping
     - Cut and fill works
     - Construction of retaining walls
     - Embankment works
     - Preparation of site and access for construction of bridge and widening works
     - Installation of road drainage infrastructure.
   - Windblown dust from exposed surfaces and stockpiles
3. Construction works including:
   - Construction of temporary ancillary facilities
   - Bridge widening construction works including:
     - Site preparation including establishment of temporary haul roads and pile and crane pads including placement of layers of crushed rock or recycled concrete.
     - Construction of substructures and super structures
   - Pavement widening works including
     - Placement of select zone material and concrete base
     - Spreading and compaction of aggregate
   - Finishing works
   - Windblown dust from exposed surfaces and stockpiles
4. Trackout including:
     - Heavy vehicle deliveries transporting dusty construction materials to site.
     - Heavy vehicles transporting dusty demolition waste material or excess cut material to suitable waste facility
     - Construction vehicle transfer dust onto the road after travelling on unpaved roads or exposed areas within the construction footprint.

All construction dust emissions outlined above have been considered by the construction dust assessment undertaken in **Section 3.3.2**. Dust impacts were assessed in accordance with the IAQM guidelines as discussed in **Section 4.1**.

Mobile and stationary plant combustion emissions during construction

Mobile and stationary plant emissions are largely attributed to exhaust emissions from fuel combustion and include gaseous pollutants such as NO_2, CO, PAHs and VOCs as well as particulates (PM_{10} and $PM_{2.5}$). Combustion emissions would also be associated with light and heavy vehicles traveling to and from the construction ancillary facilities.

Section 2.2 and **Section 6.1.6** provides an overview of construction vehicle movements and mobile and stationary plant equipment for the construction. The methodology and results of the assessment of potential air quality impacts for mobile and stationary plant combustion emissions during construction are discussed in **Section 4.1.5** and **Section 6.3** respectively.

Odour emissions during construction works

Odour emissions during construction activities are not common. However, it is possible that during construction activities odorous material may be encountered. These are typically associated with contaminated soil or excavated material with high organic loads that generate offensive odours. Sources of odorous emissions are commonly identified as part of the contaminated land assessment undertaken for a project. A qualitative discussion of the potential for odorous impacts have been discussed further in **Section 6.4** as per the assessment methodology described in **Section 4.1.4**. .

Operational vehicle emissions

Operational impacts from the Proposed Modification are due primarily to changes in vehicle numbers, vehicle speeds, vehicle fleet mix over time and changes to emission factors on the widened Westlink M7 (over time the car fleet changes with older cars being replaced with newer cars which emit lower amounts of pollution resulting in lower overall fleet emissions over time).

Vehicle emissions include both exhaust and non-exhaust emissions. Exhaust pollutant emissions are due to fuel combustion and include gaseous pollutants such as NO_2, CO, PAHs and VOCs as well as particulates (PM_{10} and $PM_{2.5}$). Non-exhaust emissions from vehicles are generally limited to particulates and include processes such as brake wear, tire wear and suspension or resuspension of road dust due to the movement of the vehicles on a road.

Vehicle emission estimations for pollutants of interest are discussed in **Section 4.2.5.2** and potential ground level air pollutant concentrations from the Proposed Modification are discussed in **Section 7.0**.

3.0 Air quality legislation, strategies, guidance and criteria

3.1 Overview

The construction and operational activities of State Significant Infrastructure (SSI) transport projects such as the Proposed M7 Westlink Modification have the potential to increase air pollutant emissions and associated ambient air quality concentrations. Environmental assessment and management in NSW are governed through the application of acts and regulations which define how projects of this scale should be assessed and if acceptable, ultimately approved.

Assessment of air quality impacts are undertaken through the consideration of legislation and guidance material which is tasked with reducing and managing the potential for air pollution and its exposure to the natural environment and the community.

This section provides an overview of the relevant air quality legislation (**Section 3.2**), guidance documents (**Section 3.2.2**) and ambient air quality criteria (**Section 3.4**).

This section excludes broader state-wide strategies and legislation for regulating vehicle emissions. **Appendix B** provides a description of important federal and NSW state government strategies to promote reductions in vehicle emissions through cleaner transport, engines, and fuels. It also provides a list of key legislation used to regulate light and heavy on-road vehicle emission standards in Australia.

3.2 Legislation, regulations and standards

3.2.1 National Environment Protection Council Act 1994 (Cth)

The *National Environment Protection Council Act 1994* (Cth) establishes and provides authority to the National Environment Protection Council (NEPC) to make National Environment Protection Measures (NEPMs) and to assess and report on their implementation and effectiveness in participating jurisdictions. NEPMs are a special set of national objectives designed to assist in protecting or managing aspects of the environment. Regarding concentrations of air pollutants, the two relevant NEPMs are as follows:

- *National Environment Protection (Ambient Air Quality) Measure 2021* (AAQ NEPM)
- *National Environment Protection (Air Toxics) Measure 2004* (Air Toxics NEPM)

The AAQ NEPM was designed to create a nationally consistent framework for monitoring and reporting on common ambient air pollutants. The Air Toxics NEPM provides a framework for monitoring, assessing, and reporting on ambient levels of air toxics and was designed to collect information to facilitate the development of standards for ambient air toxics. The air quality standards associated with the Ambient Air Quality and Air Toxic NEPMs are provided in **Section 3.4.1**.

The *National Environment Protection Council Act 1994* (Cth) also administers the *National Environment Protection (National Pollutant Inventory) Measure 2021* which is used the collect a broad base of information on emissions including air emissions from all industry sectors and reports and disseminates this information to the community in a useful as accessible form.

3.2.2 Protection of the Environment Operations Act 1997 (NSW) (POEO Act)

The *Protection of the Environment Operations Act 1997 (NSW*) (POEO Act) is the key piece of environment protection legislation administered by the EPA. The object of the POEO Act is to achieve the protection restoration and enhancement of the quality of the NSW environment.

The Act provides board allocation of environmental responsibilities between the NSW EPA, local councils, and other public authorities. The POEO Act also allows for the provision of Protection of the Environment Polices (PEPs), Environmental protection Licences (EPLs) and environmental protection notices. It also has a three-tier regime relating to environmental protection offences.

The objects of the POEO Act relevant to air quality are to:

- to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development,
- to ensure that the community has access to relevant and meaningful information about pollution,
    - to reduce risks to human health and prevent the degradation of the environment using mechanisms that promote the following—
        - pollution prevention and cleaner production,
        - the reduction to harmless levels of the discharge of substances likely to cause harm to the environment,
        - the making of progressive environmental improvements, including the reduction of pollution at source,
        - the monitoring and reporting of environmental quality on a regular basis,
- to rationalise, simplify and strengthen the regulatory framework for environment protection,
- to improve the efficiency of administration of the environment protection legislation,

The POEO Act also allows for the provision of delegate legislation including the Protection of the Environment Operations (Clean Air) Regulation 2021 as described in **Section 3.2.3**

The POEO Act is supported by NSW EPA documents that provide statutory methods for assessing and sampling air pollutants including:

- Approved methods for the modelling and assessment of air pollutants in NSW
- Approved methods for the sampling and analysis of air pollutants in NSW.

3.2.3 Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW)

The Protection of the Environment Operations (Clean Air) Regulation 2010 (NSW) (POEO Clean Air Regulation 2010) under the POEO Act prescribes the requirements for several air pollutant generating activities in NSW. Requirements include domestic solid fuel heater certification, controlled burning, and installation of pollution control devices on certain motor vehicles, petrol supply standards, emission standards for industry groups and control storage and transport of volatile organic compounds.

The POEO Clean Air Regulations refer to EPA documents that provide statutory methods for assessing and sampling air pollutants including the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2017) (Approved Methods). The approved methods are discussed further in **Section 3.3.1** with ambient air quality criteria discussed in **Section 3.4**.

3.3 Guidance documents

3.3.1 Approved methods for modelling and assessment of air pollutants in NSW

The *Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2017) (The Approved Methods) under Part 5 of the POEO Clean Air Regulation 2010 provides the statutory methods for modelling and assessment from air emissions in NSW. The document outlines procedures for:

- Emissions inventories
- Meteorological data preparation
- Accounting for background data and cumulative impact assessment
- Dispersion modelling methodology
- Interpretation of modelling results
- Impact assessment criteria

- Modelling chemical transformation
- Procedures for developing site specific emission limits.

Under Section 2.1 of the approved methods two levels of impact assessment are defined for dispersion modelling:

- **Level 1**: a screening level dispersion modelling technique using worst-case input data
- **Level 2**: a refined dispersion modelling technique using site specific input data

A Level 2 assessment of operational impacts from the Proposed Modification has been undertaken in accordance with the Approved Methods methodology and is discussed further in **Section 4.2.3**. Interpretation of dispersion modelling results for the Proposed Modification involves comparing predicted pollutant ground level concentrations to the EPA's impact assessment criteria under the Approved Methods. Impact assessment criteria are presented in **Section 3.4**.

Although there are no publicly announced planned changes to criteria outlined in the Approved Method for Modelling document, changes to the existing NEPM standards in 2021 have the potential to affect the NSW EPA criteria in the future. It is expected that the NSW EPA will likely adopt the criteria defined by the 2021 NEPM resulting in an update to the Approved Method for Modelling bringing the NEPM changes into effect in NSW. Application of the lower NEPM standards to the Proposed Modification is considered unlikely to change any of the conclusions or recommendations reached in this assessment. Further discussion on the differences between the NEPM standards and the approved methods are discussed in **Section 3.4.2**.

3.3.2 Assessment for Dust from Demolition and Construction 2014

The United Kingdom (UK) Institute of Air Quality Management *Guidance on the assessment of dust from demolition and construction* (IAQM 2014) document provides a qualitative risk assessment process for the potential unmitigated impact of dust generated from demolition, earthmoving, and construction activities.

The IAQM methodology assesses the risk of impacts associated with demolition and construction without the application of any mitigation measures. The assessment provides a classification of the risk of dust impacts to both human and ecological receptors which then allows the identification of appropriate mitigation measures commensurate with the level of risk.

The IAQM methodology is widely accepted for the assessment of potential dust impacts associated with demolition and construction from road projects in NSW and other states in Australia. The IAQM methodology has been adopted to assess the potential dust impacts from the Proposed Modification. The methodology has been modified to account for local conditions as follows:

- Modification to the risk assessment matrix to account for more stringent PM_{10} criteria set by NSW EPA.
- Additional parameters were added that apply specifically to road construction projects. These are detailed in **Table 4-2**.
- Sensitivity classification of ecological receptors has been modified to account for:
    - Protected areas in NSW based on conservational status as defined by NSW *National Parks and Wildlife Service* (NPWS);
    - Nationally and NSW listed Threatened ecological communities (TEC).
    - Environmental conservation areas listed under the Local Environmental Plan (LEP).

The modified IAQM methodology for assessment of construction dust impacts from the Proposed Modification is described in **Section 4.1**.

3.3.3 Air pollution from road transport good practice guide

As at the drafting of this document, the Transport Special Interest Group (TSIG) under the Clean Air Society of Australia and New Zealand (CASANZ) is currently drafting the *Good Practice Guide for the*

Assessment and Management of Air Pollution from Road Transport (GPG). The GPG has been funded by transport government departments from NSW, South Australia, Western Australia, Queensland, Victoria, and New Zealand with the aim of providing a standardised approach for the assessment of road transport emissions. The guide is currently being developed to meet the needs of environmental regulators and road agencies/authorities in Australia and New Zealand and provide:

- Enhanced consistency across projects and jurisdictions
- Reduced risk of projects being over or under scrutinised
- Increased cost-efficiency, i.e. savings in time and resources previously spent developing and justifying assessment methods
- Presentation of a transparent process
- Clear communication of assessment procedures for regulators, proponents, community, and other stakeholders.

The assessment framework involves characterisation of the potential impacts from the Proposed Modification to determine the appropriate assessment methodology.

While the final guide has not yet been publicised, it is expected to outline the methodology for undertaking a detailed air quality assessment (including dispersion modelling) for the operational impacts of large projects that include complex design features. Assessment of the Proposed Modification required a detailed assessment of the operational impacts due to complex urban environments and regulatory requirements as part of the SEARs. Based on preliminary viewing of the GPG, the operational assessment methodology described in **Section 4.2** is expected to be closely aligned with the GPG.

With regards to construction assessment methodology, the GPG is also expected to include a modified IAQM approach adapted for assessment in Australia and New Zealand, with specificity to road transport projects. While the GPG document is currently not published the proposed modified IAQM methodology adapted for the assessment of NSW projects used in this technical report (as described in **Section 3.3.2** and **Section 4.1**) is expected to be relatively consistent with the new methodology likely to be recommended by the GPG.

3.3.4 Guideline for Assessing and Minimising Air Pollution in Victoria

In NSW the Approved Methods (EPA 2017) document forms the basis of the assessment methodology for the modelling and assessment of air pollutants from development.

The recently released *Guideline for Assessing and Minimising Air Pollution in Victoria* (VIC EPA 2022) (referred to here after as the VIC EPA Guideline) provides additional guidance in relation to classification and identification of sensitive land uses.

The VIC EPA Guideline recommends in addition to the identification of sensitive land uses surrounding a Project additional descriptive data by the Australian Bureau of Statistics (ABS) be analysed to characterise the potentially exposed population. Potential health risks associated with air emissions are related to the location, size and vulnerability of the exposed population as the likelihood and consequence of health effects of air pollution is unlikely to be equally distributed in the population.

The guideline recommends a broad assessment be undertaken using simple socio-economic indicators, relating to population density and vulnerability to characterise the receiving environment. Identification of population size and vulnerability using ABS data has been undertaken in accordance with the VIC EPA Guideline as described in **Section 5.5.2**. While this guideline does not strictly apply in NSW (given it is guideline prepared for use in Victoria), the underlying methodology does add to this report and as such has been considered in the impact assessment.

3.3.5 Australian Incremental Guideline for Particulate Matter

Health impacts associated with $PM_{2.5}$ concentrations are discussed in **Appendix A**. There is no threshold that has been identified regarding $PM_{2.5}$ concentrations that are not associated with health impacts. It is therefore important to examine any predicted incremental increase in ground level $PM_{2.5}$ concentrations at sensitive receptors associated with the Proposed Modification.

There is currently no formal guidance in Australia on the health assessment of the incremental particulate impacts for proposed developments, despite the requirement to assess such impacts as part of the environmental planning process. Several other AQIA assessments for TfNSW projects have used all-cause mortality risk[3] as an endpoint for assessing the potential health risk from predicted incremental increase in ground level $PM_{2.5}$ concentrations ($\Delta PM_{2.5}$). For the WestConnex projects, the highest acceptable increase in risk was an increase in annual mortality of 1 in 10,000, which equated to a value for $\Delta PM_{2.5}$ of between 1.5 µg/m^3 and 1.8 µg/m^3.

The paper *An Australian incremental guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions* (Capon, A. & Wright J. 2019) provides a recommended incremental guideline that can be used to assess the impact of $PM_{2.5}$ from infrastructure development on a population.

Like previous AQIAs in NSW the paper utilises all-cause mortality risk[4] as an endpoint for assessing the potential health risk from predicted incremental increase in ground level $PM_{2.5}$ concentrations as also used by the US EPA and UK's Committee on the Medical Effects of Air Pollutants.

Annual incremental concentrations of $PM_{2.5}$ for 1 in 1,000,000, 1 in 100,000 and 1 in 10,000 mortality rates using national and state ABS population data were calculated the following equation:

$$\Delta_{PM2.5} = \frac{\ln\left(1 + \frac{\Delta AR \ \times population\ size}{number\ of\ total\ deaths\ in\ the\ population}\right)}{\beta}$$

Where:

$\Delta_{PM2.5}$	=	Change in $PM_{2.5}$ concertation
ΔAR	=	Change in absolute risk (AR) where the absolute risk is equal to the number of deaths divided by the population. The change in AR was calculated is equal to absolute risk between a population at the higher annual average $PM_{2.5}$ concertation (AR_H) minus the absolute risk from the same population without the predicted increase in annual average $PM_{2.5}$ concertation (AR_L).
β	=	slope coefficient relevant of 0.0058, based on a relative risk of all-cause mortality of 1.06 per 10 µg/m^3 change in $PM_{2.5}$ concentrations

Calculated annual $\Delta PM_{2.5}$ for 1 in 1,000,000, 1 in 100,000 and 1 in 10,000 mortality rates were then used to define risk tolerances consistent with Section 7.3 of the Approved Methods (EPA 2017). Recommended assessment criteria for annual $\Delta PM_{2.5}$ exposure are discussed further in **Section 3.4.3** and **Section 3.5**.

3.4 Ambient air quality criteria and standards

3.4.1 NEPM standards

Ambient Air Quality NEPM

The AAQ NEPM standards under the NEPC Act (see **Section 3.2.1**) are aimed at achieving adequate protection of human health and wellbeing and apply to air quality experienced by the general population within a region. Under this general exposure approach, the standards are applicable to urban sites away from specific sources of pollution such as heavily trafficked streets and industrial smokestacks. The AAQ NEPM does not prescribe sanctions for non-compliance with the air quality standards and does not compel or direct air pollution control measures (NEPC 2021 and NEPC 2021a).

The AAQ NEPM standards as recently amended on 18 May 2021 are shown in **Table 3-1.**

The May 2021 amendment to the AAQ NEPM standards included changes to the standards for NO_2, SO_2 and O_3 concentrations and averaging periods. These changes have resulted in recommended

[3] Baseline of incidence of all-cause mortality calculated for population age of 30 years and over.
[4] Baseline of incidence of all-cause mortality calculated for population age of 30 years and over.

maximum 1-hour and annual average concentrations for NO_2 and maximum 1-hour and 24-hour concentrations for SO_2 that are lower than NSW EPA air quality criteria (see **Section 3.4.2)**.

In the *Key Changes to the Ambient Air Quality Measure agreed by Ministers April 2021* statement issued by the NEPC (NEPC 2021a) it was asserted that standards in the AAQ NEPM are not intended to be applied as an environmental standard by regulators without consideration of regulatory impacts in their jurisdictions. The Explanatory Statement clarifies this intent of the NEPM as a standard for reporting representative ambient air quality within an airshed, and not as a regulatory standard.

Primary pollutants of interest for the Proposed Modification shown in **Table 3-1** as discussed in **Section 2.2.2** include CO, NO_2, PM_{10} and $PM_{2.5}$.

Table 3-1 NEPM Ambient Air Quality standards as updated 18 May 2021

Item	Pollutant	Averaging period	Maximum concentration standard	
			ppm	µg/Nm³
1	Carbon monoxide (CO)	8 hours	9.0	11,250
2	Nitrogen dioxide (NO_2)	1 hour	0.08	164
		1 year	0.015	31
3	Photochemical oxidants (as ozone)	8 hours	0.065	139
4	Sulfur dioxide (SO_2)	1 hour	0.10	286
		1 day	0.02	57
5	Lead	1 year	-	0.50
6	Particles ≤ 10 microns in diameter (PM_{10})	1 day	-	50
		1 year	-	25
7	Particles ≤ 2.5 microns in diameter ($PM_{2.5}$)	1 day	-	25
		1 year	-	8
ppm = parts per million µg/Nm³ = micrograms per normal cubic metre (under standard temperature and pressure).				

In addition to the current standards in **Table 3-1**, reductions of the 1-hour SO_2 standard and 24-hour and annual average $PM_{2.5}$ standards are proposed from 2025. The revised $PM_{2.5}$ standards are considered relevant to the assessment of operational impacts from the Proposed Modification given particulates have been identified as a primary pollutant of interest in **Section 2.2.2**.

As discussed above, SO_2 concentrations attributed to operation of the Proposed Modification are anticipated to very low compared to the proposed NEPM standard due to stringent diesel and petrol fuel quantity standards in Australia that limit sulphur content[5]. This pollutant is not of concern to the Proposed Modification.

Proposed changes to the AAQ NEPM standards for 2025 are provided in **Table 3-2**.

[5] The quality of automotive fuels in Australia is regulated by the *Fuel Quality Standards Act 2000*, the *Fuel Quality Standards Regulations 2001* and the *Fuel Standard (Automotive Diesel) Determination 2001* (updated in 2019). The sulphur content in diesel fuel is limited to 10 ppm. The maximum sulphur content in fuel for petrol is currently 50ppm with a further reduction of the standard to 10ppm scheduled for 2027. Vehicle emission regulation and strategies are discussed in Annexure B.

Table 3-2 NEPM proposed changes for Ambient Air Quality standards scheduled for 2025.

Item	Pollutant	Averaging period	Maximum concentration standard	
			ppm	µg/Nm³
4	Sulfur dioxide (SO_2)	1 hour	0.075	216
7	Particles ≤ 2.5 microns in diameter ($PM_{2.5}$)	1 day	-	20
		1 year	-	7

ppm = parts per million

µg/Nm³ = micrograms per normal cubic metre (under standard temperature and pressure).

Air Toxics NEPM

The Air Toxics NEPM includes monitoring investigation levels for use in assessing the significance of monitored levels of air toxics with respect to human health. The monitoring investigation levels are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short term, it does not mean that adverse health effects automatically occur; rather some form of further investigation by the relevant jurisdiction of the cause of the exceedance is required. The relevant monitoring investigation levels defined in the Air Toxics NEPM are listed in **Table 3-3**.

Table 3-3 Air Toxics NEPM Air Quality monitoring investigation levels

Pollutant	Averaging period	Monitoring investigation level
Benzene	Annual average	0.003 ppm
Benzo(a)pyrene as a marker for Polycyclic Aromatic Hydrocarbons (PAHs)	Annual average*	0.3 ng/m³
Formaldehyde	24 hours	0.04 ppm
Toluene	24 hours Annual average	1 ppm 0.1 ppm
Xylenes (as total of ortho, meta and para isomers)	24 hours Annual average	0.25ppm 0.2 ppm

Note: All pollutants have an 8-year goal to gather sufficient data nationally to facilitate development of a standard, however to date (June 2022) no national standards have been developed from the monitoring investigation levels.

3.4.2 NSW EPA air quality impact assessment criteria

In NSW, air quality impact assessment criteria are listed under Section 7 of the Approved Methods (EPA 2017) as discussed in **Section 3.3.1**. The pollutant specific criteria and corresponding averaging period for individual pollutants identified in **Section 2.2.2** are shown in **Table 3-4.**

Assessment of individual pollutants is based on pollutant type for pollutants listed in **Table 3-4**:

- Air quality impact assessment criteria for the following pollutants are assessed at sensitive receptor locations[6]:
  - Particulate matter (PM_{10} and $PM_{2.5}$)
  - Nitrogen dioxide (NO_2)
  - Carbon monoxide (CO)
- Air quality impact assessment criteria for the following pollutants are assessed at or beyond the boundary of the site (road property boundary in this case):
  - Volatile Organic Compounds (VOCs) including:
    - Benzene
    - Formaldehyde
    - Toluene
    - Acetaldehyde (ethanal)
    - Xylene
    - 1,3 butadiene
  - Polycyclic Aromatic Hydrocarbons (PAHs) (as Benzo(a)pyrene).

Table 3-4 NSW EPA air quality criteria

Pollutant	Averaging period	Criteria ($\mu g/m^3$)
Nitrogen Dioxide	1 Hour Maximum	246
	Annual Average	62
Carbon Monoxide	1 Hour Maximum	30,000
	8 Hour Maximum	10,000
Particulate matter (PM_{10})	24 Hour Maximum	25
	Annual Average	8
Particulate matter ($PM_{2.5}$)	24 Hour Maximum	25
	Annual Average	8
Benzene	99.9^{th} Percentile 1-hour average	29
Formaldehyde	99.9^{th} Percentile 1-hour average	20
1,3-butadiene	99.9^{th} Percentile 1-hour average	40
Toluene	99.9^{th} Percentile 1-hour average	360
Acetaldehyde	99.9^{th} Percentile 1-hour average	42
Ethylbenzene	99.9^{th} Percentile 1-hour average	8000
Xylene	99.9^{th} Percentile 1-hour average	190
PAHs (as Benzo(a)pyrene)	99^{th} Percentile 1 Hour	0.4
$\mu g/m^3$ = micrograms per cubic metre		

As discussed above, prior to the May 2021 publication of the updated air Quality NEPM, the NSW EPA criteria in **Table 3-4** were consistent with the AAQ NEPM standards. Following the May 2021 amendment of the AAQ NEPM standards the maximum 1-hour and annual average concentrations for

[6] Sensitive receptors under the Approved Methods are defined as a location where people are likely to work or reside, including any potential future receptors. Sensitive receptors are discussed further in Section 5.5.

NO_2 listed in the NSW EPA Approved Methods for Modelling are less stringent than the AAQ NEPM standards reported in **Table 3-1**.

Additionally, a further reduction in the maximum 24-hour and annual average $PM_{2.5}$ standards are proposed to come in to force under the AAQ NEPM in 2025 (see **Table 3-2**). The proposed changes would result in even more stringent standards when compared to the NSW EPA criteria.

A comparison of the existing NSW EPA criteria and AAQ NEPM standards in force, as well as proposed changes for $PM_{2.5}$ are provided in **Table 3-5**.

Table 3-5 Comparison of NSW EPA Air Quality impact criteria and NEPM criteria

Compound	Averaging Period	NSW EPA criteria (µg/m³)	AAQ NEPM standard (µg/m³)
Particulate matter ($PM_{2.5}$)	24 Hour Maximum	25	20*
	Annual Average	8	7*
Nitrogen Dioxide	1 Hour Maximum	246	164
	Annual Average	62	31
*Standard is not currently in force and is proposed for 2025.			

It needs to be noted that currently, air pollution in many areas of the Sydney basin already exceed the 2021 $PM_{2.5}$ standards.. Broad government action in air quality across the Sydney basin is needed to address this situation and application of this lower standard to the Proposed Modification is considered unlikely to change any of the conclusions or recommendations reached in this assessment.

3.4.3 Health criteria for particulates

The paper *An Australian incremental guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions* (Capon, A. & Wright J. 2019) provides a recommended incremental guideline that can be used to assess the impact of $PM_{2.5}$ from infrastructure development on a population. Recommended risk assessment criteria for annual $\Delta PM_{2.5}$ exposure; based on risk tolerances consistent with Section 7.3 of the Approved Methods (EPA 2017) are presented in **Table 3-6**.

Table 3-6 Recommended incremental health assessment criterion for annual $PM_{2.5}$ exposure

Incremental annual average $PM_{2.5}$ concentration (µg/m³)	Increased risk of mortality	Risk acceptability and suggested interpretation	
		Risk classification	definition
0 - 0.02	<1 in 1,000,000	**Negligible**	Development poses negligible health risk
0.02 - 0.17	1 in 1,000,000 – 1 in 100,000	**Acceptable**	Development needs to show use of best practice with consideration of reasonable and feasible measures to reduce pollutant load
0.17 - 1.7	1 in 100,000 – 1 in 10,000	**Tolerable**	Only if best practice is proven and reasonable, and feasible measures have been demonstrated. At this level, costly interventions are now considered reasonable and feasible, that would not have been in the acceptable range

Incremental annual average $PM_{2.5}$ concertation (µg/m³)	Increased risk of mortality	Risk acceptability and suggested interpretation	
		Risk classification	definition
>1.7	> 1 in 10,000	**Unacceptable**	Development poses unacceptable level of risk to health.

Based **Table 3-6** a predicted annual $\Delta PM_{2.5}$ exposure of greater than 1.7 µg/m³ would pose an unacceptable level of risk for the Proposed Modification, while incremental increases between 0.02 µg/m³ and 1.7 µg/m³ are considered acceptable or tolerable and the development would be required to demonstrate best practice with feasible mitigation measures required dependant on the level of increased risk. Adopted annual $\Delta PM_{2.5}$ health risk criterion for the Proposed Modification is discussed in **Section 3.5**.

3.5 Adopted assessment criteria

3.5.1 NSW EPA air quality criteria

The following air quality assessment criteria for the Proposed Modification in **Table 3-7** has been adopted based on the ambient air quality criteria in the Approved Methods.

Table 3-7 NSW EPA Air Quality criteria

Pollutant	Averaging Period	Criteria (µg/m³)
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	246
	Annual Average	62
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 µg/m³
Ethylbenzene (C_8H_{10})	99.9th Percentile 1-hour average	8000 µg/m³
Xylene (C_8H_{10})	99.9th Percentile 1-hour average	190 µg/m³
PAHs (as Benzo(a)pyrene)	99th Percentile 1 Hour	0.4
µg/m³ = micrograms per cubic metre		

3.5.2 Recommended Health Risk Assessment Criteria

As discussed in **Section 3.3.5** and **Appendix A**, there is no threshold below which there are no associated health impacts for particulates. Therefore, in addition to the criteria in **Table 3-7**, particularly given the high annal $PM_{2.5}$ concentrations within the Sydney Basin as later discussed in **Section 5.2.4** incremental health assessment criteria for annual $PM_{2.5}$ exposure have also been adopted for this assessment.

Table 3-8 provides the risk assessment criteria for annual $\Delta PM_{2.5}$ exposure; as recommended in *An Australian incremental guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions* (Capon, A. & Wright J. 2019). This assessment criteria are also based on risk tolerances consistent with Section 7.3 of the Approved Methods (EPA 2017). Individual receptors have been assessed based on their level of risk as defined in **Table 3-6** with a predicted annual $\Delta PM_{2.5}$ exposure of greater than 1.7 µg/m^3 considered an unacceptable level of risk for the Proposed Modification

Table 3-8 Recommended incremental health assessment criterion for annual $PM_{2.5}$ exposure

Incremental annual average $PM_{2.5}$ concertation (µg/m^3)	Increased Risk of Mortality	Risk acceptability and suggested interpretation	
		Risk Classification	Definition
0 - 0.02	<1 in 1,000,000	**Negligible**	Development poses negligible health risk
0.02 - 0.17	1 in 1,000,000 – 1 in 100,000	**Acceptable**	Development needs to show use of best practice with consideration of reasonable and feasible measures to reduce pollutant load
0.17 - 1.7	1 in 100,000 – 1 in 10,000	**Tolerable**	Only if best practice is proven and reasonable, and feasible measures have been demonstrated. At this level, costly interventions are now considered reasonable and feasible, that would not have been in the acceptable range
>1.7	> 1 in 10,000	**Unacceptable**	Development poses unacceptable level of risk to health.

Based on **Table 3-6** a predicted annual $\Delta PM_{2.5}$ exposure of greater than 1.7 µg/m^3 is considered to pose an unacceptable level of risk for the Proposed Modification, while incremental increases between 0.02 µg/m^3 and 1.7 µg/m^3 are considered acceptable or tolerable and the development would be required to demonstrate best practice with feasible mitigation measures required dependant on the level of increased risk. Adopted annual $\Delta PM_{2.5}$ health risk criterion for the Proposed Modification is discussed in **Section 3.5**.

4.0 Assessment methodology

The assessment of the construction and operational impact associated with the Proposed Modification have been separated into two distinct assessment methodologies as follows:

- Qualitative construction impact assessment (**Section 4.1**)
- Quantitative operational impact assessment (**Section 4.2**).

Potential impacts from dust generation during construction have been assessed using the UK Institute of Air Quality Management (IAQM), 2014 *Guidance on the assessment of dust from demolition and construction*. The assessment provides a classification of the risk of dust impacts which then allows the identification of appropriate mitigation measures commensurate with the level of risk.

A qualitative impact assessment was also undertaken for potential construction impacts associated with combustion emissions from construction vehicles and plant equipment and potential odour emissions associated with earthworks.

Operational impacts have been assessed quantitatively through the adoption of a dispersion modelling methodology which uses a dispersion model to make predictions of expected pollutant levels at receptors surrounding the Proposed Modification. The operational assessment has been undertaken in accordance with the NSW EPA Approved Methods for Modelling and is consistent with recent large scale road assessment projects undertaken in NSW.

4.1 Construction assessment methodology

4.1.1 Study area

The Proposed Modification construction footprint including construction ancillary facilities is expected cover an area of approximately 142 hectares and is shown in Figure 4-8 to Figure 4-12 of the modification report.

Potential dust risk is relative to the dust sensitivity of sensitive receptors and their proximity to the construction boundary. Buffer distances of 20m, 50m, 100m, 200m and 350m from the construction works boundary have been used to define the study area for the construction assessment undertaken in **Section 6.0.** Multiple buffer distances have been used to assess the potential sensitivity of receptors to dust and this is explained further in **Section 3.3.5**.

Given the length of the road and the diverse range of land uses along the roadway i.e. varying from high density residential to commercial industrial and agricultural uses, the assessment area was divided up into several discrete areas with common land uses (as shown in **Figure 4-1** and **Figure 4-2**). A brief description of each area (including land uses as well as key access roads and construction ancillary facilities) is provided in **Table 4-1** with a more detailed analysis of the different areas provided in the construction impact assessment (**Section 6.0**).

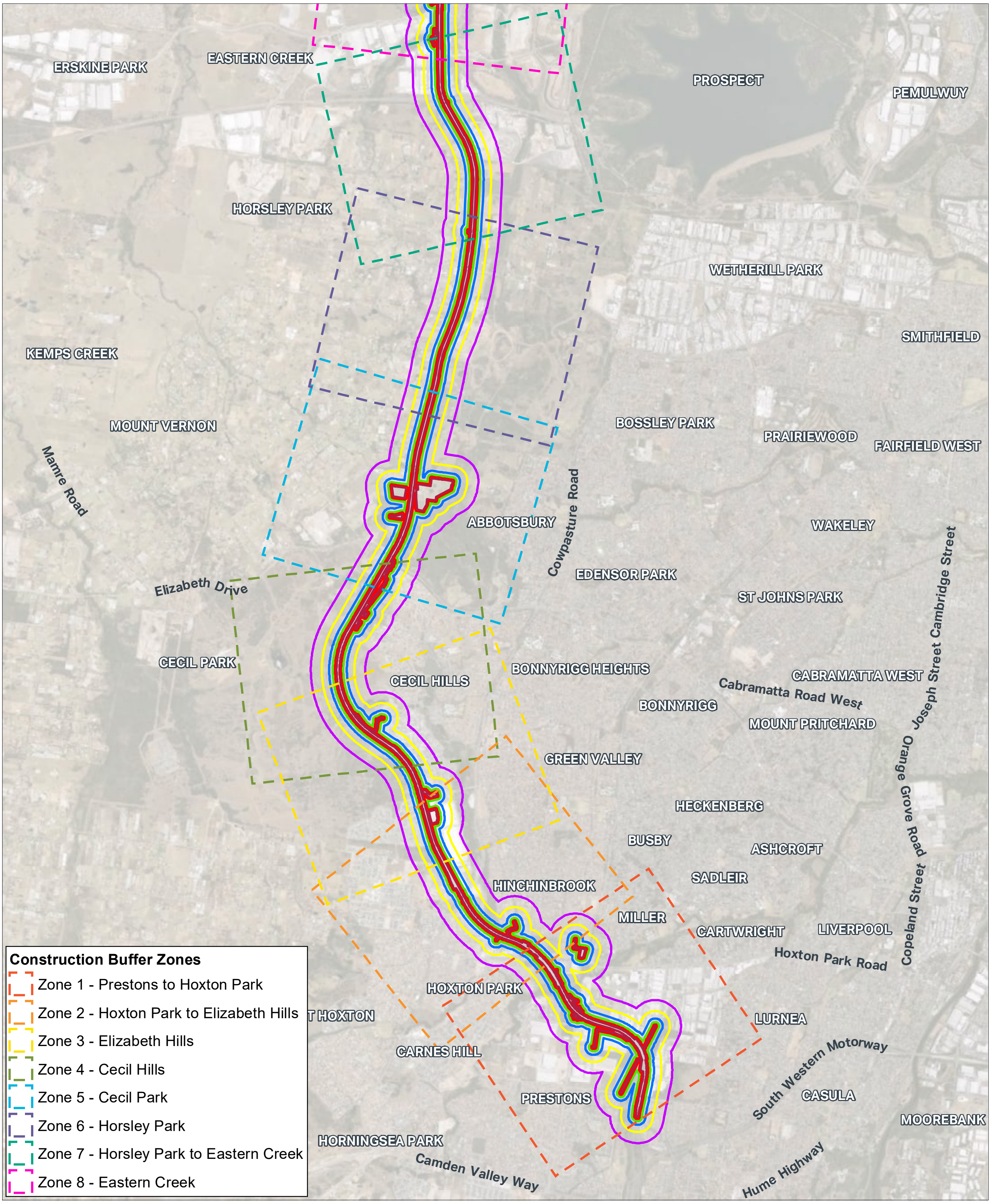


FIGURE 4-1: OVERVIEW OF DISCRETE CONSTRUCTION DUST ASSESSMENT AREAS - SHEET 1 OF 2

AECOM

Legend

- Construction footprint
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

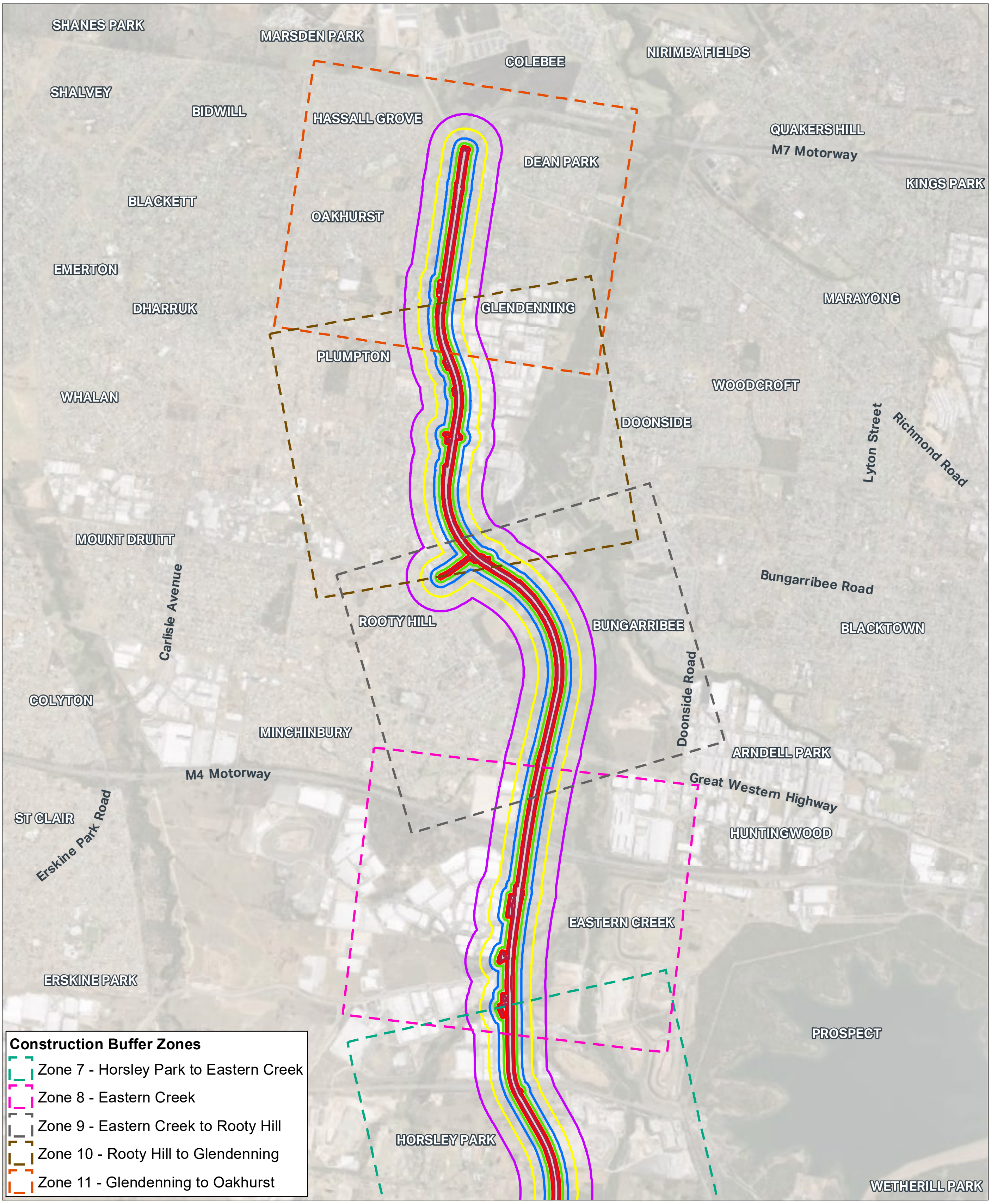


FIGURE 4-1: OVERVIEW OF DISCRETE CONSTRUCTION DUST ASSESSMENT AREAS - SHEET 2 OF 2

N

0 1 2 km

AECOM

Legend

- Construction footprint
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

Source: Imagery © Department of Customer Service 2020

Table 4-1 Zones for assessment of air quality impacts

Location	Description
Zone 1 Prestons to Hoxton Park	• Land use is primarily general and heavy industry use with some low density residential and some environmental conservation and residual native vegetation areas. • Construction vehicle access via Jedda and Ash Roads. • Construction ancillary facilities proposed at 345 Hoxton Park Road
Zone 2 Hoxton Park to Elizabeth Hills	• Land use is primarily low density and general residential with some general industry, business development, public recreational areas, and some residual native vegetation. • Construction vehicle access via Hoxton Park Road. • Zone construction ancillary facilities proposed near the Hoxton Industrial zone on Blackbird Close and Aviation Road.
Zone 3 Elizabeth Hills	• Land use is parklands and environmental conservation areas with some general and low density residential. • Zone construction ancillary facilities proposed near the Hoxton Industrial zone on Blackbird Close and Aviation Road as discussed in Zone 3.
Zone 4 Cecil Hills	• Land use is parklands and environmental conservation areas with some general and low density residential. • Construction traffic access roads via Dobroyd Road and Aviation Drive. • Construction ancillary compound and zone construction ancillary facilities just under 1km south of Elizabeth Drive on eastern side of Westlink M7 • Construction work over Hinchinbrook Creek
Zone 5 Cecil Park	• Land use is predominantly a mix of rural residential, recreational land, environmental conservation areas and remnant native vegetation. • Construction ancillary facilities and construction zone ancillary facilities within 1 km to the north of Elizabeth Drive.
Zone 6 Horsley Park	• Land use is a mix of rural residential, horticulture/agriculture and areas of environmental conservation areas and remnant native vegetation. • Construction vehicle access via Redmayne Road • Construction ancillary facilities and construction zone ancillary facilities near Redmayne Road.
Zone 7 Horsley Park to Eastern Creek	• General industrial, waste management, rural residential, agriculture/horticulture, mining, open space, environmental conservation areas and remnant native vegetation. • Construction vehicle access to the site via Austral Bricks Access Road. • Bridge widening of M7 over Austral Bricks Access Road • Construction ancillary facilities and construction zone ancillary facilities near bridge widening works and just before old Wallgrove Road
Zone 8 Eastern Creek	• Land uses include industrial and manufacturing, recreational land, commercial services, and some environmental conservation areas and remnant native vegetation. • Heavy vehicle access travelling to and from site may access the area via Great Western Highway and via Wallgrove Road. • Construction ancillary facilities and construction zone ancillary facilities just after old Wallgrove Road and just before Light Horse Interchange.

Location	Description
Zone 9 Eastern Creek to Rooty Hill	• Land use is primary urban residential and public recreational land with some commercial premises and environmental conservation areas with remnant native vegetation. • Heavy vehicles traveling to and from site may access the area from Mavis Street via Rooty Hill Road. • No construction zone compounds, or ancillary facilities are proposed in this zone.
Zone 10 Rooty Hill to Glendenning	• Land use is predominantly urban residential and service facilities. • Heavy vehicles entering and existing the site via Woodstock Avenue • Construction zone compound and ancillary facilities to be located near Woodstock Avenue
Zone 11 Glendening to Oakhurst	• Land use is primarily urban residential with some public recreational facilities and service facilities. There are also some small areas of remnant native vegetation and environmental conservation areas. • No construction zone compounds, or ancillary facilities are proposed in this zone.

4.1.2 Dust assessment methodology

Potential impacts from dust generation during construction have been assessed using the UK Institute of Air Quality Management (IAQM), 2014 *Guidance on the assessment of dust from demolition and construction*. This document provides a qualitative risk assessment process for the potential unmitigated impact of dust generated from demolition, earthmoving, construction activities and trackout as described in **Section 3.3.2**.

The IAQM guidance process is a four-step risk-based assessment of dust emissions associated with demolition, land clearing and earth moving and construction activities. The IAQM assessment process is described in the following sections.

This assessment has been informed by construction and demolition volumes and equipment usage information provided in Section 4.3 of the modification report.

4.1.2.1 Step 1 – screening assessment

Step 1 of the IAQM assessment requires the determination of whether there are any receptors close enough to warrant further assessment. An assessment is required where there is a human receptor within:

- 350 m from the boundary of a construction ancillary facility or boundary of construction works, or
- 50 m from the route used by construction vehicles on public roads up to 500 m from the construction works or construction ancillary facility entrance.

A detailed assessment is also required if an ecological receptor is within:

- 50m of the boundary of the site, or
- 50 m from the route used by construction vehicles on public roads up to 500 m from a site entrance.

4.1.2.2 Step 2 – dust risk assessment

Step 2 in the IAQM is a risk assessment tool designed to appraise the potential for dust impacts due to unmitigated dust emissions. The key components of the risk assessment involve defining:

- dust emission magnitudes (Step 2A)
- the surrounding area’s sensitivity to dust emissions (Step 2B)
- combining these in a risk matrix (Step 2C) to determine a potential risk rating for dust impacts on surrounding receptors.

Additional details on steps 2A, 2B and 2C are provided in the following sections.

Step 2A – dust emission magnitude

Dust emission magnitudes are estimated according to the scale of works being undertaken classified as small, medium or large. The IAQM guidance provides examples of demolition, earthworks, construction and trackout to aid classification (refer **Table 4-2**).

It should be noted that the IAQM guidance document provides generic activity criteria for estimating dust emission magnitude from construction and demolition projects and construction activity criteria have been modified to account for road projects.

Table 4-2 Emission magnitudes for small, medium and large demolition and construction activities

Activity	Activity criteria	Small	Medium	Large
Demolition	Total building volume (m^3)	<20,000	20,000–50,000	>50,000
	Material type	Material with low dust generating potential	Potentially dusty material	Potentially dusty and includes crushing and screening
	Demolition height	<10m AGL	10-20m AGL	>20m AGL
Earthworks	Total site area (m^2)	<2,500	2,500–10,000	>10,000
	Number of heavy earth moving vehicles active at one time	<5	5-10	>10
	Total material moved (tonnes (t))	<20,000	20,000–100,000	>100,000
	Bund height	< 4m	4 to 8m	> 8m
	Fine content of soil type	Low fine content (e.g. sand)	Moderately fine content (e.g. Silt)	High fine content (e.g. Clay)
Construction	Total building volume (m^3)	<25,000	25,000–100,000	>100,000
	Road length	<1km	1-2km	>2km
	Construction Duration	< 6months	6 – 12 months	>12 months
	Construction ancillary facilities & laydown areas*	Temporary laydown area only	1 Construction ancillary facilities & Laydown area	> 1 Construction ancillary facilities & Laydown areas
	Operation of plant equipment including diesel generators.	No or minor reliance	Moderate reliance	Heavy reliance
Trackout	Number of heavy vehicle movements per day	<10	10-50	>50
	Surface material dust potential	Low fine content (e.g. sand)	Moderately fine content (e.g. Silt)	High fine content (e.g. Clay)
	Length of unpaved road access	<50m	50-100m	>100m

< represents less than
> represents greater than

Step 2B – sensitivity of the surrounding area

Under the IAQM Guidance document a sensitive receptor is defined as a location that may be affected by dust emissions during demolition and construction. Human receptors include locations where people spend time and where property may be impacted by dust. Ecological receptors are habitats that might be sensitive to dust.

The "sensitivity" component of the risk assessment is determined by defining the surrounding areas sensitivity to dust soiling, human health effects and ecologically important areas. This is described further below.

Sensitivity of the area to dust soiling and human health effects

The IAQM methodology classifies the sensitivity of an area to dust soiling and human health impacts due to particulate matter effects as high, medium, or low. The classification is determined by a matrix for both dust soiling and human health impacts (refer **Table 4-3** and **Table 4-4** respectively). Factors used in the matrix tables to determine the sensitivity of an area are as follows:

- receptor sensitivity (for individual receptors in the area):
  - high sensitivity: locations where members of the public are likely to be exposed for eight hours or more in a day. (e.g. private residences, hospitals, schools, or aged care homes)
  - medium sensitivity: places of work where exposure is likely to be eight hours or more in a day
  - low sensitivity: locations where exposure is transient, around one or two hours maximum. (e.g. parks, footpaths, shopping streets, playing fields)
- number of receptors of each sensitivity type in the area
- distance from source
- annual mean PM_{10} concentration (only applicable to the human health impact matrix).

Table 4-3 Surrounding area sensitivity to dust soiling effects on people and property

Receptor sensitivity	Number of receptors	Distance from the source (m)			
		<20	20-50	50-100	100-350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

The IAQM guidance provides human health sensitivities for a range of annual average PM_{10} concentrations (i.e. >32, 28-32, 24-28 and <24 µg/m^3). It is noted in the IAQM guidance that the human health sensitivities are tied to criteria from different jurisdictions (UK and Scotland). The annual average PM_{10} criteria for Australia differ from the UK and Scotland and as such concentrations corresponding to the risk categories need to be modified to match Australian conditions.

The annual average criterion for PM_{10} in NSW is 25 µg/m^3 (refer **Section 3.5**) and therefore the scaled criteria for NSW is:

- >25 µg/m^3
- 22-25 µg/m^3
- 19-22 µg/m^3
- <19 µg/m^3.

The background PM_{10} concentrations in the region surrounding the Proposed Modification are outlined in **Section 5.2.3**, which notes that regional annual average PM_{10} concentrations between 2015 and 2018 vary from less than 19 μg/m³ to just below 25 μg/m³. The majority of annual PM_{10} concentrations however fit into the 19-22 μg/m³ as such this PM_{10} category has been adopted for the IAQM assessment.

Note that 2019 and 2020 annual average data is not used for this assessment as it is heavily influenced by the 2019/2020 bushfire period and is not considered representative of long-term conditions.

Table 4-4 provides the IAQM guidance sensitivity levels for human health impacts for the ranges outlined above for the annual average PM_{10} concentrations and highlights (in bold outline) the relevant range for NSW.

Table 4-4 Surrounding area sensitivity to human health impacts for annual average PM_{10} concentrations

Receptor sensitivity	Annual average PM_{10} concentration	Number of receptors	Distance from the source (m)				
			<20	<50	<100	<200	<350
High	>25 μg/m³	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	22-25 μg/m³	>100	High	High	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	19-22 μg/m³	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<19 μg/m³	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>25 μg/m³	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	22-25 μg/m³	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	19-22 μg/m³	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<19 μg/m³	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	≥1	Low	Low	Low	Low	Low

The sensitivity for each construction activity defined by the IAQM guidance is assessed for the Proposed Modification. This results in a sensitivity rating for the construction footprint along with ratings for portions of the construction footprint for each construction activity. The ratings depend on the sensitivity of the receptors and the distance from the edge of the construction footprint. As shown in **Table 4-3** and **Table 4-4** the greater the distance from the construction footprint (the source), the lower the rating. The highest rating achieved is adopted as the final rating for that group of receptors.

It should be noted that this is not a quantitative human health assessment and risks discussed in this context need to be understood in terms of the IAQM guidance. For a group of receptors, a risk rating indicates the risk that group of receptors may experience unmitigated dust concentrations above the NSW criteria, with the associated potential health effects linked to that criterion. Once mitigated through the application of air emissions mitigation measures (as part of a well-designed air quality management plan), the dust impacts would be expected to be negligible.

Sensitivity of area to ecological impacts

Ecological impacts from construction activities occur due to deposition of dust on ecological areas. The sensitivity of ecological receptors can be defined by the following:

- High sensitivity ecological receptors
  - locations with international or national designation and the designation features may be affected by dust soiling
  - locations where there is a community of particularly dust sensitive species
- Medium sensitivity ecological receptors
  - locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown
  - locations within a national designation where the features may be affected by dust deposition
- Low sensitivity ecological receptors
  - locations with a local designation where the features may be affected by dust deposition.

The sensitivity of an ecological area to impacts is assessed using the criteria listed in **Table 4-5**. Ecological receptors are discussed further and **Section 5.5.3**, the study area contains remnant vegetation including some threatened endangered communities and the area has a long history of disturbance. Given the area contains particularly important plant species, where its dust sensitivity is uncertain or unknown and local designation areas where the features may be affected by dust deposition the study area receptor sensitivity would be considered low to medium based on sensitivity classification listed above.

Table 4-5 Sensitivity of an area to ecological impacts

Receptor sensitivity	Distance from source (m)	
	<20	20–50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

4.1.2.3 Step 2C – unmitigated risks of impacts

The dust emission magnitude as determined in Step 2A is combined with the sensitivity as determined in Step 2B to determine the risk of dust impacts with no mitigation applied. **Table 4-6** provides the risk ranking for dust impacts from construction activities for each scale of activity as listed in **Table 4-2**.

Table 4-6 Risk of dust impacts (for dust soiling and human health impacts)

Activity	Surrounding area sensitivity	Dust emission magnitude		
		Large	Medium	Small
Demolition	High	High	Medium	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Negligible
Earthworks	High	High	Medium	Low

Activity	Surrounding area sensitivity	Dust emission magnitude		
		Large	Medium	Small
	Medium	Medium	Medium	Low
	Low	Low	Low	Negligible
Construction	High	High	Medium	Low
	Medium	Medium	Medium	Low
	Low	Low	Low	Negligible
Trackout	High	High	Medium	Low
	Medium	Medium	Low	Negligible
	Low	Low	Low	Negligible

4.1.3 Step 3 – management strategies

The outcome of Step 2C is used to determine the level of management that is required to ensure that dust impacts on surrounding sensitive receptors are maintained at an acceptable level. A high or medium-level risk rating suggests that management measures must be implemented during the Proposed Modification. Mitigation measures should be specifically designed to minimise the emissions from the source to which they are applied and implemented at an appropriate level e.g., low level road watering on a dry highly trafficked roadway may not reduce dust impacts by the desired amount.

4.1.4 Step 4 – reassessment

The final step of the IAQM methodology is to determine whether there are significant residual impacts, post mitigation, arising from a proposed development. The IAQM guidance states:

For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be “not significant”.

Based on this expectation, as well as experience within Australia, construction activities with targeted mitigation measures can achieve high degrees of dust mitigation which significantly reduce dust impacts to a negligible level.

4.1.5 Combustion emissions

As discussed in the IAQM 2013 experience of assessing the exhaust emissions from onsite mobile and stationary equipment as well as construction traffic suggests they are unlikely to make a significant impact on local air quality. Therefore, quantitative assessment of combustion emissions from construction of the Proposed Modification is not required.

Potential impacts from combustion emissions from construction pf the Proposed Modification has been qualitatively assessed is **Section 6.3.** The qualitative assessment of combustion emissions from site plant and on-site traffic takes into consideration the estimated daily vehicle movements and type of plant equipment required during construction as discussed in **Section 6.1.6**.

4.1.1 Odour emissions

A qualitative assessment of odour impacts from construction works associated with the Proposed Modification are provided in **Section 6.4**. Potential sources of odour would largely be limited to potential disturbance of acid sulphate soils or contaminated soil during earthworks.

4.2 Operational assessment methodology

Assessment of operational projects from the Proposed Modification was undertaken as a Level 2 Assessment in accordance with the Approved Methods (EPA 2017). This section describes the operational air quality assessment methodology for the Proposed Modification.

Broadly speaking, the assessment of the effect of a large-scale infrastructure project on air quality involves the collection of a range of data which are combined with a dispersion model to predict the concentration of a pollutant at a location (whether that location is a sensitive receptor location or at an arbitrary point within the modelling domain to enable the generation of a contour plot). The data required for this study can be categorised as follows:

- ***Description of the study area***: this sets the boundaries of the overall project or provides context to the overall analysis that occurs later in the report.
- ***Modelling scenarios***: the modelling scenarios present the basis for each modelling run, in terms of things like modelling year, project assumptions e.g. either with the Proposed Modification or without the Proposed Modification. These scenarios then form the basis of the impact assessment comparisons i.e. comparisons between with and without project at a certain calendar year in the future along with comparisons between future calendar year emissions and an existing scenario.
- ***Model selection discussion***: selection of a dispersion model is an important step as it provides justification for the use of the model chosen for the Proposed Modification. A detailed model selection justification is vital to ensuring that the selected model is appropriate for the Proposed Modification.
- ***Dispersion modelling inputs***: modern dispersion models require a wide range of information to ensure the results are as representative as possible of the airshed in which the model is situated. There are several different categories of input data critical to the modelling, including meteorology, terrain characteristics and receptor locations (to name but a few), which have all been discussed below.
- ***Emissions Inventory***: along with the dispersion modelling inputs outlined above, an estimate of the air pollutant emissions are required for the Proposed Modification. The inventory includes all aspects of the Proposed Modification relevant to the emissions from the roadway, which has been divided up into a series of “links” which represent a portion of the roadway.

The above project data inputs have been further described in the following sections.

4.2.1 Study area

The area of interest for the Proposed Modification covers a 26-kilometre-long stretch of road connecting the M5 Motorway at Prestons, the Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek. Given the size of the Proposed Modification and a need to ensure sufficient resolution of local terrain, receptor spacing and road characteristics are represented within the modelling domain the study area has been broken up into two modelling domains:

- **Domain 1:** Southern modelling domain is presented in **Figure 4-3** and covers Preston’s to Horsley Park**.**
- **Domain 2:** Northern modelling domain is presented in **Figure 4-4** and covers the area from Horsley Park to Oakhurst.

Additional details including coordinates for each of the modelling domains are discussed further in **Section 4.2.4**.

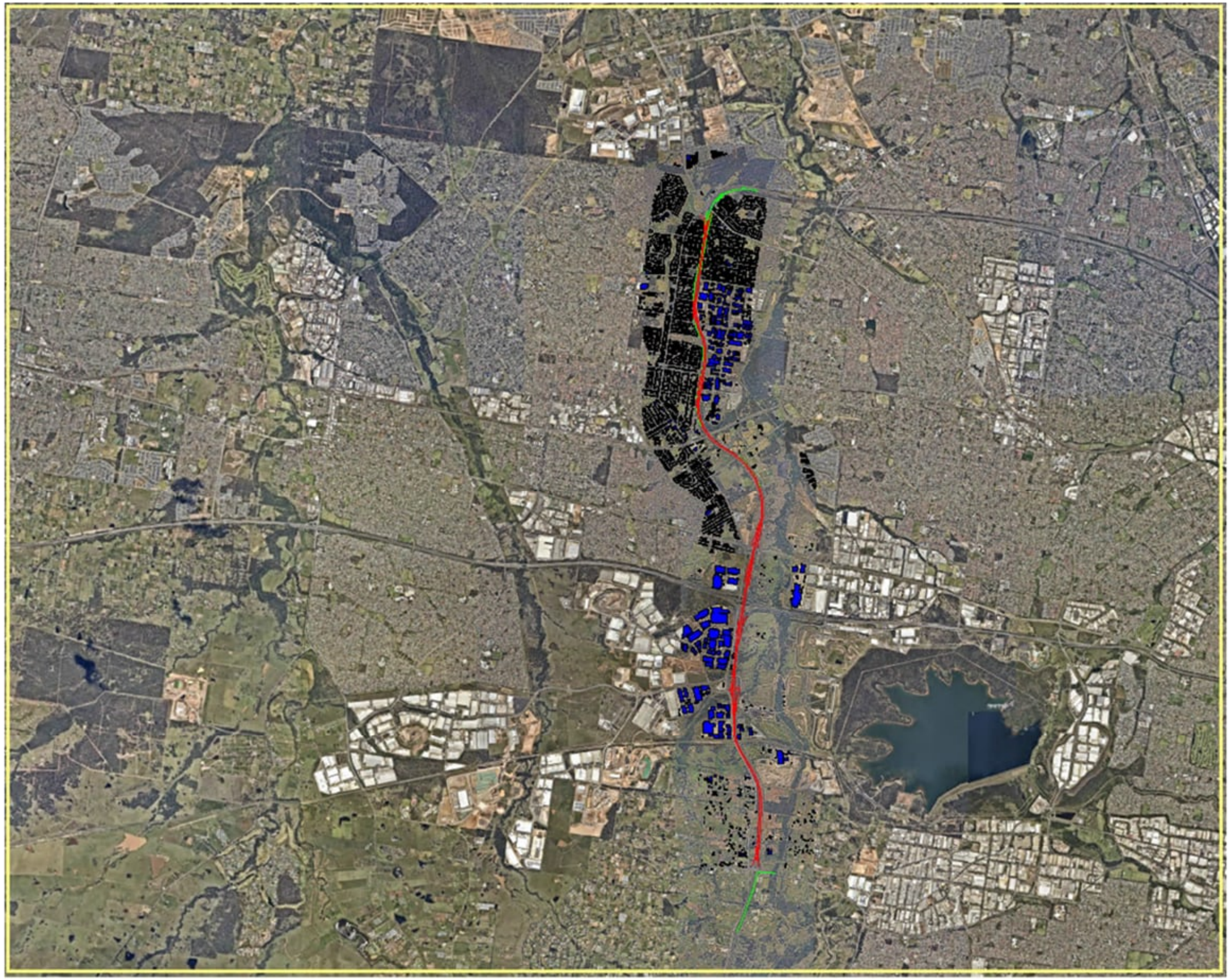


Figure 4-3 Study area for southern modelling domain

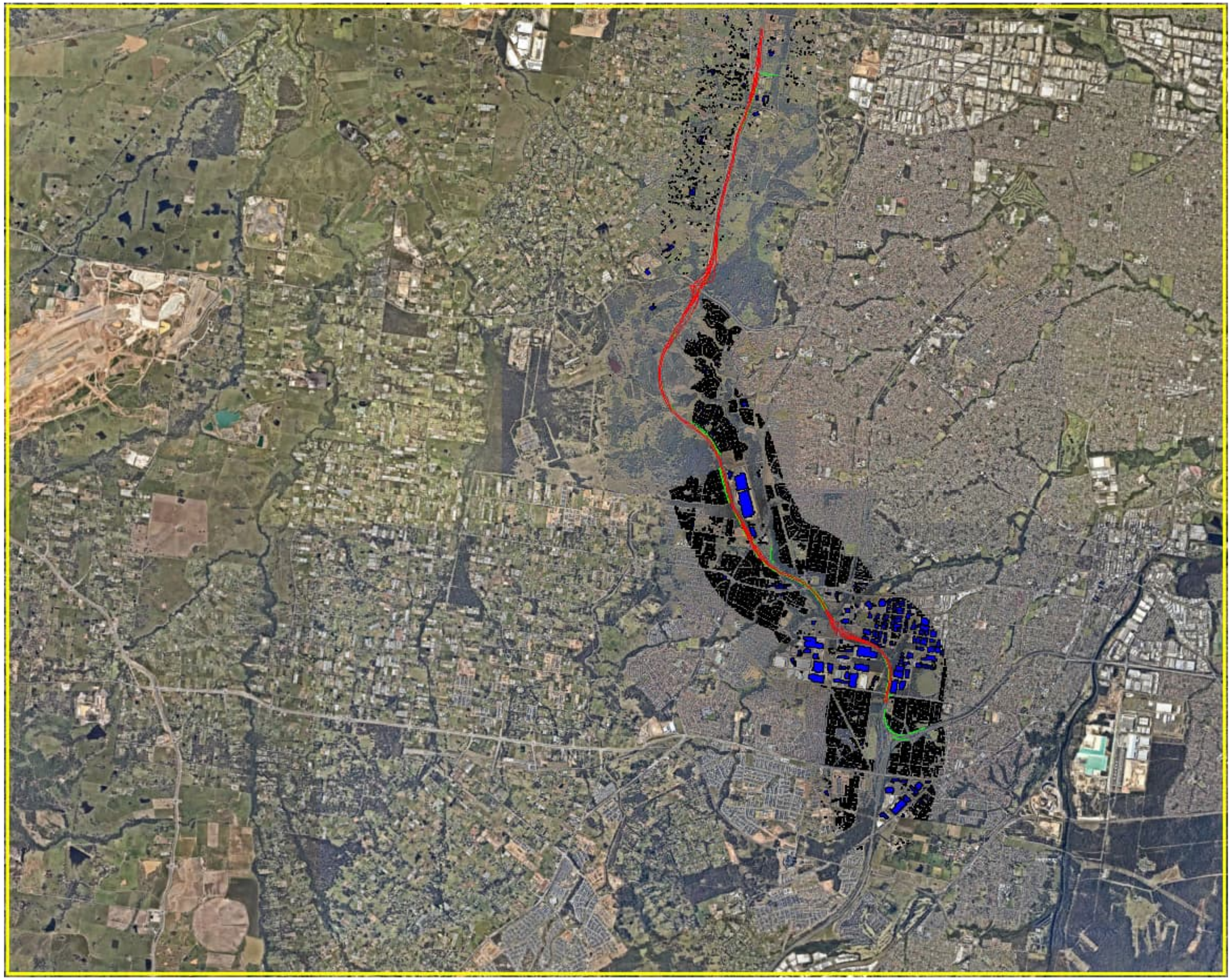


Figure 4-4 Study area for northern modelling domain

4.2.2 Modelling scenarios

Dispersion modelling scenarios define how the emissions from a site are combined for use in a dispersion model. Information on physical source dimensions, pollutant emission rates and variable operational modes are combined to try and ensure the scenarios represent a realistic picture of the overall emissions profile.

The scenarios modelled in this assessment were based on existing roadway emissions (based on 2021) and future roadway emissions (based on 2026 and 2036 both with and without the Proposed Modification). These scenarios are aimed at providing an estimate of the existing and future air quality concentrations for the Westlink M7.

Five modelling scenarios were investigated for the Proposed Modification to determine the potential impacts of the Proposed Modification from an air quality perspective. The modelling scenarios developed for this assessment are described in **Table 4-7**.

Table 4-7 Modelled scenarios

ID	Name	Description
Scenario 1	**Existing**	Westlink M7 traffic operations based on 2021 traffic volumes based on the existing motorway traffic lane layout
Scenario 2	**Do Nothing** Design Opening Year	Westlink M7 traffic operations based on 2026 traffic volumes without the Proposed Modification utilising existing motorway traffic lane layout. The 2026 traffic data accounts for the operation of M12 and included modelling of on and off ramps at the M7/M12 intersection.
Scenario 3	**Proposed Modification** Design Opening Year	Westlink M7 traffic operations based on 2026 based on the proposed upgraded traffic lane layout. The 2026 traffic data accounts for the operation of the M12 and included modelling of on and off ramps at the M7/M12 intersection.
Scenario 4	**Do Nothing** 10 Years after Opening	Westlink M7 traffic operations based on 2036 traffic volumes without the Proposed Modification utilising existing motorway traffic lane layout. The 2036 traffic data accounts for the operation of the M12 and included modelling of on and off ramps at the M7/M12 intersection.
Scenario 5	**Proposed Modification** 10 Years after Opening	Westlink M7 traffic operations based on 2036 based on the proposed upgraded traffic lane layout. The 2036 traffic data accounts for the operation of the M12 and included modelling of on and off ramps at the M7/M12 intersection.

Given that the existing Westlink M7 is an existing road, the focus of this investigation and the above scenarios is demonstrating that the changes to air quality as a result of the modification to the Westlink M7 will not result in an unacceptable change to air quality in the environment surrounding the Motorway. The results section and impact assessment are focused on the demonstration that the change is acceptable, not whether the roadway itself complies with environmental standards.

4.2.3 Model selection

The land use along the Westlink M7 consists of a mixture of commercial / industrial buildings, rural, low and medium density residential buildings, vacant land, forested land, and parks and sports fields.

Within the commercial / industrial areas, there are many large warehouse-type buildings, up to 15 m in height with large building footprints dominating each site. In addition, there are several noise walls up to about 8 m in height located along the M7 at different locations. .

Given the nature of the Proposed Modification and its immediate surrounds which result in complex micro-scale air flows, the use of a dispersion model able to predict these air flows on an appropriate scale and predict concentrations in the near field is required. The common dispersion models used for complex modelling scenarios (AERMOD, CALPUFF and historically CALINE) do not perform well within 100 m, in highly complex terrain or around buildings or other barriers and therefore an alternative model is proposed. Given its ability to provide dispersion concentrations on micro-scale grids within complex building environments, the GRAL model has been used for this assessment.

GRAL is a Lagrangian Particle model developed at the Institute for Internal Combustion Engines and Thermodynamics, Technical University Graz, Austria specifically to assess the dispersion of pollutants from roadways and tunnel portals (Oettl et al., 2002; Oettl et al., 2003; Oettl et al., 2005). GRAL has been extensively evaluated against experimental data from five different tunnel portals both in flat and complex terrain, with high and low traffic volumes, namely the Enrei, Hitachi and Ninomiya tunnels in Japan (Oettl et al., 2003), and the Enrentalerbergtunnel in Austria (Oettl et al., 2002). GRAL has also been compared to other models (ADMS, LASAT, MUMO).

AECOM has been in direct contact with GRAZ University and the GRAL developers to discuss the model's evaluation procedures, scientific basis and application in Australia. Through this relationship, the model and its evaluation data have been thoroughly reviewed, providing confidence in the use of the model for projects in Australia.

Of particular note, the GRAL model has algorithms which effectively consider the flow of air over buildings which form complex building wakes which affect the dispersion of pollutants. This is a particular advantage over Gaussian plume models in this particular application given the many large buildings and noise walls close to the edge of the Proposed Modification.

4.2.4 Dispersion modelling inputs

The GRAMM / GRAL model requires a range of data inputs that need to be defined prior to running the model. These data can be broadly separated into the following categories:

- Meteorological data;
- Terrain data;
- Land use data;
- Building data;
- Receptor locations; and
- Source emissions data.

A flow chart outlining the dispersion modelling process adopted for this assessment, including input and output data is presented in **Figure 4-5**. The dispersion modelling inputs used in this assessment have been described below, with exception to source emission data which is discussed in **Section 4.2.5.** Dispersion model results have been discussed in **Section 7.0**.

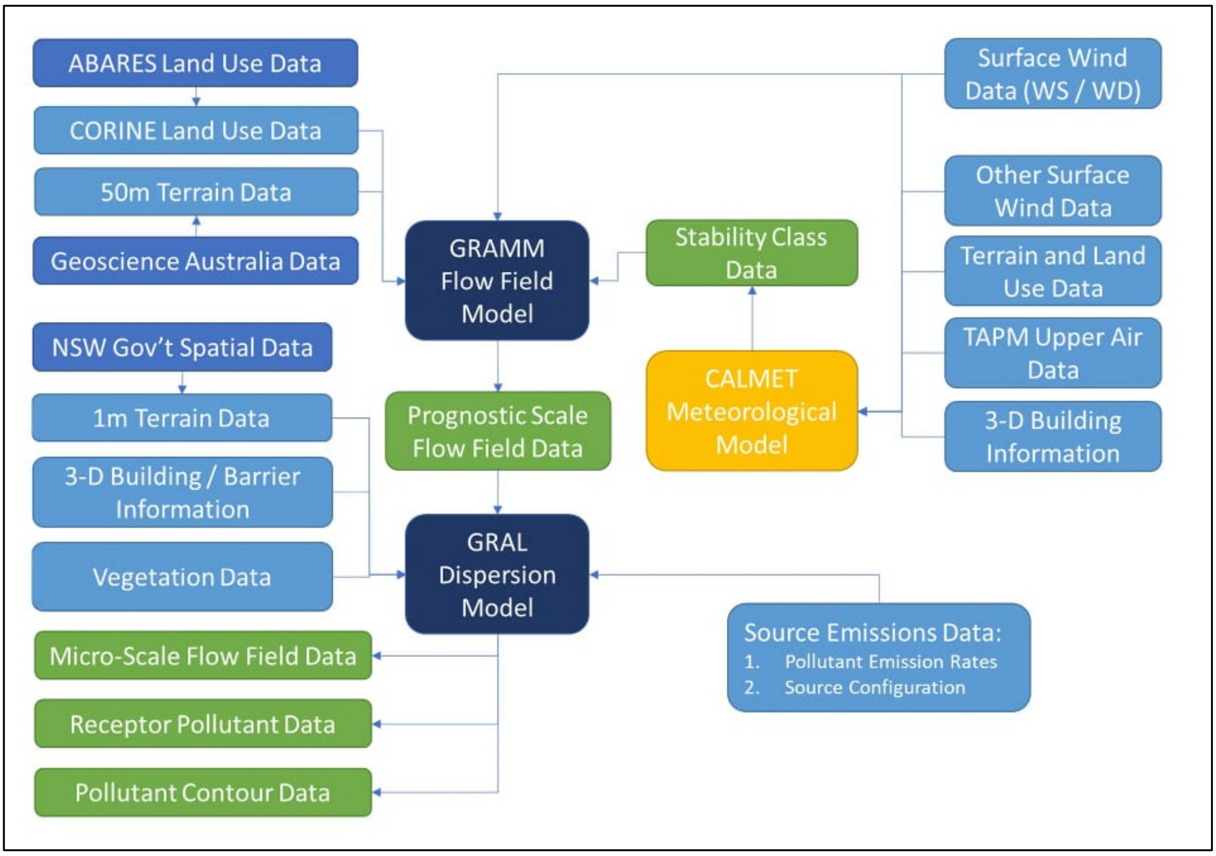


Figure 4-5 Site model program and input flow chart

4.2.4.1 Dispersion meteorology

Meteorological data is vital to a dispersion modelling project as it directly influences the direction that the pollution is transported from the source, the degree of mixing that occurs in the atmosphere and the size and extent of the plume as it moves away from the source.

The meteorological data used by the GRAL dispersion model is developed through the use of the meteorological data pre-processor, GRAMM, which takes raw meteorological data and geophysical information from the modelling domain and generates a three-dimensional data set ready for use in GRAL.

The GRAMM modelling process consists of a multi-step procedure aimed at generating a three-dimensional wind field that is as representative of local conditions as possible. The meteorological modelling process includes several stages of analysis and modelling which progressively develops and improves the meteorological data that is used by GRAL. The stages of data analysis and processing for GRAMM meteorological data preparation are as follows:

- Preparation of geophysical data (terrain data and land use information) for the modelling domain;
- Development of a synthetic meteorological data set;
- Running of the GRAMM model using the synthetic meteorological data set;
- Identification and assessment of surface observation stations within the modelling domain to evaluate their applicability;
- Selection of meteorological data from an appropriate time period
- Development of a CALMET dataset to enable stability classes to be generated for surface observation stations
- Match to observation (MTO) function in GRAMM is utilised using firstly synthetic flow field data and secondly observation station data to produce a refined flow field data set for use in GRAL.

Additional details on the GRAMM modelling process are further described in the following section and in **Appendix F**. Further detail on the above steps is provided below.

Preparation of GRAMM domain geophysical data

Geophysical data for the GRAMM model consisting of topographical data and land use data is processed into a format accepted by the GRAMM model. Topographical data (5m digital elevation model) was sourced from the Elvis database.

Land use data was sourced from the ABARES[7] data Land Use codes were converted manually from the ABARES values to the CORINE values that are used in GRAMM.

Development of a synthetic meteorological data set

The purpose of the synthetic meteorological data set is to provide the GRAMM model with all possible meteorological conditions from which the GRAMM model can then use to generate wind fields across the modelling domain for all possible wind situations. For this project, there were 4,536 synthetic meteorological conditions considered which included the following meteorological conditions:

- *Wind direction*: 36 wind sectors of 10° sectors
- *Wind Speed*: 21 wind speed categories considered including 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 9.0, 10.0m/s
- *Stability Class*: all stability classes considered for all wind speed and direction data.

GRAMM was run for all synthetic meteorological conditions which generated 4,536 wind fields which were evaluated by the match to observation function within the GRAMM program.

The MTOfunction is to find the best fit between computed wind fields and measured data for a given number of observation stations (Oettl et al, 2020). It is important to understand that the MTO function does not generate new wind fields itself, rather it looks at the observational data from the meteorological stations within a domain and select the wind fields that best fit the observed conditions at the observational station(s). The end-product of this procedure is a time series of wind fields which is used as meteorological data for the GRAL model. This approach has been shown to generate meteorology that is much better than simply using single station meteorology for the generation of GRAMM data for use in GRAL (RMS 2017)

Identification and assessment of surface observation stations

As described above, the MTO function uses observational data to develop a meteorological data set from a range of synthetic conditions. The observational data is critical to this process as the observational data serves as the basis for the statistical MTO analysis. Given the reliance of the MTO function on observational data, the data used for the analysis needs to be as representative as possible of the overall domain and where possible unaffected by localised effects which may skew the results e.g. buildings or trees close to an observation station can skew wind patterns which may in turn skew the MTO function.

Several stations were identified within the two GRAMM domains that may be considered representative of the area. These stations were as follows:

1. Southern Domain:
    a. Badgerys Creek BoM station
    b. Horsley Park BoM Station; and
    c. Liverpool DPE Station.
2. Northern Domain:
    a. Horsley Park BoM Station;
    b. St Marys DPE Station; and

[7] Land use data download - DAWE

c. Prospect DPE Station.

Location of the BOM and DPE monitoring stations and the corresponding GRAMM domains are shown in **Figure 4-7**.

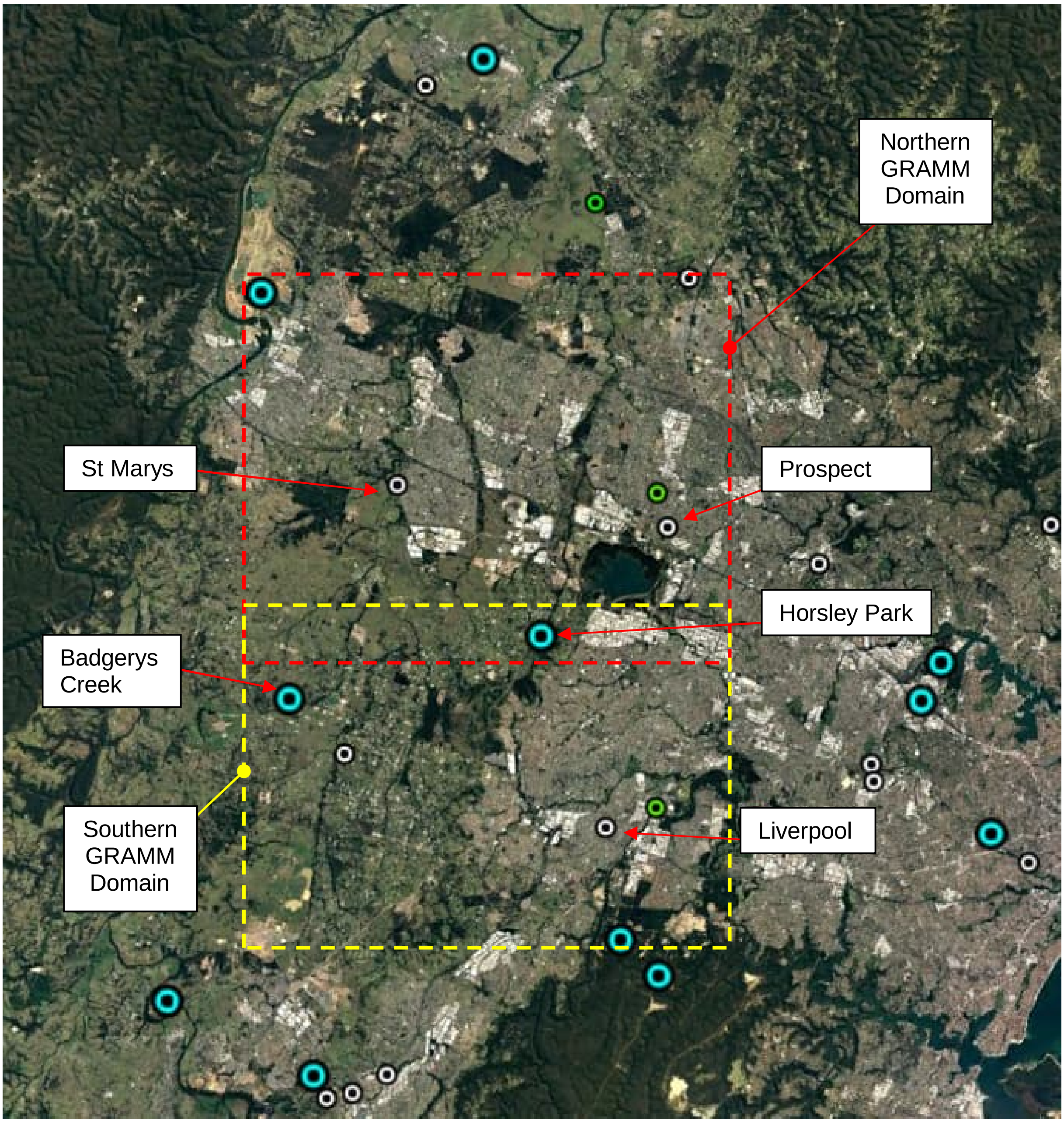


Figure 4-6 Location of DPE and BoM monitoring stations used in the GRAMM modelling

Physical characteristics and monitored data for the stations identified above were examined to determine whether these locations were acceptable for use in the modelling. A detailed analysis of each station has been included in **Appendix C**. The findings of the analysis showed that reasonable results were obtained using data from all three stations in each domain and all stations were used in the MTO analysis.

Development of a CALMET dataset

Stability class data is required as an input to the MTO process. To enable the development of stability classes, a CALMET run was undertaken, and stability classes extracted at the location of the surface stations. A total of 23 meteorological stations (operated by either DPE (EES) or BoM) were identified within or close to the Sydney region surrounding the Westlink M7 study area and were considered to be suitable for inclusion in the CALMET meteorological model. Stations used to calculate stability classes for use in the CALMET model to provide the stability classes for the GRAMM model are shown in **Figure 4-7**. A detailed analysis of the meteorological station suitability and CALMET settings are provided in **Appendix C**.

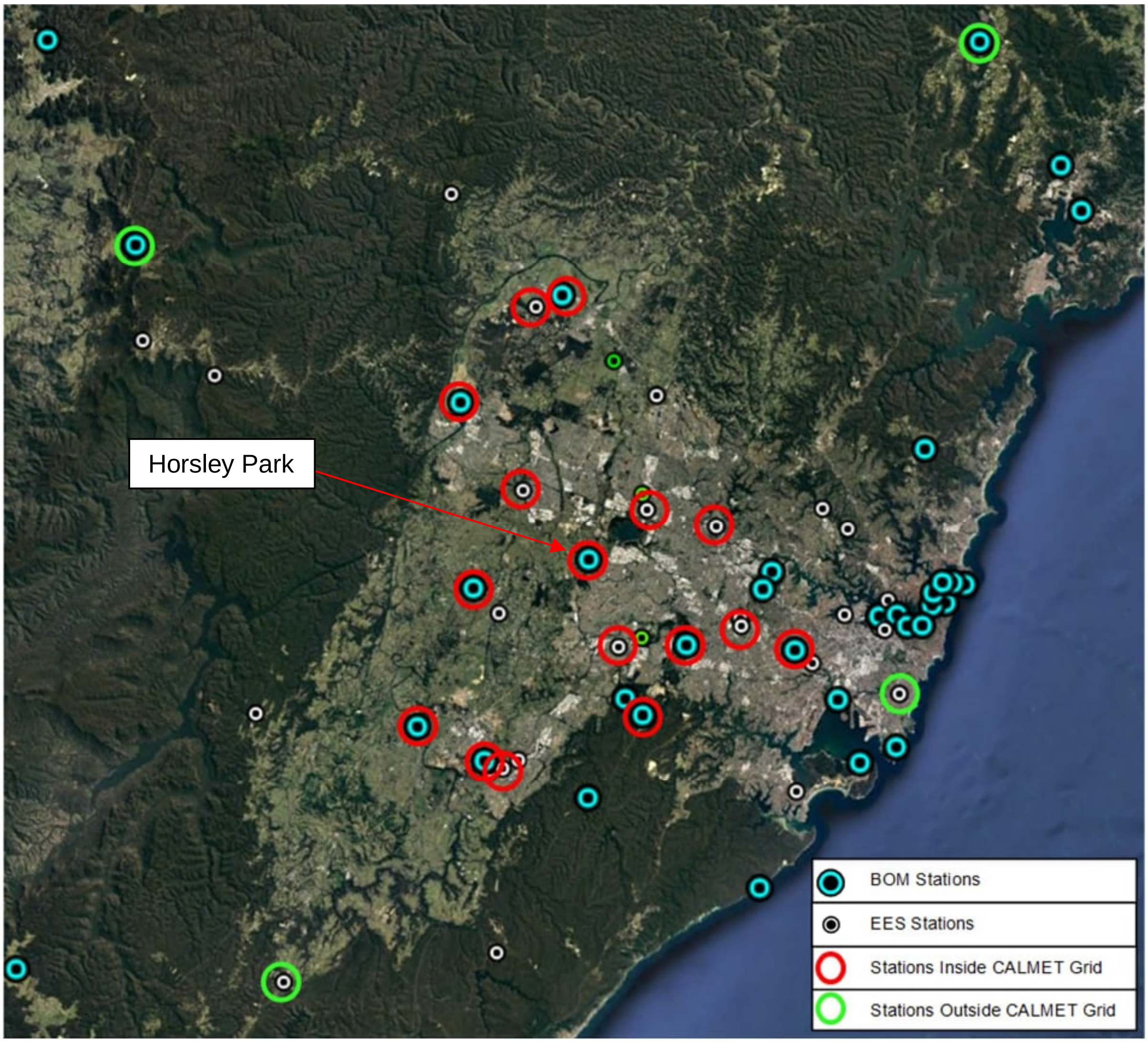


Figure 4-7 Location of Regional DPE and BoM monitoring stations used for CALMET modelling

Match to Observation Function

Following the preliminary GRAMM modelling of the synthetic meteorological data, assessment of the observation stations and the generation of stability classes from CALMET data, a meteorological data file for the 2016 to 2018 period was developed in GRAMM meteorology input format. This data was entered into the MTO function within GRAMM and a time series of meteorological conditions best matching the surface station observations generated from the MTO modelling run.

The MTO function can be adjusted using a weighting factor for each station allowing a closer, more representative station to more heavily influence the MTO process. A range of weightings were trialled for the surface stations to determine a best fit MTO outcome in GRAMM. A summary of the trialled weightings are presented in **Appendix F**. Of the options trialled and discussed, the option using the three stations with equal weighting was selected for the southern domain and the options with Horsley Park weighted highest followed by Prospect with St Mary's weighted the lowest was selected for the northern domain.

A further comparison of observed winds at the Horsley Park BoM station and the GRAMM MTO data at the Horsley Park BoM station location are presented in **Figure 4-8**. This shows that there is a reasonable correlation of winds between the Horsley Park observations and the GRAMM predictions. Average winds speeds are a little higher in the observations compared with the MTO data, which is likely to be conservative and hence acceptable for the Proposed Modification. The frequency of calm conditions (< 0.5 m/s winds) is higher for the MTO data, which again is expected to result in the MTO data being slightly more conservative. Overall, the GRAMM wind data appears suitable for use in this assessment.

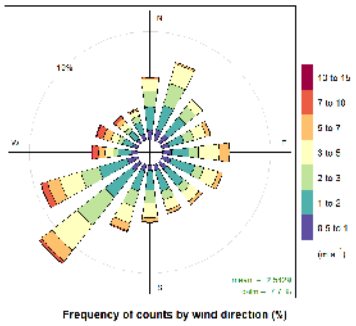
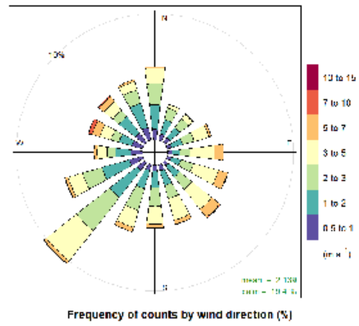
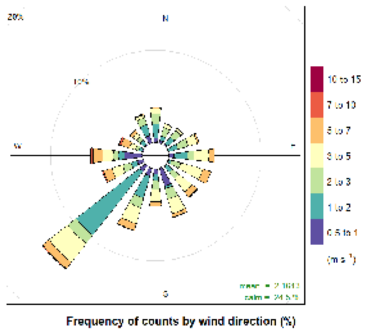
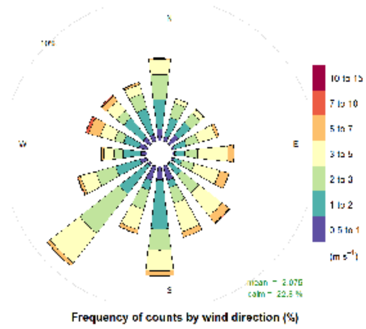
Southern Domain Horsley Park	Northern Domain Horsley Park
2016-2018 Measured	
	
2016-2018 MTO Data	
	

Figure 4-8 Horsley Park measured and MTO wind rose comparison

A range of wind fields were extracted for analysis as part of the meteorological data verification process. The most frequent wind condition experienced for the MTO modelling domain shown below in **Figure 4-9 and Figure 4-10**. The GRAMM wind fields showed that winds across the study area were generally consistent for the most common wind condition and only mildly affected by terrain and land use as wind speeds change across the domain.

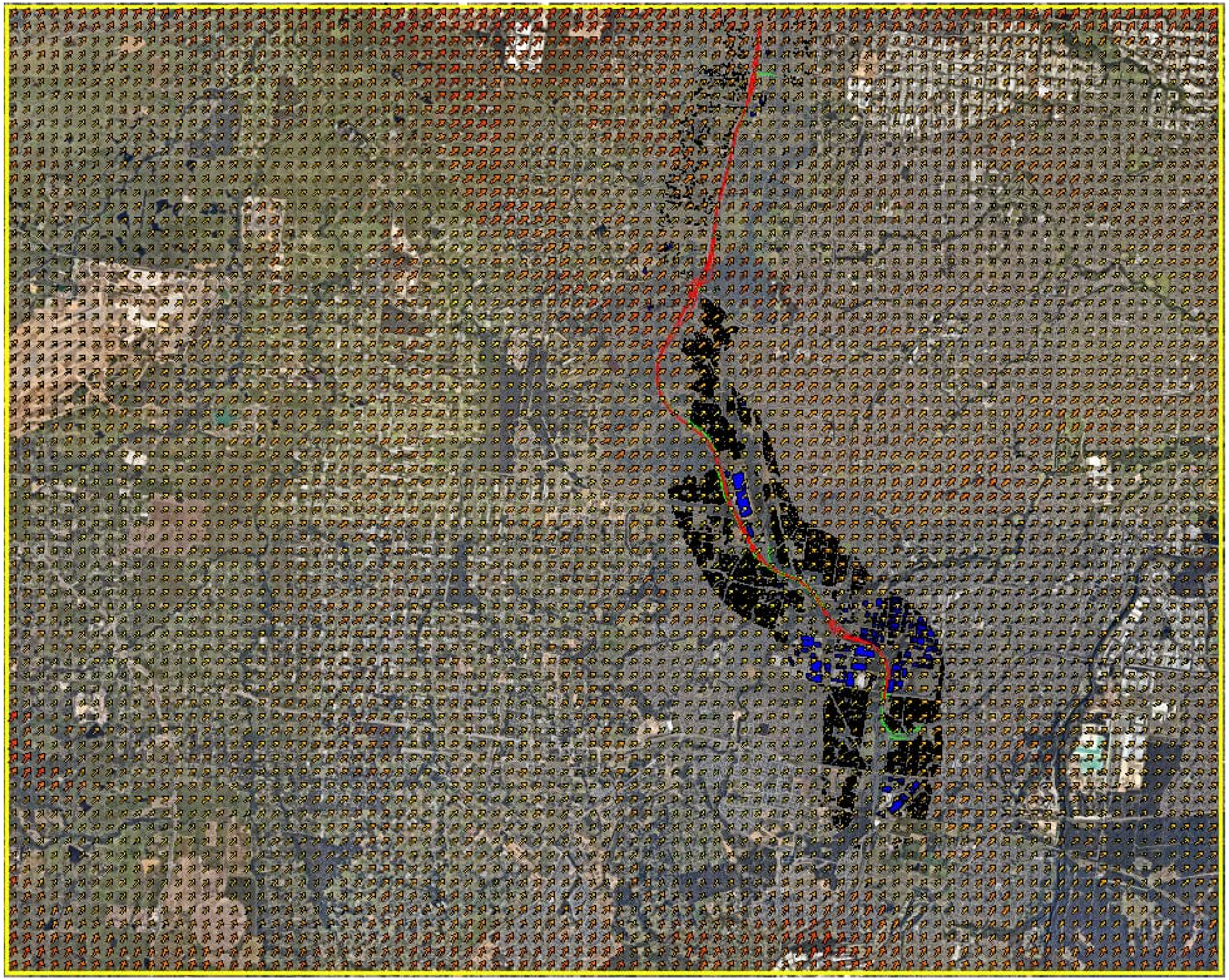


Figure 4-9 Most common wind field for the Southern Domain

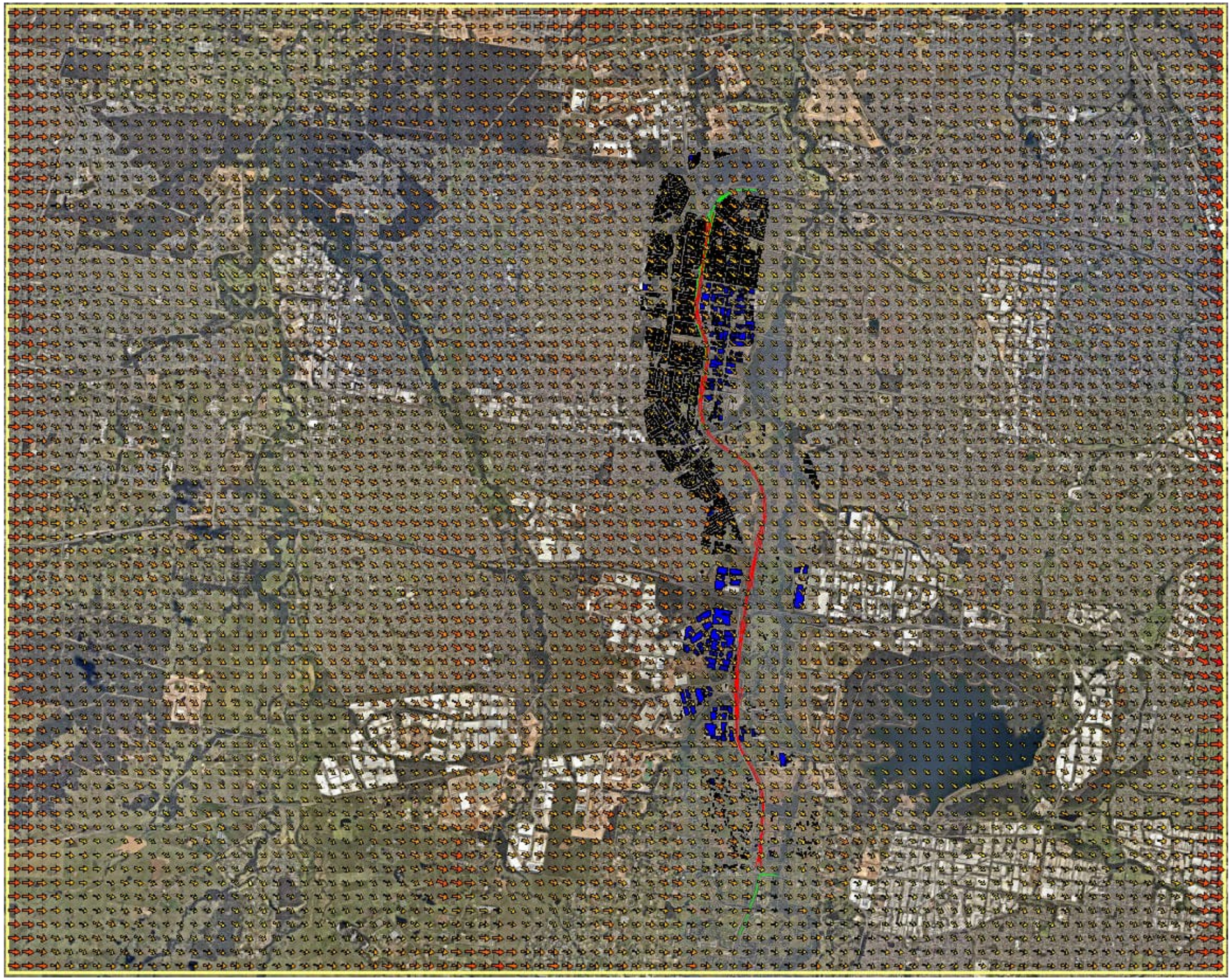


Figure 4-10 Most common wind field for Northern Domain

4.2.4.2 Terrain data

Terrain data has been extracted for both the GRAMM and the GRAL meteorological data development from 5m NSW Government Spatial Services Digital Elevations Models (DEMs) database. For the GRAMM domain the 5 m DEMs were resampled to a 50 m resolution to account for the large size of the GRAMM domain. 5 m resolution data is still considered to be very high-resolution data for the GRAMM domain, which produces a 250 m resolution wind field over each of the two GRAMM modelling domains. The terrain data used by the GRAMM model to develop the regional wind fields is displayed in **Figure 4-11** and **Figure 4-12** (along with the GRAL domain and the buildings included in the GRAL modelling run for context).

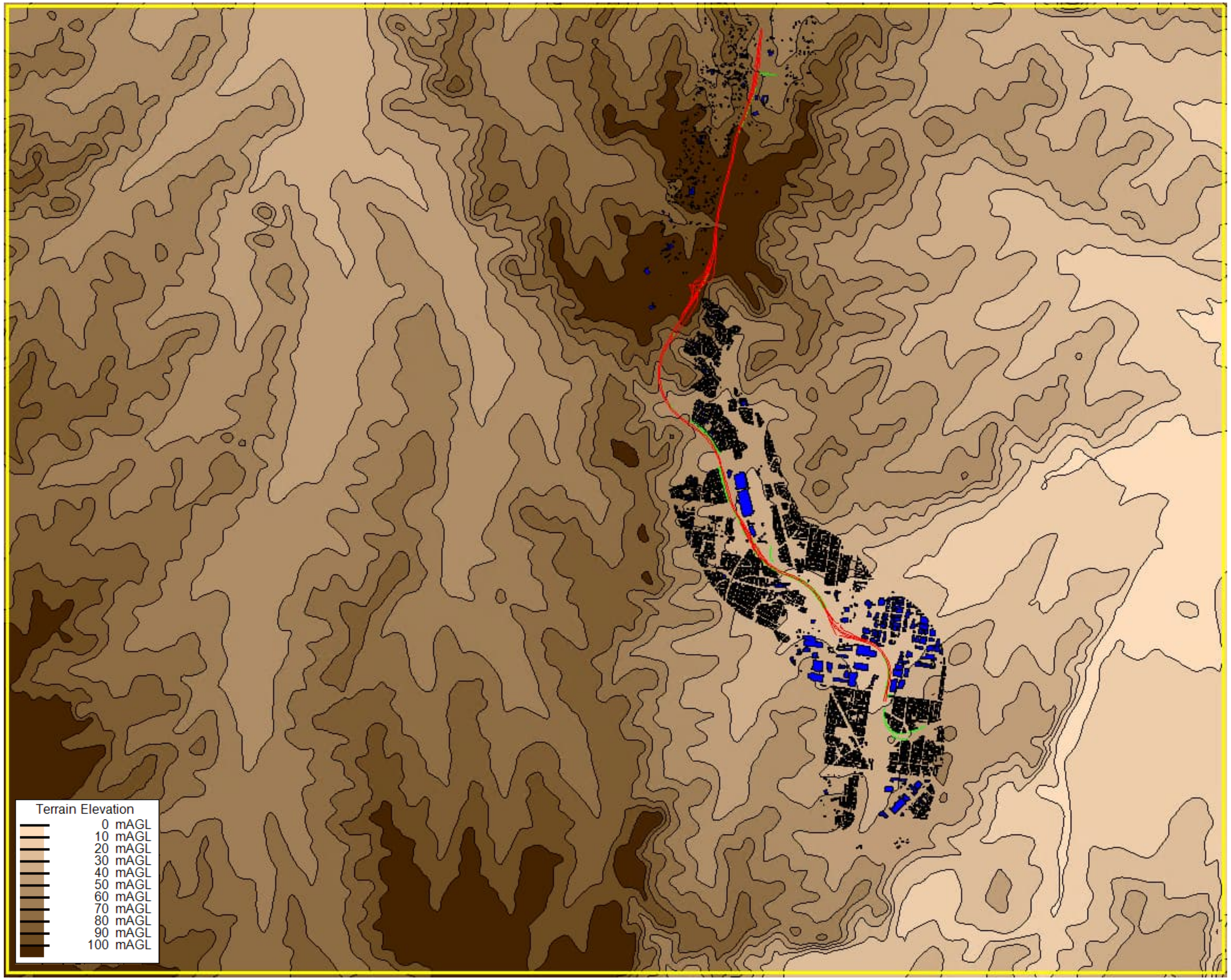


Figure 4-11 GRAMM terrain data representation (Southern Domain)

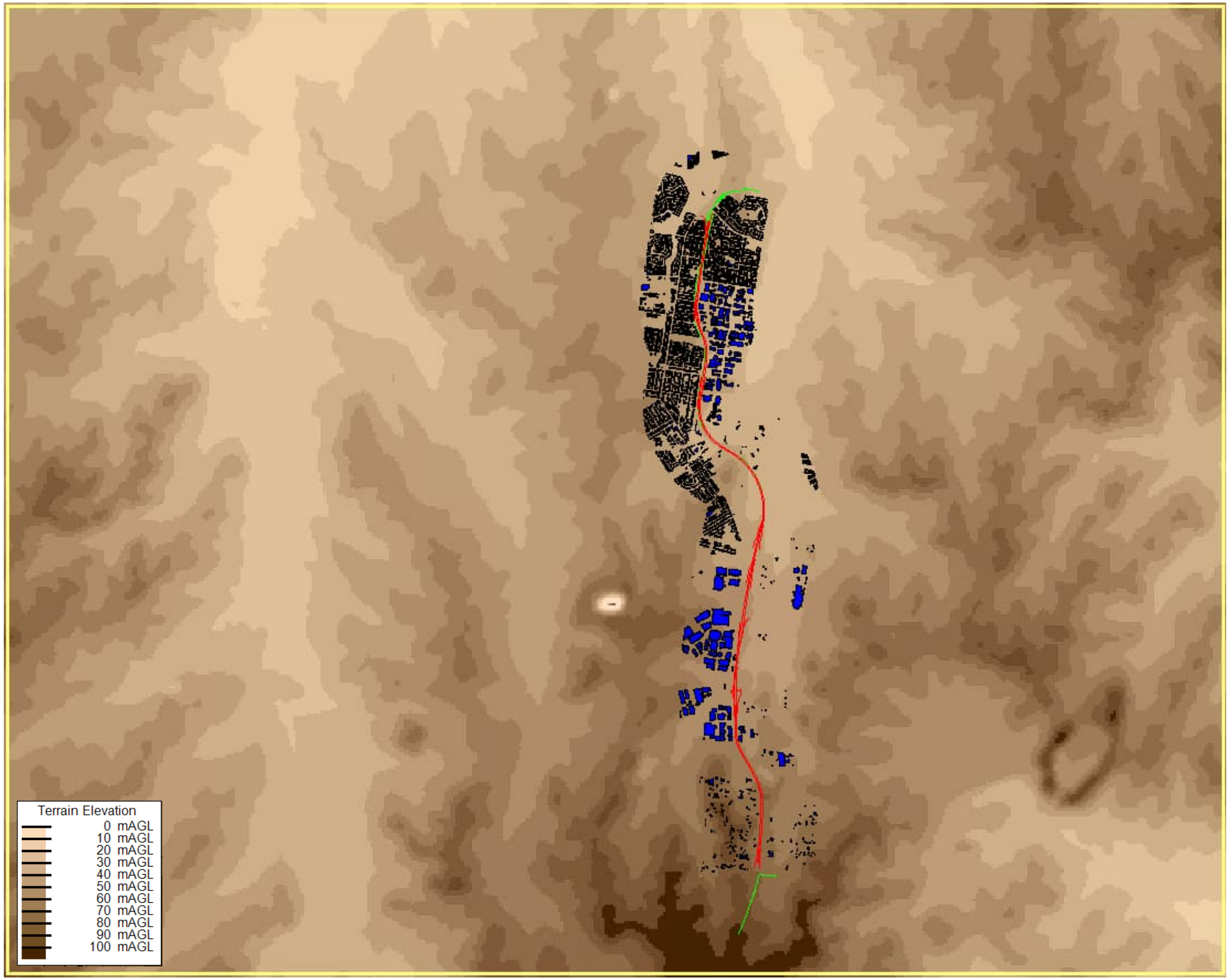


Figure 4-12 GRAMM terrain data representation (Northern Domain)

The GRAL model also produces wind fields for the dispersion calculations. GRAL wind fields are based on GRAMM wind fields as an initial guess with the winds flows around the obstacles (buildings, vegetation etc) calculated before calculations are undertaken to calculate the plume dispersion.

A 5 m terrain resolution data set was used by this study due to the large size of the GRAL modelling domain and the level of detail required to accurately resolve wind flows around buildings on a small scale. A plot showing the terrain included in the GRAL modelling has been provided in **Figure 4-13**, along with the buildings and roads included in the dispersion modelling.

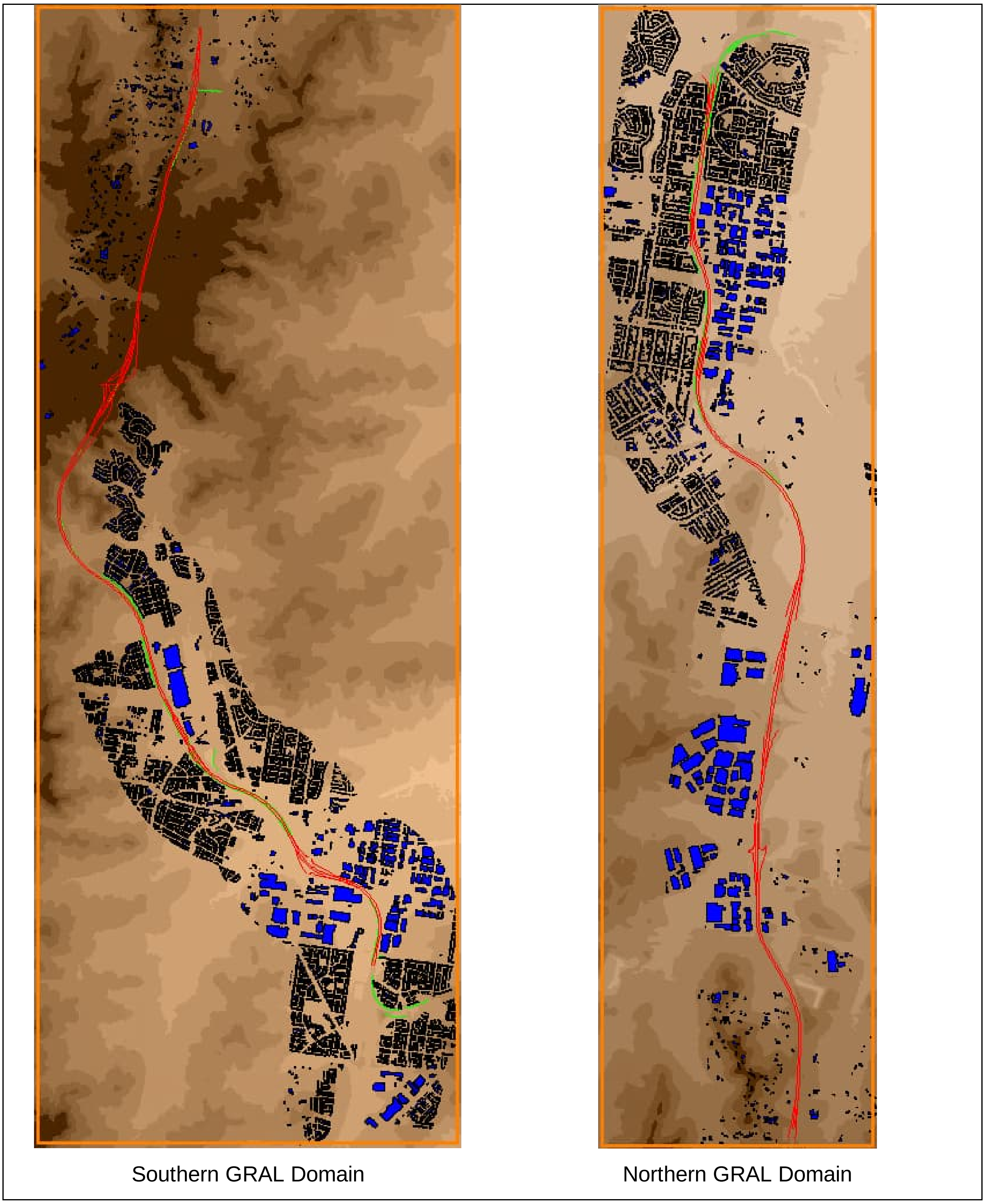


Figure 4-13 GRAL terrain data representation (5m resolution)

Terrain data used for the CALMET data generation was obtained from the SRTM 30 m Global Terrain Database. This data was used to establish the overall terrain heights used to generate the meteorology extracted from CALMET for use in the GRAMM model and the CALPUFF model. The terrain for the CALMET domain is discussed in **Appendix C**.

4.2.4.3 Land use data

Changes in land use can affect how air moves across the earth's surface with factors such as surface roughness, soil moisture, albedo (measure of the diffuse reflection of solar radiation), and heat conductivity all influencing wind speed and direction over the modelling domain. A more detailed description of the land use scheme use and the effects of the different settings is provided in the GRAL documentation.

GRAMM model uses the CORINE land use scheme which outlines land uses according to 44 different categories as defined in the GRAMM user manual. Data for use in the modelling was extracted using GIS techniques from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) "Catchment Scale Land Use of Australia", December 2018 version. Cross checks with recent satellite imagery showed a good match with the ABARES data across the Southern and Northern modelling domains and surrounding areas.

The land use categories which were applicable for the GRAMM domain for this assessment are shown in **Table 4-8**. Spatial distribution of land use in the GRAMM domain are presented in **Figure 4-14**.

Table 4-8 CORINE codes adopted in the Sydney basin

CORINE Code	Land use description
111	Continuous urban fabric
112	Discontinuous urban fabric
121	Industrial or commercial units
122	Road and rail networks and associated land
124	Airports
131	Mineral extraction sites
132	Dump sites
141	Green urban areas
211	Non-irrigated arable land
212	Permanently irrigated land
221	Vineyards
222	Fruit trees and berry plantations
223	Olive groves
231	Pastures
241	Annual crops associated with permanent crops
242	Complex cultivation patterns
313	Mixed forest
321	Natural grasslands
324	Transitional woodland-shrub
421	Salt marshes
511	Water courses
512	Water bodies
522	Estuaries

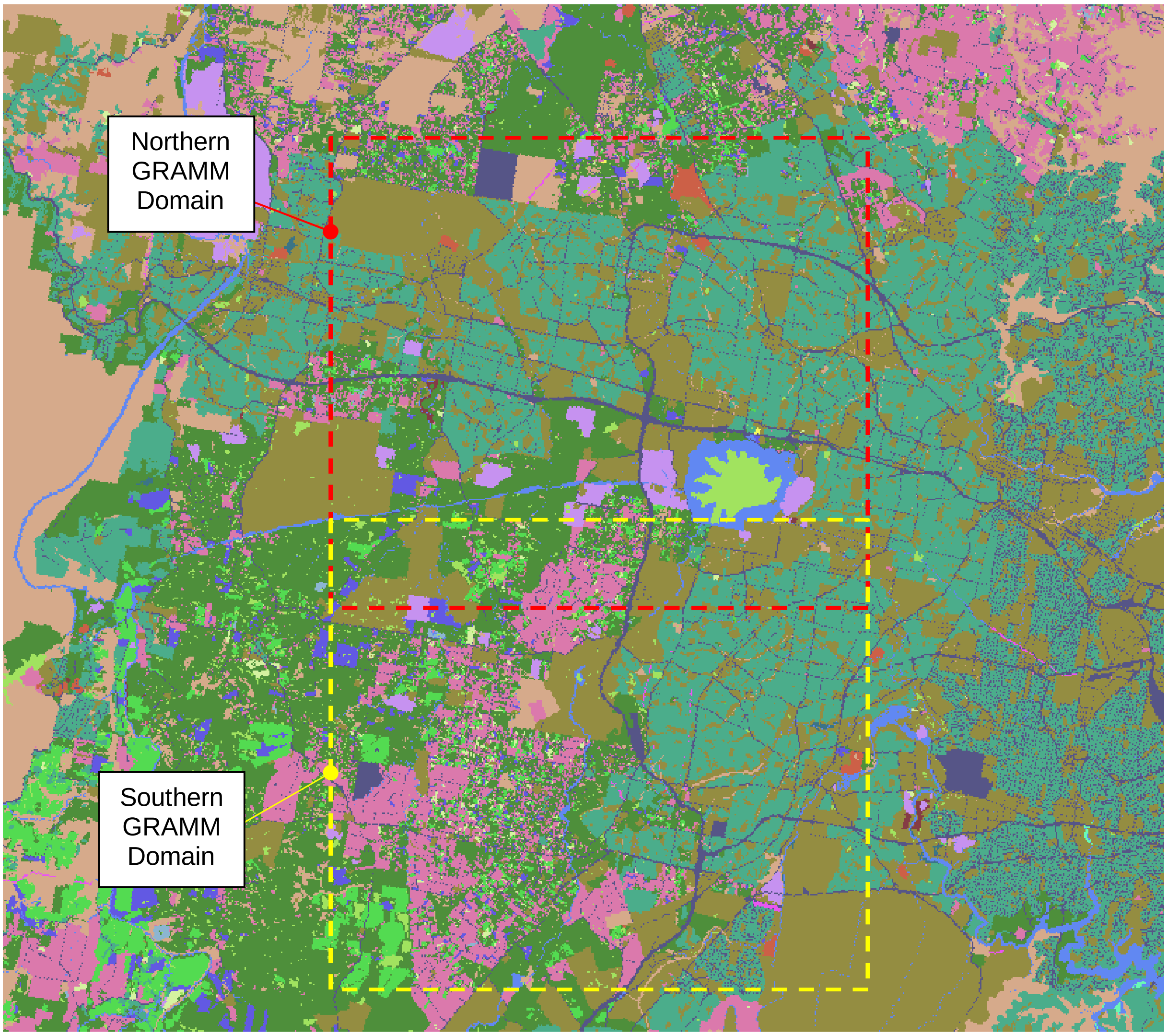


Figure 4-14 **GRAMM land use data representation – This is a diagrammatic representation of data only**

4.2.4.4 Building data

Building data are critical to the flow of air around the buildings neighbouring the roadway. Buildings need to be considered as part the air quality assessment to ensure the effect of the buildings on the plume dispersion are appropriately considered. GRAL accepts building heights, ground elevation, building vertices, and roof area. These data were obtained from GIS databases, aerial photography and observations of buildings along the M7. The locations of buildings used in GRAL are presented graphically in **Figure 4-15**.

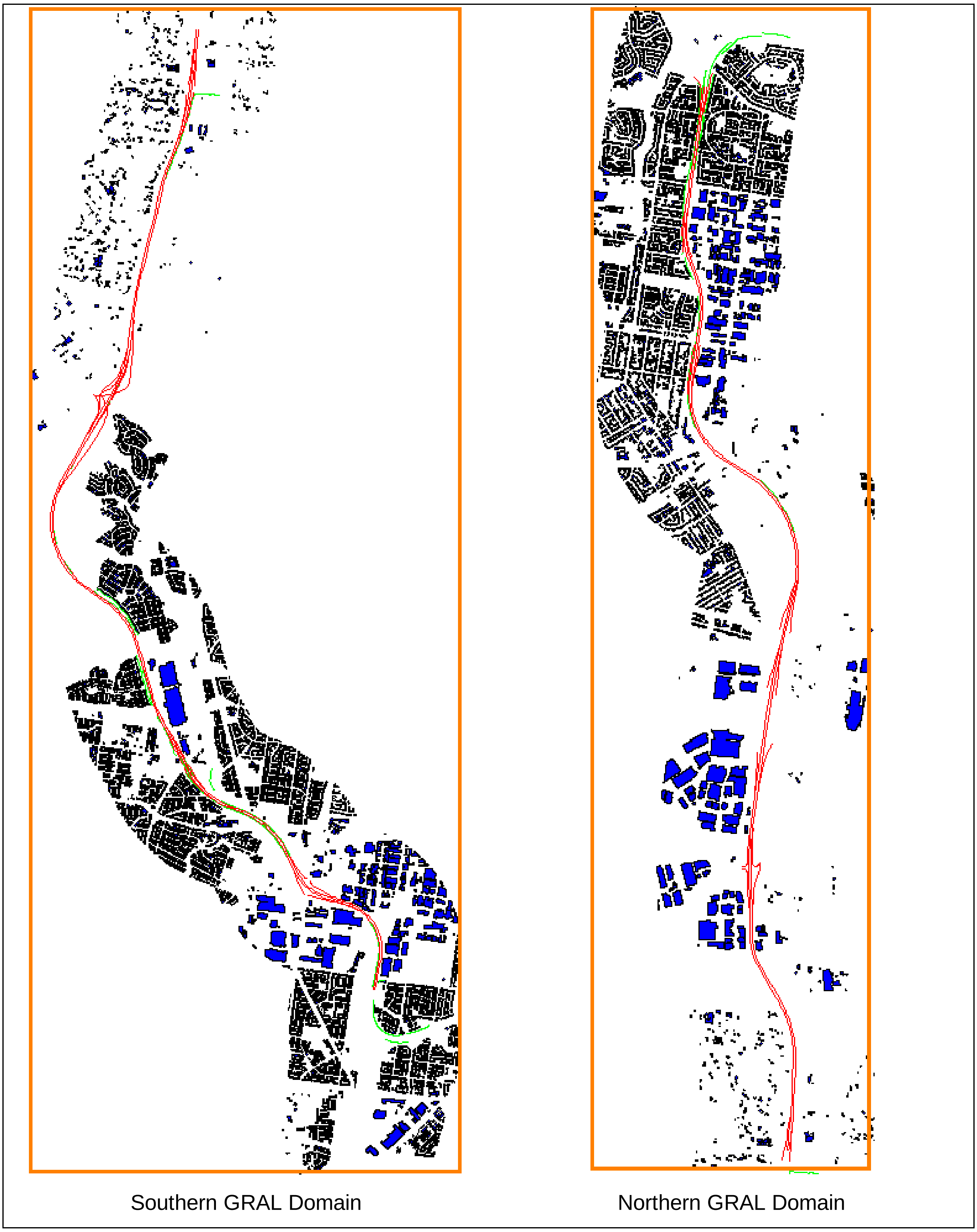


Figure 4-15 Buildings included in the GRAL domain

4.2.4.5 Discrete receptors

Air pollutants such as NO_2 and $PM_{2.5}$ must be assessed at nearby sensitive receptor locations, whereas toxic pollutants such as Benzene or PAH must be assessed at or beyond the boundary of a premises. Receptors for the Proposed Modification were placed at representative locations along the length of the roadway for both the Southern and Northern domains. Results are presented in terms of the concentrations at the sensitive receptor locations along the M7 motorway. In addition, several cross sections have been included along the length of the motorway to try and understand the concentrations as the plume moves away from the roads edge.

Receptor locations included in the modelling are presented in **Figure 4-16**.

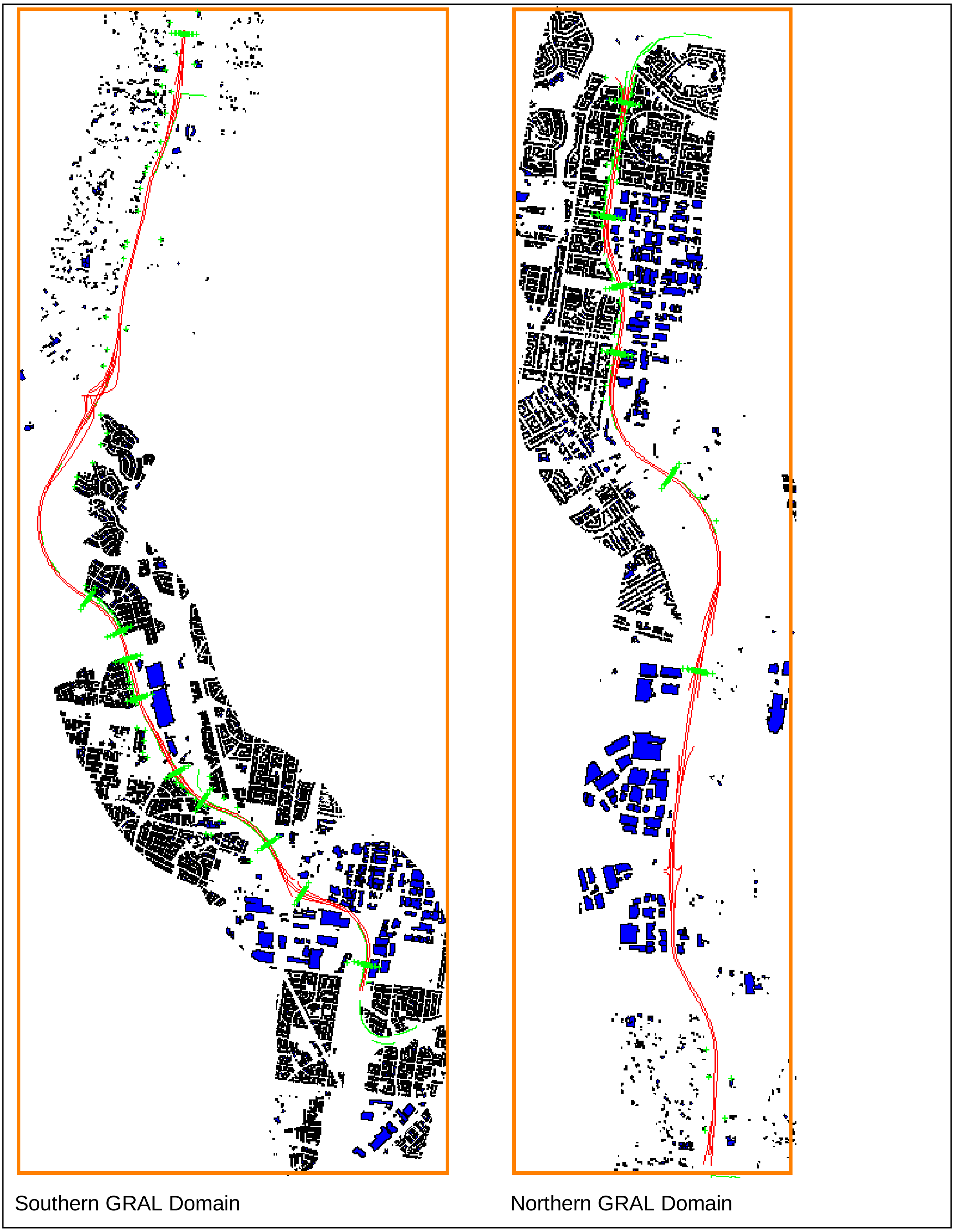


Figure 4-16 **Southern and Northern Domain Sensitive Receptors (receptors shown as green crosses)**

4.2.4.6 GRAMM and GRAL settings

GRAMM and GRAL model parameters used for this assessment are presented in **Table 4-9** and **Table 4-10**, respectively. The settings were selected based on guidance provided in Ottl et. al. (2020) and the GRAL and GRAMM manuals for the March 2022 release.

Table 4-9 GRAMM model settings

Parameter	Value	
	Southern Domain	Northern Domain
Version	March 2022	
Meteorological grid domain	22.0km x 17.5km	22km x 17.5km
Horizontal grid resolution	250 m	
Reference grid coordinate (origin)	288000m, 6237000m	288000m, 6251500m
Vertical thickness of first layer	10 m	
Number of vertical layers	15	
Vertical stretching factor	1.4	
Relative layer height	(Layer 15) 3874 m	
Surface meteorology coordinates	Badgerys Creek (289920m, 6246952m) Horsley Park (301708m, 6255298m) Liverpool (306572m, 6243489m)	Horsley Park (301708m, 6255298m) St Marys (293255m, 6258315) Prospect (306900m, 6258700m)
Simulation length	3 Years (2016-2018)	
Number of synthetic wind speed categories	24	
Synthetic wind speed categories	0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 9.0, 10.0, 12.0, 14.0, 16.0m/s	
Number of meteorological conditions[1]	1346	1489
Maximum time step	10 seconds	
Modelling time	3600 seconds	
[1] Number of meteorological conditions reflects the number of binned conditions (common meteorological conditions), not the number of conditions used to calculate results. Number of hours considered for the calculation of modelling statistics is 26,280 hours (hours between 2016 and 2018).		

Table 4-10 GRAL model settings

Parameter	Value	
	Southern Domain	Northern Domain
Version	March 2021	
Flow field grid domain	5,440m x 14,760m	3010m x 12,630m
Horizontal grid resolution	5m	
Vertical thickness of first layer	2m	
Number of vertical layers		
Vertical stretching factor	2-20m AGL – 1.02,	

Parameter	Value	
	Southern Domain	Northern Domain
	20-50m AGL – 1.05 50-150m AGL – 1.10 150-250m AGL – 1.20 250m+ AGL- 1.20	
Number of horizontal slices	1 (2m)	
Relative layer height	79 (11297m maximum layer height)	
Dispersion time	3600 seconds	
Particles per second	400	
Surface roughness	0.2	
Roughness of building walls	0.01m	
Latitude	-34	
Modelled height of receptors	2 m	
Number of source groups	78	72
Terrain	Complex terrain - original terrain data used for GRAL (see data presented in **Section 4.1.2.1**)	

4.2.5 Emissions inventory

The air quality assessment considers emissions to air due to the operation of motor vehicles on the existing and proposed configurations of the M7 and access ramps. Motor vehicles create emissions to air from the combustion and evaporations of fuels to power the vehicles and non-combustion processes such as tyre, brake and road wear.

To enable a spatially accurate emissions profile along the length of the M7, the surface road and the on/off access ramps were divided into a series of unique links to allow for changes in the road profile and traffic behaviours.

The emissions calculation methodology was consistent between scenarios. Emissions rates for each unique link were calculated as summarised by the below high-level generic formula:

$$Total\ Emission\ Rate = \{(Base\ Hot\ EF \times Speed\ Factor \times Grade\ Factor) + non-exhaust)\}\ \text{x Traffic Volume}$$

Cold start emissions were not considered due to the assessment being focused on motorway operations where vehicles are assumed to be at operating temperature before entering the motorway. Evaporative emissions were also not considered due to the complexity of quantifying them at an hourly resolution, whilst also being largely controlled by vehicle emissions systems, rendering the emissions insignificant in comparison to combustion emissions.

There are several factors which need to be considered when determining the emissions from a vehicle fleet. The factors relevant to this investigation are summarised below in **Table 4-11**, and described further in **Section 4.2.5.2**.

Table 4-11 Emission rate dependencies

Parameter	Dependencies	Comment
Base emission factor	Source of emission factors	NSW EPA Air Emissions Inventory 2013 Calendar Year: On road mobile air emissions inventory (AEI)
	Year of assessment (2021, 2026, 2036)	2021 scenario used 2016 base EF's 2026 scenario used 2026 base EF's 2036 scenario used 2036 base EF's
	Fleet mix (traffic composition)	Modelled based on traffic fleet mix as provided by traffic engineers for existing and future scenarios.
	Pollutant	Emission factors are calculated individually for each pollutant for entry into the model
	Vehicle class	Emissions vary by vehicle class, i.e.: light vs heavy vehicles. Light and heavy vehicles have been further spit according to the different sub-variants of the traffic fleet mix.
	Fuel type	Emissions vary by fuel type, i.e.: petrol vs diesel and emissions have been calculated to reflect variability in fuel usage across the fleet.
	Road type	Road types variability has been considered by the emissions calculations i.e.: congested traffic vs free flowing traffic for a given average speed
	Road grade	Variability in road grade affects emissions from vehicles on the road. Emissions rates have been calculated taking into consideration the road grade.
	Non-exhaust emissions	Non-exhaust generated pollutants generated from the non-combustion sources, i.e.: brake, tyre and road wear.
	Evaporative losses[1]	Emissions of VOCs not due to combustion
	Cold start emissions[1]	Additional emissions, due to the vehicles running "richer" (and other inefficiencies) before reaching normal operating temperature
Speed factor	Source of speed factor data	AEI, 6th order polynomial calculations considering road type base speed, and modelled speed, per link, per hour of day.
	Traffic speed	Emission rates vary by vehicle speed. Data used in the modelling was based on expected average speed for a one-hour period for each road link.
Grade factor	Source of grade factors	PIARC (2019), Road Tunnels: Vehicle Emissions and Air Demand for Ventilation
	Grade	Factor varies by road grade, i.e.: varies between -6% to 6%

Parameter	Dependencies	Comment
Traffic volume	Source of traffic volumes	2021 scenario traffic numbers obtained from traffic count data. 2026/2036 traffic numbers obtained from traffic modelling
	Total volume	AADT data calculated for all road links and tunnel modelling scenarios. Data obtained from traffic model.
	Traffic data resolution	Weekday 24-hour cycle

[1] : These emissions are not included in the emission rate calculations

Below is a generic example of all inputs required to calculate a single road link emission rate for a single emission year (2021), single pollutant (PM_{10}) and single vehicle class (diesel truck), which would form a part of an emission rate model input timeseries.

$$
\begin{aligned}
ER\ (kg.h.km) \ &= \{Hot\ Base\ EF\ (2021 * PM_{10} * Truck * Diesel * Highway * 2\%)\} \\
&\times \{Speed\ Factor\ (80kmh * PM_{10} * Truck * Diesel * Highway)\} \\
&\times \{Grade\ Factor\ (80kmh * PM_{10} * Truck * Diesel * 2\%)\} \\
&+ \{Non_{exhaust}\,(PM_{10} * Truck * Highway)\} \\
&\times \{1\ hour\ Traffic\ Volume\ (2018 * 7am * Truck * Diesel)\}
\end{aligned}
$$

4.2.5.1 Dispersion modelling road input data

Each unique road link (length of road between two know points) is entered into the model individually and modelled at 1kg/hr/km to create a prediction timeseries for each link covering every hour of the day for a one-year period. Each road link model input group is known as a “source group”. Emission rates for each link were extracted from the traffic model in the same units of kg/hr/km for each hour of the day to create “scaling factors” to apply to a timeseries of data for each source group. These scaling factors were applied to the modelled data to create a “scaled” results timeseries for each link / source group which aligns with each of the scenarios for the assessment, i.e. year and with or without project.

Results from each individual link were then summed to determine the ground level concentration at each gridded and sensitive receptor. Additionally, “difference” timeseries were generated by subtracting the “no project” timeseries from the “with project” timeseries’ to determine the effects of the Proposed Modification on air quality at each receptor location.

The M7 covers approximately 27km of road from north to south and, as outlined above, was modelled across two smaller domains to aid with processing time (modelling and receptor timeseries extraction). Southbound and Northbound links as defined in the model are presented in **Appendix H**.

4.2.5.2 Emission factors

Hot running base emission factors and non-exhaust emission factors were obtained from the DPE / NSW EPA in Microsoft Excel worksheet format as a simplified version of the NSW EPA Air Emissions Inventory for the Greater Metropolitan Region in NSW - On Road Mobile Emissions model for the 2013 calendar year (AEI). The AEI comprehensively compared and reviewed emissions from multiple models, public resources and Australian based testing campaigns to determine the published emission factors. The AEI is considered one of the most comprehensive and up to date resources for vehicle emissions in NSW and was considered suitable for the assessment as the Proposed Modification traffic was well represented by the AEI vehicle classes.

Base emission factors required adjustment through the calculation of correction factors to determine specific emission rates for each unique road link. The correction factors account for the terrain, the vehicle class and driving behaviours. Each influencing factor is introduced below and discussed in the following sections:

- Year of assessment and emissions year
- Pollutants

- Vehicle classes
- Fuel types
- Road types
- Road grade (±% slope) – correction factor
- Speed – correction factor
- Non-exhaust emissions
- Cold start emissions (not modelled)
- Evaporative emissions (not modelled).

Year of assessment and emissions year

Year of assessment or emissions year influences emission rates as vehicle emissions standards in Australia are based on the vehicles Australian Design Rule (ADR), which is assigned based on the manufacture date of the vehicle. Generally, emissions standards increase in stringency over time, however the base hot emission factors do not align exactly with the ADR emission standards for the emission year as there is a lag between more stringent emission standards coming into effect and reduced emissions from vehicles on the road, due to the replacement rate of vehicles. This results in equivalent classed vehicles (e.g. petrol passenger vehicles) having varying emission rates due to their age and emissions standards at the time of their manufacture.

The years assessed for the Proposed Modification were:

- 2021 – base case
- 2026 – project opening
- 2036 – project opening + 10 years.

Deterioration of vehicle components because of age and kilometres travelled is another factor that can influence emission rates, and these have also been considered in the AEI base emission factors.

The AEI base emission factors generally reduce over time, driven by the replacement of older vehicles resulting in a higher proportion of vehicles complying with more stringent emissions standards.

The AEI emission factor years selected to represent the emission years were:

- 2016 for the 2021 existing scenario
- 2026 for the 2026 Proposed Modification opening scenario
- 2036 for the Proposed Modification opening + 10 scenario (2036).

An additional layer of conservatism is also applied to this assessment as projected emission factors for the 2036 project scenarios do not include draft mandates to vehicle emission standards discussed in **Appendix B**. Specifically, when implemented the draft Regulatory Impact Statement (RIS) for Light and Heavy Vehicle Emissions (Commonwealth Government 2020 and 2020a) would result in a lowering of emission rates for NO_2, PM_{10} and $PM_{2.5}$ from July 2027 onward. As such emission factors for the 2036 scenario are expected to be conservative.

Pollutants

The base pollutant emission factors sourced from the AEI were as follows:

- Oxides of nitrogen (NOx)
- Hydrocarbons (HC) – termed Total Volatile Organic Compounds (TVOC) in this assessment
- Carbon monoxide (CO)
- Particulate matter <10µm (PM_{10}) – exhaust.
- Particulate matter <10µm (PM_{10}) – non-exhaust

- Particulate matter <2.5µm ($PM_{2.5}$) – non-exhaust.

PM2.5 - exhaust

$PM_{2.5}$ – exhaust was calculated as a ratio of PM_{10} – exhaust, specific to vehicle class and fuel type for exhaust emissions in the Sydney region. The ratios were developed from annual emissions data sourced from the AEI. The ratios used are presented below:

Table 4-12 $PM_{2.5}$: PM_{10} ratios for vehicle and fuel classes

Vehicle Class	$PM_{2.5}$:PM_{10} ratio
Petrol Passenger Vehicle (PPV)	95.2%
Diesel Passenger Vehicle (DPV)	96.8%
Petrol Light Commercial Vehicle (PLCV)	95.4%
Diesel Light Commercial Vehicle (DLCV)	96.8%
Rigid Truck (RIG)	97.0%
Articulated Truck (ART)	97.0%
Diesel Bus (BUSD)	97.0%

Speciated VOCs

VOC's are modelled as total VOC (TVOC) and are speciated by applying a speciation profile (ratio) to determine the concentrations of individual compounds. Speciation profiles are based on the 2013 AEI reported annual emissions for the Sydney region due to on-road mobile sources.

The speciation profile applied to TVOC's is presented below in **Table 4-13**.

Table 4-13 TVOC speciation profile

Species	Percent of TVOC
1,3 Butadiene	0.55%
Acetaldehyde	0.56%
Benzene	2.38%
Formaldehyde	1.41%
Toluene	4.97%
Xylene	3.70%

Polycyclic Aromatic Hydrocarbons (PAH's)

PAH's are calculated as a ratio from total VOC emissions using annual totals for on road mobile emissions.

The method for calculation was as follows:

1. Determined the ratio of total PAH:VOC from the summary data in the 2008 and 2013 AEI, for Sydney (SYD) and the greater metropolitan region (GMR). The PAH totals are reported in "as emitted" masses and as such are not directly applicable to the ground level concentration criteria, as the mass emission has not been converted to benzo[a]pyrene equivalent ($PAH_{b[a]p}$).
2. Speciated PAH emission data from the 2008 AEI (speciated data not publicly available in the 2013 AEI) is converted to $PAH_{b[a]p}$ by using potency equivalency factors (PEF), in order of preference, from:
   - NSW EPA Approved Methods
   - Office of Environmental Health Hazard Assessment (OEHHA)

- Tasmanian EPA

Where a PEF was not available for an individual PAH species, the species was considered insignificant to health impacts and removed from any further calculations. The following values were calculated:

- Total PAH (as non- b[a]p equivalent) sum of only the species that had PEF's
- $PAH_{b[a]p.}$ (sum of all species with PEF's as b[a]p)
- A ratio was calculated from the two values, Total PAH: $PAH_{b[a]p,}$ which created a factor to convert PAH to $PAH_{b[a]p.}$

Note removing the species that don't have PEF's creates a level of conservatism by creating a lower total PAH to $PAH_{b[a]p}$ ratio.

3. The final $PAH_{b[a]p}$:VOC ratio was calculated by multiplying the ratios from the above two steps, which converts the total PAH to $PAH_{b[a]p}$ to ratio against total VOCs, as per the below equation:

$$\mathrm{PAH}_{b[a]p}\!:\mathrm{VOC} \;=\; \mathrm{PAH}\!:\mathrm{VOC} \;\times\; \mathrm{PAH}\!:\mathrm{PAH}_{b[a]p}$$

The $PAH_{b[a]p}$:VOC ratio was then applied to VOC predictions to generate $PAH_{b[a]p}$ predictions as necessary to assess against the $PAH_{b[a]p}$ criteria.

Data from the 2008 and 2013 AEI, for Sydney and the GMR was compared to determine the most conservative $PAH_{b[a]p}$:VOC ratio. The data is summarised below in **Table 4-14**, with the ratio used in the assessment denoted in bold.

Table 4-14 PAH to VOC ratio

Statistic	Unit	SYD, 2008	SYD, 2008	GMR, 2008	GMR, 2013
PAH total	kg	89,800	54,281	117,000	70,756
VOC total	kg	23,512,000	12,641,062	29,504,000	16,123,791
Total PAH:VOC	%	0.38%	0.43%	0.40%	0.44%
PAH:$PAH_{b[a]p}$	%	0.52%	0.52%	0.52%	0.52%
$PAH_{b[a]p}$:VOC	%	0.0020%	0.0022%	0.0021%	**0.0023%**

Note: Previous road assessments in the Sydney region have used the benzo[a]pyrene species alone from a reduced speciated list of PAH's (Environment Australia, 20003) to determine a $PAH_{b[a]p}$:VOC ratio, as opposed to the method detailed above. The method detailed above was preferred as the emission data is more recent, specific to Sydney and the GMR and considers all AEI reported species of PAH.

Base hot running emission factors used in the assessment are presented in **Appendix G**.

Vehicle class

The fleet mix (traffic composition) of vehicles was provided as "light" and "heavy" from traffic count data for the 2021 scenario, and traffic modelling for the 2026 and 2036 scenarios. To best quantify vehicle emissions, light and heavy vehicles were further refined to the seven AEI vehicle classes shown in **Table 4-15** below, along with the equivalent modelled data class.

Table 4-15 Vehicle classes

AEI class	Modelled data class
PPV	Light
DPV	Light
PLCV	Light
DLCV	Light

AEI class	Modelled data class
RIG	Heavy
ART	Heavy
BUSD	Heavy

To enable the conversion from simple light and heavy vehicles to the seven AEI vehicle classes, further statistics were considered.

The Australian Bureau of Statistics, Survey of Motor Vehicle Use, Australia (ABS, 2020) data was used to determine vehicle class split, within the categories light and heavy. For example, for "light" vehicles, 81% are passenger vehicles (PV) and 19% are light commercial vehicle (LCV). The passenger and light commercial vehicles were then further refined using AEI projected fuel splits by emission year (i.e.: 2016, 2026, 2036). For example, of total PV in 2016, 87% are petrol and 13% are diesel. All heavy vehicles were modelled as diesel as alternatively fuelled heavy vehicles numbers are insignificant.

The vehicle class composition data was equally adjusted to total 100% to account for the omitted alternatively fuelled vehicle classes, such as LPG fuelled vehicles, motorcycles, hybrid vehicles etc. For example, if PV's were 49.5% petrol, 49.5% diesel and 1% LPG, the fuel split data would be adjusted to 50% petrol and 50% diesel to ensure total vehicle emissions are calculated and modelled.

The data used to define the vehicle classes is presented below in **Table 4-16**.

Table 4-16 Vehicle class statistics

Data ID	ABS data	AEI ID	AEI fuel split			Final composition[1]		
			2016	2026	2036	2016	2026	2036
LIGHT	PV 81%	PPV	87%	79%	66%	71%	64%	54%
		DPV	13%	21%	34%	10%	17%	28%
	LCV 19%	PLCV	34%	14%	26%	6%	3%	5%
		DLCV	66%	86%	74%	12%	16%	14%
HEAVY	RIG 73%	RIG	100%	100%	100%	73%	73%	73%
	ART 15%	ART	100%	100%	100%	15%	15%	15%
	BUS 12%	BUSD	100%	100%	100%	12%	12%	12%

1: $Final\ Composition\ =\ ABS\ data\ \times\ AEI\ fuel\ split$

The above tabulated data is also charted below in **Figure 4-17**, with heavy vehicles omitted as they do not vary across the years due to being modelled as 100% diesel.

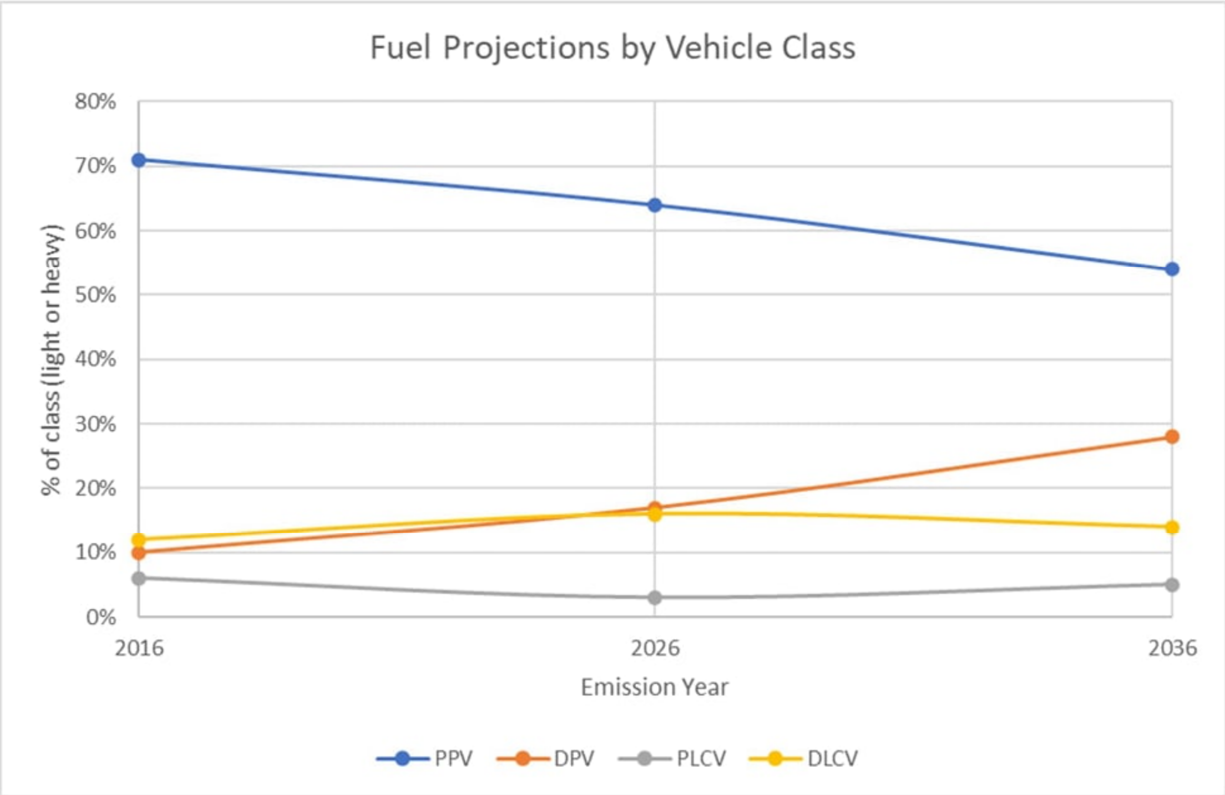


Figure 4-17 **Fuel projection by vehicle class for 2016, 2026, 2036**

Fuel type

Petrol and Diesel combustion emissions were calculated based on the traffic modelling for fleet mix for 2021, 2026 and 2036. As detailed above, emissions from alternatively fuelled vehicles were not calculated as they were considered to contribute only a minor contribution to total fleet emissions.

This simplification is expected to result in a conservative estimate as generally alternatively fuelled electric and LPG vehicles would be expected to have lower emissions than petrol and diesel vehicles.

Road type

The AEI included five road types to tailor emissions due to the expected driving behaviour, presented in **Table 4-17**. The road type used for this assessment was “Freeway/Motorway” as a best fit for the M7.

Table 4-17 Road definition

Road type	AEI code	definition/description
Local/Residential	Centroid Conn	Secondary roads with prime purpose of access to property. Characterised by low congestion and low levels of heavy vehicles. Generally one lane each way, undivided with speed limits of 50 km/h maximum. Regular intersections, mostly unsignalised, low intersection delays.
Arterial	Local/Coll	Provide connection from local roads to arterial roads and may provide support role to arterial (RTA defined) roads for movement of traffic during peak periods. Distribute traffic within residential, commercial and industrial areas. Speed limits 50-70 km/h, 1-2 lanes. Regular intersections, mostly uncontrolled. Lower intersection delays than Residential, but significant congestion impact at high volume to capacity ratios (V/C)

Road type	AEI code	definition/description
Commercial arterial	Sub-Arterial	Major road for purpose of regional and inter-regional traffic movement. Provides connection between motorways and sub-arterials/collectors. May be subject to high congestion in peak periods. Speed limits 60-80 km/h, typically dual carriageway. Regular intersections, many signalised, characterised by stop-start flow, moderate to high intersection delays and queuing with higher V/C ratios
Commercial highway	Arterial	Major road for purpose of regional and inter-regional traffic movement. Provides connection between motorways and sub-arterials/collectors. May be subject to moderate congestion in peak periods. Speed limits 70-90 km/h, predominantly dual carriageway. Lesser intersections than commercial arterial with smoother flow, but subject to some congestion at high V/C.
Freeway/Motorway	MW/FWY	High volume arterial roads with primary purpose of inter-regional traffic movement with strict access control (i.e. no direct property access). Speed limits 80-110 km/h, predominantly 2+ lanes and divided. Relatively free flowing and steady in non-congested, slowing with congestion approaching V/C limit, but minimal stopping

Road grade

The AEI does not include correction factors to account for grade (slope of the road), i.e. emissions variability due to traveling uphill or downhill. Generally travelling on a positive grade (uphill) creates higher emissions than travelling on flat or negative grade (downhill) as vehicle engines need to work harder, requiring additional fuel, which in turn creates additional emissions.

Correcting for grade was considered important for this project as there are terrain influences across the ~27km length of the Proposed Modification and for this reason grade factors were sought from other sources. The Tool for Roadside Air Quality (TRAQ) includes grade factors calculated from PIARC's *Road Tunnels: Vehicle Emissions and Air Demand for Ventilation* report, as have other AQIAs for recent road projects in NSW. PIARC (2019) data was used to calculate grade factors for this Proposed Modification. The PIARC emission factors, and therefore calculated grade factors, consider:

- Vehicle class
- Fuel type
- Pollutant
- Speed
- Grade

Example Grade Factor Calculation

$$Example\ data: \{PV, 60kmh, NOx.\ 0\%\ grade\ =\ 132.8g.h\ \&\ 2\%\ grade\ =\ 191.4g.h\}$$

$$\therefore PV, 60kmh, NOx, 2\%\ grade\ factor\ = \frac{132.8}{191.4} = 1.44\ (no\ unit)$$

The calculations were repeated to create specific grade factors for all combinations of vehicle class, fuel type, speed, pollutant and grade. Note PIARC does not have emission rates for TVOC, therefore CO grade factors were assumed for TVOC.

By applying grade factors to the AEI base emission factors, a refined emission factor was developed which considers the terrain influences for unique each road link.

An average road grade was calculated for each road link using google earth elevation data to determine the rise or fall, expressed as a percentage. The google earth elevation profile from north to south (southbound) is presented below in **Figure 4-18**, and a chart presenting road grade by Link ID as modelled in **Figure 4-19**.

Figure 4-18 **Southbound google earth elevation profile**

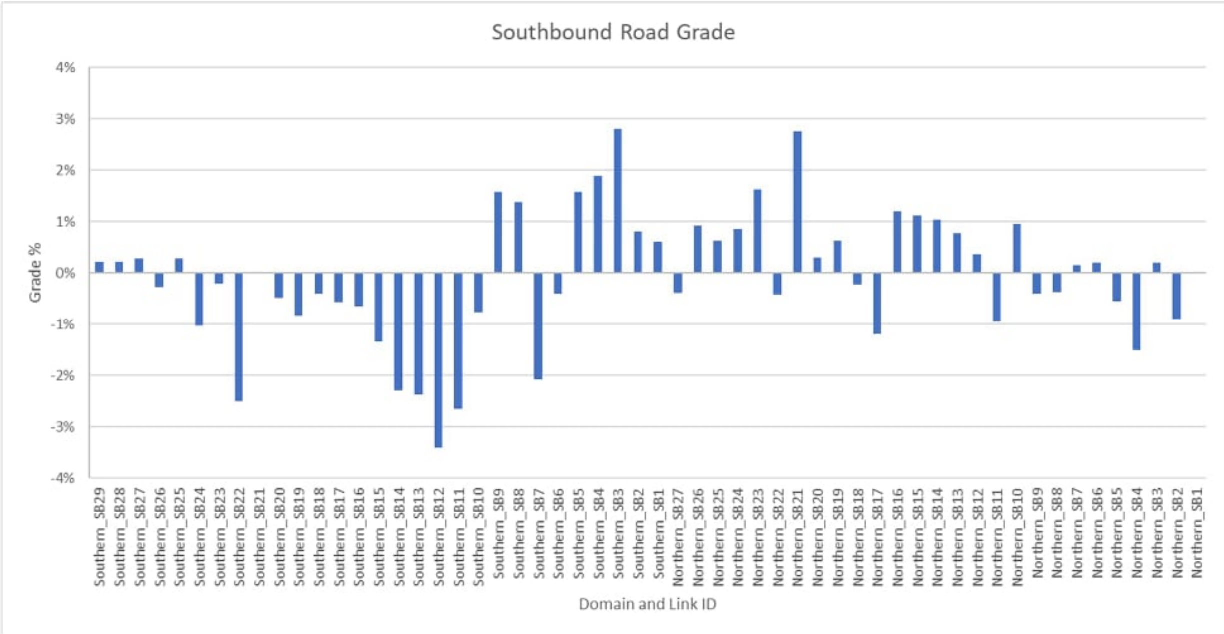


Figure 4-19 **Road grade links as modelled**

All road grade factors as used in the assessment are presented in **Appendix G**.

Speed

Speed data for the roads in the assessment area was provided as an hourly profile for the hours 4am – 7pm from the traffic modelling, covering 2018, 2026 and 2036, with and without the Proposed Modification. Speeds in the hours outside of the data range were assumed to be at the speed limit due to a low volume of traffic on the roads in those hours. An example of a single section of road with and without the Proposed Modification is presented below in **Figure 4-20**.

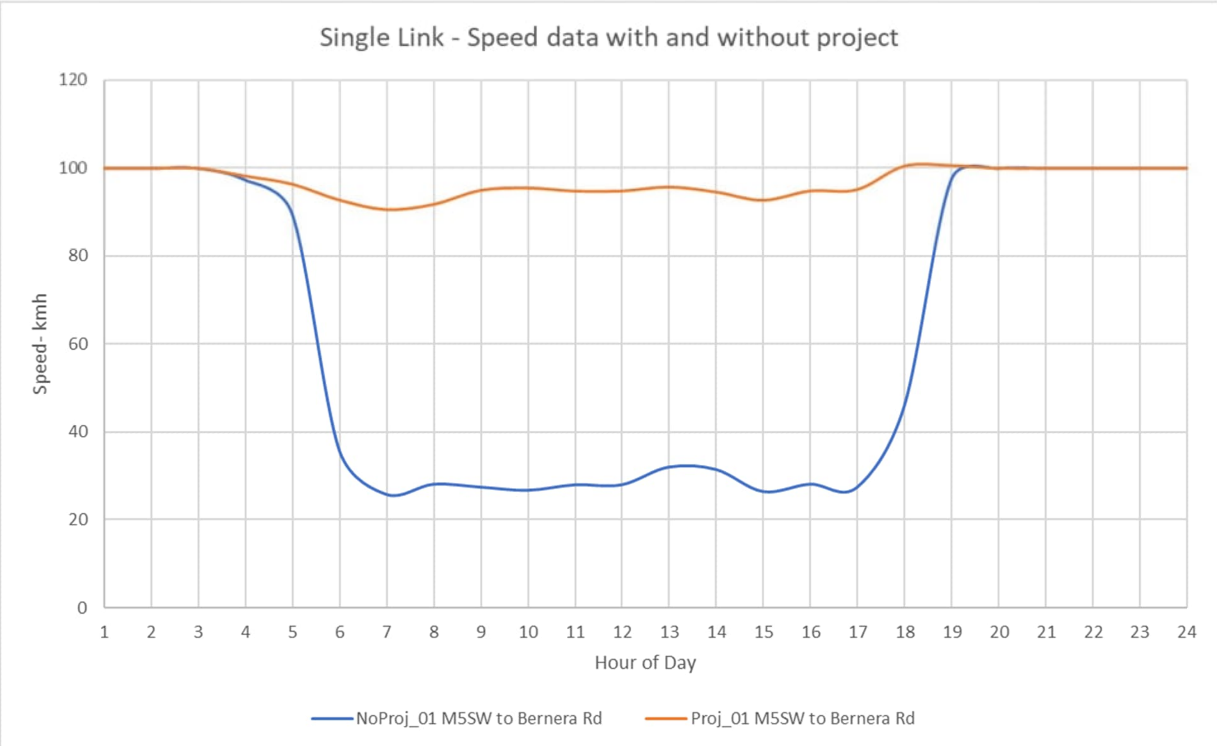


Figure 4-20 Example speed data

The AEI provides speed correction factor (SCF) coefficients specific to vehicle class and fuel type in the form of 6th order polynomials, with the below formula used to calculate the correction factors:

$$SCF = aV^6 + bV^5 + cV^4 + dV^3 + eV^2 + fV^1 + g$$
$$where:$$
$$a - g = SCF\ coefficients$$
$$V = speed$$

The fleet composite base emission factors already consider a base speed dependant on the road type, e.g., 'highway' assumes an average speed of 56kmh. Therefore, to determine a further refined speed correction factor a multi-step calculation using the above formula is required to determine the ratio between the base speed and the defined speed, the calculation steps were:

1. Calculate 'SCF_{base}' using road type speed (eg.highway = 56kmh)
2. Calculate 'SCF_{link}' using specific traffic data (eg 60kmh)
3. Calculate the 'SCF_{final}' using the below formula:
4. $SCF_{final} = SCF_{link} \div SCF_{base}$
5. Apply the SCF_{final} to the base emission rate.

The use of the calculated final speed correction factors from 24-hour speed data profile results in a further refined emission rate specific to each unique link. This provides a level of refinement above using only the road type average speed.

SCF performance

SCF_{final} factors were generated and plotted using the methodology detailed above to visualise the effects of speed on emission rates relative to the baseline road type speed, defined in the AEI as 56kmh for highway road type. The curves generally follow a "U" shape where slower or faster than the baseline speed results in an increasing SCF_{final} as the difference between the base speed and link speed increases.

It should be noted that polynomials should not be used beyond certain limits as extrapolation of data can become increasingly erroneous. **Figure 4-21** below shows that beyond 90kmh some factors become increasingly lower or negative which is considered erroneous data. Therefore, in the process of quantifying emissions rates all speed data was capped at a maximum of 90kmh to ensure speed correction factors were performing as intended.

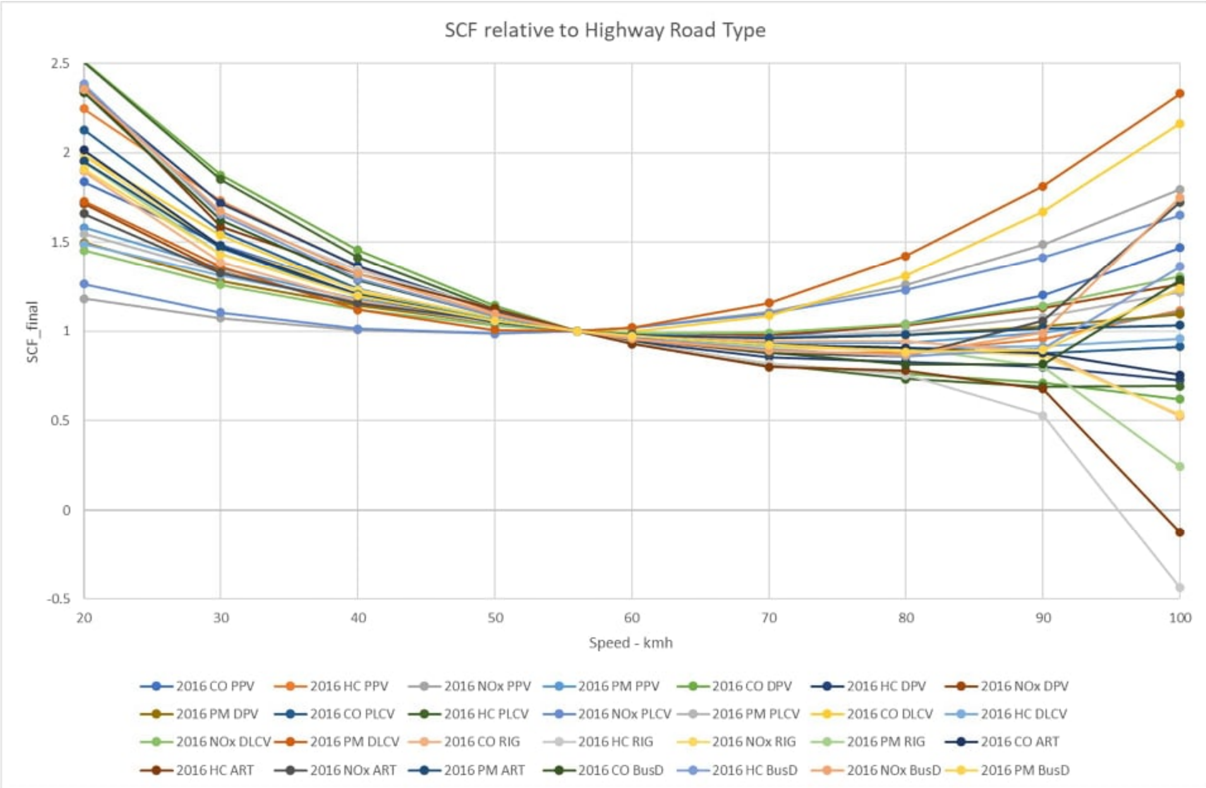


Figure 4-21 2016 SCF final relative to highway road type by vehicle class

Non-exhaust emissions

Non-exhaust emissions due to tyre, brake and road wear were sourced from the AEI and are specific to vehicle class, fuel type and road type. The emissions were added to the base emission factors for PM_{10} and $PM_{2.5}$.

Evaporative losses

Emissions of VOCs not due to combustion were not included in the assessment as they are overly complex to estimate and generally would not equate to quantities likely to cause a material impact to air quality along the M7.

Cold start emissions

Cold start emissions factors were not applied to the base emission factors, as vehicles using the M7 would be assumed to be at operating temperature.

Traffic volume

The hot running base emissions factors represent the emissions of a single vehicle over a distance (grams per kilometre). The emissions factors are multiplied by the traffic volume per hour to determine total mass of emissions per road link, per hour. To get the required level of detail for the hourly diurnal cycle, the 2021, 2026 & 2036 traffic volume data includes:

- Hourly traffic volume by road link to determine the typical diurnal cycle, to ensure peak and non-peak periods are accurately modelled.
  - For 2021 the hourly traffic data was sourced from traffic counters.
  - For 2026/2036 the hourly traffic data covered the hours of 7am – 5pm, with scaling to AADT used for the remaining hours (6pm – 6am) to create a 24 hour diurnal pattern. This is

considered acceptable as existing hourly traffic counts enable data generation specific to the assessment area.

Figure 4-22 shows an example of one section of road showing the difference between the hourly volumes of light and heavy vehicles. Light vehicles generally show higher morning and afternoon peaks associated with commuting, whilst heavy vehicles build from the morning hours and maintain a similar volume through to the afternoon.

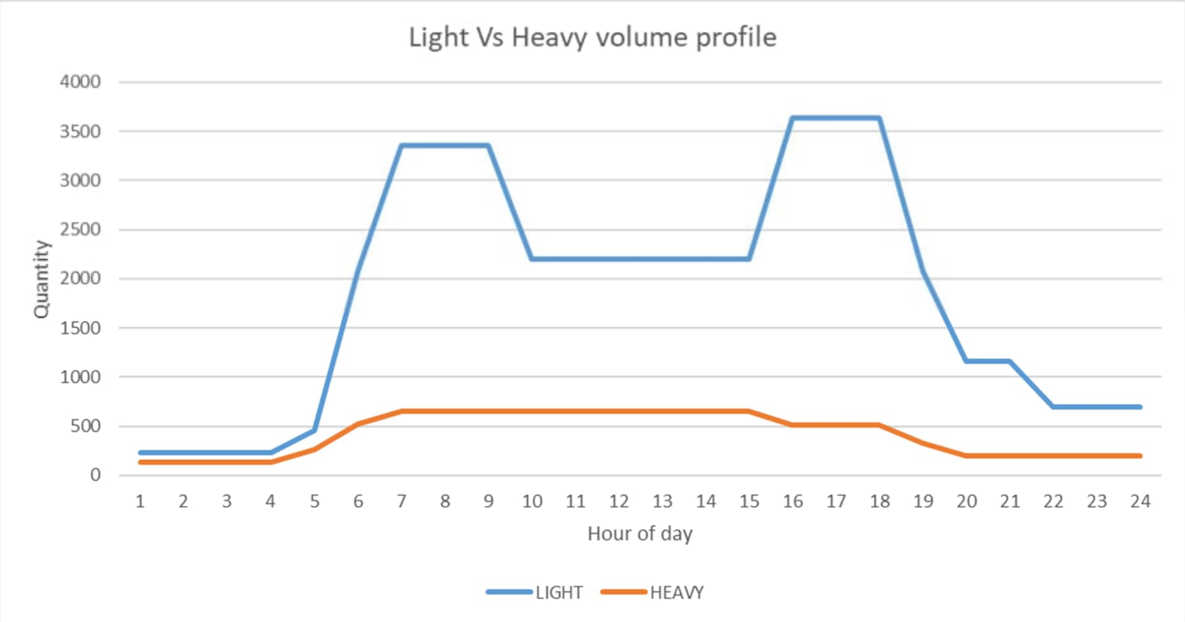


Figure 4-22 **Light vs heavy volumes by hour of day**

4.2.5.3 Traffic speed and fleet volume data analysis

As discussed above, the Proposed Modification to the Westlink M7 traffic conditions encompasses a wide variety of changes, including traffic fleet mix changes, changes to emissions factors over time, changes to the traffic speed conditions and changes to traffic volumes. The two areas where the changes are expected to make the most marked difference are the traffic speed and traffic volumes. One of the overarching objectives of this project is to decrease travel time and increase the capacity of the motorway to accommodate future growth, which relates directly to speed and traffic volumes. To aid in the understanding of the results, an analysis of the projected traffic speed data and traffic volumes used in the emissions inventory is presented in the following sections.

Traffic Speed Data Analysis

Traffic speed has been extracted from the dispersion modelling input data at each road link along the 29km of roadway. Data has been presented in **Figure 4-23** and **Figure 4-24** for the northbound and southbound lanes respectively in terms of three time periods as follows:

- Off-peak period – time periods prior to the morning peak and after the evening peak. Speeds have been averaged for this time period
- Peak traffic period – time period when traffic is at its peak levels. Typically, between 7am and 9am in the morning and between 4pm and 6pm in the afternoon.
- Interpeak traffic period – traffic volumes are typically higher than during the off-peak periods but lower than during the peak periods.

The traffic data shows that without the Proposed Modification, average northbound and southbound traffic speeds are expected to generally decrease along the M7 with time, with the slowest no-project speeds expected in 2036.

Speeds would generally be higher with the Proposed Modification in both 2026 and 2036, with the biggest improvements in 2036.

Northbound speeds at the southern end of the alignment, between 0-10 km chainage (south of Elizabeth Drive) would be notably improved with the Proposed Modification during peak and inter-peak hours.

Southbound lanes would also see an improvement in speeds with the Proposed Modification. The biggest improvements would be between 6-9km chainage (between Cowpasture Road and Elizabeth Drive) and between 18-20km chainage (between Great Western Highway and Old Wallgrove Road).

With the Proposed Modification, speeds would be higher in 2026 than 2036 for both northbound and southbound lanes.

Figure 4-23 **Speed data, northbound, with and without the Proposed Modification**

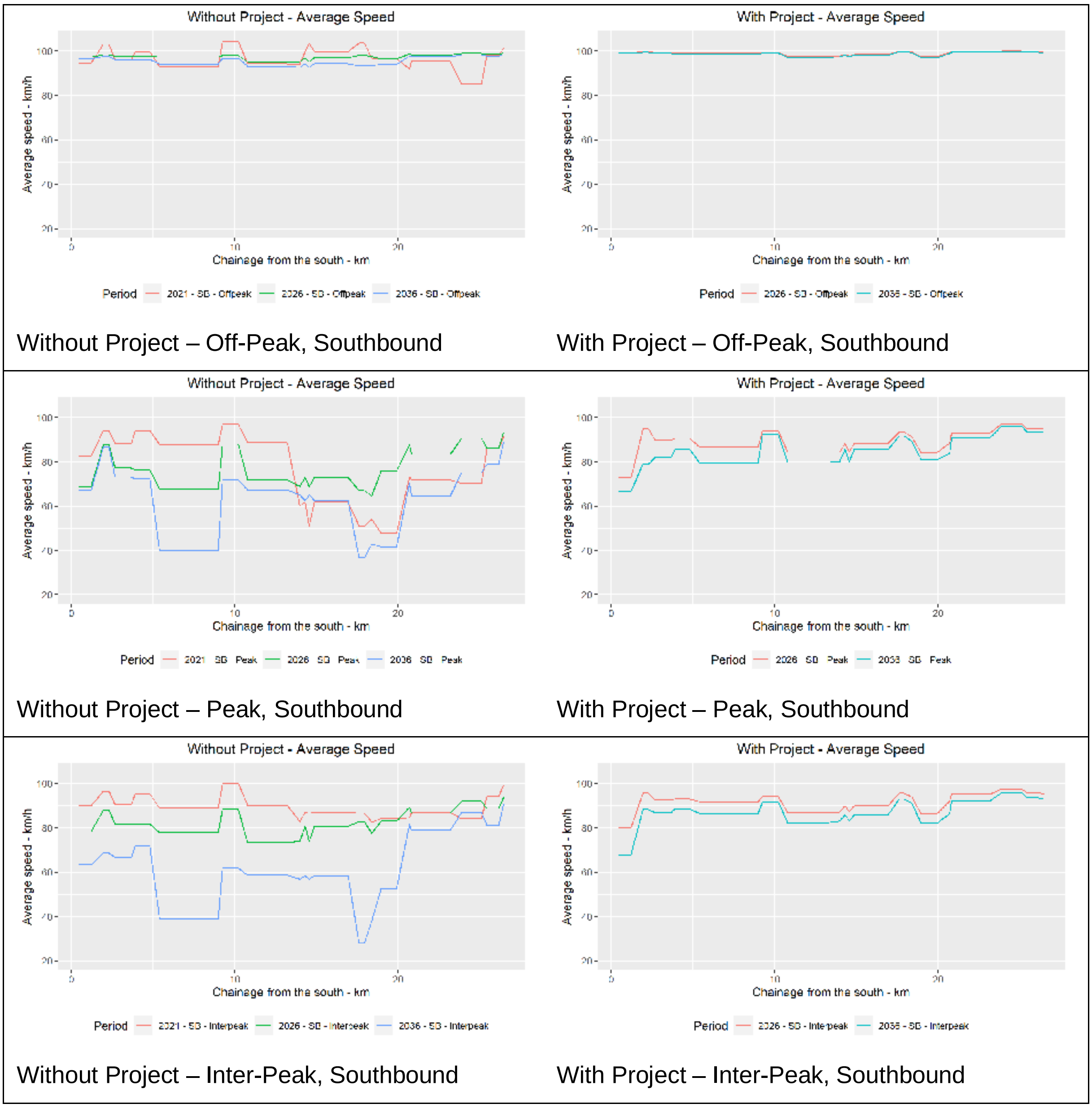


Figure 4-24 Speed data, southbound, with and without the Proposed Modification

Traffic volume data analysis

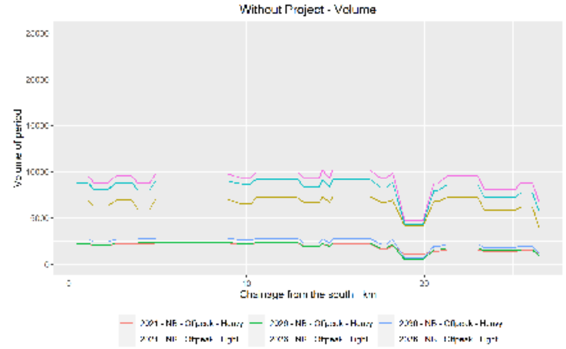
Traffic volume data has been extracted from the dispersion modelling input data at each road link along the 29km of roadway. Data has been presented as AADT for light and heavy vehicles in **Figure 4-25** and **Figure 4-26** for the northbound and southbound lanes respectively in terms of three time periods as follows:

- Off-peak period – time periods prior to the morning peak and after the evening peak. Speeds have been averaged for this time period
- Peak traffic period – time period when traffic is at its peak levels. Typically, between 7am and 9am in the morning and between 4pm and 6pm in the afternoon.
- Interpeak traffic period – traffic volumes are typically higher than during the off-peak periods but lower than during the peak periods.

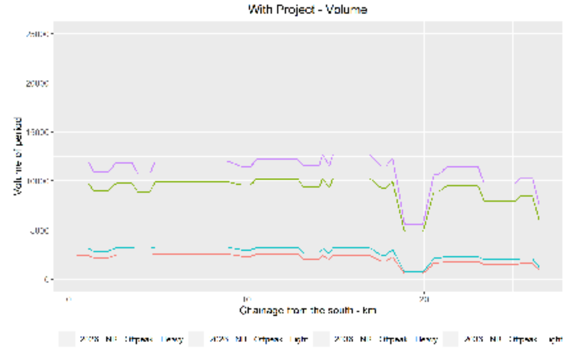
Without the project, both light and heavy vehicle numbers are expected to increase with time, in both northbound and southbound direction.

With the Proposed Modification, light vehicle numbers are predicted to increase much more than without the project. Up to about 40 % and 30% more light vehicles are predicted in the northbound and south bound directions respectively, in 2036 during peak hours (depending on the location along the alignment), compared with no project. Heavy vehicle numbers are also predicted to be higher with the project than without, but to a lesser extent than for light vehicles.

Overall, the extra lanes of the Proposed Modification are predicted to result in higher traffic numbers on the M7 mainline.

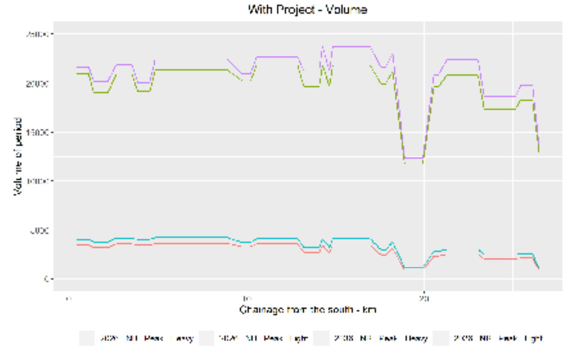


Without Project – Off-Peak, Northbound



With Project – Off-Peak, Northbound

Without Project – Peak, Northbound



With Project – Peak, Northbound

Without Project – Inter-Peak, Northbound

With Project – Inter-Peak, Northbound

Figure 4-25 **Traffic volume data, northbound, with and without the Proposed Modification**

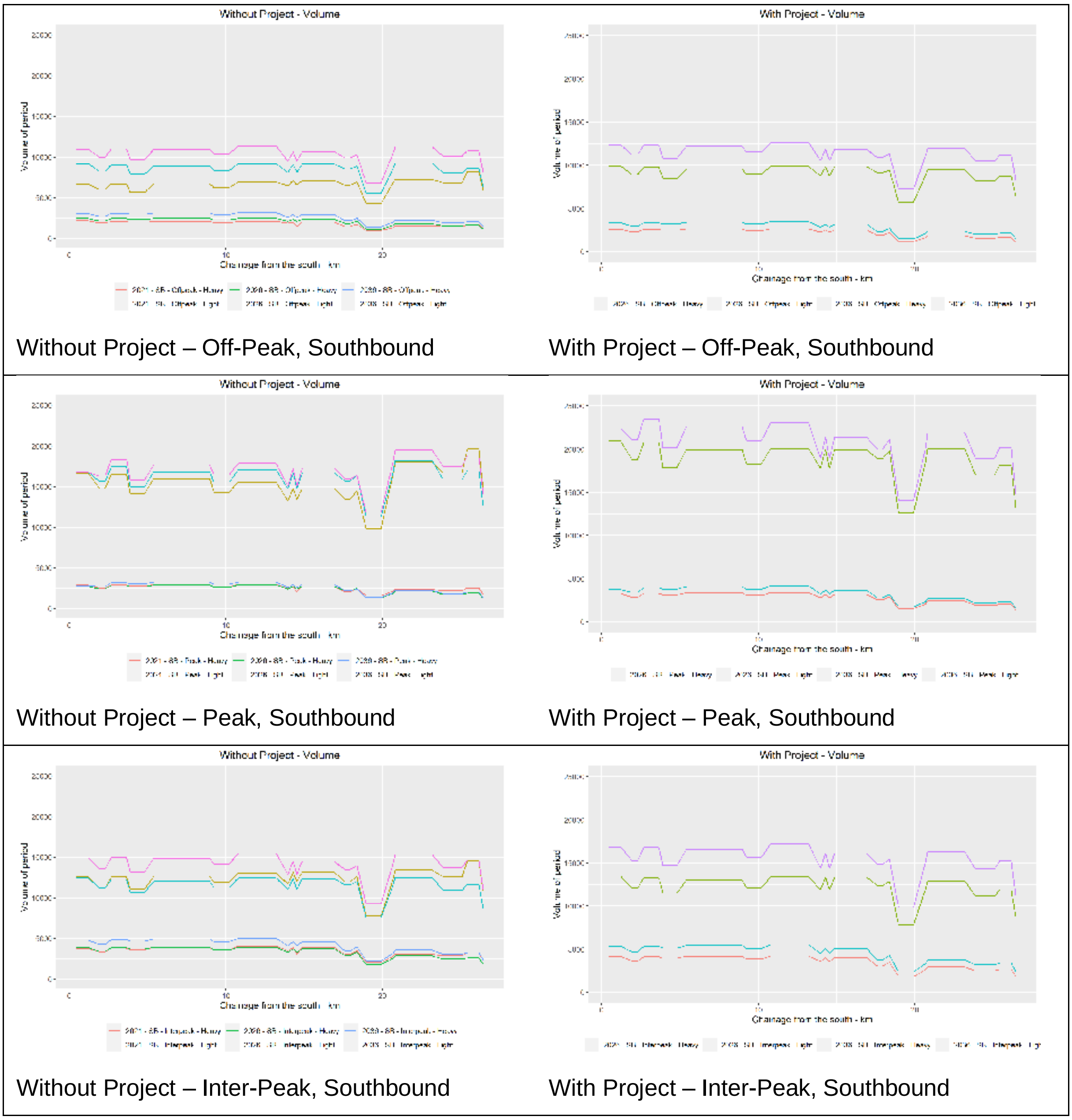


Figure 4-26 Traffic volume data, southbound, with and without the Proposed Modification

4.2.6 Traffic network analysis

The AQIA methodology for the M7 widening project as described in **Section 4.2.1** to **Section 4.2.5** has been undertaken assuming emissions from the mainline of the M7 motorway along with the emissions associated with the onramp and off-ramps.

Broader network air quality modelling was not undertaken to account for the potential changes in road traffic volumes in the surrounding road network which may be influenced by the proposed widening of the Westlink M7. As such, a qualitative assessment of and how those potential changes could impact the air quality predictions made by the AQIA.

While a detailed quantitative assessment of the redistribution of air pollutants within the regional airshed within the context of the wider road network has not been undertaken **Section 7.2** provides a brief qualitative analysis of potential air quality impacts associated with the surrounding road network.

4.2.7 Background data interpolation

Existing background concentrations of pollutants are required to add to predicted model results to assess the potential cumulative impacts of air emission from a project. This is typically done using either a single background value or a timeseries of background values that are added to model predictions at every sensitive receptor, without consideration of spatial variation across the modelling domain.

Given that the Proposed Modification spans a distance of about 27 km and spatial variation in hourly background concentrations would be expected to occur across the study area, a variable background assessment methodology was needed.

To account for this spatial variability, spatially varying background data was generated across the study area using the closest eight DPE air monitoring stations. Hourly data for NO_2, PM_{10} and $PM_{2.5}$ were obtained from the DPE stations and used to generate a timeseries of interpolated pollutant concentrations specific to each modelled receptor location. These timeseries were then combined with predicted model concentrations for each sensitive receptor to enable the calculation of total cumulative receptor concentrations. Predicted cumulative concentrations for NO_2, PM_{10} and $PM_{2.5}$ are discussed in **Appendix I**.

The interpolation process for NO_2, PM_{10} and $PM_{2.5}$ is further detailed in **Appendix D**. Due to the existing low ground level concentrations for CO localised variability is of lower significance. Assumed maximum 1-hour and 8-hour background concentrations for CO are based on worst case observational data discussed in **Section 5.2.2**.

4.2.8 NO_X conversion methodology

Nitrogen oxides are produced in most combustion processes and are formed during the oxidation of nitrogen in fuel and nitrogen in the air. During high-temperature processes, a variety of oxides are formed, including nitric oxide (NO) and nitrogen dioxide (NO_2).

One of the challenges of modelling NO_x emissions is how to determine the amount of NO_2 at a receptor given that NO reacts (oxidises) in the atmosphere to form NO_2 over time. Early studies (Hegg *et al*., 1977) showed that the rate of oxidation is controlled by the rate of plume mixing rather than by gas reaction kinetics. Ozone is usually the chemical that is responsible for most of the oxidation, but other reactive atmospheric gases can also oxidise NO. GRAL assumes that the pollutants are inert, neutrally buoyant gases; i.e. the model does not account for any chemical transformations or heavy gas effects. As such, the transformation of NO_x to NO_2 needs to be done in the post-processing stage.

NO generally comprises 95% of the volume of NO_X at the point of emission. The remaining NO_X consists of NO_2. The conversion of NO to NO_2 requires ozone to be present in the air, as ozone is critical to photochemical reaction from NO to NO_2. Ultimately over time, however, much of the NO emitted into the atmosphere will be oxidised to NO_2 and then further to other higher oxides of nitrogen.

There are several methodologies outlined in the NSW EPA Approved Methods document for the calculation of NO_2 concentrations from predicted NO_X concentrations and other methods that have been developed since the publication of the Approved Methods. Three common methods utilised in road projects are:

1. Assumption of 100% of the NO_X reports as NO_2. This is a highly conservative assumption and should only be used in situations where emissions of NO_X are low; and
2. US EPA Ozone Limiting Method (OLM). The OLM assumes that approximately 10% of the initial NO_X emissions are emitted as NO_2. If the ozone (O_3) concentration is greater than 90% of the predicted NO_X concentrations, all the NO_X is assumed to be converted to NO_2, otherwise NO_2 concentrations are predicted using the equation $NO_2 = \{0.1 * NO_X + 46/48 * O_3\}$. This method assumes instant conversion of NO to NO_2 in the plume, which overestimates concentrations close to the source since conversion usually occurs over periods of hours. This method is described in detail in DEC (2005a).
3. NO_2/NO_x Ratio method using empirical relationship. This method uses observational data from the Sydney basin to develop a NO_2/NO_x ratio. There are two types of empirical methods that can be utilised for the conversion of NO_X data to NO_2 concentration. The two methods are:

a. A constant NO_2/NO_x ratio is assumed. This is referred to as the US EPA's Ambient Ratio Method (ARM)

b. An empirical NO_2/NOx ratio is calculated based on measured NOX and NO2 concentrations in an airshed.

Method 1 above were not considered appropriate for use in this project given that it is highly over-conservative and likely to significantly overpredict NO_2 concentrations. Method 2 was not considered realistic as its assumptions regarding instantaneous conversion of NO to NO_2 are not be expected to be accurate over the small distance between the roadway and the receptors alongside the M7. The variable ratio method (Method 3) considers $NO_X:NO_2$ ratios at a range of distances from the roadside across the Sydney basin and is considered to provide a reasonable estimate of the upper bound of NO conversion to NO_2.

The variable NO_2/NO_x ratio method was adopted using observational data from across the Sydney Basin and the equations obtained from the analysis were used to predicted ground-level NO_2 concentrations from the Proposed Modification. The equation utilised in the assessment are as follows (Pacific Environment, 2015):

For $[NO_X]_{Total}$ concentrations less than 140µg/m^3,

$$\frac{[NO_2]_{Total}}{[NO_X]_{Total}} = 1.0$$

For $[NO_X]_{Total}$ concentrations greater than 140µg/m^3 and less than or equal to 1,375µg/m^3:

$$\frac{[NO_2]_{Total}}{[NO_X]_{Total}} = a \times [\mathrm{NO}_X]_{Total}{}^{b}$$

Where:

a = 52

b = -0.80

For $[NO_X]_{Total}$ concentrations greater than 1,375µg/m^3,

$$\frac{[NO_2]_{Total}}{[NO_X]_{Total}} = 0.16$$

This methodology is consistent with the methodology used for other recent large road infrastructure projects in the Sydney Basin including WestConnex M4 East and the Warringah Freeway upgrade.

4.3 Existing development cumulative impact assessment

A qualitative cumulative air quality assessment has been undertaken for construction and operation of the Proposed Modification in **Section 6.4** and **Section 7.2**. The cumulative impact assessment considers the following projects in **Table 4-18** that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed. Additional information on developments included in the cumulative impact assessment can be found in the modification report.

The cumulative impact assessment was based on the residual impacts of the Proposed Modification (i.e. those that are expected to exist after application of management and mitigation measures). It should be noted that the operational cumulative assessment should not be confused with the reporting of cumulative impacts from the Proposed Modification in **Section 7.1** which refers to the incremental impacts from the Westlink M7 and background air quality concentrations.

Table 4-18 Projects included in cumulative assessment

Project Name and ID	Approval Status	Expected construction period / overlap with Proposed Modification	Distance from Proposed Modification
The Sydney Zoo Modification SSD-7228	Approved (08/2020)		1 km east, Western Sydney Parklands
Light Horse Interchange Business Hub Eastern Creek SSD-9667	Approved	2022 to 2023. Construction expected to be finished by Q3 2023.	Western Sydney Parklands. South East Corner of M7 and M4
Saint Peter and Paul Assyrian Primary school SSD-9210	Approved (Dec, 2020)	TBC	17-19 Kosovich Place, Cecil Park, 2178
Gazorp Industrial Estate SSD-5248	Approved (Aug 2020)	Under construction	813-913 Wallgrove Road, Horsley Park
M12 Motorway SSI-9364	Approved	Q1 2022 to 2025; operation by 2025	East-west motorway between the M7 Motorway near Cecil Hills and The Northern Road at Luddenham.
Mamre Road Upgrade	Approved (Dec, 2020)	construction is planned to start in 2022 and be completed in 2025.	7km west of M7
Sydney Metro - Western Sydney Airport SSI-10051	Approved (Aug 2020)	2021 - 2026	5 km west
Western Sydney Airport	Approved	Currently under construction. Operation to begin in 2026	Over 5km to the west
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area. Future strategic government project	Approved (Dec, 2020)		

Project Name and ID	Approval Status	Expected construction period / overlap with Proposed Modification	Distance from Proposed Modification
Horsley Drive upgrade	Approved (08/2020)	Detailed design is expected to be completed by early 2022. After we finish detailed design we will run a competitive process to appoint a construction industry contractor to deliver the major construction work on the upgrade. We expect major construction to begin early 2023.	
The Northern Road upgrade (approved and under construction) SSI-7127	Approved	Construction completed jn late 2021	Approx 10 kms west of M7
Horsley Drive Business Park SSD-7664-Mod-1	Approved (Dec, 2020)	Operation in 2022/2023	2km east, corner of Cowpasture Road and Trivet Street
Moorebank Intermodal Precinct West - Stage 2 SSD-7709	Approved (08/2020)	Construction commenced in April 2022	Moorebank Ave
Sydney International Speedway SSI-10048	Approved	Anticipated to be completed by September 2021	1.2 km east of the M7 (near Prospect Reservoir)
Momentum Industrial estate Modification Revised Layout and Earthworks SSD-5248-Mod-1	Approved (23/12/2021)		813-913 Wallgrove Road, Horsley Park
Elizabeth Drive Upgrade	Development Application Stage	Environmental Assessment currently being prepared. Public exhibition expected after Proposed Modification Public Exhibition.	Intersects Westlink M7 at Cecil Hill,

4.4 Limitations

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on a number of different variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve some level of simplification of these very complex processes based on our understanding of the processes involved and their interactions, available input data, and processing time and data storage limitations.

These simplifications come at the expense of accuracy, which particularly affects model predictions during certain meteorological conditions and for source emission types. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those wind speeds less than 1 m/s) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these known deficiencies, the model outputs tend to provide conservative estimates of pollutant concentrations at particular locations.

While the models contain a large number of variables that can be modified to increase the accuracy of the predictions under any given circumstances, the constraints of model use in a commercial setting, as well as the lack of data against which to compare the results in most instances, typically precludes extensive testing of the impacts of modification of these variables. With this in mind, model developers typically specify a range of default values for model variables that are applicable under most modelling circumstances. These default values are recommended for use unless there is sufficient evidence to support their modification.

As a result, the findings of dispersion modelling provide an indication of the likely level of pollutants within the modelling domain. While the models, when used appropriately and with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time. However as stated above, however, the model predictions are typically conservative, and tend to over predict maximum pollutant concentrations at receiver locations.

This assessment was undertaken with the data available at the time of the assessment. Should changes to the Proposed Modification be made, further assessment may be required to determine if the findings of this assessment are still applicable.

5.0 Existing environment

The existing environment in the area surrounding the Proposed Modification includes a description of the conditions around the Modification that may affect air quality. These conditions are typically categorised into background air quality (or existing pollutant concentrations), regional meteorology, an analysis of the terrain in the modelling domains, the land use in the modelling domains and a description of the sensitive receptors surrounding the Modification.

This section provides a description of the existing environment as it relates to existing air quality, local meteorology, terrain, land use and receptors.

Summary of existing environment

The existing environment has been examined in terms of the regional meteorology, existing pollutant levels, terrain features in the modelling domain, land use characteristics in the modelling domain and the receptors close to the Westlink M7.

Meteorological analysis focused on the Horsley Park Bureau of Meteorology station given its central location to the overall project, its proximity to the M7 motorway and its wind speed and direction having characteristics similar to observations across the south-western Sydney basin area. Meteorology showed a predominance of south-westerly and south-easterly winds with lower proportion of winds from all other directions. Calm conditions were high with average calms of 17.8% observed between 2010 and 2019 and average wind speeds were 2.2m/s. Seasonal winds showed minor variation with summer wind patterns being the only season where significant changes were observed from the annual wind patterns (absence of south-westerly winds in summer). Meteorology used for the assessment is considered representative of the regional conditions and is considered acceptable for use in the dispersion modelling.

Existing pollutant levels showed that when compared with existing NSW EPA standards, NO_2 and CO concentrations fall well below their respective standards at all stations examined. PM_{10} concentrations (apart from the 2019 / 2020 bushfire period) showed a small number of exceedances across the monitoring period between 2015 and 2020. These exceedances were largely due to unusual events like dust-storms, backburning or bushfires. $PM_{2.5}$ concentrations generally exhibited the same pattern as PM_{10} with minor exceedances noted across the monitoring periods. Annual average $PM_{2.5}$ concentrations were shown to approach or exceed the annual average $PM_{2.5}$ EPA criteria at all monitoring station locations examined by the study. The exceedance of the 24-hour PM_{10} and $PM_{2.5}$ criteria and the exceedance of the $PM_{2.5}$ annual average criteria have been discussed further in the cumulative impact assessment section and the results section of the report.

Terrain around the Proposed Modification is best categorised as coastal hinterland with rolling hills and a minor valley extending from the west of the southern end of the current Westlink M7 to around the St Marys region. There may be a minor effect of the terrain on the plume dispersion under specific meteorological conditions, but overall, the terrain is only expected have a limited influence on the plume dispersion.

Land use along the existing Westlink M7 is a mixture of urban residential, general industrial, waste management, parklands, low density residential, rural residential, agriculture and horticulture, recreational land and environmental conservation areas and remnant native vegetation. The land use patterns vary significantly along the length of the motorway which has been utilised in the dispersion model setup to ensure it has been accounted for in the results.

5.1 Meteorology

Meteorology in the area surrounding the site is affected by several factors such as terrain and land use. Wind speed and direction are affected by topography and land use at the local scale (typically on a scale of a few meters to 150km), while synoptic scale winds affect wind speed and direction on a much larger scale (commonly at distances of over 500-1000km). Wind speed and direction are important variables in assessing potential air quality impacts, as they dictate the direction and distance air pollutant plumes travel.

The Proposed Modification covers a 29-kilometre-long stretch of road local meteorological conditions and as such meteorological conditions across the study area are likely to be influenced by varying topography and land use characteristics along the alignment at the local scale. Both the DPE and BoM operate a network of ambient pollutant and meteorological data monitoring stations at several locations across the Sydney basin. A macro-scale analysis of wind speed and direction data is presented across the Sydney Basin in **Figure 5-1**.

The macro wind analysis shows that meteorology in the Sydney basin in the area close to the Westlink M7(roughly located central to the figure) is reasonably consistent with conditions dominated by south to south-westerly winds with a higher proportion of north-westerly winds evident further north in the Sydney basin toward St Marys and Prospect monitoring stations. The Horsley Park BoM station was selected for a more detailed analysis given its location is roughly central to the southern half of the Sydney basin, it is situated within both the northern and southern GRAMM domains and the station is situated close to the existing Westlink M7 motorway.

Ten years of meteorological data at the BoM Horsley Park Station was analysed between 2010 and 2019. **Figure 5-2** provides ten-year annual average and seasonal wind roses for the BoM Horsley Park Station. On an annual basis, the dominant wind direction is from the southwest with an annual average wind speed of 2.2 m/s. Calm conditions (defined as wind speeds less than 0.5 m/s) occur approximately 17.8 % of the time. The low annual average wind speed combined with the high occurrence of calms suggest periods with poor localised dispersion of air pollutants due to more stable atmospheric conditions. Additional wind rose data has been presented and analysed in finer detail in **Appendix C**.

Seasonally averaged wind roses provided in **Figure 5-2** show a higher proportion of south-westerly winds during the autumn and winter months, which is similar to winds observed in the annual wind rose (although the frequency distribution of these winds during the cooler months is higher). During the summer months, a higher proportion of south south-easterly to easterly winds are observed and wind directions in spring were found to be highly variable with no dominant trend observed. On a seasonal basis average wind speeds were found to be similar ranging from 1.9 m/s in the autumn to 2.4 m/s in the summer. A high proportion of calms was observed across all seasons ranging from 16% to 20% indicating poor dispersal conditions are quite common throughout the year.

The implications of the above wind data on the Proposed Modifications are that there may be periods where plume dispersion may be poor and during those periods elevated concentrations of pollutants may occur at receptors close to the boundary of the motorway.

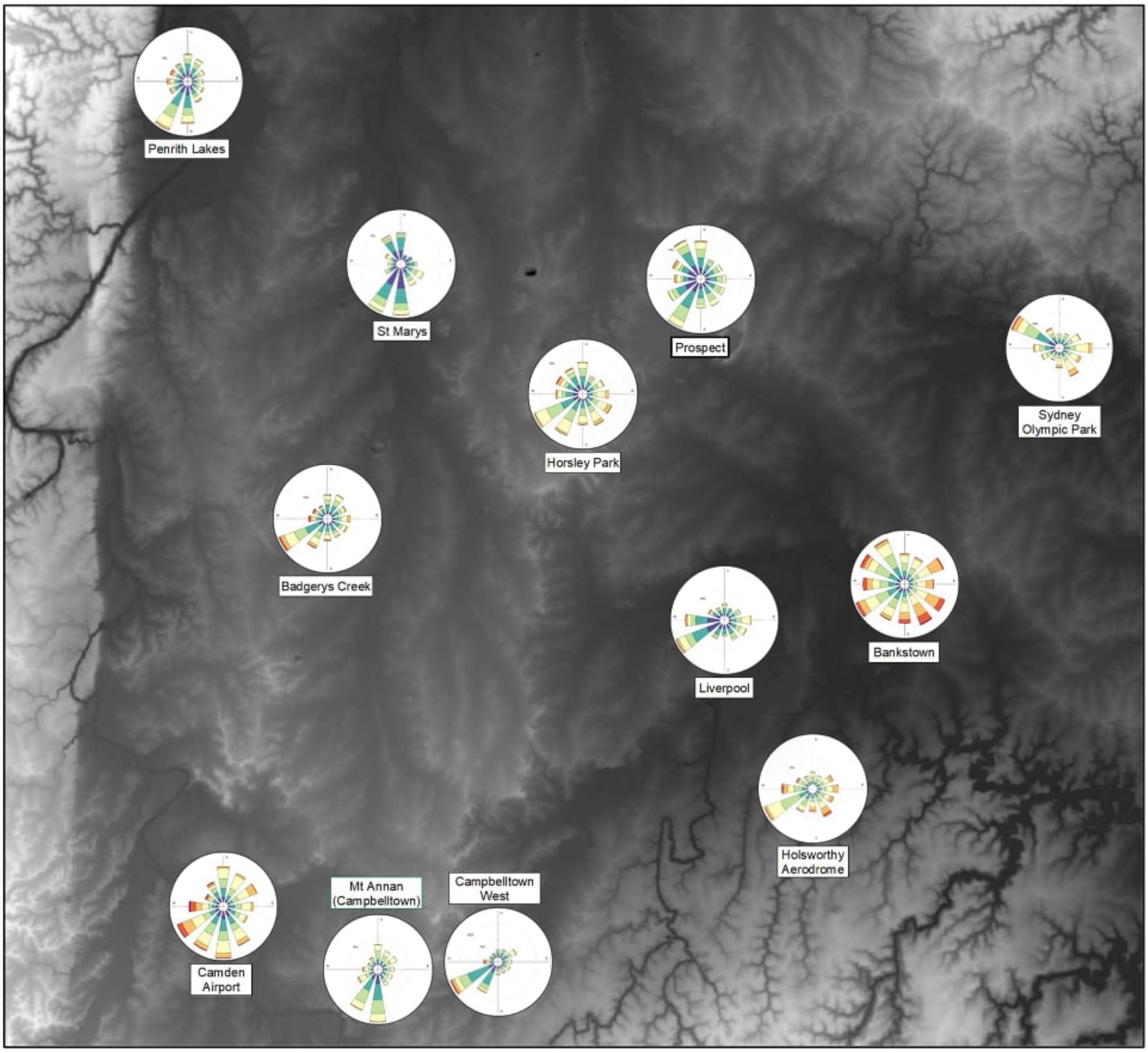


Figure 5-1 Location of DPE and BoM monitoring stations close to Modification

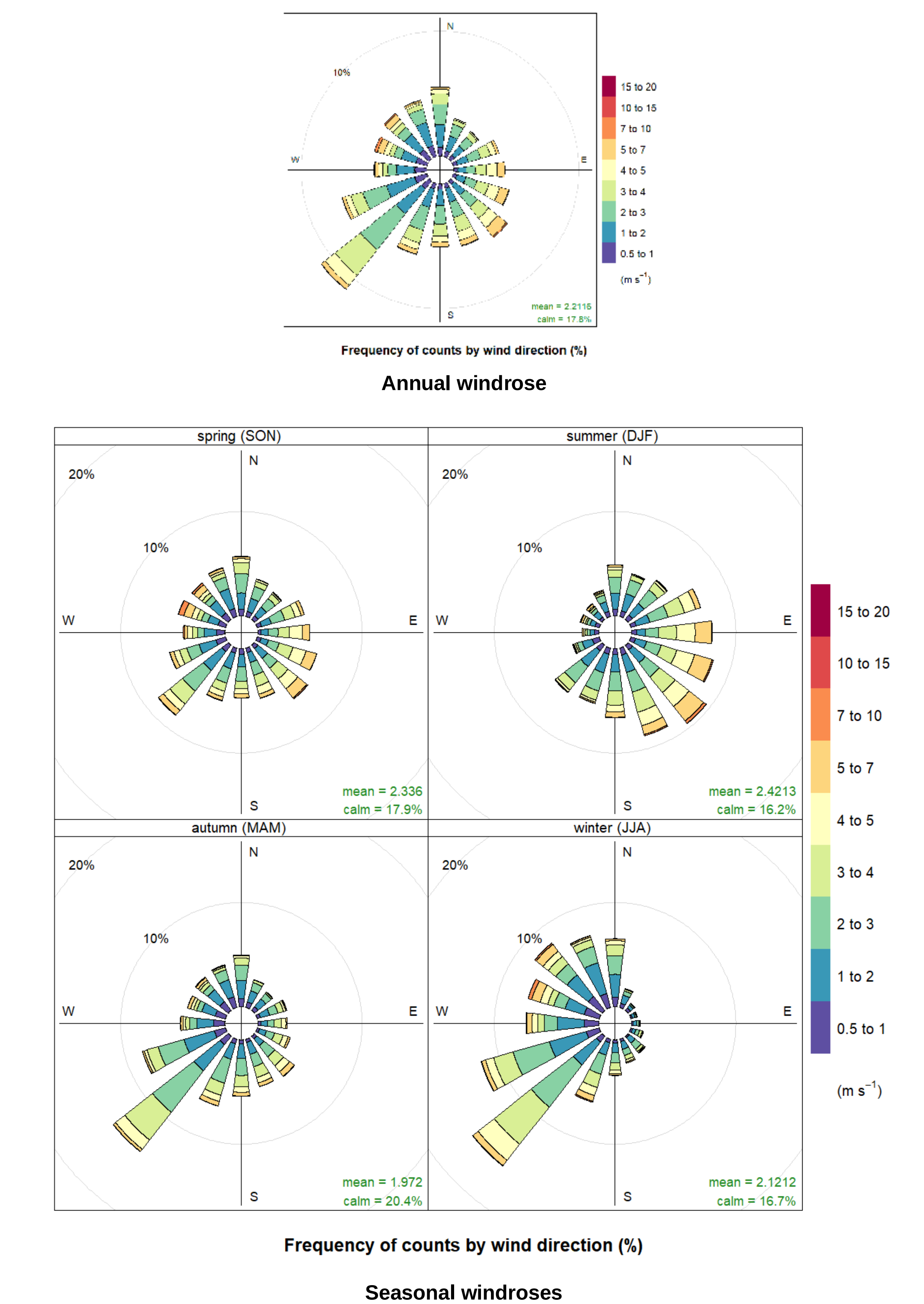


Figure 5-2 Annual and seasonal wind roses at BoM Horsley Park - 2010 to 2019

Ten-year annual average rainfall and temperature data for Horsley Park BoM is presented in **Figure 5-3**. General seasonal trends observed show that temperature declines heading into and during the winter months with a gradual increase leading into the summer period. The hottest month January with an average maximum temperature of 29 °C and the coldest month is July with an average minimum temperature of approximately 7 °C.

Average rainfall tends to follow a similar trend to temperature with a general decline around the winter period with an increase during the summer. February was found to have the highest rainfall while the month of May was found to have the lowest rainfall.

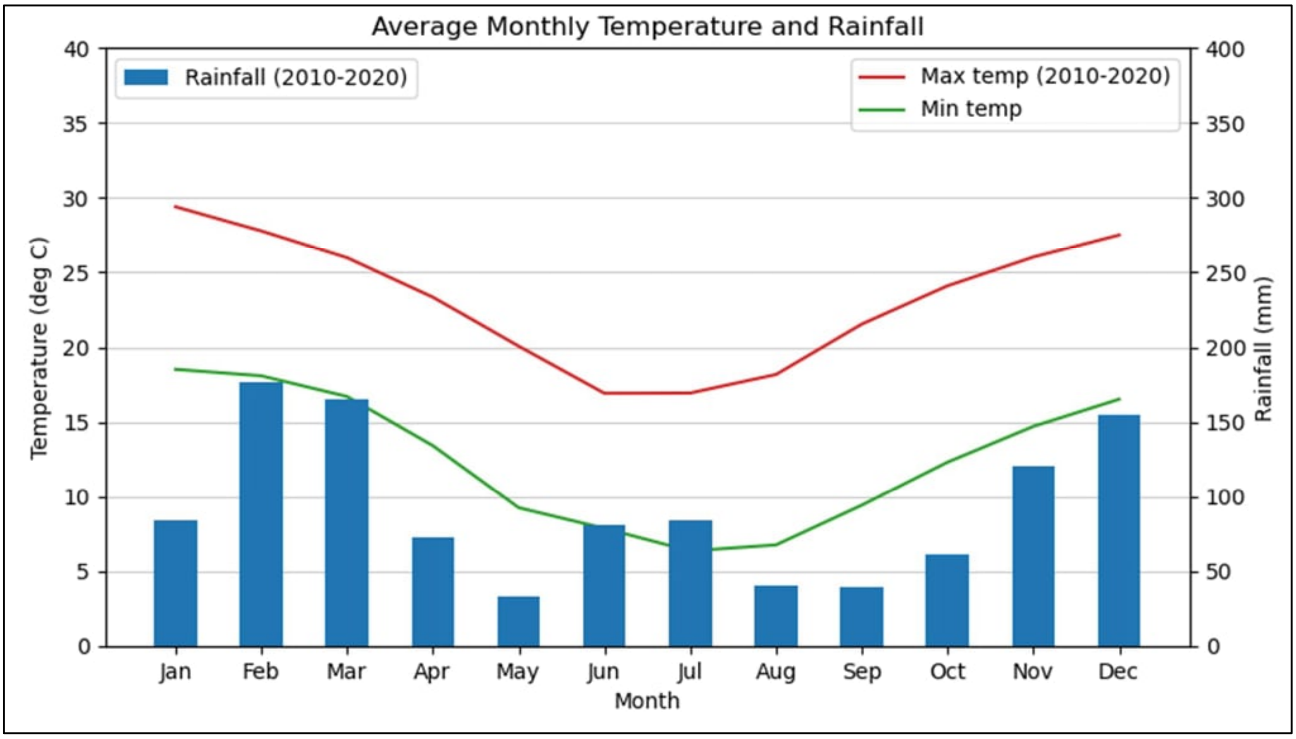


Figure 5-3 Temperature and rainfall averages at BoM Horsley Park - 2010-2020

A total of 23 meteorological stations (operated by either DPE and BoM) were identified within or close to the Sydney region surrounding the Westlink M7 area and were considered to be suitable for inclusion in the CALMET meteorological modelling with the station suitability analysis included as **Appendix C**. Stations in the Sydney basin used to calculate stability classes for use in the GRAMM model are shown in **Figure 4-7**.

Several of the stations identified close to the Westlink M7 were also identified as suitable for inclusion in the GRAMM meteorological modelling with the location of these monitoring stations shown in **Figure 4-6**.

5.2 Existing air quality

The pollutants of prime interest in NSW are Ozone, NO_2 and particulates, with regional levels of certain pollutants approaching or exceeding the national standards prescribed in the National Environment Protection Measure for Ambient Air Quality (NEPM). The M7 is expected to generate emissions of NO_2, CO, particulates and VOC. Of these pollutants identified, only NO_2, CO and particulates need to be considered cumulatively with existing background concentration, necessitating an analysis of the background air pollutant concentrations.

Background air pollution is characterised through ambient monitoring undertaken by DPE at locations throughout the Sydney basin. Eight stations were investigated in total, with four in Northern Domain for the GRAL model and four in the Southern Domain for the GRAL model. The stations selected were based on available data and proximity to the Proposed Modification. Data from the following DPE stations were included in the background air quality investigation and are listed in **Table 5-1**. The location of each station is presented in **Figure 5-4**.

Table 5-1 DPE stations and pollutants monitored

DPE station name	Domain Location	Pollutants monitored and data examined
Bringelly	Southern Domain	NO_2, PM_{10}, $PM_{2.5}$
Campbelltown West	Southern Domain	NO_2, CO, PM_{10}, $PM_{2.5}$
Liverpool	Southern Domain	NO_2, CO, PM_{10}, $PM_{2.5}$
Liverpool SWAQS	Southern Domain	NO_2, PM_{10}, $PM_{2.5}$
Parramatta North	Northern Domain	NO_2, CO, PM_{10}, $PM_{2.5}$
Prospect	Northern Domain	NO_2, CO, PM_{10}, $PM_{2.5}$
Rouse Hill	Northern Domain	NO_2, PM_{10}, $PM_{2.5}$
St Marys	Northern Domain	NO_2, PM_{10}, $PM_{2.5}$

Figure 5-4 Location of the DPE stations investigated – blue for Northern Domain, red for Southern Domain

A summary of the data collected at the above stations has been provided in **Table 5-2** and **Table 5-3**.

Table 5-2 Southern Domain monitoring station summary data (2015-2020)

Pollutant	Averaging period	Bringelly						Campbelltown West						Criteria
		2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020	
NO_2	1 Hour Max	55.4	61.5	73.8	73.8	69.7	61.5	127.1	110.7	125.1	110.7	121.0	104.6	246
	Annual Average	8.1	9.9	10.2	11.4	11.2	6.3	19.6	20.6	21.6	21.9	21.9	18.7	62
CO	1 Hour Max	-	-	-	-	-	-	1625	1750	1625	2250	5750	3125	30000
	8 Hour Max	-	-	-	-	-	-	1250	1500	1000	1875	3625	2875	10000
PM_{10}	24 Hour Max	57.0	61.6	83.7	93.0	217.7	241.8	69.7	50.1	53.1	72.3	132.0	249.7	50
	Annual Average	15.8	17.0	19.8	21.2	24.3	18.3	15.6	16.0	15.7	17.8	22.4	17.0	25
	No. Exceedances	1	3	6	8	26	11	1	1	1	3	26	10	0
$PM_{2.5}$	24 Hour Max		21.6	52.5	55.6	178.0	78.1	17.5	35.8	25.0	42.1	106.0	69.0	25
	Annual Average		7.6	7.5	8.1	11.3	8.5	8.0	7.9	7.3	8.3	11.5	7.5	8
	No. Exceedances	0	0	2	4	28	12	0	3	0	2	28	12	0
Pollutant	**Averaging period**	**Liverpool**						**Liverpool SWAQS**						**Criteria**
		2015	**2016**	**2017**	**2018**	**2019**	**2020**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
NO_2	1 Hour Max	123.0	96.4	131.2	127.1	102.5	98.4	-	-	-	-	104.6	82.0	246
	Annual Average	20.1	23.7	25.1	25.2	24.6	22.0	-	-	-	-	23.0	15.2	62
CO	1 Hour Max	2875	2750	2750	3000	4625	3000	-	-	-	-	6500	2625	30000
	8 Hour Max	250	2375	2250	2375	2250	2625	-	-	-	-	2375	2250	10000
PM_{10}	24 Hour Max	68.6	68.7	74.0	101.5	178.9	195.1	-	-	-	-	157.3	159.4	50
	Annual Average	18.5	19.5	20.7	24.2	28.0	21.0	-	-	-	-	23.2	27.4	25
	No. Exceedances	1	3	2	13	30	8	0	0	0	0	22	10	0
$PM_{2.5}$	24 Hour Max	32.2	50.8	56.4	45.4	156.0	73.6	-	-	-	-	141.2	91.2	25
	Annual Average	8.4	8.7	8.9	10.1	12.8	9.1	-	-	-	-	12.1	13.5	8
	No. Exceedances	2	4	4	8	34	8	0	0	0	0	31	13	0

Table 5-3 Northern Domain DPE monitoring station summary data (2015-2020)

Pollutant	Averaging period	Parramatta North						Prospect						Criteria
		2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020	
NO2	1 Hour Max	-	-	82.0	131.2	143.5	75.9	108.7	108.7	123.0	104.6	100.5	88.1	246
	Annual Average	-	-	15.5	22.0	21.2	15.4	21.6	20.1	20.1	18.7	17.7	15.1	62
CO	1 Hour Max	-	-	375	1625	7125	3500	2375	2000	2000	1625	6875	2625	30,000
	8 Hour Max	-	-	125	1375	4000	2500	0	1875	1375	1375	3500	2250	10,000
PM10	24 Hour Max	-	-	35.1	107.4	195.3	188.9	68.7	110.1	61.1	113.3	182.8	245.8	50
	Annual Average	-	-	23.7	21.6	25.5	19.3	17.6	19.0	19.0	21.9	25.9	20.1	25
	No. Exceedances	-	-	0.0	8.0	22.0	9.0	1.0	4.0	2.0	8.0	25.0	10.0	0
PM2.5	24 Hour Max	-	-	13.9	42.1	130.1	72.9	29.6	84.9	30.1	47.5	134.1	70.8	25
	Annual Average	-	-	9.2	9.2	10.4	8.2	8.2	8.7	7.7	8.4	11.5	8.6	8
	No. Exceedances	-	-	0	4	21	10	1	5	3	4	25	13	0

Pollutant	Averaging period	Rouse Hill						St Marys						Criteria
		2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020	
NO2	1 Hour Max	-	-	-	-	102.5	69.7	65.6	86.1	75.9	75.9	67.6	69.7	246
	Annual Average	-	-	-	-	11.5	10.1	8.3	7.5	8.7	10.3	8.1	7.9	62
CO	1 Hour Max	-	-	-	-	7750	15000	-	-	-	-	-	-	30000
	8 Hour Max	-	-	-	-	4500	2375	-	-	-	-	-	-	10000
PM10	24 Hour Max	-	-	-	-	216.2	220.3	53.0	100.2	49.9	100.5	159.8	260.3	50
	Annual Average	-	-	-	-	27.3	18.3	15.1	16.0	16.1	19.3	24.6	18.9	25
	No. Exceedances	-	-	-	-	24.0	10.0	1.0	3.0	0.0	2.0	26.0	11.0	0
PM2.5	24 Hour Max	-	-	-	-	183.5	61.3	-	93.2	38.2	80.5	101.3	82.5	25
	Annual Average	-	-	-	-	12.6	7.0	-	7.8	7.0	7.8	10.2	7.5	8
	No. Exceedances	-	-	-	-	24	10	-	5	3	4	23	10	0

The following sections discuss the measured pollutant concentrations at the selected stations for the period 2015 to 2020. The calendar years 2019 and 2020 are not considered representative of long-term trends due to the effect on air quality of the widespread bushfire events at the end of 2019 and start of 2020; and also due to the reduction in traffic and associated air emissions during 2020 as a result of COVID-related lock downs. The data for these years is presented for completeness, however the pollutant measurements from the 2015 to 2018 period are considered more representative of the long-term air quality trends in the Sydney basin, and the investigation of existing air quality concentrations therefore focused on these years.

5.2.1 Nitrogen dioxide

NO_2 was monitored periodically at Rouse Hill between 2015 to 2019, Parramatta north between 2015 to 2017 and Liverpool SWAQS between 2015 to 2018. Remaining stations measured continuously from January 2015. Monitoring data across all stations showed that Nitrogen dioxide levels in the ambient environment were well below current NSW EPA criteria. With the maximum short term NO_2 concentration reaching only 59% of the existing criteria.

General seasonal trends in pollutant concentration were observed with higher concentrations occurring during winter and lower concentrations noted in summer.

No significant change to the NO_2 concentrations were noted for the bushfire period of 2019 these seasonal trends and event concentrations follow the expected patterns and as such the NO_2 data is considered reasonable for use in the assessment for cumulative impact assessment. A small decrease in NO_2 concentrations was noted across the 2020 period likely because of the decrease in road traffic due to the effect of COVID-related lockdowns.

5.2.1.1 1-hour average NO_2

Measured 1-hour averages at DPE stations situated in the Proposed Modifications Southern Domain are presented in **Figure 5-5**. The highest measured concentration was 131.2 µg/m^3 in 2017 at the Liverpool station.

Measured 1-hour averages at DPE stations situated in the Proposed Modifications Northern Domain are presented in **Figure 5-6**. The highest measured concentration was 143.5 µg/m^3 in 2019 at the Parramatta North station.

The average 90th percentile 1-hour average NO_2 concentration across the North Domain stations was 34.3 µg/m^3 and a result of 39.4 µg/m^3 respectively across the South domain stations.

This percentile concentration is important for understanding that although the highest concentration is still well below the criteria, generally NO_2 concentrations above 40 µg/m^3 are not frequent.

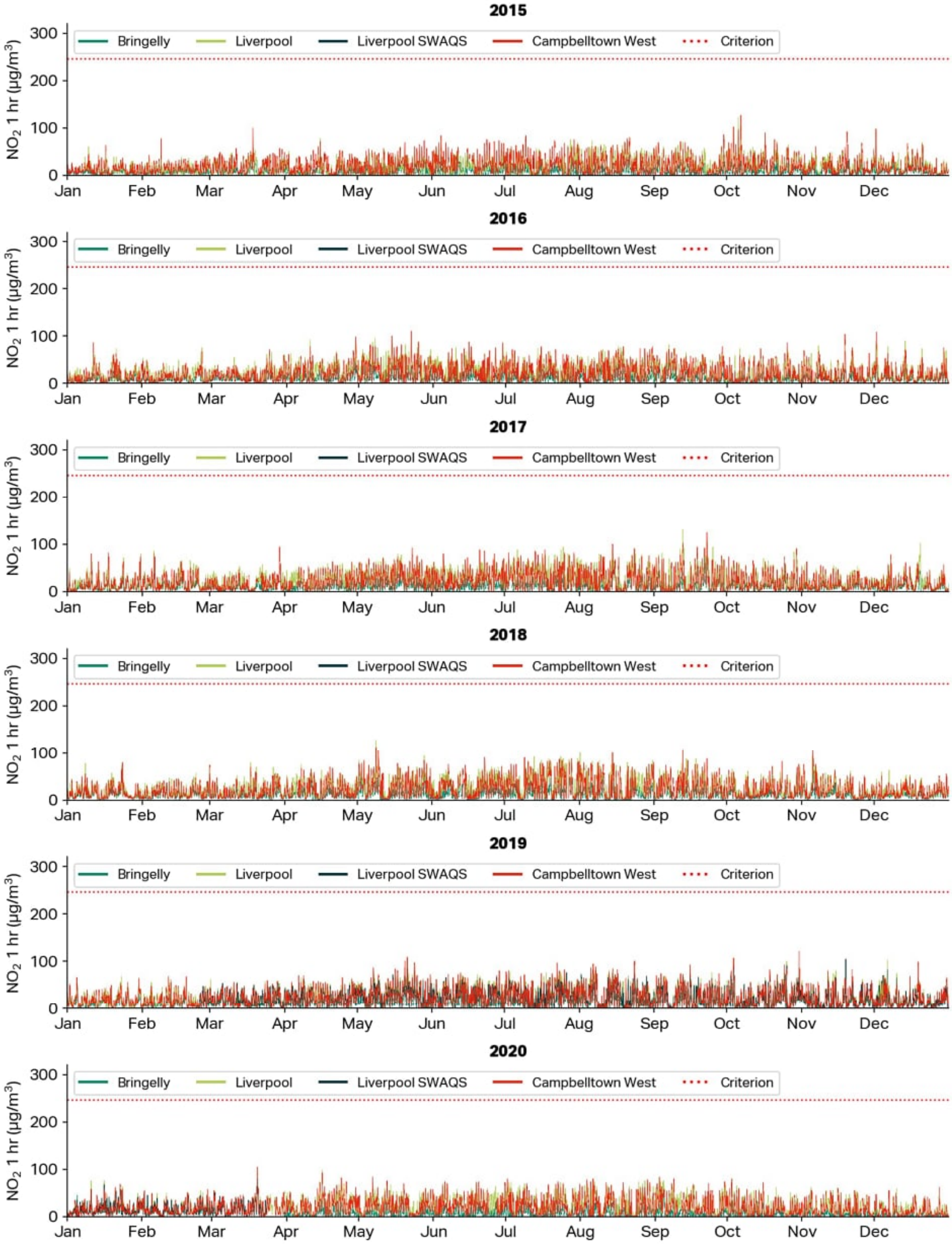


Figure 5-5 1-hour average NO_2 measurements at DPE stations in the Proposed Modification Southern Domain – 2015-2020

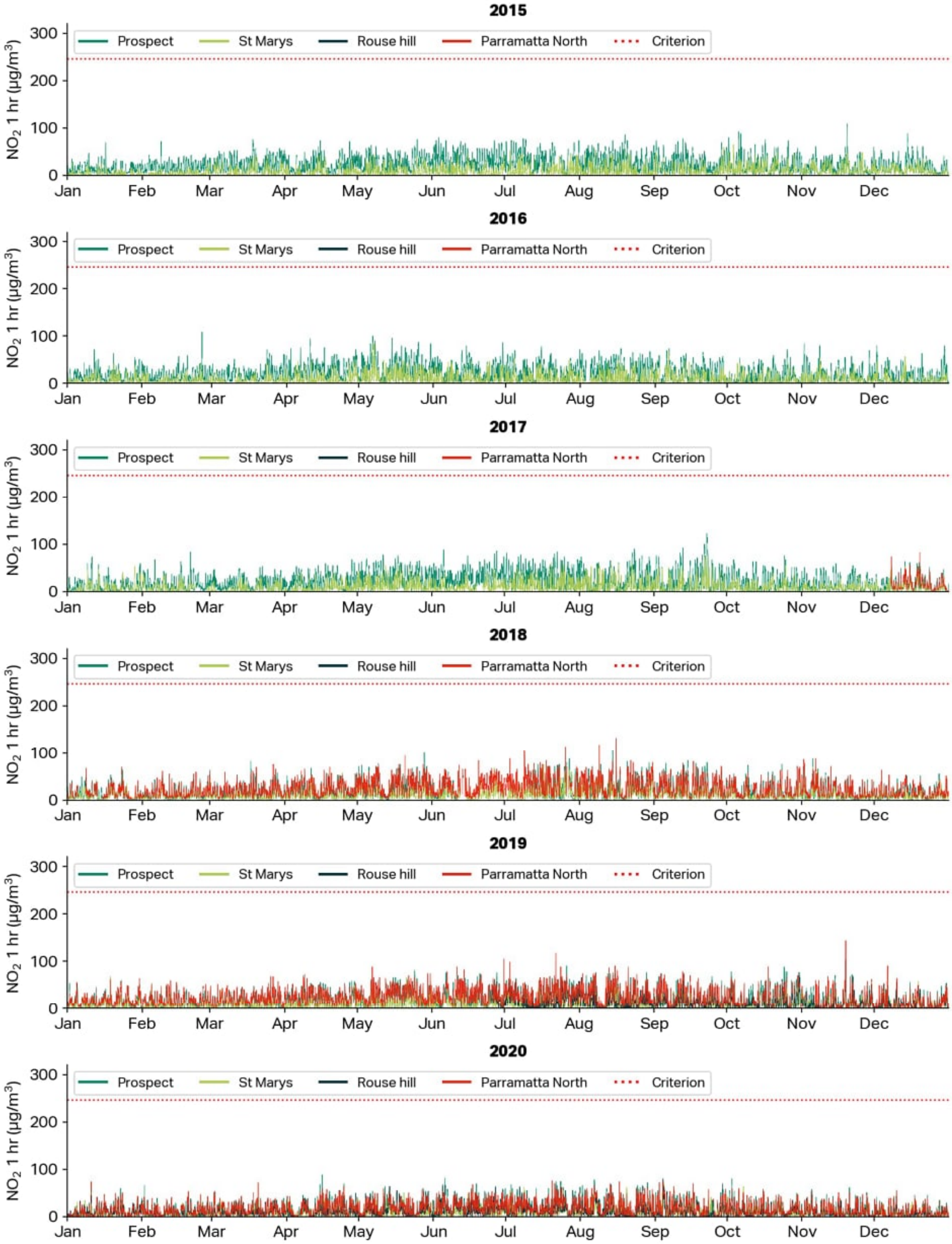


Figure 5-6 1-hour average NO_2 measurements at DPE stations in the Proposed Modification Northern Domain – 2015-2020

5.2.1.2 Annual average NO_2

Annual average NO_2 concentrations for the Proposed Modifications South Domain are presented in **Figure 5-7** with annual average NO_2 concentrations in the North Domain presented in **Figure 5-8**.

The highest annual average result of 25.2 µg/m^3 was recorded in 2018 at the Liverpool station within the South domain and a result of 21.9 µg/m^3 recorded at the Parramatta north station in 2018 within the North domain.

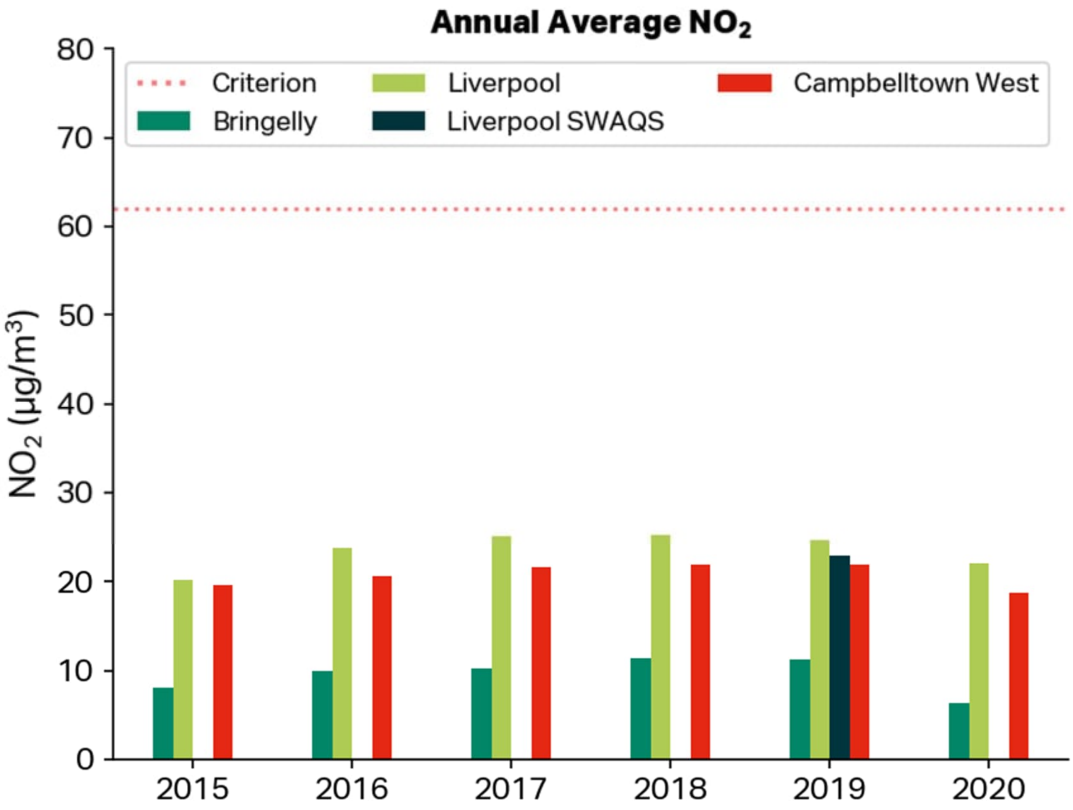


Figure 5-7 Annual average NO_2 measurements at DPE stations in the Proposed Modification Southern Domain – 2015-2020

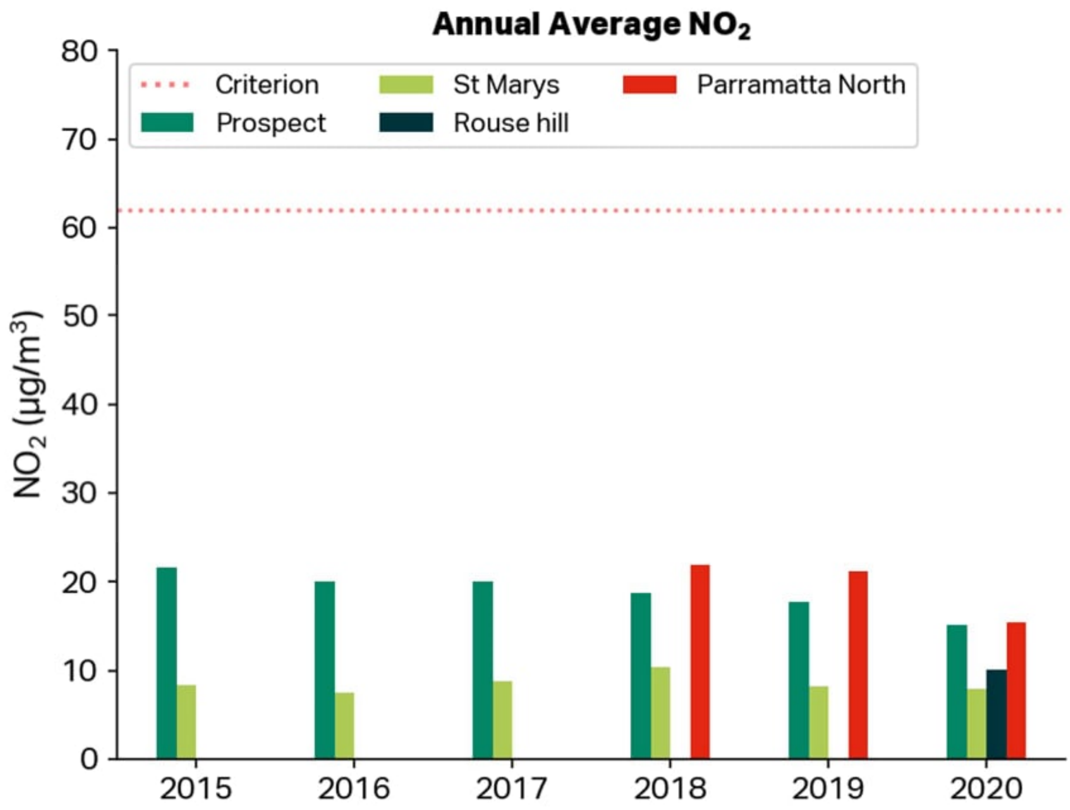


Figure 5-8 Annual average NO_2 measurements at DPE stations in the Proposed Modification Northern Domain – 2015-2020

5.2.2 Carbon monoxide

CO was monitored continuously across the Liverpool, Campbelltown West, Prospect and Parramatta North monitoring stations during the period 2015 to 2020. Stations at St Marys and Bringelly were not equipped to monitor CO and therefore no data was available during this period. Stations at Rouse Hill and Liverpool SWAQS monitored CO on a periodic basis over the period 2019 to 2020. Due to the possible biased data from the 2019 bushfires in the area during this period and the effect of COVID related lockdowns on traffic related emission sources, this data was not used.

Monitoring data across all available DPE stations show that CO levels in the ambient environment are well below the 1-hour and 8-hour average criterions. CO concentrations reached a maximum of 20% of the 1-hour average Carbon monoxide criterion, and 20% of the 8-hour average criterion between the years 2015-2018.

General seasonal trends in pollutant concentration were observed with higher concentrations occurring during winter and lower concentrations noted in summer.

5.2.2.1 1-hour average CO

Measured 1-hour averages of CO are presented below in **Figure 5-9** to **Figure 5-12** for all selected stations. The highest measured concentration between the period of 2015-2018 was 3,000 µg/m^3 recorded at the Liverpool station in 2018, located within the Proposed Modification's Southern Domain. To assess changes along the northern part of the motorway alignment, the highest measured concentration in the northern section of the Proposed Modification was obtained from the Prospect station in 2015 and was 2,375 µg/m^3.

Both measured maximum concentrations were well below the noted 30,000 µg/m^3 1-hour average criterion.

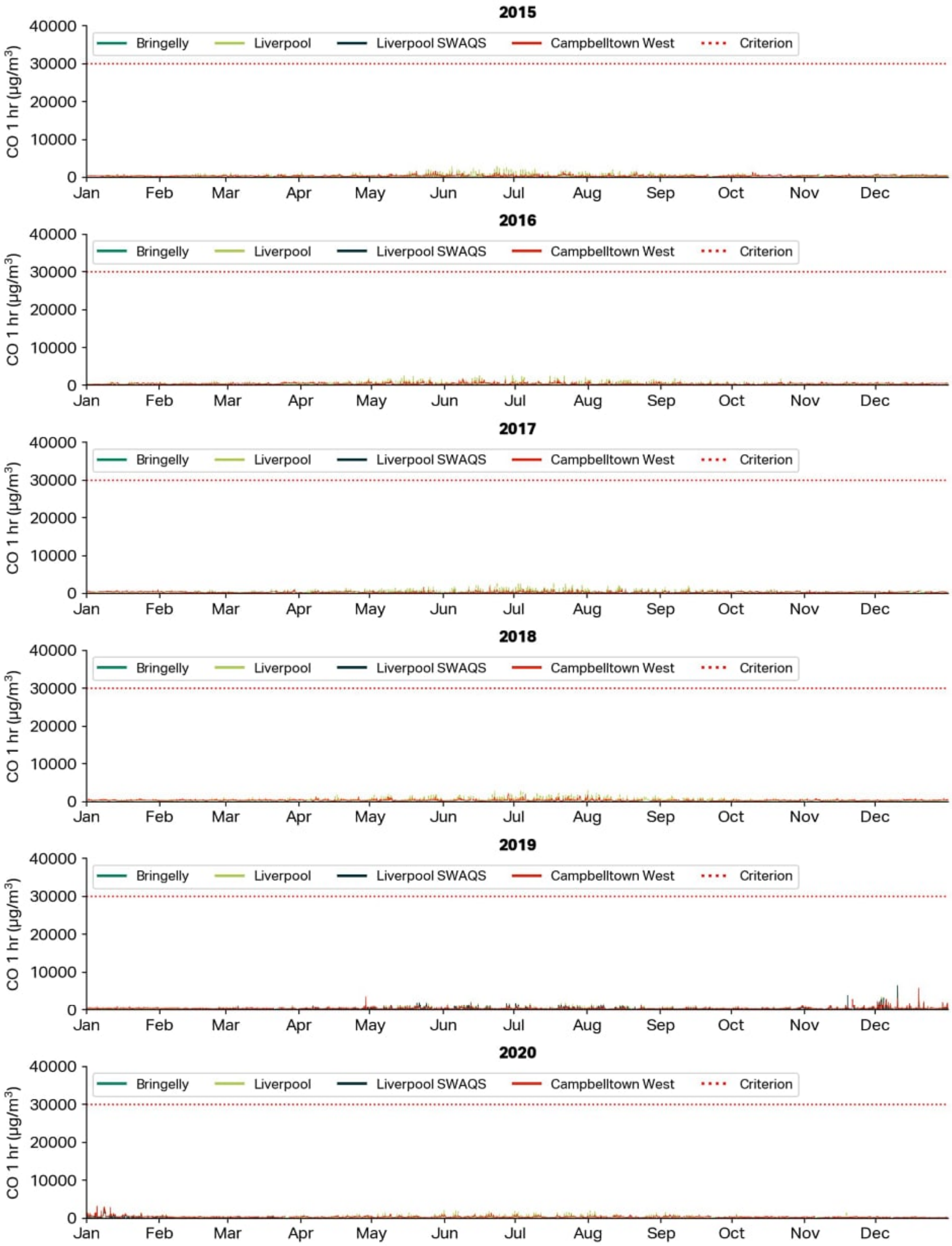


Figure 5-9 1-hour CO concentrations –Southern Domain – 2015-2020

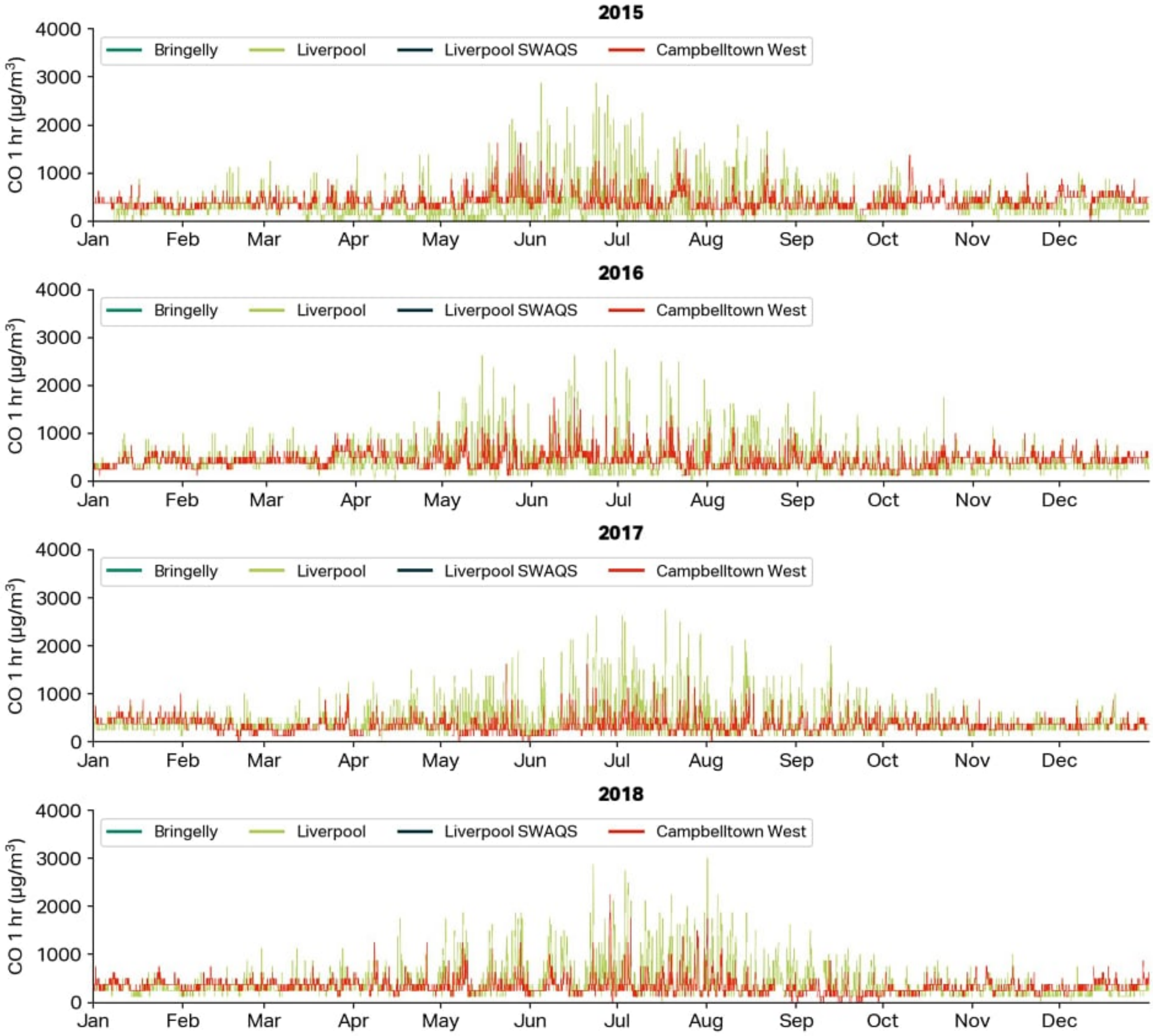


Figure 5-10 1-hour CO concentrations – Southern Domain – 2015-2018 – (criterion of 30,000 µg/m³ not shown)

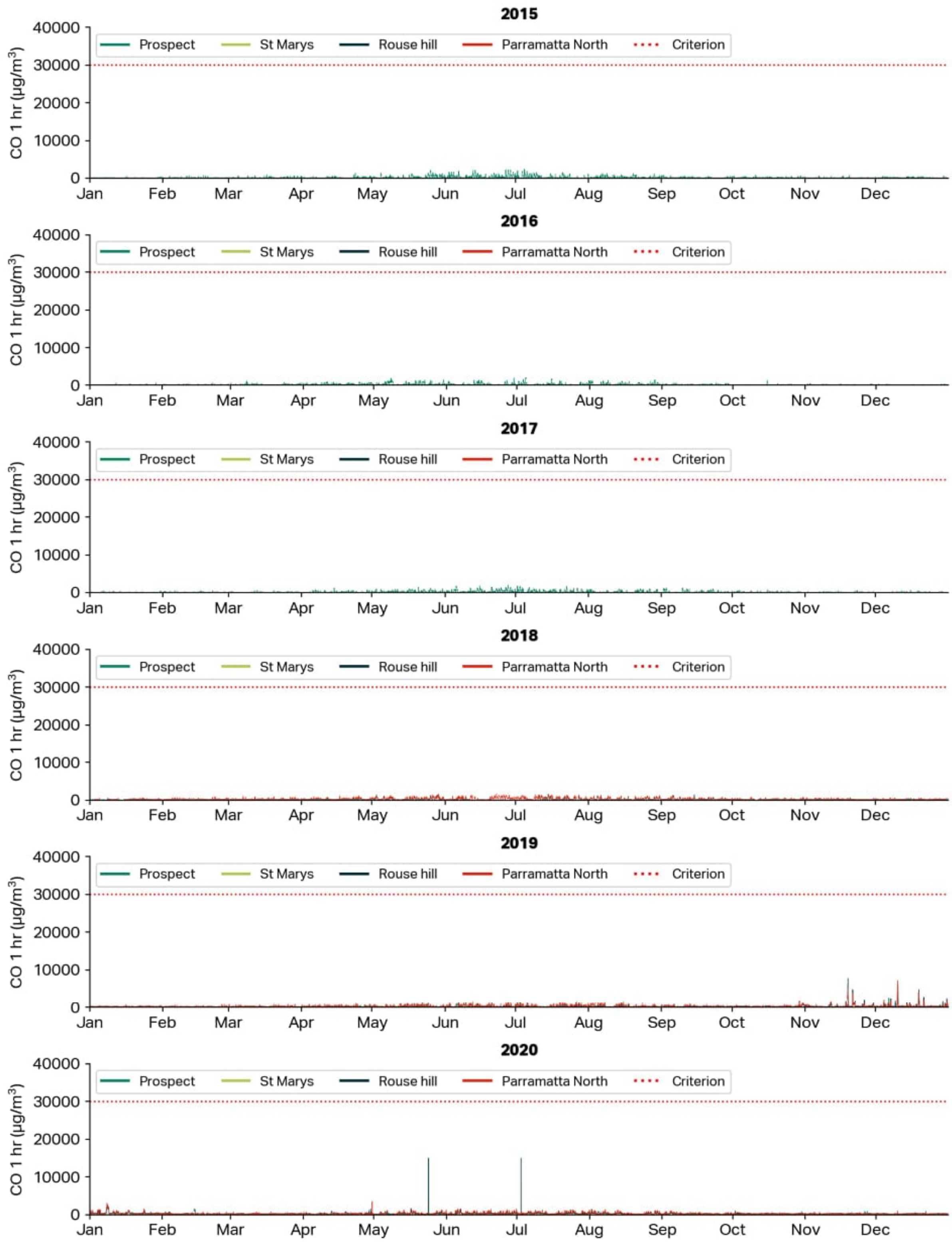


Figure 5-11 **1-hour CO concentrations – Northern Domain – 2015-2020**

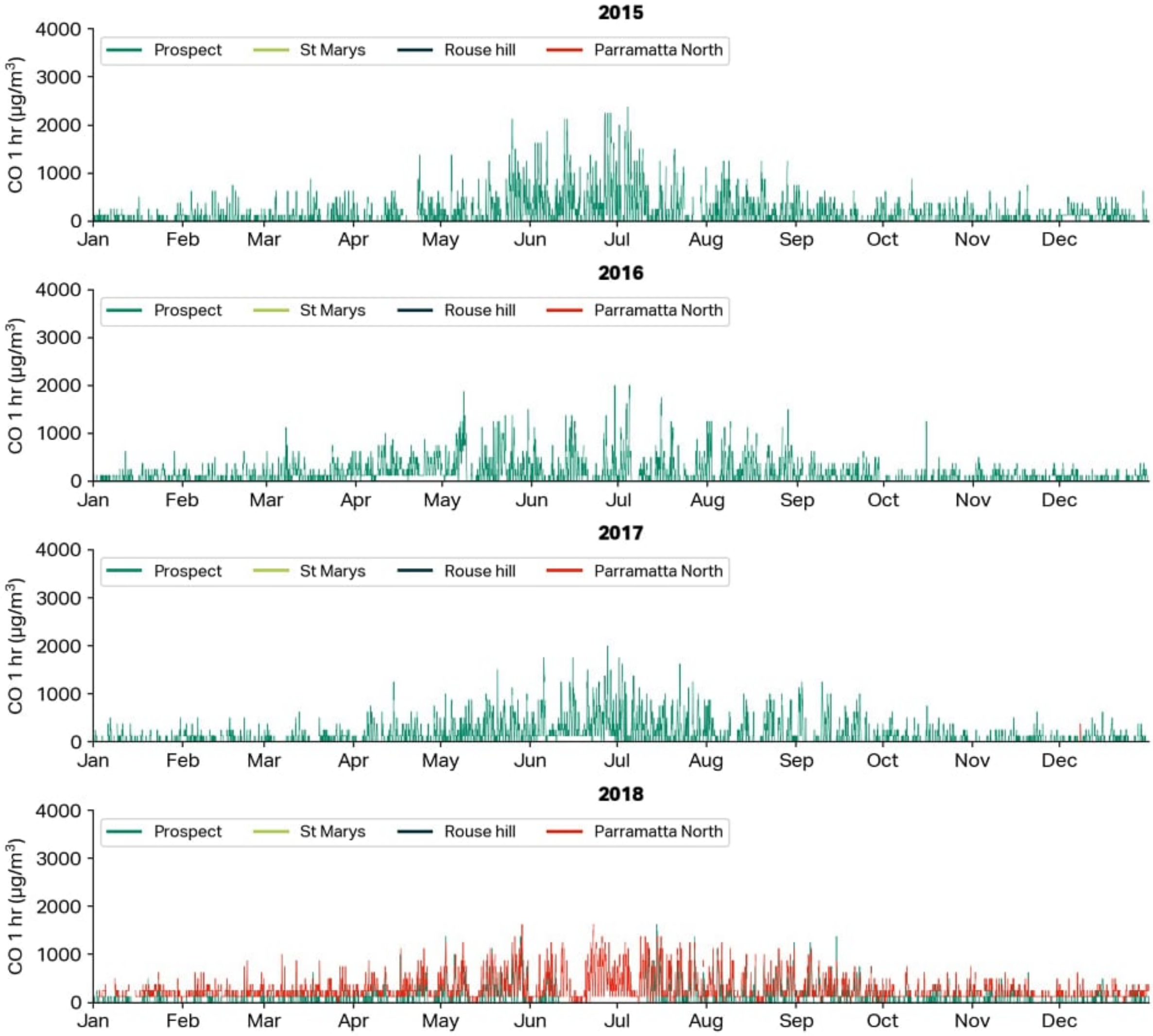


Figure 5-12 **1-hour CO concentrations – Northern Domain – 2015-2018 – (criterion of 30,000 µg/m³ not shown)**

5.2.2.2 8-hour average CO

Measured 8-hour averages of CO are presented below in **Figure 5-13** to **Figure 5-16** for all selected stations. The highest measured concentration for 2015-2018 period was 2,016 µg/m³ recorded at the Liverpool station in 2016, located within the Proposed Modification's Southern domain. For reference to assess changes along the alignment, the highest measured concentration in the northern section of the Proposed Modification was 1,578 µg/m³ at the Prospect station in 2015.

Both measured concentrations are well below the noted 10,000 µg/m³ 8-hour average criterion.

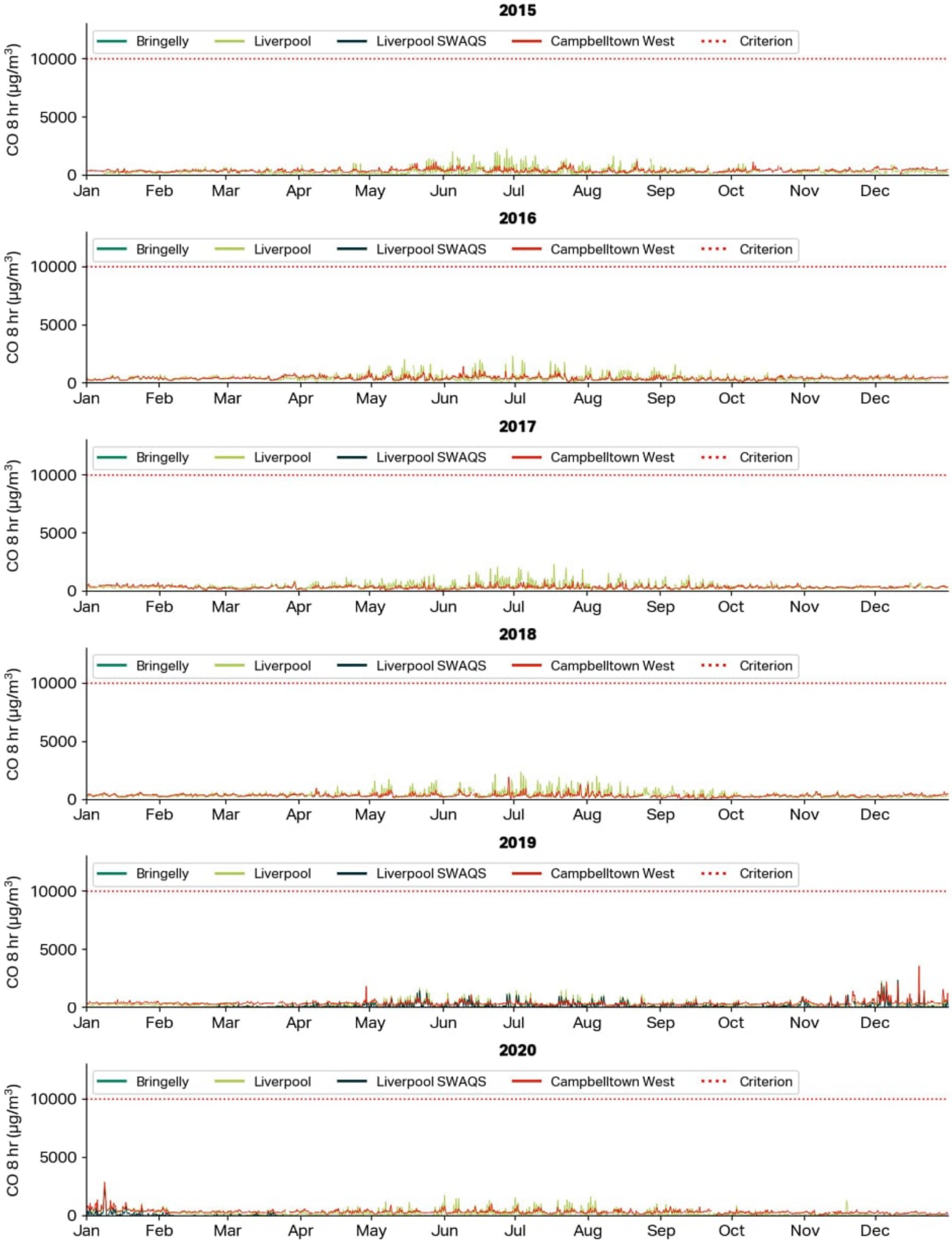


Figure 5-13 **8-hour CO concentrations –Southern Domain – 2015-2020**

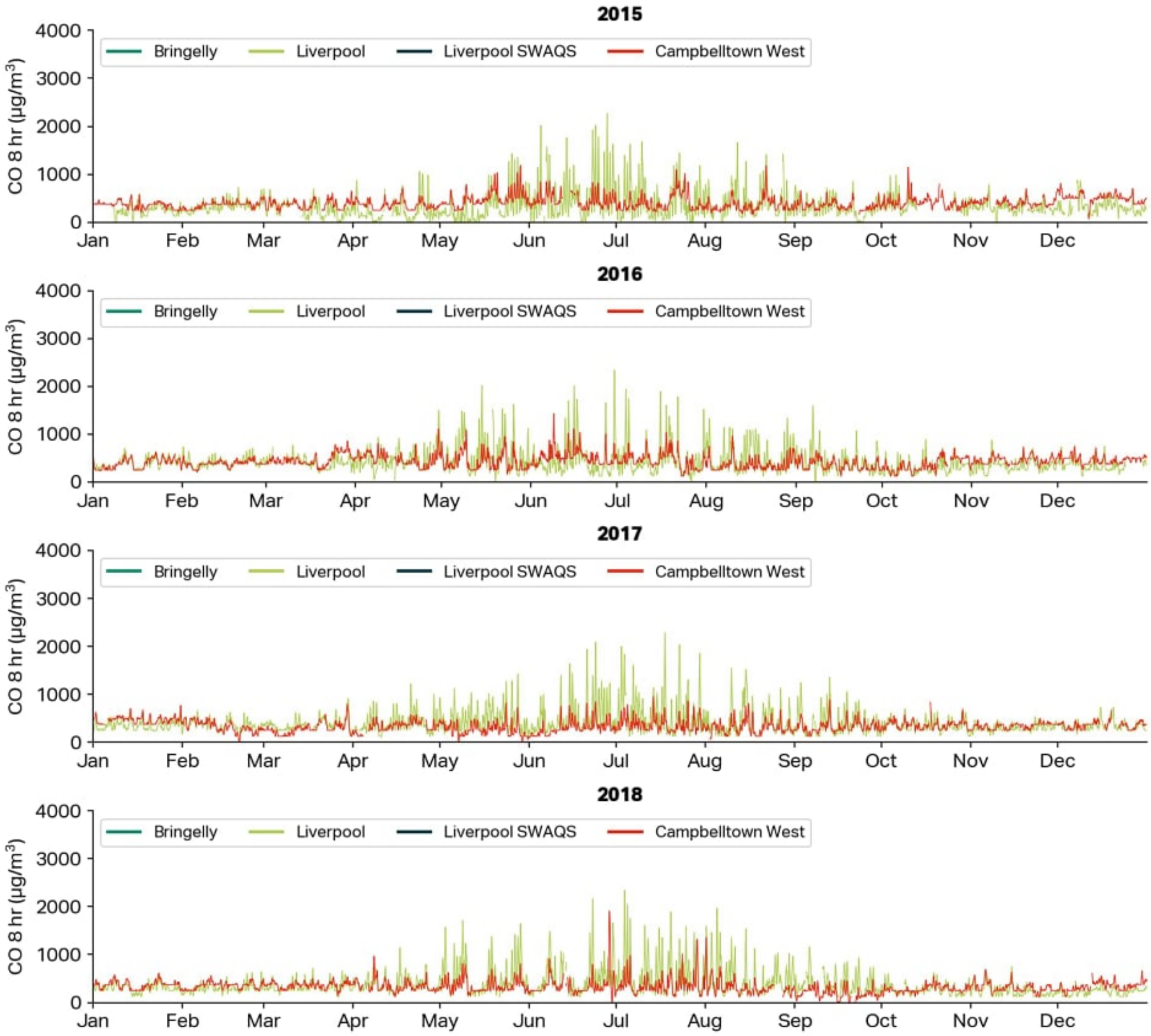


Figure 5-14 8-hour CO concentrations –Southern Domain – 2015-2018 - criterion of 10,000 µg/m^3 not shown

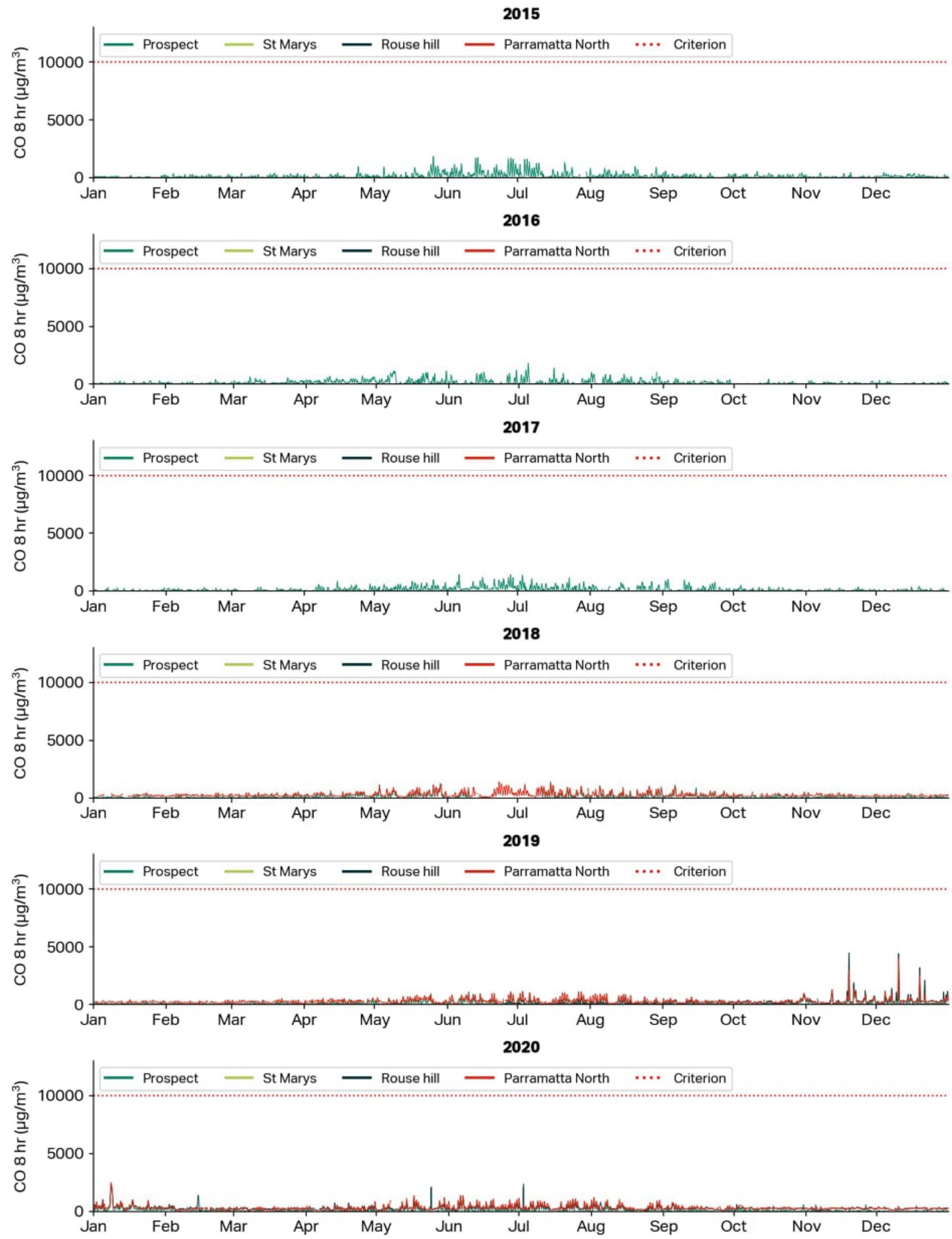


Figure 5-15 **8-hour CO concentrations –Northern Domain – 2015-2020**

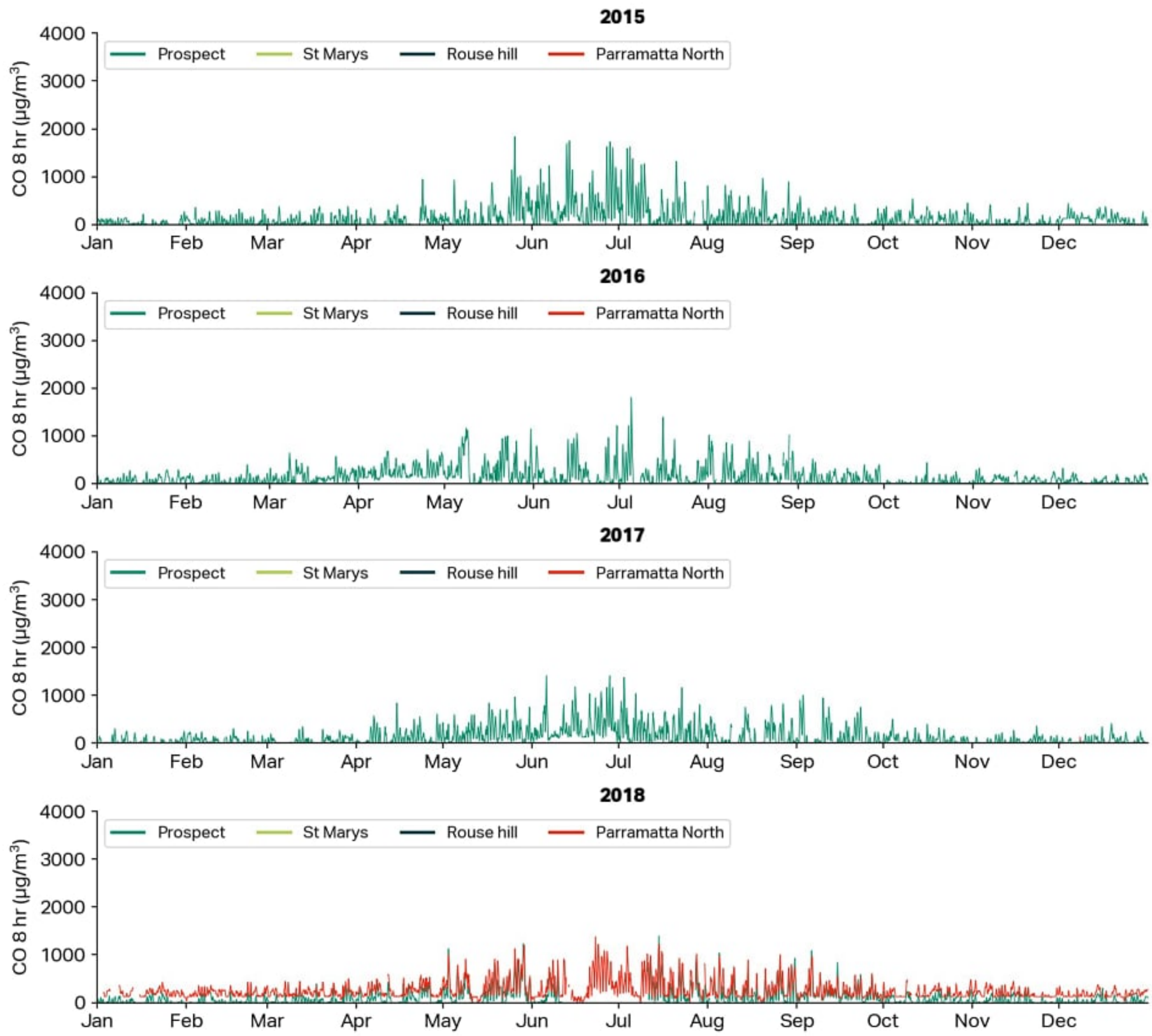


Figure 5-16 8-hour CO concentrations –Northern Domain – 2015-2018 – (criterion of 10,000 µg/m³ not shown)

5.2.3 PM_{10}

PM_{10} was monitored at Rouse Hill, Parramatta north and Liverpool SWAQS periodically between 2015 to 2018 and then continuously from 2018, with Parramatta North monitoring continuously from 2017. All remaining stations have been monitoring continually over the period 2015 to 2020. Due to this periodic monitoring, days with less than 75 percent data capture rate were excluded from the dataset.

Particulate concentrations show that levels of dust in the ambient environment surrounding the Proposed Modification are elevated with exceedances of short-term PM_{10} criteria noted for each calendar year between 2015 to 2018. These short-term exceedances are typically attributed to unusual events like bushfires and dust storms which occurred in both 2018 and 2019. Particulate concentrations during unusual events should not be used as indicators of long-term peak particulate concentrations and compliance with EPA criteria.

Several exceedances were reported during the period 2015-2018 across each station. The highest measured 24-hour concentration across all stations was 113.3 µg/m³ reported in September 2018 at the Prospect station in the Northern Domain. This value was adopted as the background concentration for this assessment. As a comparison, the highest measured concentration the Southern domain was 101.5 µg/m³ at the Liverpool station in November 2018.

5.2.3.1 24-hour average PM_{10}

Monitored 24-hour average PM_{10} in the Southern Domain for the period 2015 to 2018 is presented in **Figure 5-17** and **Figure 5-18**.

Liverpool Station recorded the highest measured concentration and number of exceedances at 23 along with the Bringelly station. The 90th percentile 24-hour PM_{10} concentration at Liverpool and Bringelly stations were 37.4 µg/m^3 and 32.6 µg/m^3 respectively. The average 90th percentile across all stations in the South domain was 28.7 µg/m^3.

This percentile concentration is important for understanding that although the highest concentration is above the criteria, generally PM_{10} concentrations above 30 µg/m^3 are not frequent.

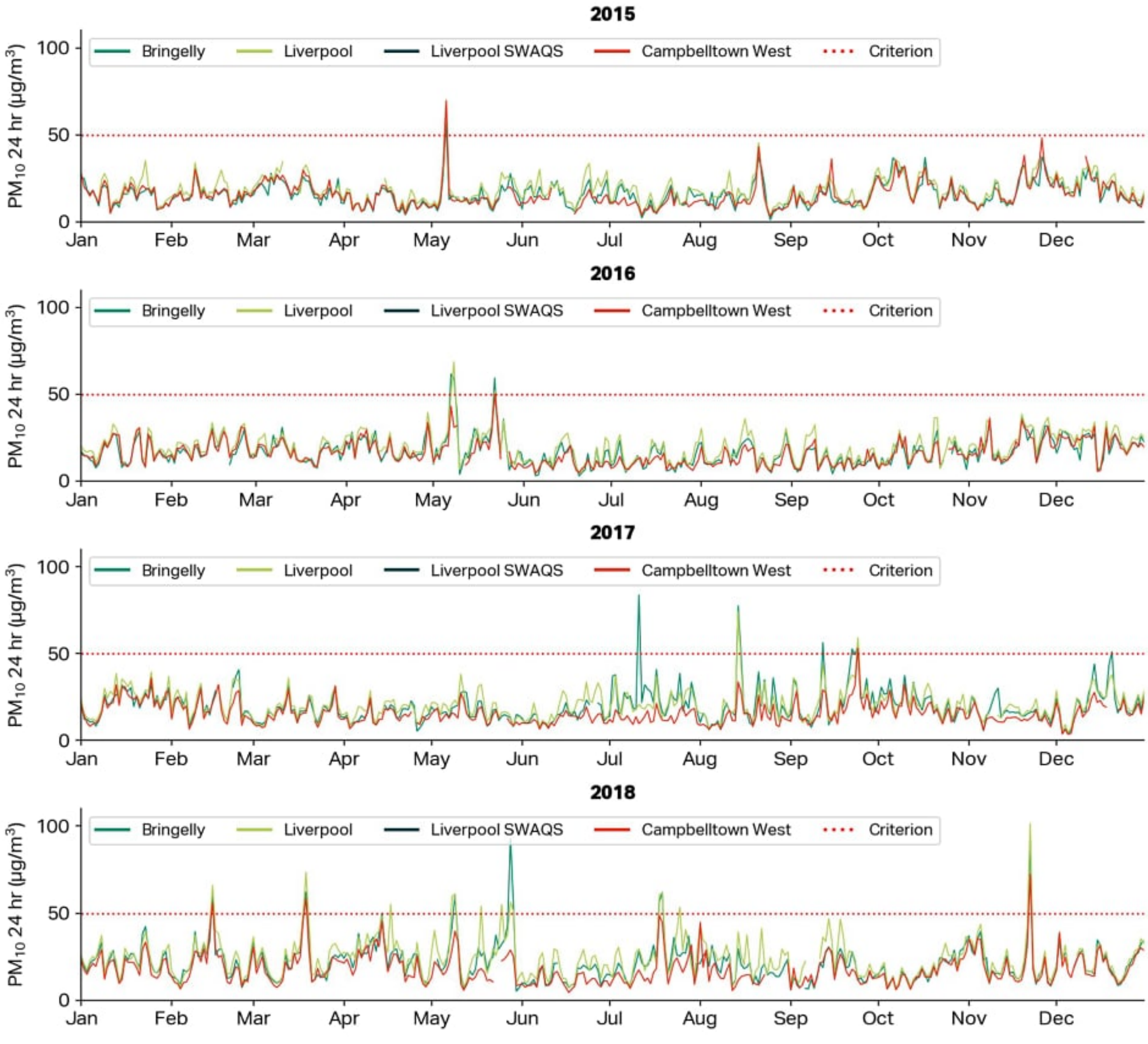


Figure 5-17 **24-hour PM_{10} concentrations –Southern Domain – 2015-2018**

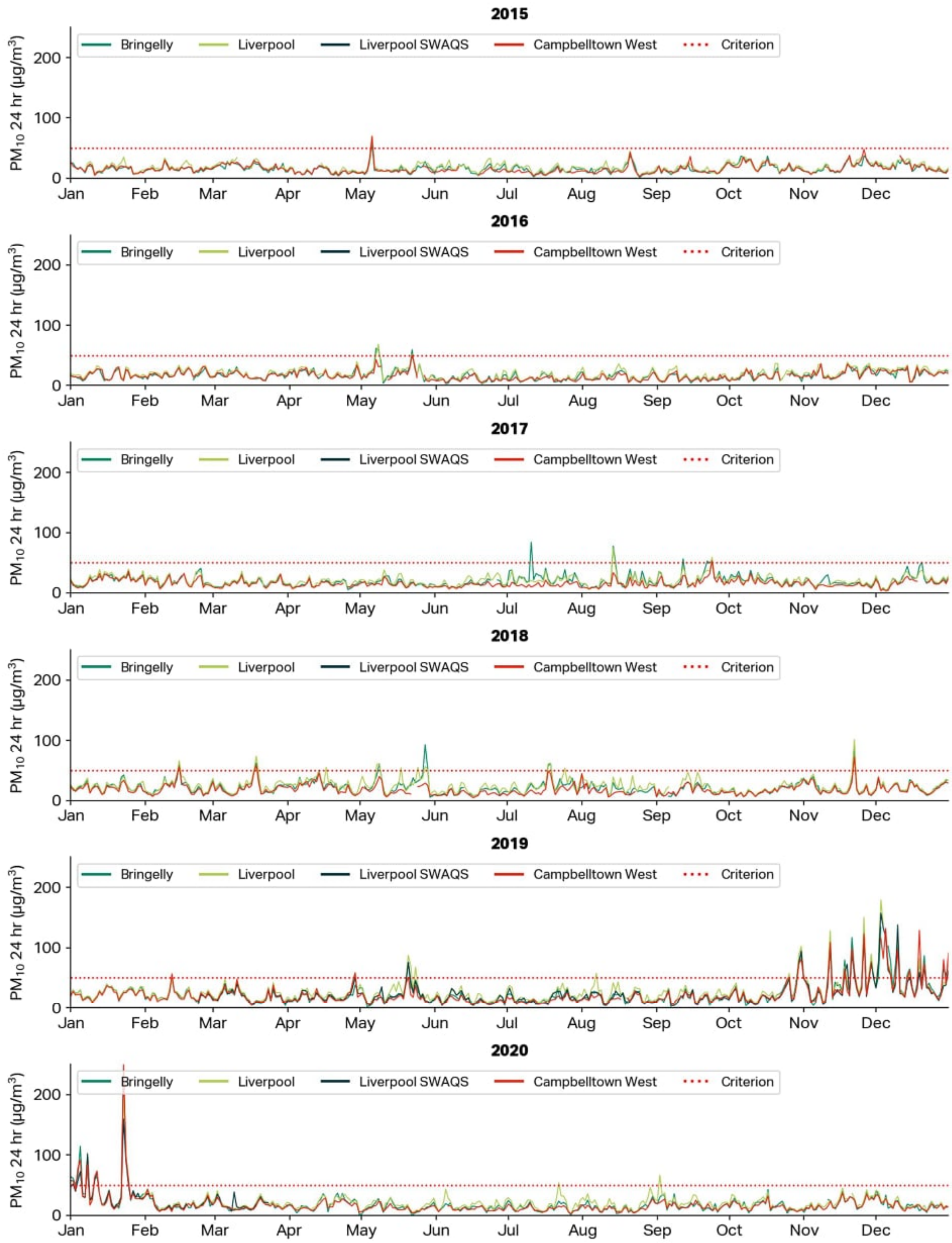


Figure 5-18 24-hour PM_{10} concentrations –Southern Domain – 2015-2020

Monitored 24-hour average PM_{10} in the northern domain for the period 2015 to 2018 is presented in **Figure 5-19**.

Prospect Station recorded the highest measured concentration and number of exceedances at 18. The 90th percentile 24-hour PM_{10} concentration at Prospect station was 33.3 µg/m^3. The average 90th percentile across all stations in the North Domain was 28.8 µg/m^3.

This percentile concentration is important for understanding that although the highest concentration is above the criteria, generally PM_{10} concentrations above 30 µg/m^3 are not frequent.

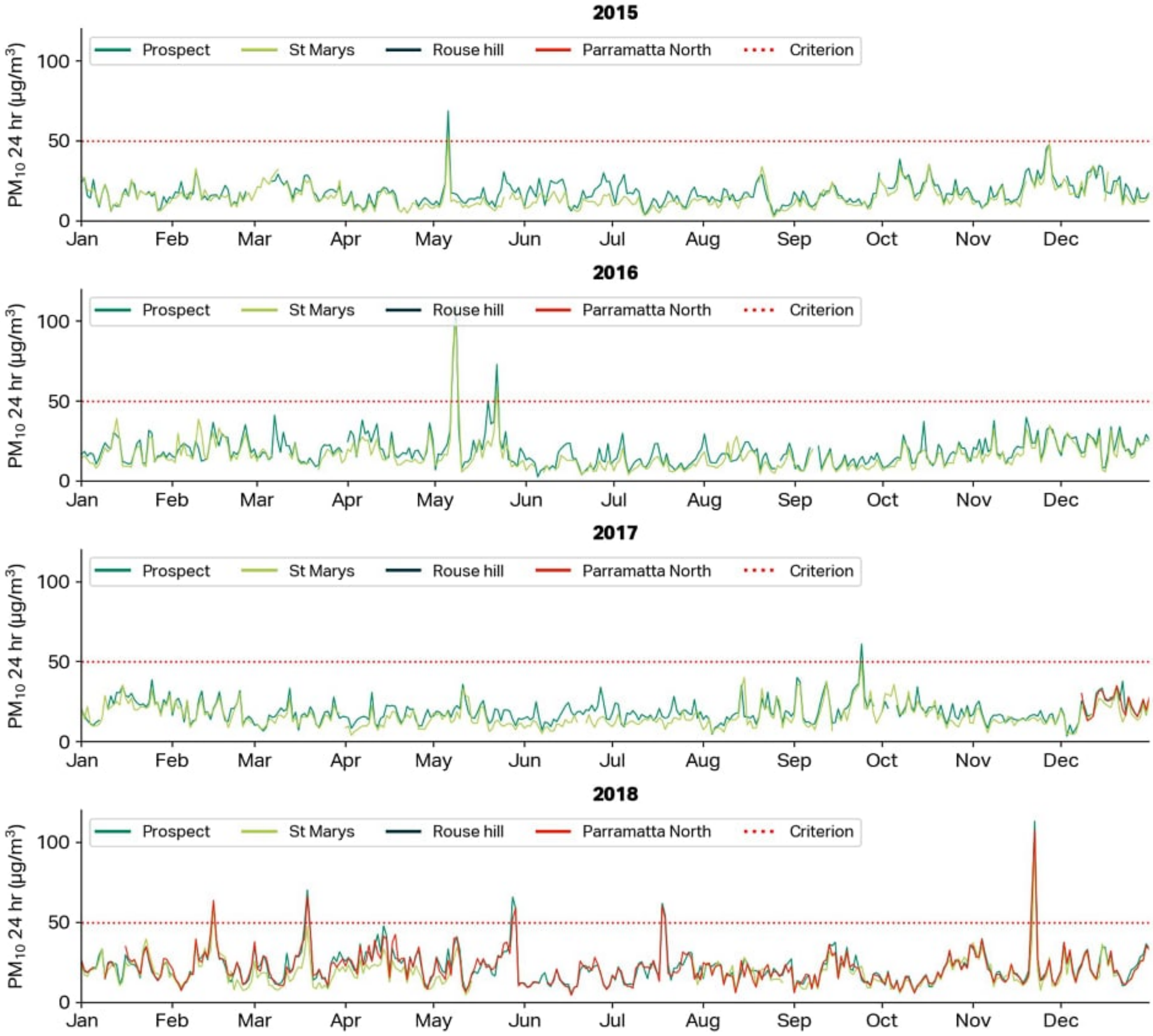


Figure 5-19 24-hour PM_{10} concentrations –Northern Domain – 2015-2018

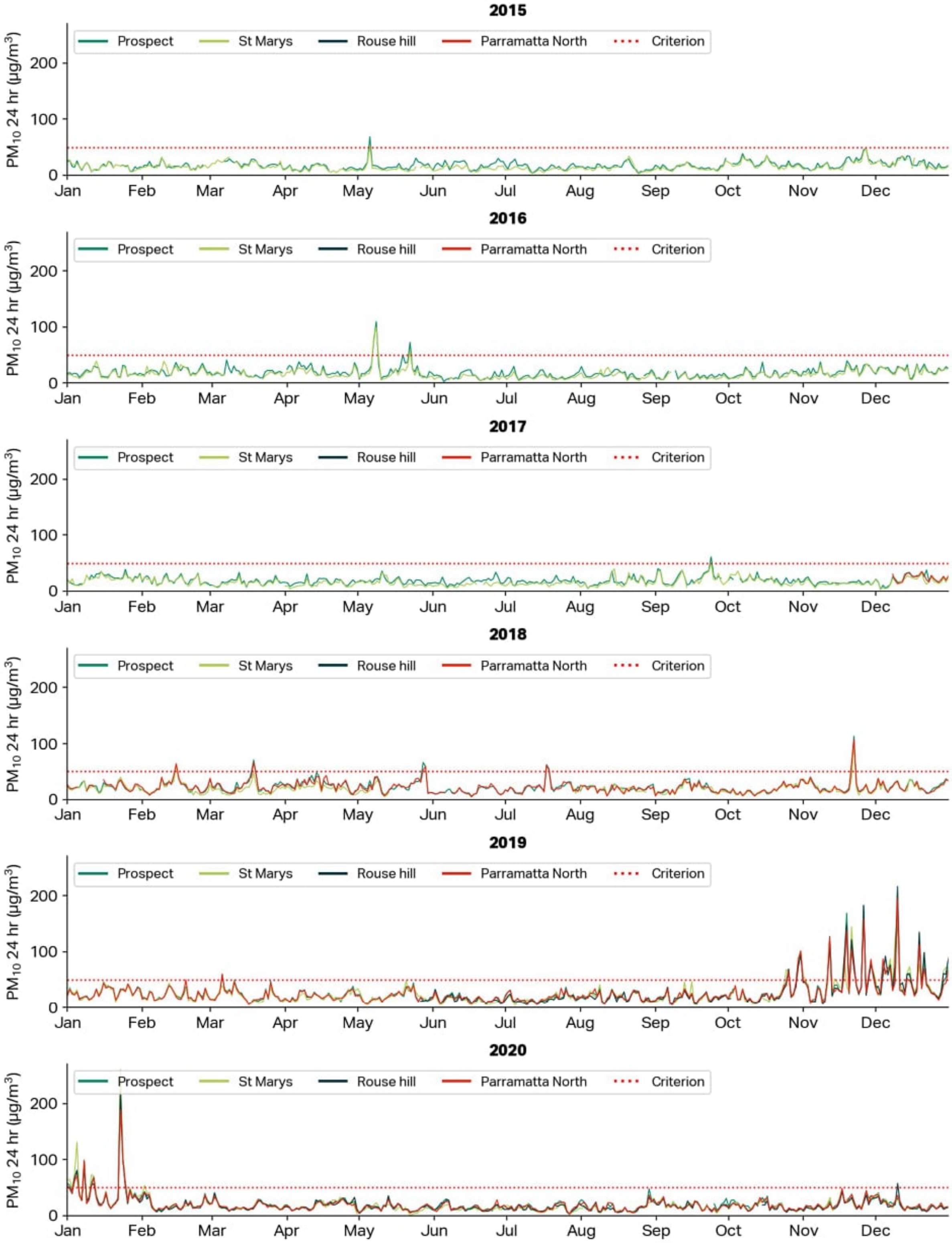


Figure 5-20 24-hour PM_{10} concentrations –Northern Domain – 2015-2020

5.2.3.2 Annual Average PM_{10}

Annual average PM_{10} concentrations are presented in **Figure 5-21** and **Figure 5-22**. Excluding the period 2019 to 2020 due to contamination by the 2019 bushfires and effects of COVID lockdowns of traffic, annual average concentrations remained below the criteria across all stations. The highest annual average PM_{10} concentrations were 24.2 µg/m^3 at the Liverpool station in 2018 in the South domain and 21.8 µg/m^3 at the Prospect station in 2018 in the North domain.

Both stations are located in close proximity to the Proposed Modification in their respective domains.

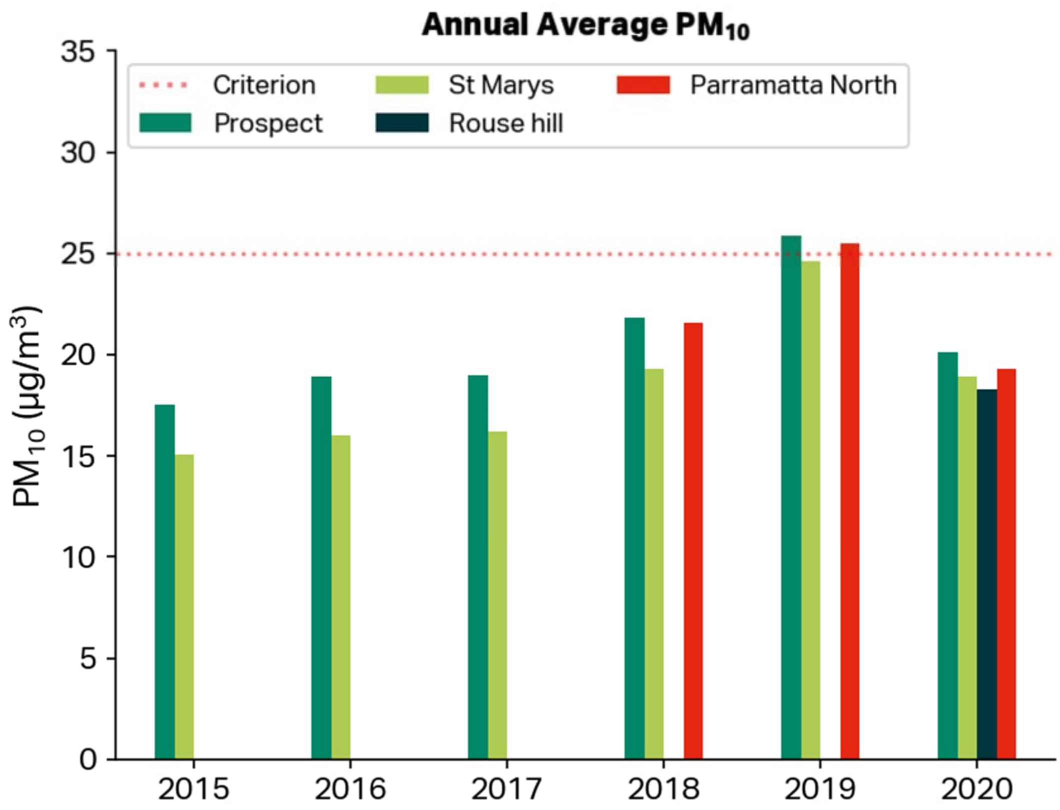


Figure 5-21 Annual average PM_{10} concentrations –Northern Domain – 2015-2020

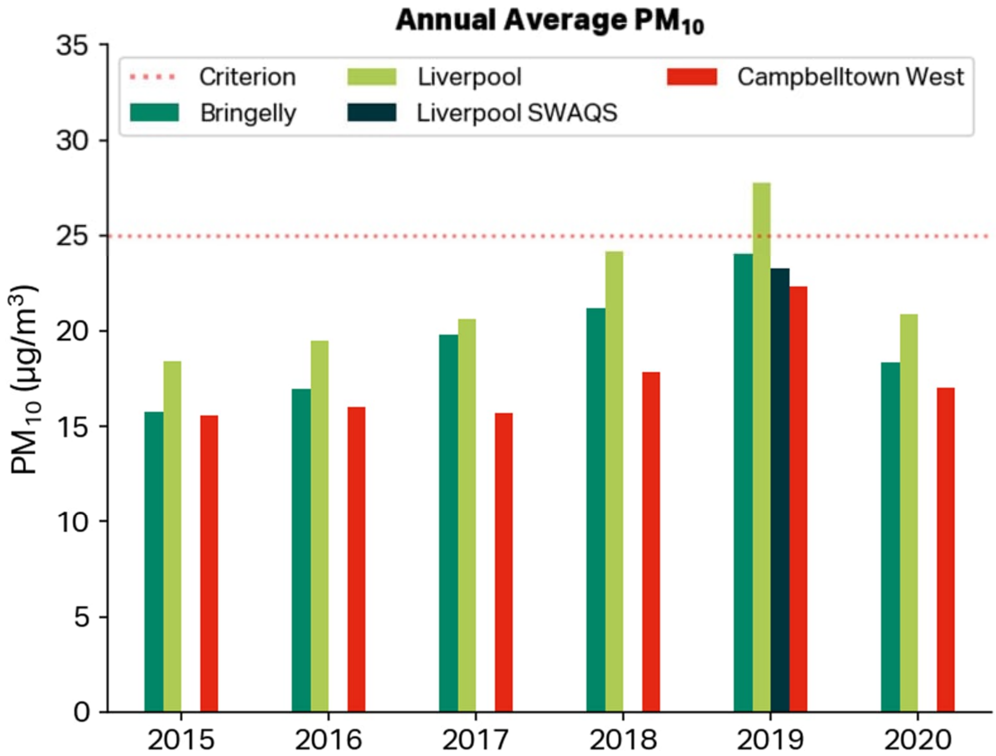


Figure 5-22 Annual average PM_{10} concentrations –Southern Domain – 2015-2020

5.2.4 $PM_{2.5}$

$PM_{2.5}$ was monitored at Liverpool continuously over the study period, with $PM_{2.5}$ being monitored periodically across all remaining stations during the 2015-2020 period. For this reason, days with less than 75 percent data capture rate were excluded from the dataset.

Particulate concentrations show that levels of dust in the ambient environment surrounding the Proposed Modification are elevated with exceedances of short-term $PM_{2.5}$ criteria noted for each calendar year between 2015 to 2018. These short-term exceedances are typically attributed to unusual events like bushfires and dust storms which occurred in both 2018 and 2019. Particulate concentrations during unusual events should not be used as indicators of long-term peak particulate concentrations and compliance with EPA criteria.

Numerous exceedances were reported during the period 2015-2018 across 80% of stations. The highest measured 24-hour concentration across all stations was 93.2 µg/m^3 reported in May 2016 at St Marys station in the Northern Domain. This value was adopted as the background concentration for this assessment. As a comparison, the highest measured concentration the Southern Domain was 56.4 µg/m^3 at the Liverpool station in August 2017.

5.2.4.1 24-hour average $PM_{2.5}$

Monitored 24-hour average $PM_{2.5}$ in the Southern domain for the period 2015 to 2018 is presented in **Figure 5-23**.

Liverpool recorded the highest measured concentration and the highest number of exceedances at 21. The 90th percentile 24-hour $PM_{2.5}$ concentration at Liverpool station was 16.7 µg/m^3. The average 90th percentile across all stations in the North Domain was 13.1 µg/m^3.

This percentile concentration is important for understanding that although the highest concentration is above the criteria, generally $PM_{2.5}$ concentrations above 16 µg/m^3 are not frequent.

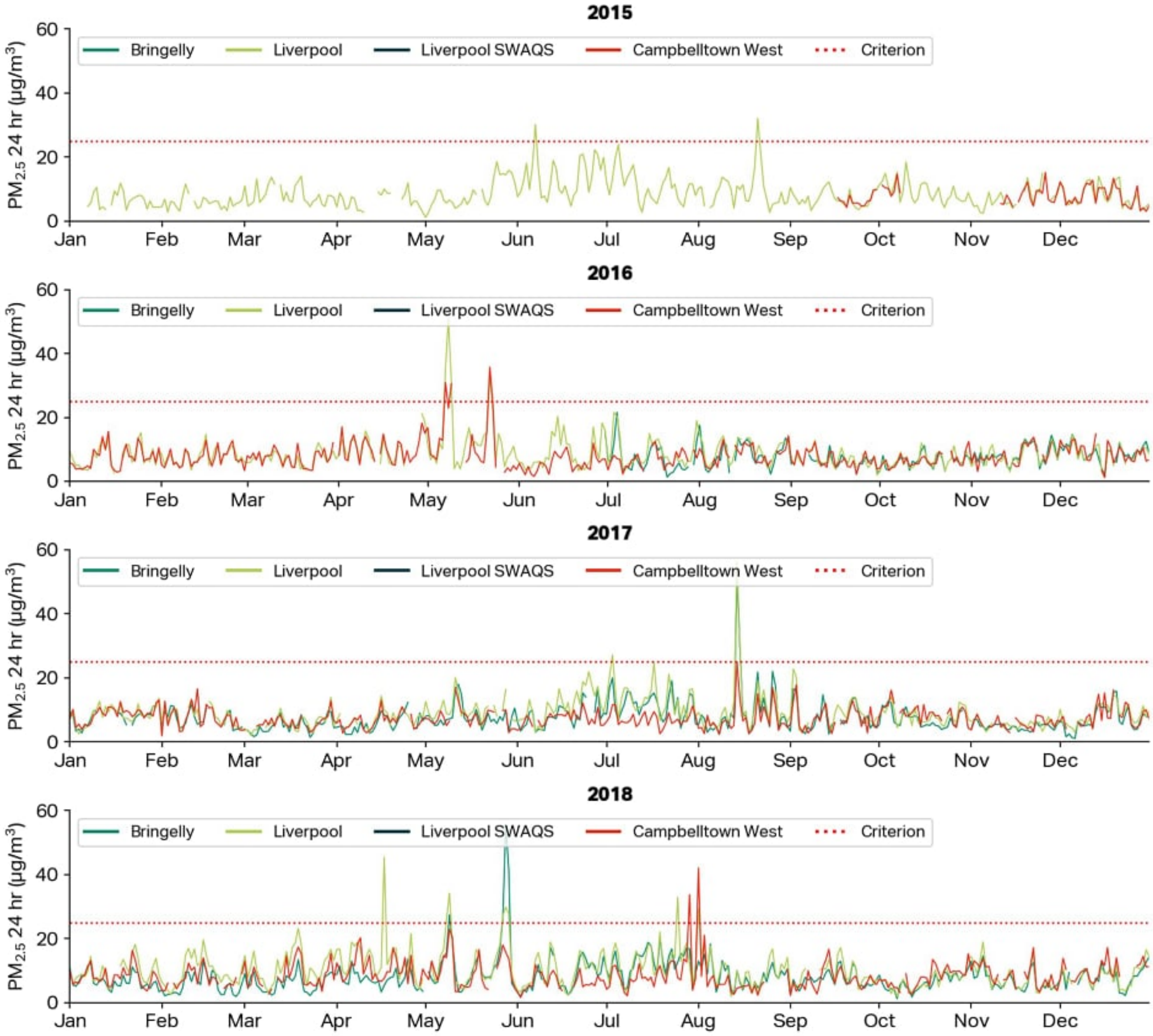


Figure 5-23 24-hour $PM_{2.5}$ concentrations –Southern Domain – 2015-2018

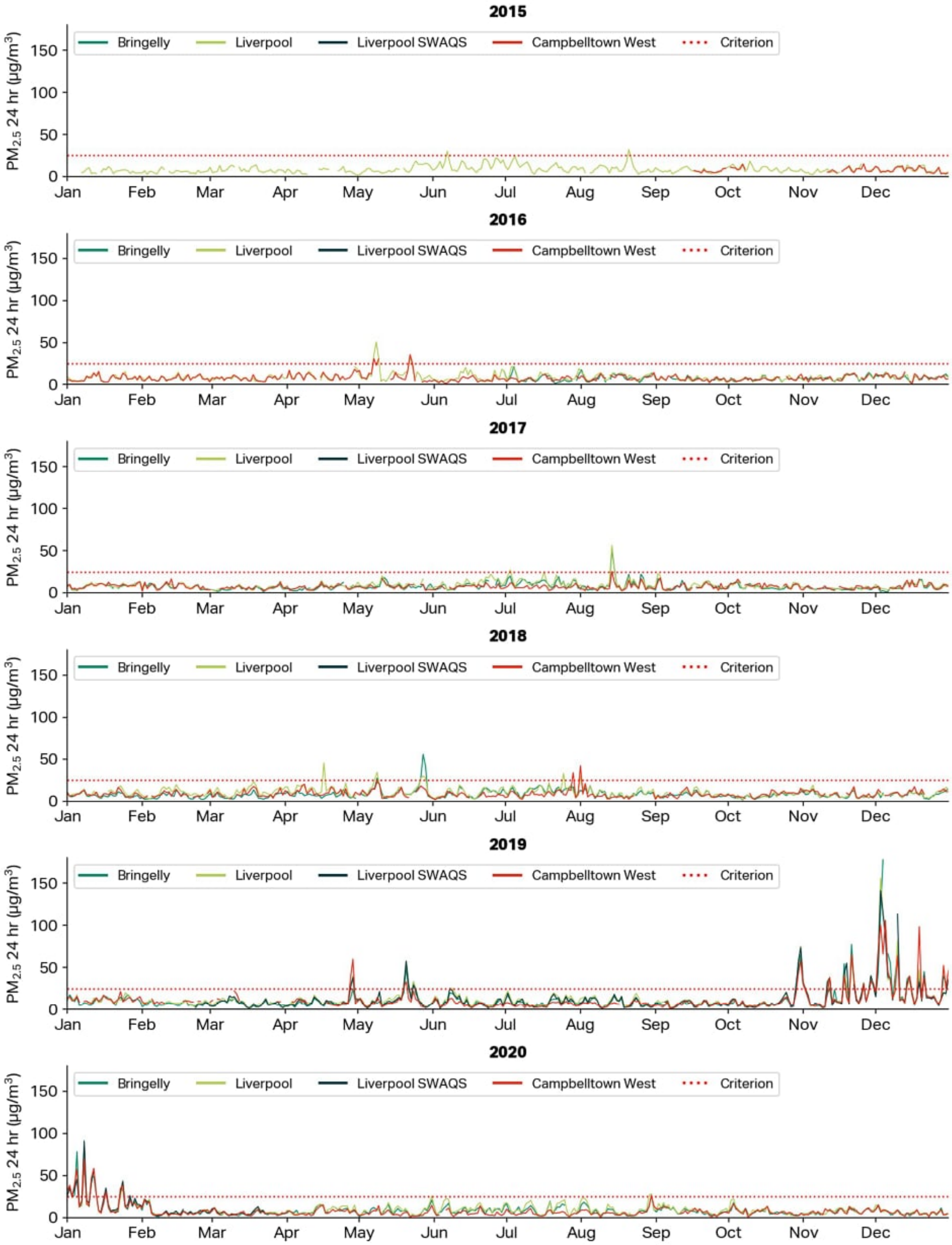


Figure 5-24 24-hour $PM_{2.5}$ concentrations –Southern Domain – 2015-2020

Monitored 24-hour average $PM_{2.5}$ in the Northern domain for the period 2015 to 2018 is presented in **Figure 5-25**.

St Marys recorded the highest measured concentration with Prospect recording the highest number of exceedances at 13. The 90th percentile 24-hour $PM_{2.5}$ concentration at Prospect station was 14.0 µg/m^3. The average 90th percentile across all stations in the North Domain was 12.5 µg/m^3.

This percentile concentration is important for understanding that although the highest concentration is above the criteria, generally $PM_{2.5}$ concentrations above 15 µg/m^3 are not frequent.

Figure 5-25 **24-hour $PM_{2.5}$ concentrations –Northern Domain – 2015-2018**

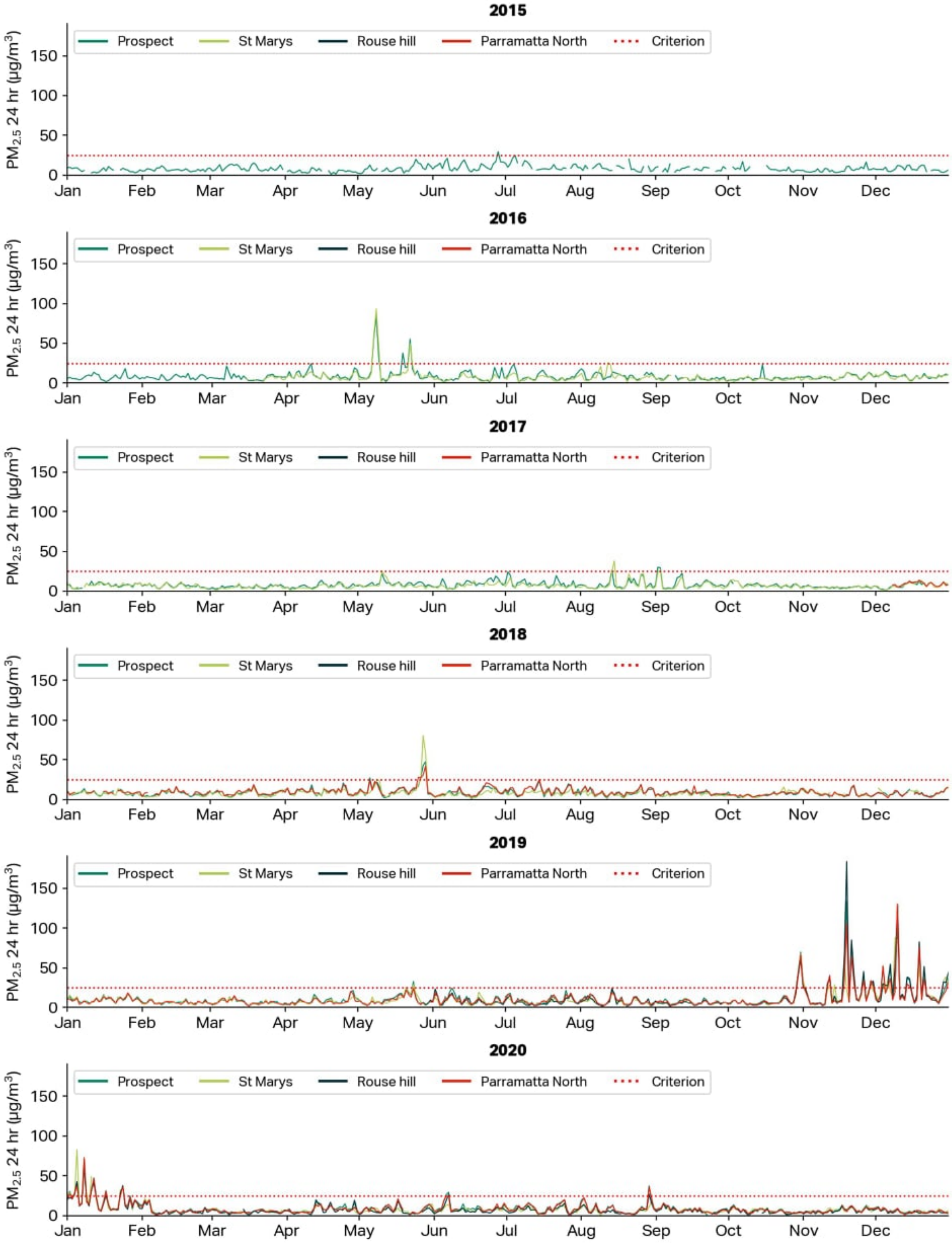


Figure 5-26 **24-hour $PM_{2.5}$ concentrations –Northern Domain – 2015-2020**

5.2.4.2 Annual average $PM_{2.5}$

Annual average $PM_{2.5}$ concentrations are presented in **Figure 5-27** and **Figure 5-28**. During the years 2015, 2016 and 2018 annual average criteria was exceeded at Prospect and Liverpool with exceedances at Parramatta north, Bringelly, and Campbelltown West in 2018. The highest annual average $PM_{2.5}$ concentrations were 10.4 µg/m^3 at Liverpool in 2018 in the South and 9.2 µg/m^3 at Parramatta north in 2018.

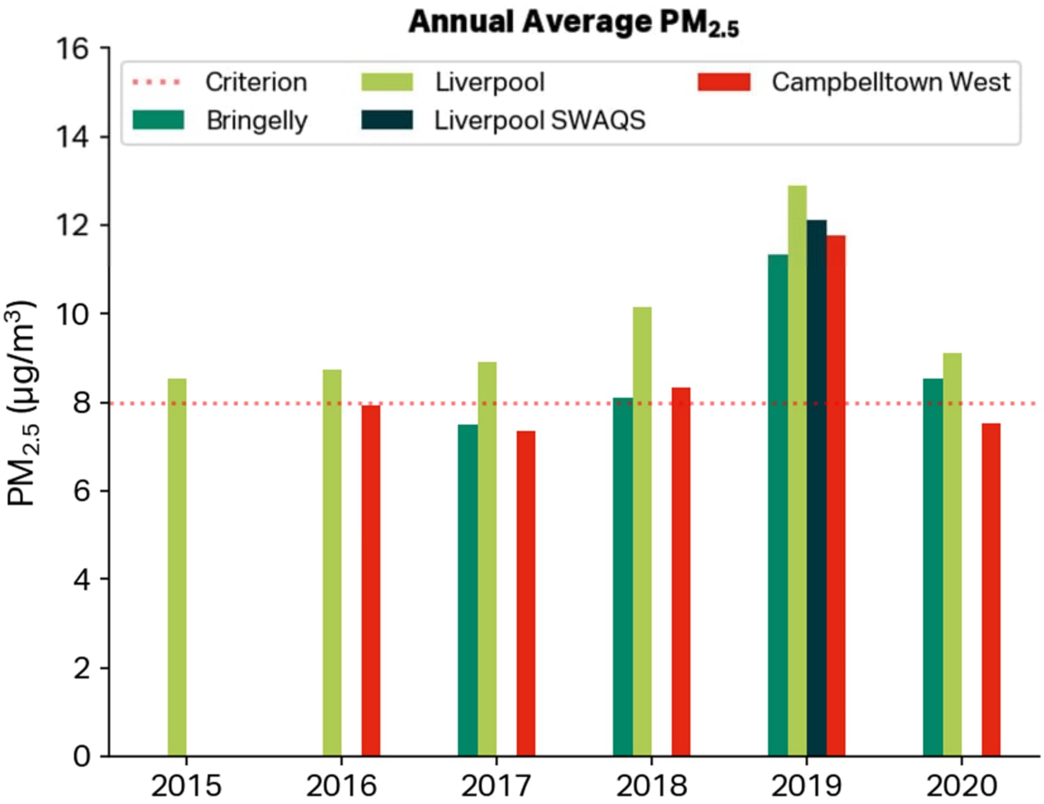


Figure 5-27 Annual average $PM_{2.5}$ concentrations –Southern Domain – 2015-2020

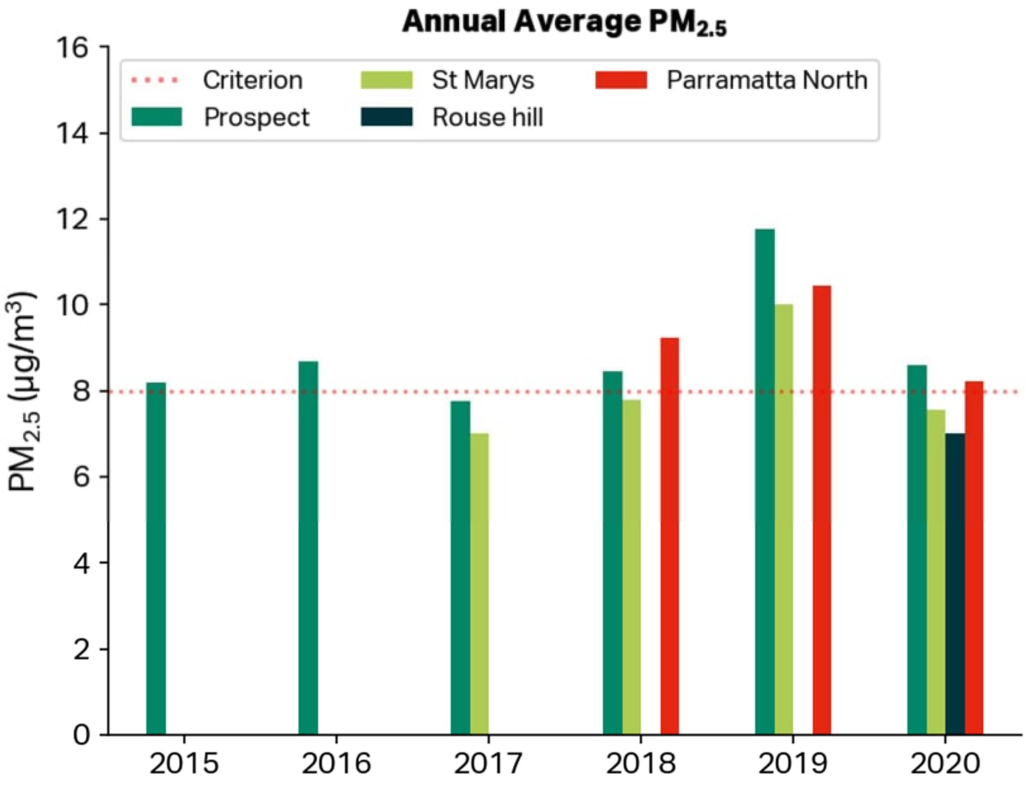


Figure 5-28 **Annual average $PM_{2.5}$ concentrations –Northern Domain – 2015-2020**

5.3 Terrain

Terrain surrounding the southern and northern sections of the alignment are shown in **Figure 5-29** Terrain data for the assessment has been sourced from the 1 m NSW Government Spatial Services DEMs database and is also discussed in **Section 4.2.4**.

Terrain elevation along the 27 kilometre stretch of the Proposed Modification of the West link M7 varies by around 100m from a low level of around 25m. Most of the alignment and surrounding area is around 30 to 50m with higher elevations observed of up to approximately 125m between Cecil Hills, near the intersection with Elizabeth Drive and Eastern Creek west of Prospect Reservoir. A minor valley is situated to the west of the M7 which extends from the southern end of the M7 to beyond the northern extent of the motorway. The effect of this terrain is likely to be that there may be some minor katabatic plume migration (from downslope winds) from around the motorway toward the western valley (although this drift is likely to be minor given the low topographical relief in the area).

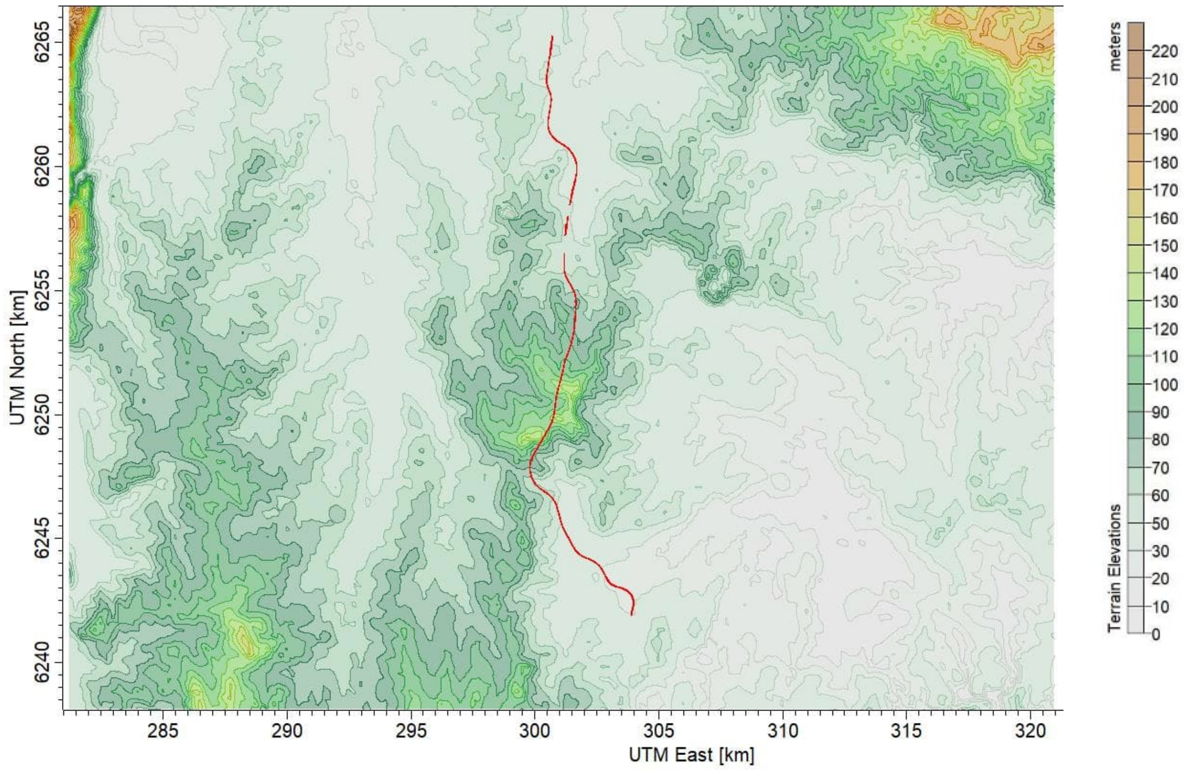


Figure 5-29 **Terrain in the region surrounding the Modification**

5.4 Land use

Land use within the study area is shown in **Figure 4-14**. Land use surrounding the 27 kilometre stretch of the Westlink M7 covers a wide range of land uses. Land use data for the Proposed Modification has been sourced from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) "Catchment Scale Land Use of Australia", December 2018 and is discussed further in **Section 4.2.4**.

In the south around Prestons, land use is dominated by general and heavy industrial interspersed with areas of environmental conservation and residual native vegetation. To the north of this industrial land, the areas of Hoxton Park and Hinchinbrook are primarily characterised as general and low density residential which have been identified as vulnerable populations and are discussed further in **Section 5.5.2**.

Between Elizabeth Hills and Horsley Park is primarily a mix of parklands, low density residential, rural residential, agriculture and horticulture, recreational land and environmental conservation areas and remnant native vegetation.

Between Horsley Park and Eastern Creek there is a wide range of land uses including general industrial, waste management, rural residential, agriculture/horticulture, open space, environmental conservation areas and remnant native vegetation. Eastern Creek is primarily comprised of industrial manufacturing, commercial services, and recreational land.

To the northern end of the alignment between Rooty Hill and Glendenning is primarily urban residential, commercial, and service facilities and recreational areas.

Additional descriptions relating to land use data used as part of the construction impact assessment are discussed in **Table 4-1** and **Table 6-1**. Additional information relating to identified sensitive receptors and populations near the Westlink M7 are also discussed in **Section 5.5**.

5.5 Sensitive receptors

The NSW EPA defines a sensitive receptor to be “a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area. An air quality impact assessment should also consider the location of known or likely future sensitive receptors” (NSW EPA, 2017).

Historically, sensitive receptors have been positioned at locations where people are expected to live and spend significant periods of time and not at places of work. Given that many people spend significant proportions of their lives at a workplace, this historical definition is not considered to present an accurate reflection of the potential impacts that may occur from air pollutant sources. As a result of this underrepresentation of commercial industrial location, sensitive receptors have been placed where anyone may “work or reside” surrounding the Site. While this definition commonly includes receptors at elevations higher than ground level e.g. high rise residential or commercial towers, elevated receptors have not been added to this model due to the lack of tall receptors in the immediate vicinity of the motorway.

Receptor locations included in the model are presented in **Figure 4-16**. Receptors were included at nearby representative commercial / industrial buildings along with the representative residential dwellings. Transect receptors were also added to enable the analysis of the road plume concentration as the plume moves away from the road centreline. Transects are also presented in **Figure 4-16.**

Gridded receptors were also modelled to enable the generation of concentration contours along the length of the motorway.

5.5.1 Highly sensitive receptors

While sensitive receptors generally refer to land uses where there is the potential for humans to be exposed to air pollutants over a period of eight hours per day or more some sensitive receptors contain a higher proportion of occupants that are more susceptible to adverse effects of air pollution. Highly sensitive receptors generally contain a higher proportion of children and elderly people as well as people generally with underlying health conditions. Highly sensitive receptors therefore include locations such as:

- Schools and childcare facilities
- Hospitals and health clinics or medical centres
- Retirement villages and aged care facilities.

A total of 18 highly sensitive receptors were identified within approximately 350m of the Westlink M7 road corridor including:

- Nine schools and childcare facilities
- Six health clinics/medical centres
- Three retirement and aged care facilities.

These 18 highly sensitive receptors have been modelled as additional discrete receptors and included in the data analysis. The location of each identified highly sensitive receptor is provided in **Figure 5-30** and **Figure 5-31** and coordinates are provided in **Appendix E**. Predicted ground level pollutant concentrations at each receptor are discussed in **Section 7.0**.

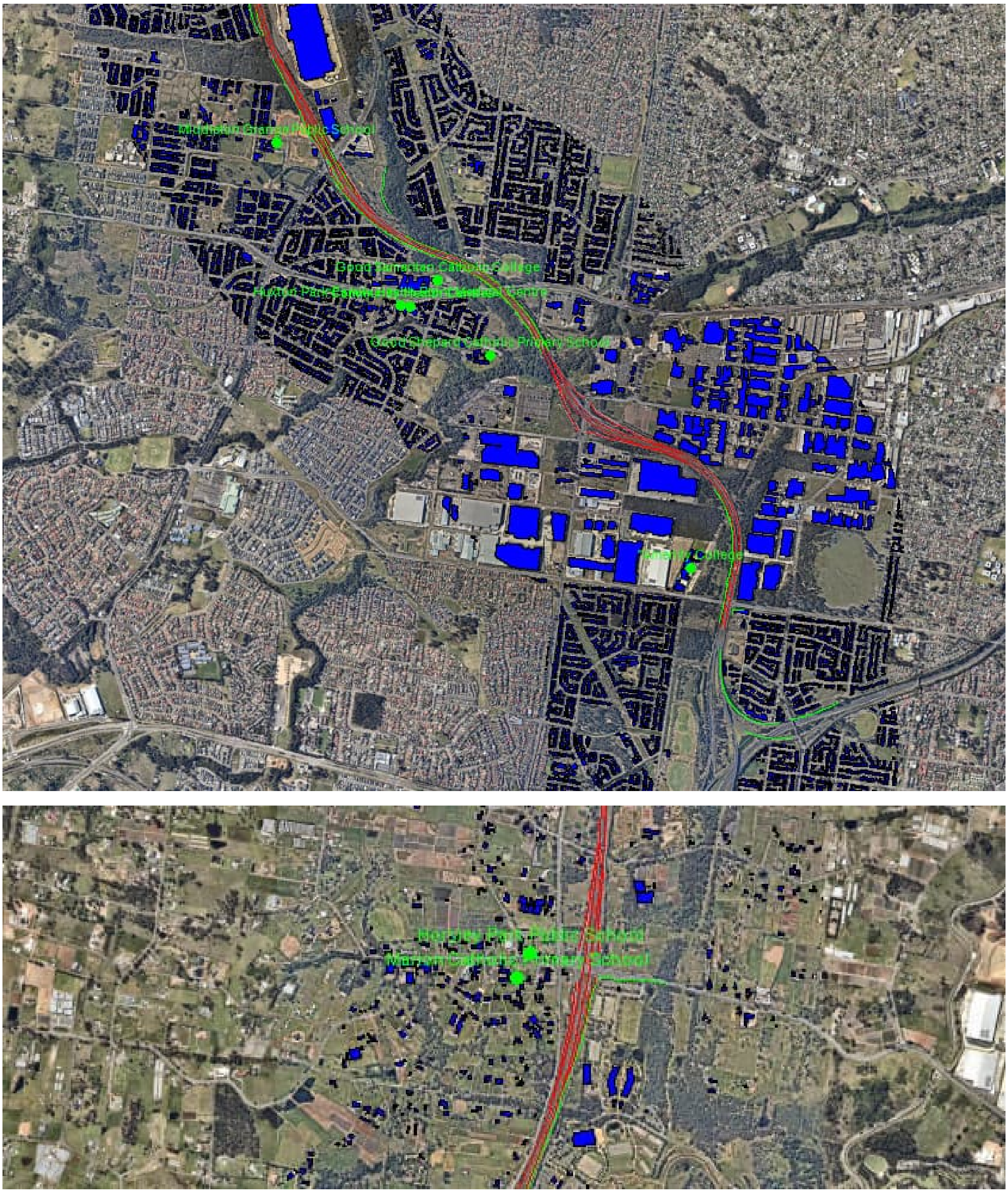


Figure 5-30 Location of identified highly sensitive receptors – Southern Domain

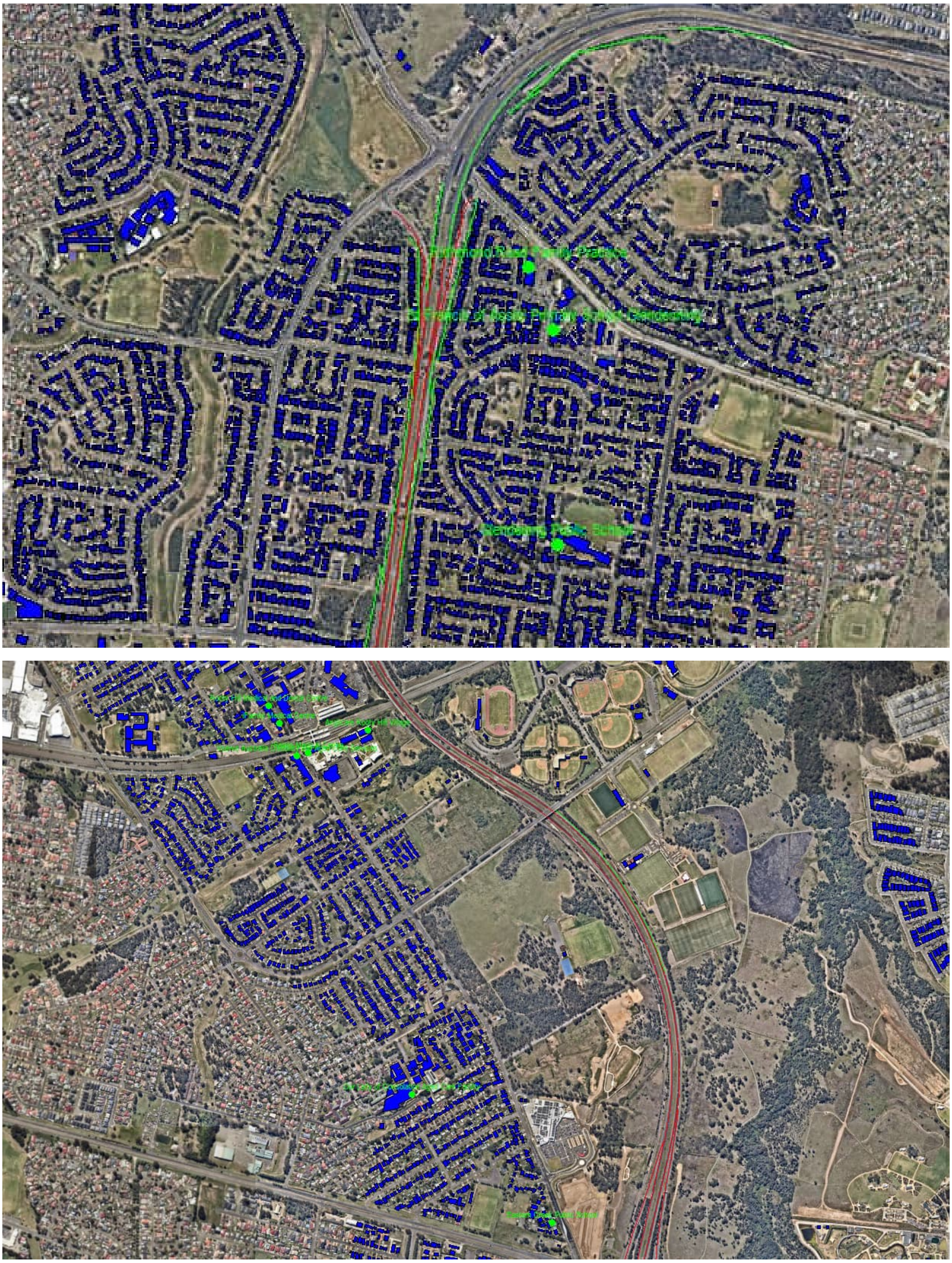


Figure 5-31 Location of identified highly sensitive receptors – Northern Domain

More information on identified highly sensitive receptors, including model identification number, property name, coordinates, and distance from the Westlink M7 is provided in **Appendix E**.

5.5.2 Population density and vulnerability

In addition to the identification of sensitive land uses surrounding the Proposed Modification, additional descriptive data has been analysed to characterise the potentially exposed population. Potential health risks associated with air emissions are related to the location, size and vulnerability of the exposed population as the likelihood and consequence of health effects of air pollution is unlikely to be equally distributed in the population. A broad assessment using simple socio-economic indicators, relating to population density and vulnerability has been undertaken to characterise the receiving environment.

5.5.2.1 Population density

Higher population density rates generally result in increased pressure on ambient air quality; due to the increased number of anthropogenic air emissions within an air shed. Population density for the receiving environment has been reported using Regional population grid data from the Australian Bureau of Statistics (ABS) data for 2019-2020 (ABS 2020).

Table 5-4 shows that population density ranges within the study area varies from less than 500 people per square kilometre to up to 2000-5000 people per square kilometre. The areas of highest density were generally within Dean Park, Oakhurt, Plumpton, Rooty Hill and Huxton Park.

Table 5-4 Population density (ABS 2019-2020)

Location	Population Density (people/km^2)
1. Dean Park to Rooty Hill	• Generally 2000-5000 people/km^2 • Some lower density population areas, mainly east of the Westlink M7 ranging from >500-2000 people/km^2
2. Rooty Hill to Cecil Hills	• Generally low population density areas of <500 people/km^2
3. Cecil Hills to Elizabeth Hills	• Generally no residential population • Some scattered higher residential density areas of 2000-5000 people/km^2.
4. Elizabeth Hills to Hoxton Park	• Population density ranges between 500 to 5000 people/km^2
5. Hoxton Park to Prestons	• Generally low population density areas south of Hoxton Park of <500 people/km^2

5.5.2.2 Population vulnerability

In addition to population density, it is important to understand the vulnerability to pollutants of the potentially affected population. An approximate indicator of the vulnerability of a community is the Index of Relative Socio-economic Disadvantage (IRSD). The IRSD is a general socio-economic index that summarises a range of information about the socioeconomic condition of people and households within an area and provides an indicator of the relative disadvantage or lack of disadvantage within a population. An IRSD with a quintile of one represents the most disadvantaged populations with low household income and a higher rate of individuals with lower qualifications and low skill occupations. Highly disadvantaged populations are considered more vulnerable to potential air quality impacts and for the purposes of this assessment have been defined by a IRSD Quintile rating of one.

IRSD values have been examined at Statical Area Level 1 (SA1), geographical areas defined by ABS, built from whole mesh blocks and have generally been designed as the smallest unit for the release of 2016 census data. SA1s have a population of between 200 and 800 people with an average population size of approximately 400 people.

A review of the 2016 IRSD data from ABS identified that SA1 IRSD Quintile values within the Proposed Modification Area range from 1 (most disadvantaged) to 5 (least disadvantaged). The majority of SA1 Populations within the study area were within Quintile 2 and Quintile 4. Only two SA1 populations were identified with a Quintile Value of 1; one at Horsley Park with a population of 156 people and one at Hinchinbrook with a population of 555; according to ABS 2016 Census data. The SA1 seven-digit identification numbers and residential population for these locations are provided in **Table 5-5** and their locations are shown in **Figure 5-32**. Both locations are considered more vulnerable to air pollution and potential air quality impacts. Potential air quality impacts for these locations from the Proposed Modification are discussed in **Section 7.1**.

Table 5-5 ABS SA1 areas with a IRSD quintile value of 1 (vulnerable communities)

SA1 ID	SA2 location	Usual residential population
1151809	Horsley Park, Kemps Creek	156
1159515	Hinchinbrook	555

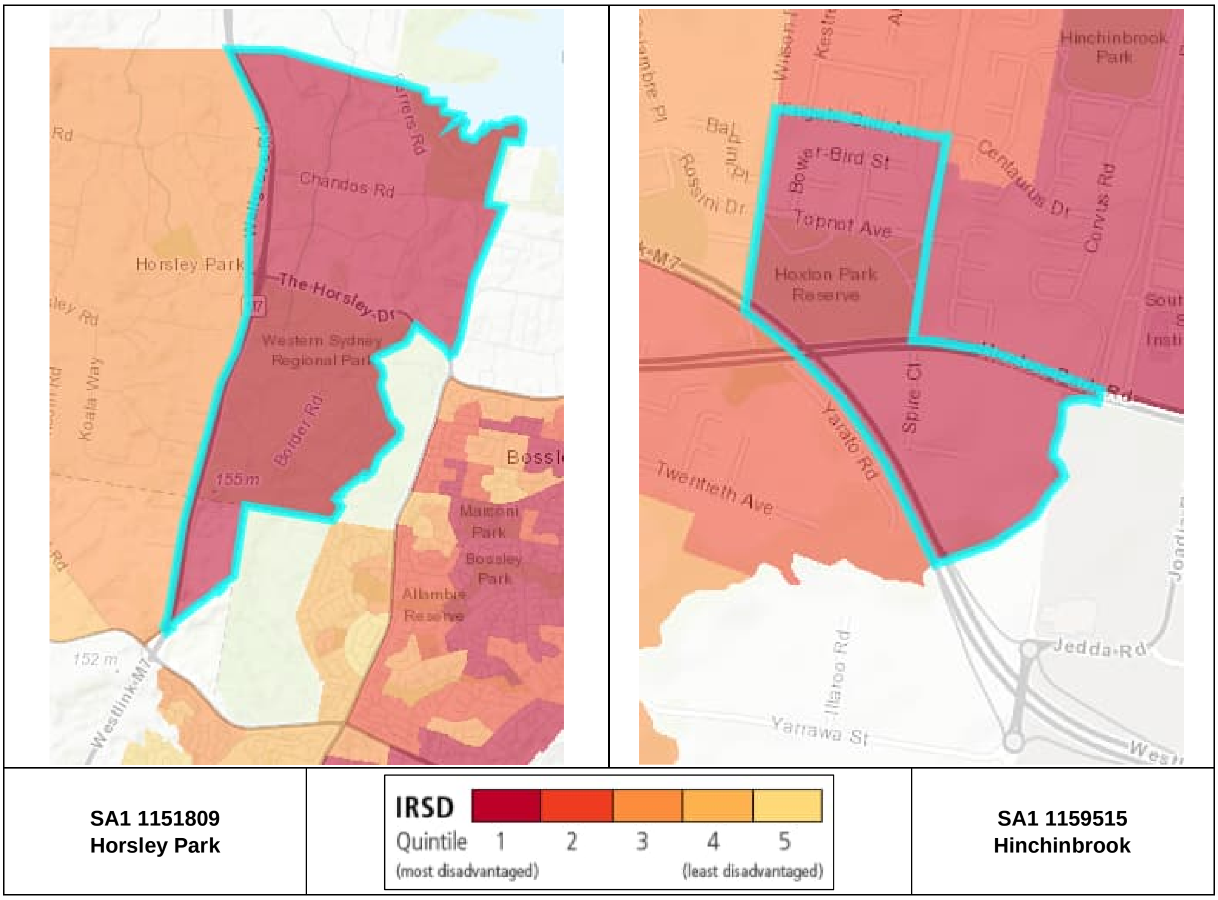


Figure 5-32 ABS SA1 areas with a IRSD quintile value of 1 (vulnerable communities) (ABS 2018)

5.5.3 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.

Like human receptors increased concentrations of atmospheric pollutants has the potential to negative affect sensitive habitats and plant communities. Potential increases can be a result of both physical and chemical impacts such as:

- 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 due to changes in acidity of soil or water
- Exposure to elevated NO_2 concentrations may result in changes to leaf chlorophyl and mineral ion content and changes to peroxidase activity in vegetation.
- Philological changes to vegetation because of increased pollutant concentrations may also have indirect effects such as increased susceptibility to stresses such as pathogens and air pollution.

Assessment of ecological impacts associated with the proposal are provided in Section 7.6 of the modification report and the Biodiversity Development Assessment Report (BDAR) is provided in Appendix H of the modification report. A summary of the existing environment is reported below:

- The study area is in the Cumberland subregion of the Sydney Basin region under the Interim Biogeographic Rationalisation for Australia (IBRA). The study area is within the Cumberland Plain Landscape which is classified as over-cleared with 89% of the landscape currently cleared
- There are small coastal wetlands[8] present within the vicinity in the southern section of the study area within the Liverpool City Council and the proximity area buffer of three of these wetlands intersects with the construction footprint
- There are no State significant biodiversity links in the study area.
- The riparian buffers 20 metres either side of one 5th order stream (Cabramatta Creek), one 4th order stream (Hinchinbrook Creek), three 3rd order streams (Maxwell Creek, a tributary of Hinchinbrook Creek, and Reedy Creek) meet the criteria for regionally significant biodiversity links as defined under the *Framework for Biodiversity Assessment* (OEH, 2018). The current condition of these regional links is disjointed
- Seven Plant Community Types (PCTs) were identified, classified into vegetation zones, and aligned with six threatened ecological communities (TECs) at risk of potential serious and irreversible impacts (SAII).
- The vegetation in the study area has a long history of disturbance and some areas have been replanted. Due to past disturbance, fragmented vegetation, lack of remnant native vegetation, non-native understorey dominance and other conditions, most of the TECs in the study area were determined as ineligible to be considered endangered under the EPBC Act.

Understanding the condition and significance of ecological receptors within the study area is important for the assessment of construction dust impacts in accordance with the IAQM methodology as discussed in **Section 4.0**. Given the remnant and degraded condition of ecological receptors the sensitivity of the area would be considered low to medium for locations where vegetation may be affected by dust deposition or where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown.

[8] As defined under State Environmental Planning Policy (SEPP) (Resilience and Hazards) 2021

6.0 Construction impact assessment

This section provides a detailed description of the construction activities and details the assessment of construction impacts from the Proposed Modification.

6.1 Detailed construction activities

A detailed description of construction works associated with the Proposed Modification is included in Section 4.3 of the modification report.

The construction footprint including construction ancillary facilities is expected to cover an area of approximately 142 hectares and is shown in Figure 4-8 to Figure 4-12 of the modification report. Construction hours are expected to be between 6am to 7pm on weekdays and 8am to 5pm on Saturdays. Additional hours outside standard construction hours are also anticipated where offline detouring and contraflow traffic arrangements are required to minimise traffic disruptions.

Construction ancillary facilities would include ‘zone’ and ‘site’ construction areas. Construction ancillary facilities and construction zone ancillary sites are briefly described in **Table 4-1** of this report and described in detail in the modification report

Key construction activities would include:

- Site establishment and demolition
- Earthworks
- Utility and drainage work
- Bridge widening works
- Pavement widening and finishing works.

Key construction activities relating to demolition, earthworks and material handling, construction, vehicle movements and plant equipment relevant to this technical report are summarised in the following subsections.

6.1.1 Demolition

The construction of the Proposed Modification would require the demolition and removal of existing structures and infrastructure located within the construction footprint. This would include:

- Bridge barriers and supports
- Existing pavement and roadway
- Median barrier treatments
- Retaining walls
- Road signs
- Some existing noise walls and barriers
- Existing utilities requiring relocation
- Existing drainage infrastructure requiring relocation; and demolition and removal of redundant drainage
- Fencing treatments.

Demolition waste would be taken to an appropriate licenced facility for recycling or reuse as appropriate.

6.1.2 Earthworks

Earthworks would be required to facilitate the Proposed Modification and would involve excavation to accommodate road widening within the existing median and outside lane shoulders and placement and compaction of fill material. Earthworks would occur specifically in relation to:

- Topsoil stripping
- Cut and fill
- Construction of retaining walls
- Embankment works
- Preparation of site and access for construction of bridge and widening works
- Installation of road drainage infrastructure.

Excavated material would be placed into trucks, which would either remove and dispose of the material or stockpile the material for future use. Material excavated during earthworks would be re-used in construction where possible. Fill material would be deposited from trucks to the location it is required and then spread with a grader and/or excavator and compacted using vibratory rollers or similar. During earthworks, water trucks would be used to assist the compaction of the material and to control dust being generated.

It is estimated that earthworks would entail 204,000 m^3 of cut material from excavation works; of this approximately 30,000 m^3 would be reused for the construction of the Proposed Modification where possible. The majority of cut material would likely be exported offsite with a net amount of cut material estimated of around 74,000 m^3.

In addition to the above cut and fill volumes an estimated addition 25,000 m^3 of topsoil and 122,000 m^3 of selected material zone (SMZ) would be needed to be imported to site (see **Section 6.1.4**).

It is possible that asbestos containing material (ACM) may be encountered during earthworks. Where this occurs, a potential management approach may be to contain the material on site and encapsulate it under the road pavement in high fill areas. Alternately, the preferred management approach may be to remove the material for disposal offsite. Management measures in the event that ACM is encountered is discussed further in Section 7.11 and Appendix L (Contamination Assessment) of the modification report.

6.1.3 Resources and waste management

A detailed list of construction resources and waste management procedures is included in Section 4.3.19 of the modification report. In addition to general fill and selected material for earthworks discussed in **Section 6.1.2** additional resources used during construction would include:

- Sand and soils for landscape work
- Pavement materials including road-base and sub-base
- Aggregate for concrete and asphalt
- Cement for concreting
- Bitumen for asphalt.

6.1.4 Construction works

The following provides a summary of the main construction works for the Proposed Modification relating to bridge and pavement widening and finishing works. Detailed information on construction works is provided in Section 4.3.9, Section 4.3.11, and Section 4.3.13 of the modification report.

Bridge widening works

The bridges proposed to be widened are described in Section 4.2.5 of the modification report. Widening of bridge structures would generally involve the following main stages:

- Site preparation, including establishment of temporary haul roads, access paths, pile and crane pads required in preparation for the bridge widening construction. This would generally consist of placement of layers of crushed rock or recycled concrete
- Construction of substructures, including piles, abutments, piers and headstocks
- Construction of superstructures, including beams, girders, decks and barriers.

Pavement widening works

Pavement widening works are described in detail in Section 4.3.11 of the modification report. Construction of road surfaces following topsoil stripping and excavation of the new pavement area (see **Section 6.1.2**.) would include placement of SMZ and pavement layers and surfacing. Specifically, this would include:

- Placement of select material such as crushed rock, recycled concrete, natural gravels or suitable soils
- Place concrete base on the selected material (a granular sub-base or concrete sub-base)
- Construction of base or sub-base using concrete pavers, or formed onsite
- Spraying a bitumen seal and spreading and compaction of aggregate
- Laying and compaction of hot asphalt on top of the aggregate.

Finishing works

Following completion of roadway construction and bridge widening, finishing works would be undertaken. This would include asphalting the carriageway surface, line marking, signage, permanent barriers and median infill, adjustments to noise walls, installation of communications infrastructure and landscaping treatments. Finishing works are described in detail under Section 4.3.13 of the modification report.

Precast yard

An onsite precast yard and storage facility may be required and would likely be sited on leased vacant or industrial land.

6.1.5 Construction vehicle movements

Construction access is expected to primarily occur from Westlink M7 and the existing adjacent road network. Some off-road access through private land would also be required such as at the SUEZ Waste Management Facility and Austral Brick access roads for delivery of construction materials and transport of construction materials across worksites. Some haulage is also expected to occur within the central median of the motorway. Haulage routes are discussed further in Section 4.3.17 of the modification report. Temporary off-motorway detour routes would also be required to support the bridge widening construction along Westlink M7.

Estimated construction traffic numbers are provided in Table 4-11 of the modification report and include a total of up to 4,400 light vehicles movements and 1,300 heavy vehicles per day during peak construction periods.

6.1.6 Construction equipment

A detailed list of construction plant equipment is included in Section 4.3.18 of the modification report. Mobile and stationary plant equipment relevant to air quality for the Proposed Modification are expected to include:

- Vacuum sucker trucks
- Water carts / trucks
- Backhoes
- Excavators
- Tipper trucks
- Articulated haulers
- Semi-trailers
- Floats
- Dozers
- Plate compactors
- Concrete pumps
- Scraper and graders
- Pavement profilers
- Asphalt milling machines
- Asphalt pavers
- Concrete pavers
- Generators
- Concrete/pavement saws
- Pneumatic jack hammers
- Utes and light vehicles
- Concrete agitator trucks
- Hi-ab trucks
- Franna cranes
- Mobile cranes
- Kibbles
- Piling rigs
- Generators
- Rollers
- Loaders
- Concrete vibrators
- Concrete drills

6.2 Dust impact assessment

Construction of the Proposed Modification is anticipated to take approximately 36 months; covering an estimated construction footprint area of area of approximately 142 hectares. Potential dust impacts during the construction period have been determined based on the IAQM construction dust assessment guidance documentation and the expected scale of the of construction activities outlined in **Section 2.2.3, Section 3.3** and **Section 4.1**.

6.2.1.1 Stage 1 screening assessment

An initial screening assessment was undertaken for each of the five construction zones defined in **Table 4-1** in **Section 4.1.1** to identify whether there were any:

- human receptors within a 350m of the construction footprint boundary.
- ecological receptors within 50m of the construction footprint boundary; and
- human or ecological receptors within 50m of the route used by construction vehicles on public roads up to 500m from the construction site.

Screening lines of 50m and 350m were drawn around the Proposed Modification construction boundaries and are shown in **Figure 6-1** to **Figure 6-11** for each of the construction zones. **Figure 6-1** to **Figure 6-11** show that there are of both human and ecological receptors within 350m and 50m respectively from the construction footprint boundary which trigger the requirement for a Stage 2 assessment.

A summary of the proximity of both human and ecological receptors examined as part of the Stage 1 Screening assessment are also presented in **Table 6-1.**

Table 6-1 Stage 1 IAQM screening assessment for construction zones.

Construction buffer zone	Stage 1 assessment
1	• Human receptors within 350m of the site. Land use is primarily general and heavy industry use with some low density residential • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
2	• Human receptors within 350m of the site. Land use is primarily low density and general residential with some general industry, business development and public recreational areas. • Ecological receptors within 50m of the site including residual native vegetation.

Construction buffer zone	Stage 1 assessment
3	• Human receptors within 350m of the site including low density and general residential, general industry, business development and public recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
4	• Human receptors within 350m of the site including low density and general residential and public recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
5	• Human receptors within 350m of the `site including rural residential and public recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
6	• Human receptors within 350m of the site including rural residential properties. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
7	• Human receptors within 350m of the site including rural residential properties and industrial facilities. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
8	• Human receptors within 350m of the site including industrial and commercial uses and public recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
9	• Human receptors within 350m of the site including urban residential, commercial premises and public recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.
10	• Human receptors within 350m of the site including urban residential properties. • There are no ecological receptors within 50m of the site.
11	• Human receptors within 350m of the site including urban residential and recreational areas. • Ecological receptors within 50m of the site including conservation areas and residual native vegetation.

In addition to the 50m and 350m screening lines **Figure 6-1** to **Figure 6-11** show additional buffer zones of 20m, 100m and 200m. These distances have been used to estimate receptor sensitivity for the Stage 2 assessment and are referred to in **Section 6.2.1.2**.

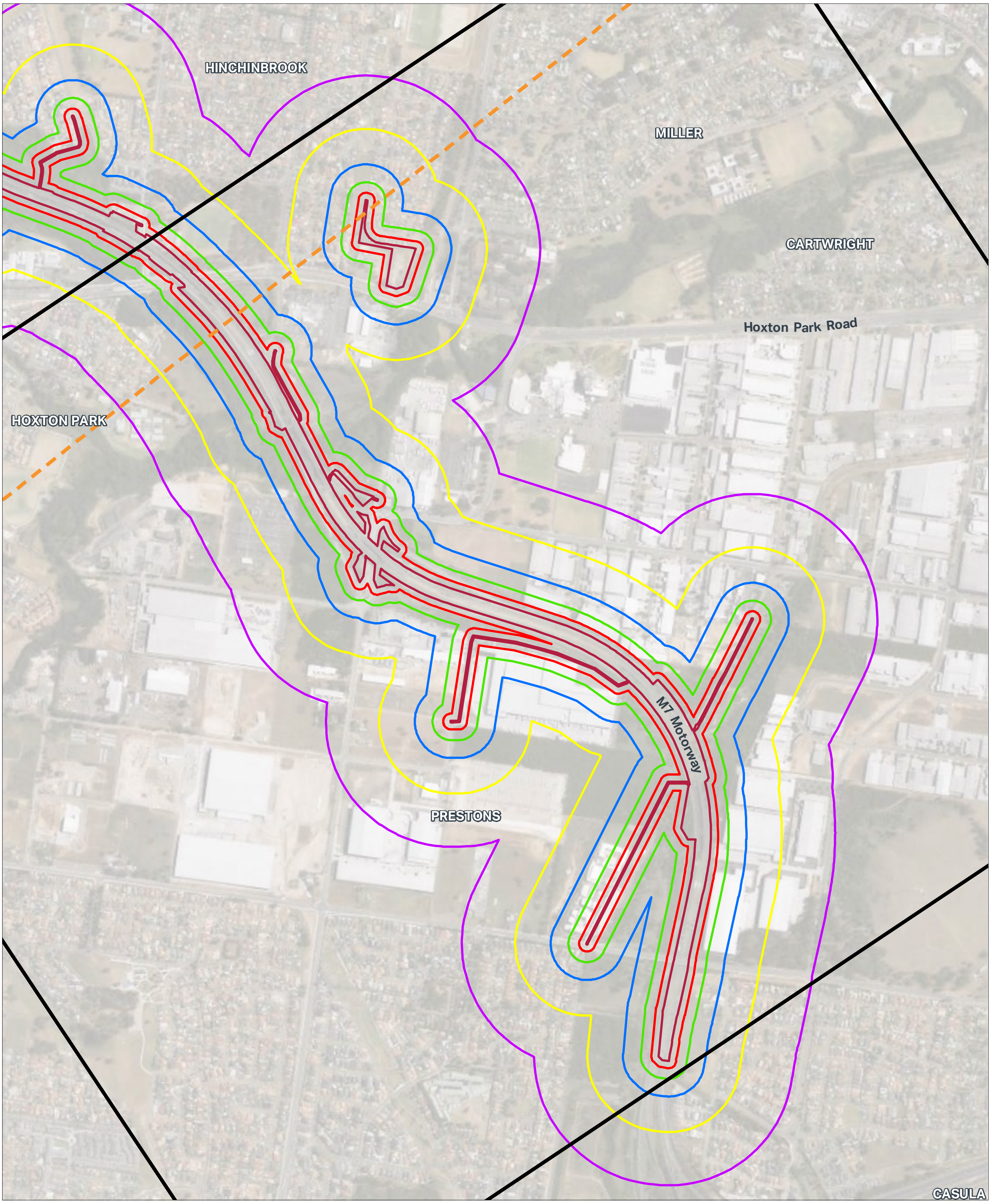


FIGURE 6-1: ZONE 1 - PRESTONS TO HOXTON PARK

N
0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 1 - Prestons to Hoxton Park
- Construction Buffer Zone 2 - Hoxton Park to Elizabeth Hills
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

Source: Imagery © Department of Customer Service 2020

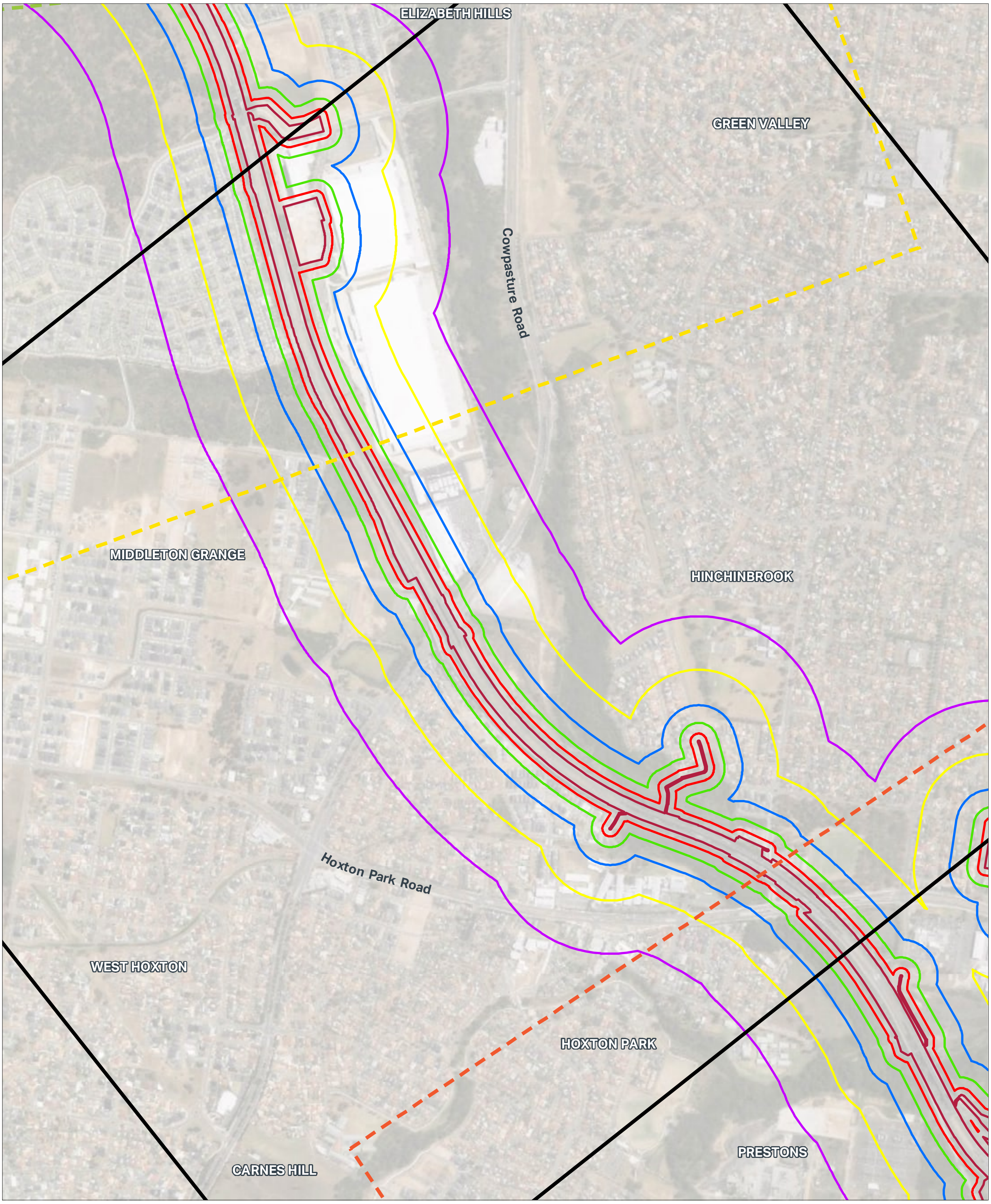


FIGURE 6-2: ZONE 2 - HOXTON PARK TO ELIZABETH HILLS

N 0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 2 - Hoxton Park to Elizabeth Hills
- Construction Buffer Zone 1 - Prestons to Hoxton Park
- Construction Buffer Zone 3 - Elizabeth Hills
- Construction Buffer Zone 4 - Cecil Hills
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

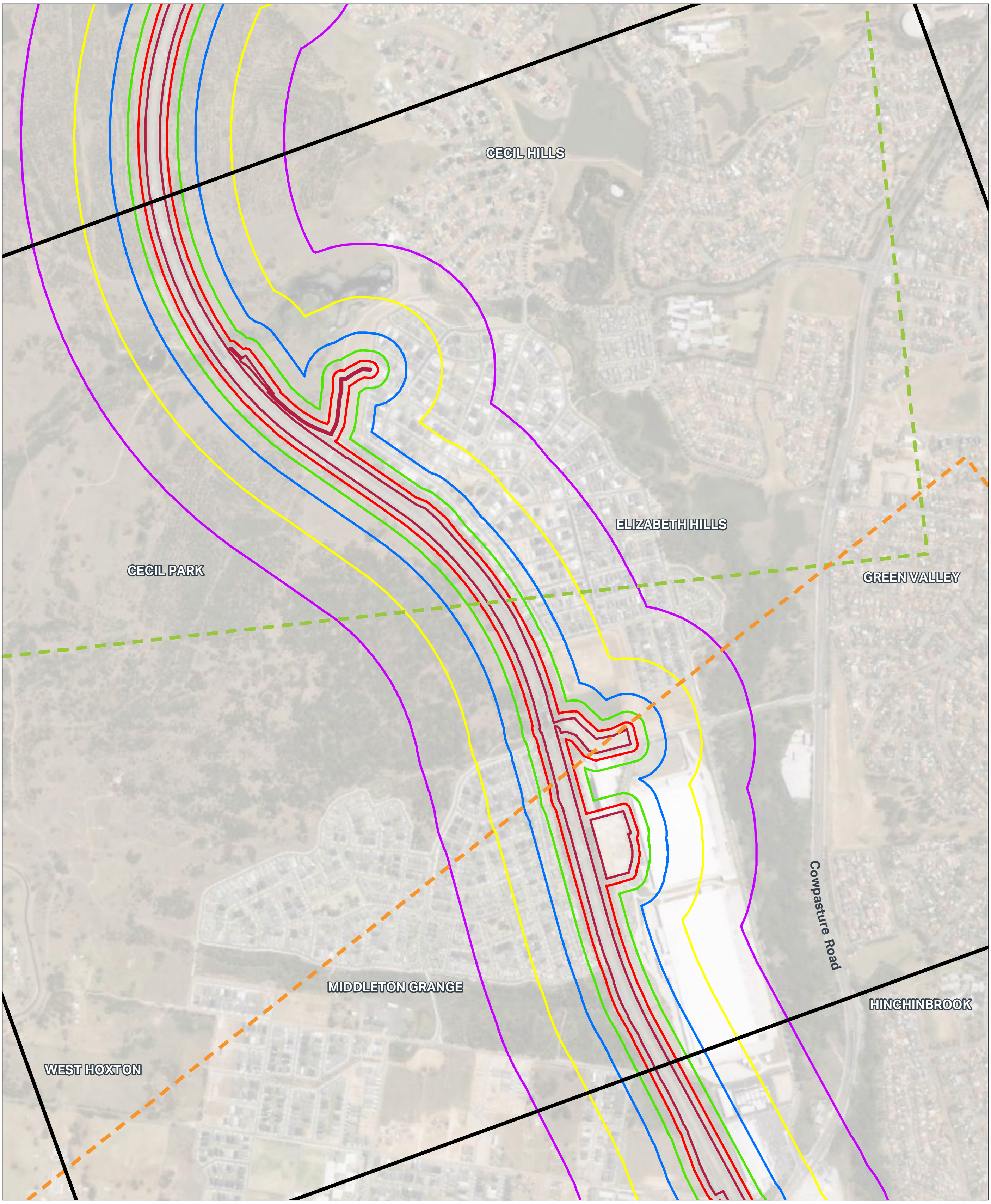


FIGURE 6-3: ZONE 3 - ELIZABETH HILLS

N
0 200 400 m

AECOM

Legend

- Construction footprint
- Construction Buffer Zone 3 - Elizabeth Hills
- Construction Buffer Zone 2 - Hoxton Park to Elizabeth Hills
- Construction Buffer Zone 4 - Cecil Hills
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

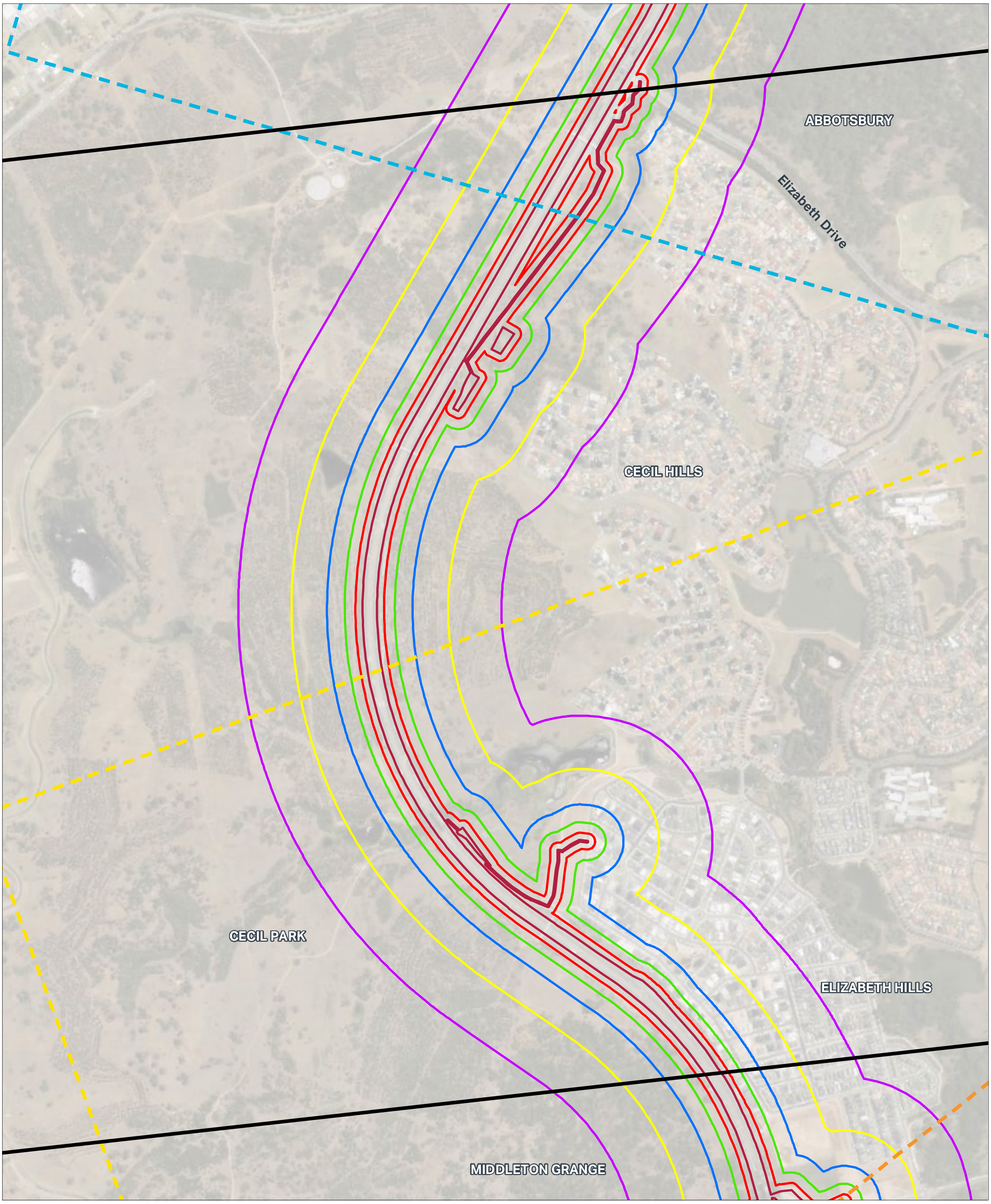


FIGURE 6-4: ZONE 4 - CECIL HILLS

N
0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 4 - Cecil Hills
- Construction Buffer Zone 2 - Hoxton Park to Elizabeth Hills
- Construction Buffer Zone 3 - Elizabeth Hills
- Construction Buffer Zone 5 - Cecil Park
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

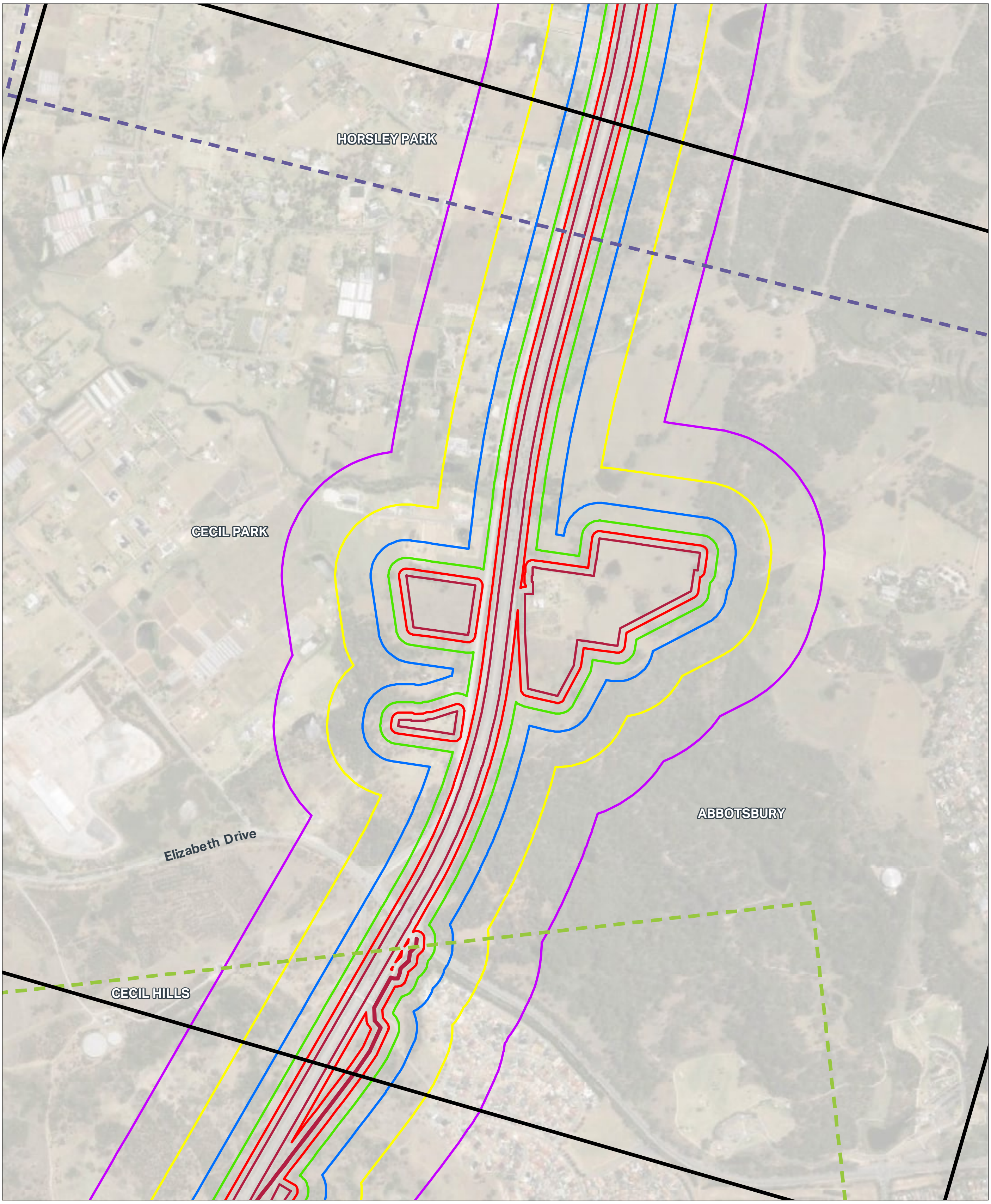


FIGURE 6-5: ZONE 5 - CECIL PARK

N 0 200 400 m

AECOM

Legend

- Construction footprint
- Construction Buffer Zone 5 - Cecil Park
- Construction Buffer Zone 4 - Cecil Hills
- Construction Buffer Zone 6 - Horsley Park
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

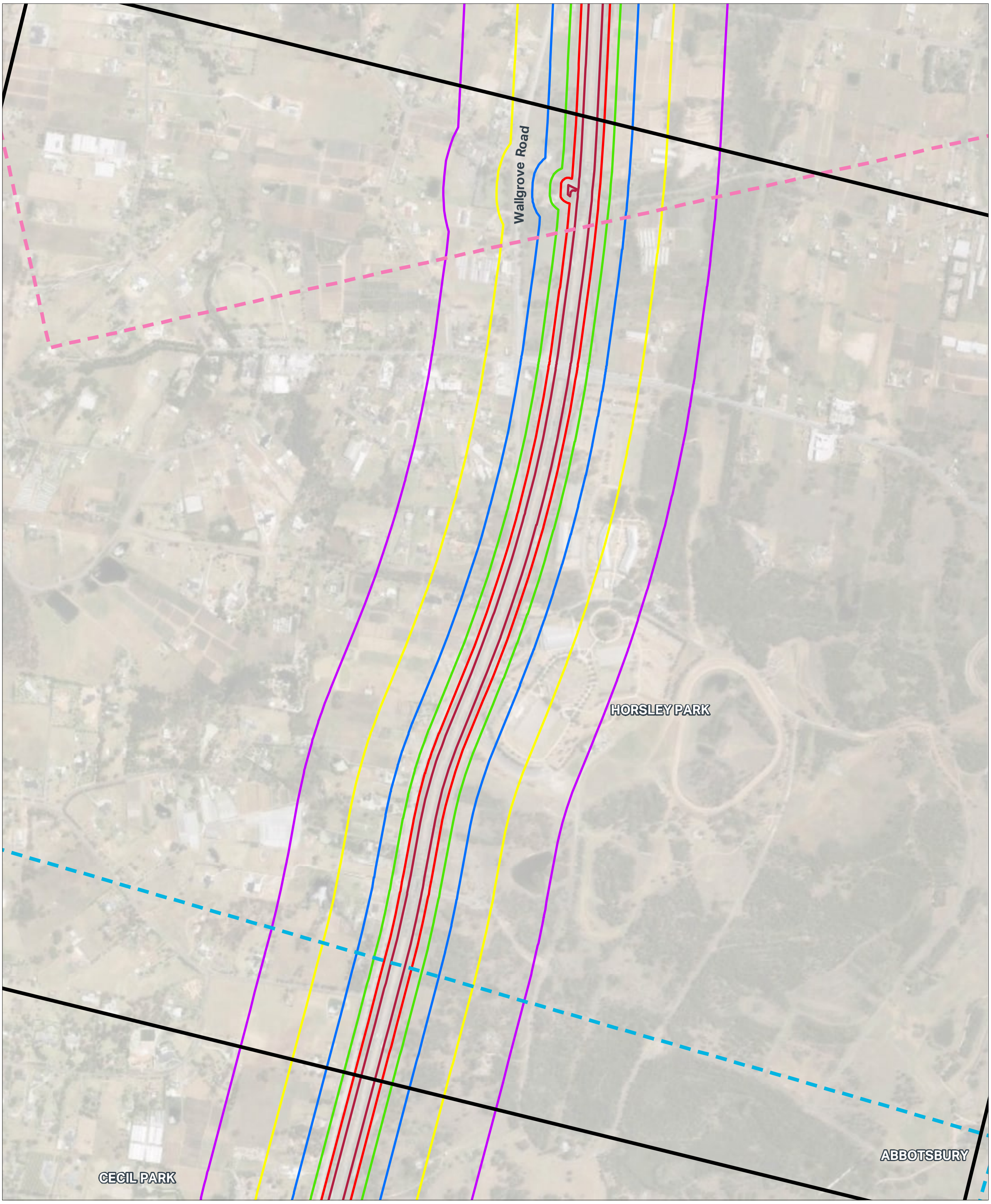


FIGURE 6-6: ZONE 6 - HORSLEY PARK

N
0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 6 - Horsley Park
- Construction Buffer Zone 5 - Cecil Park
- Construction Buffer Zone 7 - Horsley Park to Eastern Creek
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

Source: Imagery © Department of Customer Service 2020

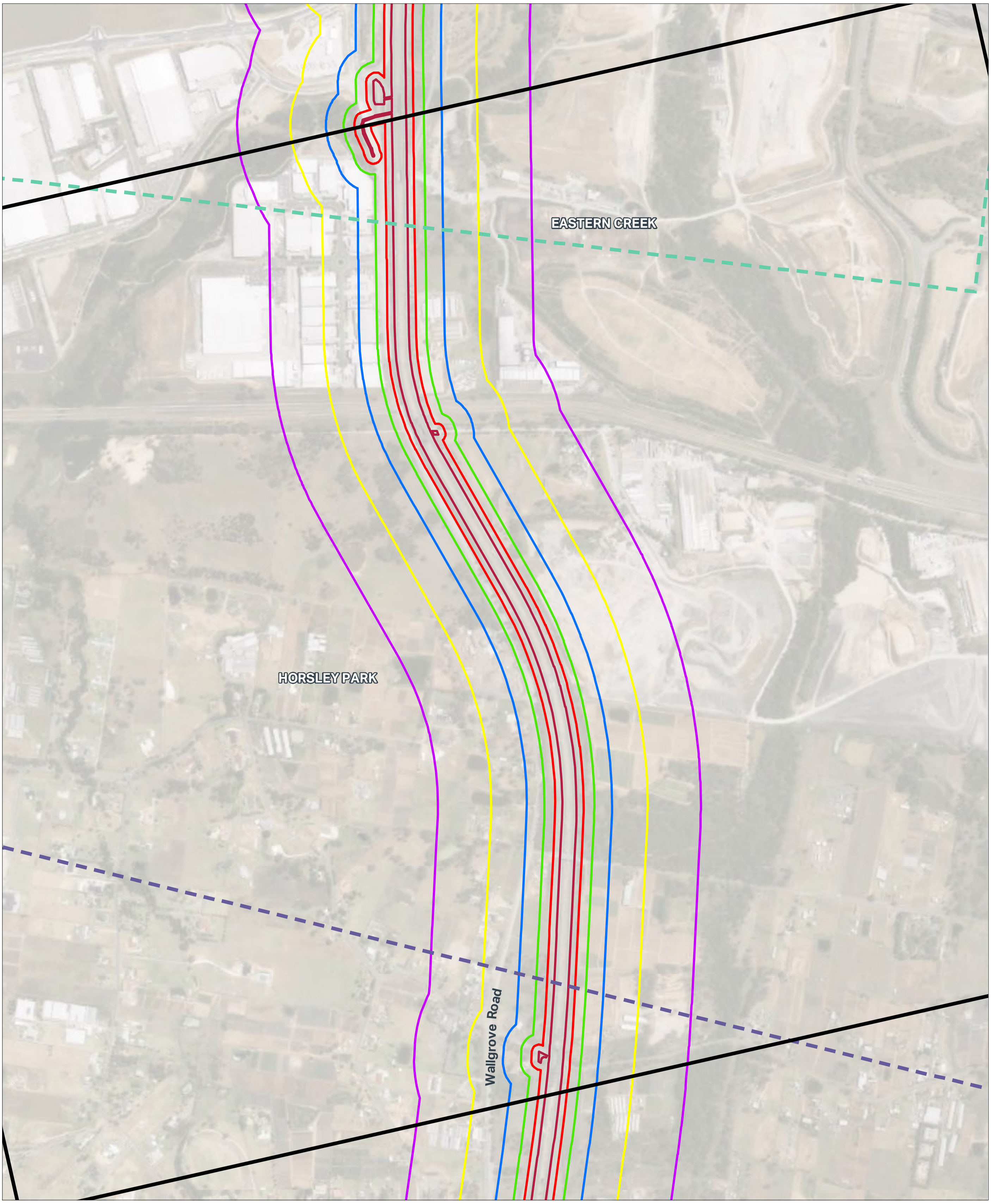


FIGURE 6-7: ZONE 7 - HORSLEY PARK TO EASTERN CREEK

N

0 200 400 m

AECOM

Legend

- Construction footprint
- Construction Buffer Zone 7 - Horsley Park to Eastern Creek
- Construction Buffer Zone 6 - Horsley Park
- Construction Buffer Zone 8 - Eastern Creek
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

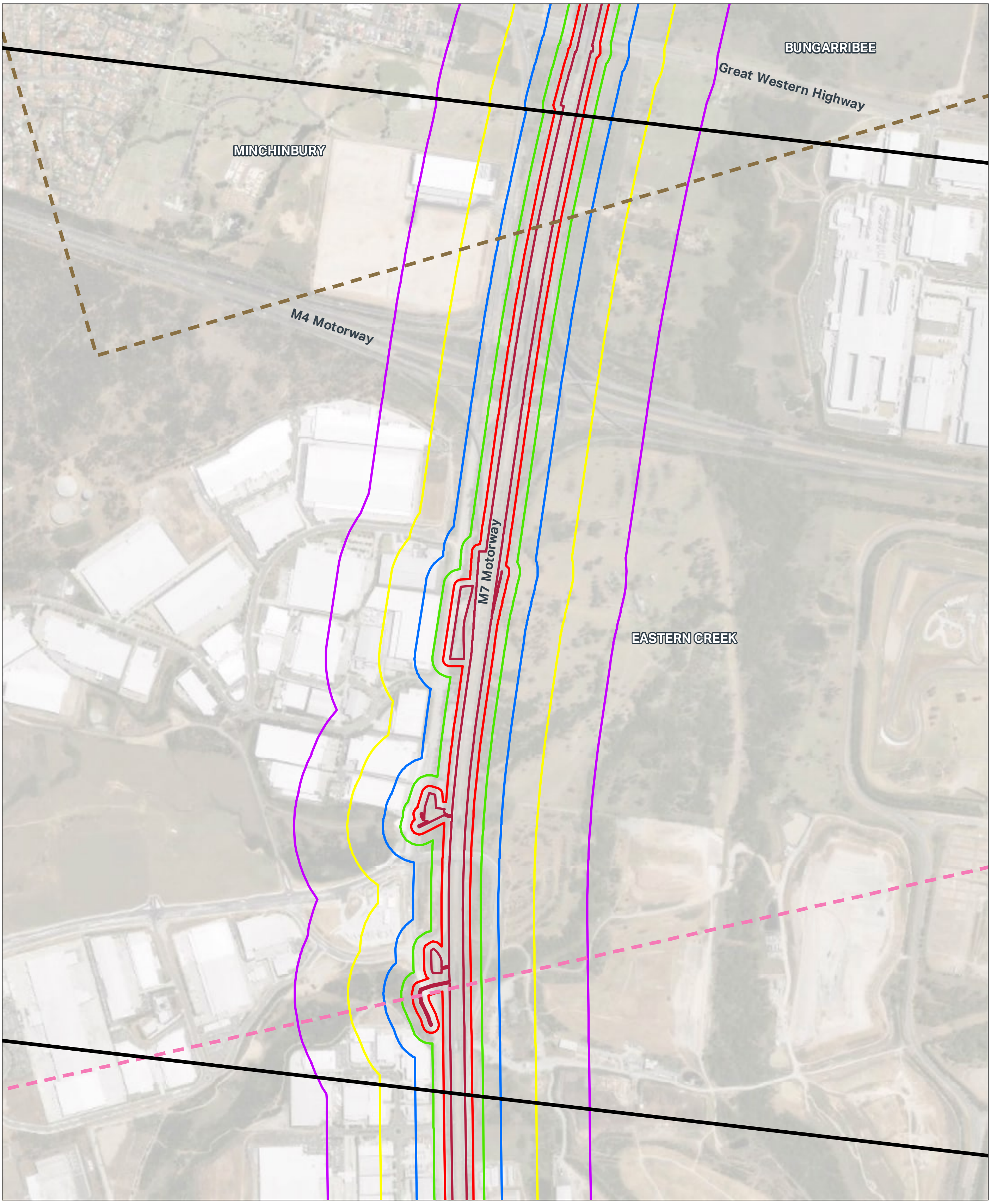


FIGURE 6-8: ZONE 8 - EASTERN CREEK

N

0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 8 - Eastern Creek
- Construction Buffer Zone 7 - Horsley Park to Eastern Creek
- Construction Buffer Zone 9 - Eastern Creek to Rooty Hill
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

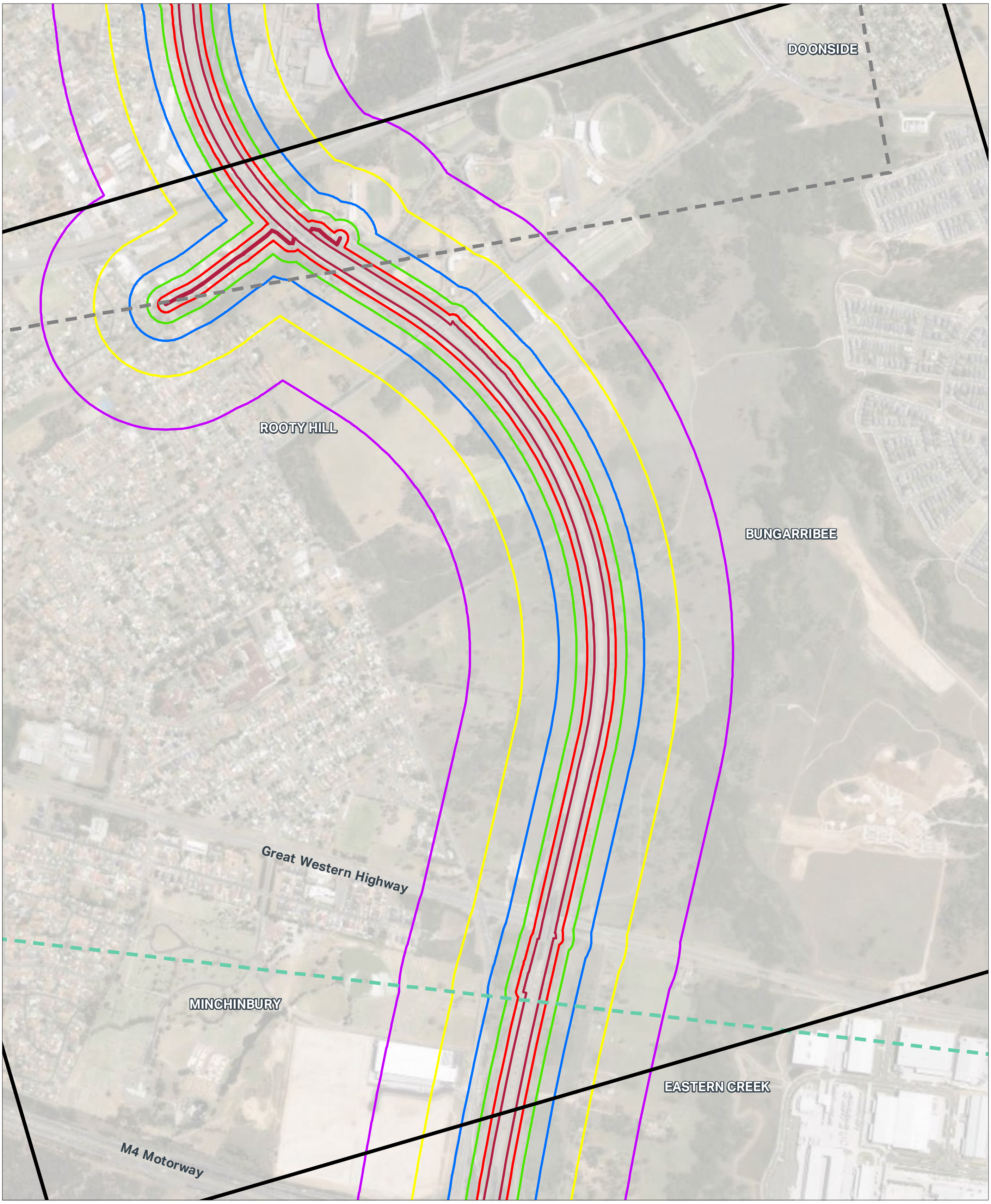


FIGURE 6-9: ZONE 9 - EASTERN CREEK TO ROOTY HILL

N 0 200 400 m

Legend

- Construction footprint
- Construction Buffer Zone 9 - Eastern Creek to Rooty Hill
- Construction Buffer Zone 10 - Rooty Hill to Glendenning
- Construction Buffer Zone 8 - Eastern Creek
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

Source: Imagery © Department of Customer Service 2020

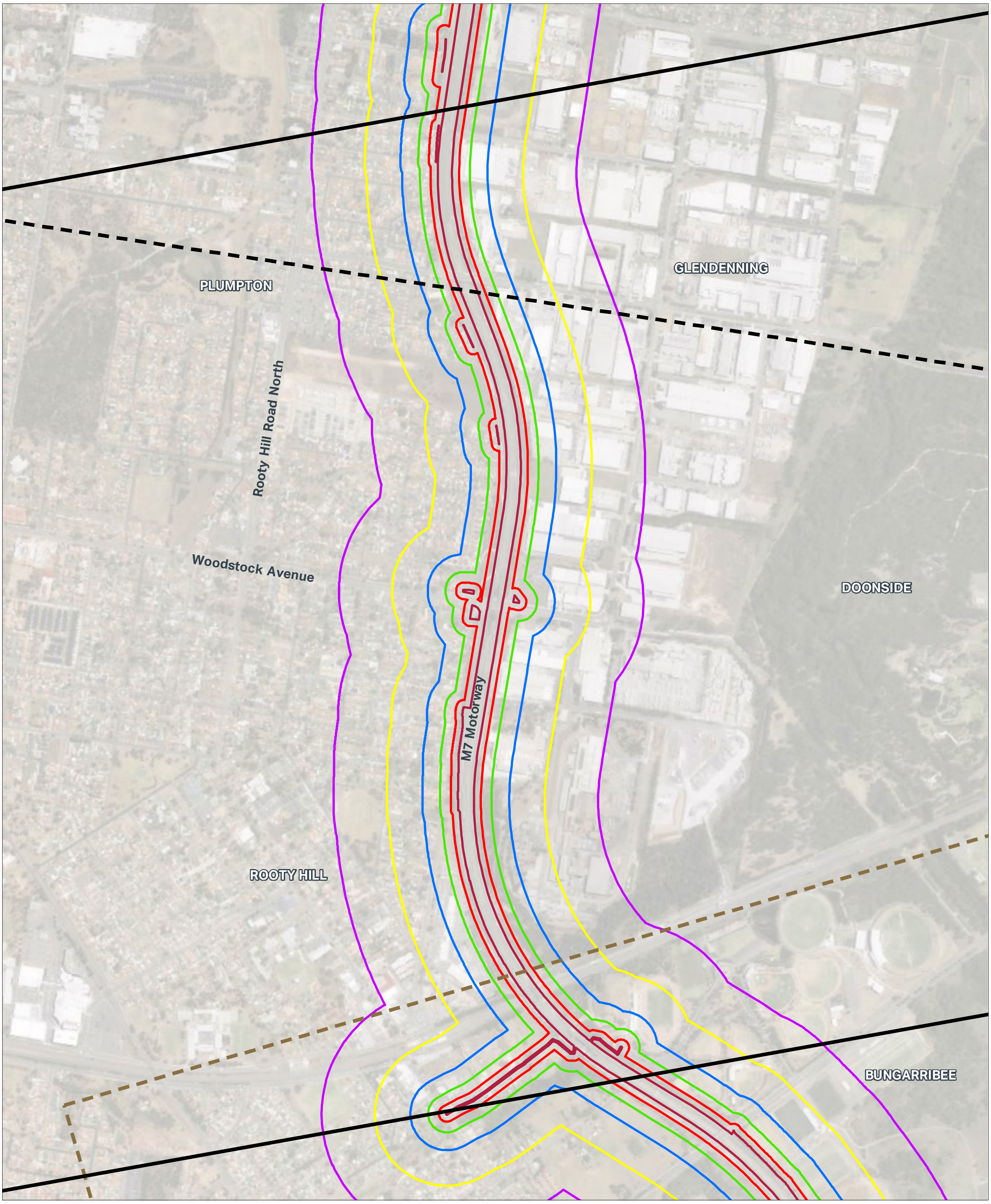


FIGURE 6-10: ZONE 10 - ROOTY HILL TO GLENDENNING

Legend

- Construction footprint
- Construction Buffer Zone 10 - Rooty Hill to Glendenning
- Construction Buffer Zone 11 - Glendenning to Oakhurst
- Construction Buffer Zone 9 - Eastern Creek to Rooty Hill
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

Source: Imagery © Department of Customer Service 2020

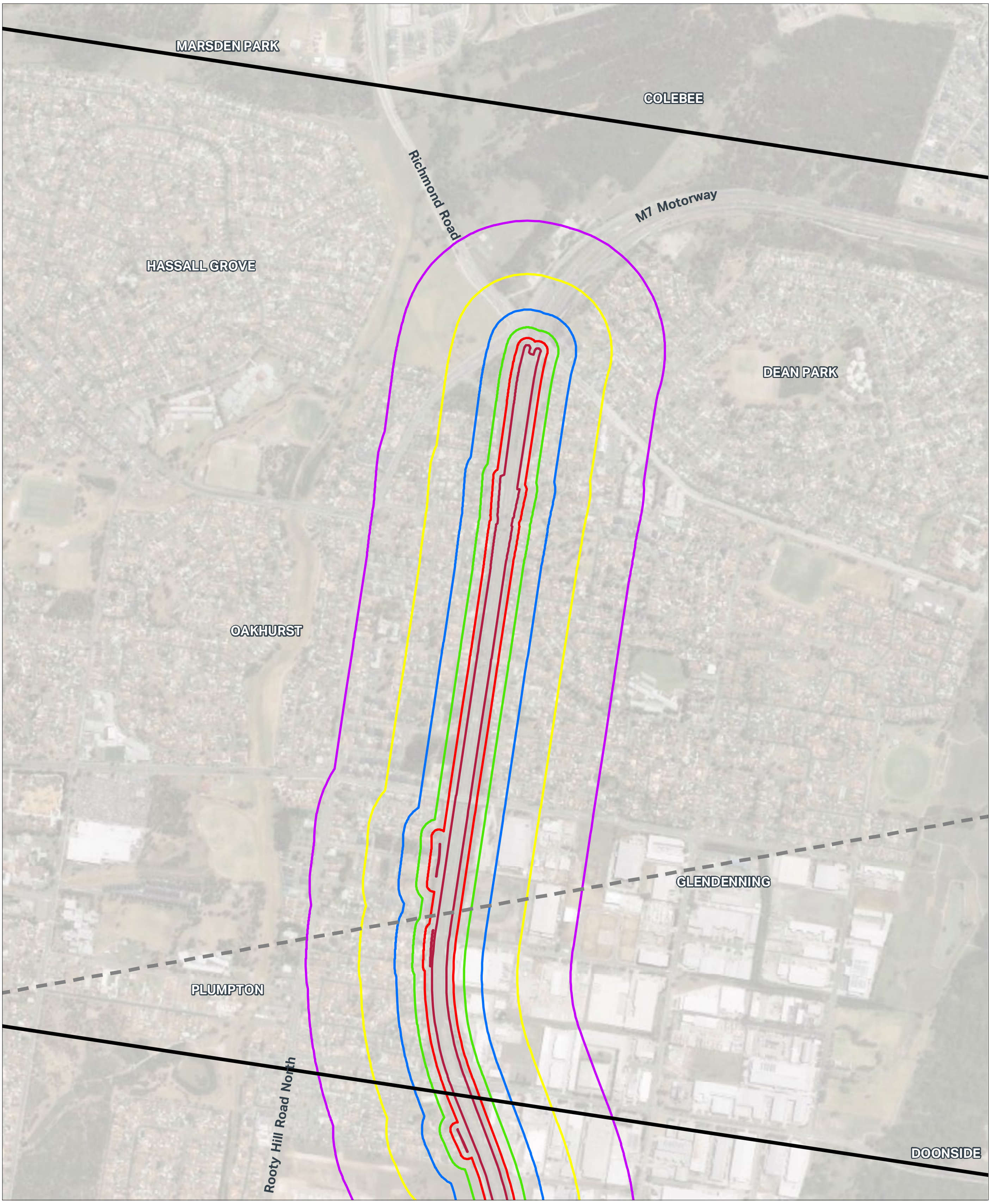


FIGURE 6-11: ZONE 11 - GLENDENNING TO OAKHURST

N
0 200 400 m

AECOM

Legend

- Construction footprint
- Construction Buffer Zone 11 - Glendenning to Oakhurst
- Construction Buffer Zone 10 - Rooty Hill to Glendenning
- 20m buffer from construction footprint
- 50m buffer from construction footprint
- 100m buffer from construction footprint
- 200m buffer from construction footprint
- 350m buffer from construction footprint

6.2.1.2 Stage 2 screening assessment

The Stage 1 screening assessment of the IAQM assessment in **Section 6.2.1.1** identified the need for a Stage 2 assessment. The Stage 2 below assessment considers the Proposed Modification construction footprint shown in **Figure 6-1** to **Figure 6-11** and provides an assessment of the potential for dust impacts due to unmitigated dust emissions from the Proposed Modification as described in **Section 4.1.2.2**.

Construction activity magnitudes

Construction activity magnitudes for each construction zone are presented in **Table 6-2**. The magnitudes have been estimated based on IAQM guidance provided in **Table 6-2** and construction activities discussed in **Section 6.1.** Construction activity magnitudes have been rated large for all activities based on the following assumptions:

- Demolition volume was estimated to be greater than 50,000m^3 as it would include removal of a wide range of structures along the 27km length of motorway including:
  - Bridge barriers and supports impacted by the Proposed Modification
  - Existing pavement and roadway impacted by the Proposed Modification
  - Median barrier treatments
  - Retaining walls
  - Road signs
  - Existing noise walls and barriers
  - Existing utilities requiring relocation
  - Existing drainage infrastructure requiring relocation; and demolition and removal of redundant drainage.
  - Fencing treatments.

  Demolition would include dusty material and may require onsite crushing of concrete and waste material
- Earthworks are expected to be substantial and were rated large as they involve:
  - 204,000 m^3 of cut material from excavation works; of this approximately 30,000 m^3 where possible would be sourced from site cuts required for the construction of the Proposed Modification. The majority of cut material would likely be exported offsite with a net amount of cut material estimated at 74,000 m^3.
  - 25,000 m^3 of topsoil and 122,000 m^3 of selected material zone (SMZ) is estimated to be imported onsite
  - Construction of retaining walls and embankment works
  - Substantial earth moving and materials handling equipment required as listed in **Section 6.1.2.**
- Construction works are extensive with the construction footprint covering an area of approximately 142 hectares and have been rated large as it includes:
  - 27km of pavement widening works including:
    - Placement of select zone material and concrete base
    - Spreading and compaction of aggregate
  - Construction of multiple conduction compounds and temporary ancillary facilities
  - Bridge widening works including
    - establishment of temporary haul roads and pile and crane pads including placement of layers of crushed rock or recycled concrete

- Construction of substructures and super structures

- Potential establishment of precast yard.

Trackout for construction works has been rated large to:

- An estimated peak heavy vehicle movement of 1,300 per day.
- Some off-road access through private land would also be required such as the SUEZ Waste Management Facility and Austral Brick access roads for delivery of construction materials and transport of construction materials across worksites.
- Some haulage is also expected to occur within the central median.
- Temporary off-motorway detour routes would also be required to support the bridge widening construction.

Table 6-2 Stage 2 IAQM assessment construction activity magnitudes

Construction activity magnitudes			
Demolition	Earthworks	Construction	Trackout
Large	Large	Large	Large

Sensitivity to dust soiling

Due to the size of the construction footprint sensitivity to dust soiling risks have been examined for each of the zones identified in **Figure 6-1** to **Figure 6-11** and are reported in **Table 6-3**. Dust risk ratings are determined by the highest risk rating attributed to a zone and have been estimated based on IAQM guidance provided in **Table 4-3** and surrounding land use as discussed in **Section 5.4**, **Table 4-1** and **Table 6-1**.

From **Table 6-3** the following has been concluded:

- Zones 1 and Zone 11 were found to have a high risk of dust soiling (prior to mitigation) due to the proximity of highly sensitive receptors close to the construction boundary.
- All other zones were found to have a moderate risk of dust soiling (prior to mitigation) due to the proximity of highly sensitive receptors close to the construction boundary.

Table 6-3 Assessment of sensitive receptor risk from dust spoiling (prior to mitigation)

Zone	Receptor sensitivity	Distance from construction site boundary			
		< 20 m	< 50 m	< 100 m	< 350 m
1	High	10-100 (High Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)
	Medium	**>1 (**Medium Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
2	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**>1 (**Medium Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
3	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**>1 (**Medium Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)

Zone	Receptor sensitivity	Distance from construction site boundary			
		< 20 m	< 50 m	< 100 m	< 350 m
4	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
5	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
6	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	10-100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
7	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	10-100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
8	High	1-10 (Medium Risk)	1-10 (Low Risk)	1-10 (Low Risk)	10-100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
9	High	1-10 (Medium Risk)	1-10 (Low Risk)	10-100 (Low Risk)	>100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
10	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
11	High	10-100 (High Risk)	>100 (High Risk)	>100 (Medium Risk)	>100 (Low Risk)
	Medium	**>1** Medium Risk	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)
	Low	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)	>1 (Low Risk)

Sensitivity to exposure to dust for human receptors

Due to the size of the construction footprint sensitivity to dust (as PM_{10}) for human health risks from have been examined for each of the zones identified in **Figure 6-1** to **Figure 6-11** and are reported in **Table 6-4**. Dust health risk ratings for human receptors are determined by the highest risk rating attributed to a Zone and have been estimated based on IAQM guidance provided in **Table 4-4** an annual average PM_{10} range of between 19 and 22 µg/m^3 and surrounding land use as discussed in **Section 5.4**, **Table 4-1** and **Table 6-1**.

From **Table 6-4** the following has been concluded:

- Zones 1 and Zone 11 were found to have a high risk to human health (prior to mitigation) due to the proximity of highly sensitive receptors close to the construction boundary.
- All other zones were found to have a moderate risk to human health (prior to mitigation) to the proximity of highly sensitive receptors close to the construction boundary.

Table 6-4 Assessment of sensitive receptor risk from exposure to dust (PM_{10}) for human receptors (prior to mitigation)

Zone	Receptor sensitivity	Distance from construction site boundary				
		< 20 m	< 50 m	< 100 m	< 200m	< 350 m
1	High	10-100 (High Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
2	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
3	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
4	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
5	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
6	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	10-100 (Low Risk)	10-100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)	**1-10** (Low Risk)

Zone	Receptor sensitivity	Distance from construction site boundary				
		< 20 m	< 50 m	< 100 m	< 200m	< 350 m
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
7	High	1-10 (Medium Risk)	10-100 (Medium Risk)	10-100 (Low Risk)	10-100 (Low Risk)	10-100 (Low Risk)
	Medium	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
8	High	1-10 (Medium Risk)	1-10 (Low Risk)	1-10 (Low Risk)	10-100 (Low Risk)	10-100 (Low Risk)
	Medium	**1-10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
9	High	1-10 (Medium Risk)	1-10 (Low Risk)	10-100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**1-10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
10	High	1-10 (Medium Risk)	10-100 (Medium Risk)	>100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)
11	High	10-100 (High Risk)	>100 (High Risk)	>100 (Low Risk)	>100 (Low Risk)	>100 (Low Risk)
	Medium	**1-10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)	**>10** (Low Risk)
	Low	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)	≥1 (Low Risk)

Sensitivity to exposure to dust for ecological receptors

Due to the size of the construction footprint dust sensitivity risks to ecological receptors have been examined for each of the Zones identified in **Figure 6-1** to **Figure 6-11** and are reported in **Table 6-5**. Dust risk ratings for ecological receptors are determined by the highest risk rating attributed to a Zone and have been estimated based on IAQM guidance provided in **Table 4-5** and surrounding land of ecological value as discussed in **Section 5.5.3**, **Table 4-1** and **Table 6-1**.

From **Table 6-5** the following has been concluded:

- Most construction zones were found to have a medium risk to ecological receptors (prior to mitigation) due to the proximity of native vegetation and areas zoned for environmental conservation purposes within 20m of the construction boundary.

- Zone 10 was found due to the high level of development was found to contain no ecological receptors of significance therefore the risk is considered negligible.

Table 6-5 Assessment of sensitive receptor risk for ecological receptors (prior to mitigation)

Zone	Receptor sensitivity	Distance from construction site boundary	
		< 20 m	20 - 50 m
1	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
2	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
3	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
4	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
5	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
6	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
7	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
8	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
9	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk
10	High	No receptors identified	No receptors identified
	Medium	No receptors identified	No receptors identified
	Low	No receptors identified	No receptors identified
11	High	No receptors identified	No receptors identified
	Medium	Medium Risk	Low Risk
	Low	Low Risk	Low Risk

Overall dust risk ratings

The potential risks for the overall Proposed Modification were found to range from Low to High, as summarised in **Table 6-6.**

Table 6-6 Summary of unmitigated risk assessment for service station excavation activities

Zone	Activity	Step 2A: Potential for dust emission	Step 2B: Sensitivity of area			Step 2C: Risk of unmitigated dust impacts		
			Dust soiling	Human health	Eco-logical	Dust soiling	Human health	Eco-logical
1 & 11	Demolition	Large	High	High	Medium	High	High	High
	Earthworks	Large	High	High	Medium	High	High	Medium
	Construction	Large	High	High	Medium	High	High	Medium
	Trackout	Large	High	High	Medium	High	High	Medium
2-8	Demolition	Large	Medium	Medium	Medium	High	High	High
	Earthworks	Large	Medium	Medium	Medium	Medium	Medium	Medium
	Construction	Large	Medium	Medium	Medium	Medium	Medium	Medium
	Trackout	Large	Medium	Medium	Medium	Medium	Medium	Medium
10	Demolition	Large	Medium	Medium	Low	High	High	Medium
	Earthworks	Large	Medium	Medium	Negligible	Medium	Medium	Negligible
	Construction	Large	Medium	Medium	Negligible	Medium	Medium	Negligible
	Trackout	Large	Medium	Medium	Negligible	Medium	Medium	Negligible

Given the unmitigated risk ratings of Low to High for the Proposed Modification, specific activity-based mitigation measures are recommended to reduce the risk of dust generation and hence impact on surrounding environment. Mitigation measures recommended are described in **Section 8.2**.

6.3 Combustion emission impact assessment

The source of combustion emissions during the Proposed Modification construction phase will be due to the combustion of petrol and diesel fuel by light and heavy vehicles traveling to and from site as well as onsite, mobile construction equipment and stationary equipment such as diesel generators. Emissions are expected to depend on the nature of the emissions source i.e., size of the equipment, usage rates, duration of operation etc. Pollutants emitted by construction vehicles are likely to include CO, particulate matter (PM_{10} and $PM_{2.5}$), NO_2, SO_2, VOCs, and PAHs.

Construction traffic is expected to fluctuate over the course of the construction program with estimated peak traffic number expected to reach up to 4,400 light vehicles movements and 1,300 heavy vehicles per day. Vehicle access for construction traffic is expected to primarily occur from Westlink M7 and the existing adjacent road network. Some off-road access through private land would also be required such as the SUEZ Waste Management Facility and Austral Brick access roads for delivery of construction materials and transport of construction materials across worksites. Some haulage is also expected to occur within the central median. Temporary off-motorway detour routes would also be required to support the bridge widening construction along Westlink M7.

Given the existing volume of traffic utilising the Westlink M7 as discussed in **Section 4.2.5** combustion emissions from construction traffic on the Westlink M7 and adjacent road network are unlikely to result in a notable reduction in ambient air quality at nearby sensitive receptors based on the construction traffic volume contribution. Any off-motorway detours due to construction works are expected to result in some localised changes to ground level pollutant concentration distribution patterns. Higher ground level concentrations would be expected within approximately 50m of any detour but would only be temporary in nature.

combustion emissions from diesel operated mobile equipment as listed in **Section 6.1.6** would also result in air pollutant emissions. As well as use of diesel generators to provide onsite power to Construction ancillary facilities and equipment where access to the electrical grid may not be readily available.

Given the typically transitory nature of construction traffic, as well as use of mobile and stationary plant equipment exhaust emissions it is unlikely to make a significant impact on local air quality. Typical mitigation and maintenance measures for operation of construction vehicles and plant equipment are discussed in **Section 8.0** and when applied adverse air quality impacts from the operation of construction vehicles and plant equipment are not expected.

6.4 Odour emissions assessment

Potential odour impacts from the site during construction would be temporary in nature. Potential sources of odour would primarily occur from the potential disturbance of acid sulphate soils (ASS) or contaminated soils during earthworks. ASS naturally occur in soils and sediments that contain iron sulphides. When exposed to air the iron sulphides in the soil react with oxygen and water to produce a variety of iron compounds and sulphuric acid, which are generally odorous.

Based on the findings of the Soils and Contamination Assessment for the Proposed Modification in the Proposed Modification report, the probability of intercepting ASS across the study area is extremely low. However, there is a potential for inland ASS to be encountered in water bodies within the study area where construction activities lower the water table by more than one metre. If potential acid sulphate soils are present, they are not expected to be excavated in large quantities, as they are limited in depth (only exist in a thin layer) and the excavation works in the areas of risk would be localised pilings and footings for the bridge structures.

Given the extremely low probability for intercepting ASS across the study area potential odour risks associated with the Proposed Modification are not considered significant. In the event ASS are encountered during excavation works good management of ASS will not only prevent the generation of sulphuric acid, but also result in a reduction of odour impacts. Potential impacts and management measures for ASS are discussed in greater detail in the Soils and Contamination Assessment for the Proposed Modification report. General air quality management measures are also discussed in **Section 8.0** of this report.

6.5 Cumulative impact assessment

6.5.1 Scoping assessment

Table 6-7 provides a qualitative cumulative assessment of construction impacts associated with other projects as listed in **Table 4-18** and in the modification report.

Table 6-7 Cumulative assessment of construction Air Quality impacts with other projects

Project Name and ID	Pollutants of interest	Cumulative assessment
The Sydney Zoo Modification SSD-7228	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Recently approved modification for extension of operational hours is considered a traffic generating development. Any increased traffic emissions from the MOD are unlikely to result in significant cumulative impacts during construction of the Proposed Modification to Westlink M7.
Light Horse Interchange Business Hub Eastern Creek SSD-9667	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Redevelopment site is adjacent to Westlink M7 is expected to complete construction in Q3 2023 which overlaps construction of Proposed Modification. Potential for some cumulative impacts to occur.
Saint Peter and Paul Assyrian Primary school SSD-9210	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	School development adjacent to Westlink M7 at Cecil Park likely to overlap construction period for the Proposed Modification. Development of the School would include bulk earthworks and soil remediation as park of site preparation works. Potential for some cumulative impacts to occur.
Gazorp Industrial Estate SSD-5248	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Gazorp Industrial estate, located on Wallgrove Road at Horsley Park is currently under construction and may overlap early work stages of construction period for the Proposed Modification. The development itself is a traffic generating development with an allotment of 1200 car spaces. Potential for minor cumulative impacts to occur in relation to dust and combustion emissions.
M12 Motorway SSI-9364	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Concurrent construction with M12 construction expected until 2015. Potential cumulative impacts associated with combustion from construction vehicles and plant equipment as well as dust generating activities due to intersection with Westlink M7.
Mamre Road Upgrade	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction of Mamre Road upgrade expected to be completed by 2025 and is concurrent with Proposed Modification construction timeline. Mamre Road upgrade is located approximately 7km west of the site as such any cumulative impacts from construction vehicle emissions are likely to be minor.
Sydney Metro - Western Sydney Airport SSI-10051	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction of Sydney Metro - Western Sydney Airport is expected to be completed by 2026 and is concurrent with Proposed Modification construction timeline. Sydney Metro - Western Sydney Airport is located 5km west of the site as such any cumulative impacts from construction vehicle emissions are likely to be minor.

Project Name and ID	Pollutants of interest	Cumulative assessment
Western Sydney Airport	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction of Western Sydney Airport is expected to be completed by 2026 and is concurrent with Proposed Modification construction timeline. Sydney Metro - Western Sydney Airport is located over 5km west of the site as such any cumulative impacts from construction vehicle emissions are likely to be minor.
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area. Future strategic government project	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction of major land release associated with Western Sydney Aerotropolis, Southwest Growth Area and Western Sydney Employment Area are likely to coincide with Proposed Modification construction timeline. Cumulative impacts associated with from construction vehicle emissions are likely to be minor.
Horsley Drive upgrade	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Pending project approval construction work for the Horsley Drive upgrade would commence in 2023; and would coincide with the Proposed Modification construction timeline. The Proposed Modification includes an upgrade of the Wallgrove Road and M7 Motorway interchange and is likely to result in cumulative impacts during construction from combustion emissions and dust generating activities.
The Northern Road upgrade (approved and under construction) SSI-7127	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	The Northern Road upgrade is around 10km west of the Westlink was completed in late 2021. No significant cumulative impacts are anticipated.
Horsley Drive Business Park SSD-7664-Mod-1	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	The business park is located approximately 2km east of the Proposed Modification on the corner of Cowpasture Road and Trivet Street and is expected to be operational by 2023. The Business Park would provide warehouse and office facilities and would be considered a traffic generating development. Minor cumulative impacts from combustion emissions are not considered significant.
Moorebank Intermodal Precinct West - Stage 2 SSD-7709	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction works associated with the Moorebank Intermodal Precinct have commenced with the facility located on Moorebank Avenue approximately 4km to the east of the M7. Cumulative impacts associated with from construction dust and construction vehicle emissions are not likely to be significant.

Project Name and ID	Pollutants of interest	Cumulative assessment
Sydney International Speedway SSI-10048	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Construction of the international speedway is expected to be completed prior to construction of the Proposed Modification. The speedway is located on Ferrers Road approximate 1.4km to the east of the Westlink M7. Combustion emissions associates with the operation of the Speedway are unlikely to result in significant cumulative impacts during construction of the Proposed Modification.
Momentum Industrial estate Modification 1 Revised Layout and Earthworks SSD-5248-Mod-1	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	The Momentum Industrial estate development includes construction of 16 warehouses and associated landscaping works. The industrial estate is located on Wallgrove Road, Horsley Park within proximity to the Proposed Modification. Some cumulative impacts are anticipated from dust and combustion emissions due to overlapping timelines.
Elizabeth Drive Upgrade	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	Proposed Elizabeth Drive Upgrade intersects with the Westlink M7. Environmental assessment of Elizabeth Drive upgrade is currently being undertaken and construction timeframes are likely to overlap with the Proposed Modification. Consideration of cumulative dust and combustion impacts would need to be considered as part of the Elizabeth Drive EA

6.5.2 Key project analysis

Of the above projects listed in **Table 6-7**; most are located at a distance sufficiently removed from the Proposed Modification construction footprint; that the potential cumulative impacts are expected to be negligible. Key Projects where there is the potential for cumulative air quality impacts during construction would include all TfNSW construction works on roads intersection with the Westlink M7 Proposed Modification where schedule construction work at intersections may coincide with construction work for the proposed modification. This includes the approved M12 Motorway and Horsley Drive upgrades and the Proposed Elizabeth Drive Upgrade.

Construction impacts from the Proposed Modification would be managed in accordance with the mitigation measures listed in **Section 8.0**. Provided potential impacts discussed in **Section 6.2** to **Section 6.4** from construction dust and construction vehicles are appropriately managed in accordance with safeguards listed in **Section 8.0** to reduce the risk of potential air quality impacts no significant cumulative impacts are anticipated. Assessment of cumulative impacts from the Proposed Elizabeth Drive Upgrade would need to be included as part of the EIS for Elizabeth Drive as lodgement of the development application for this project is expected to occur after the Westlink M7 Proposed Modification goes on exhibition.

There is also the potential for localised cumulative impacts from construction dust and combustion emissions from plant and mobile equipment from the construction of private developments adjacent to the Westlink M7. This includes the Momentum and Gazorp industrial estates, Light Horse Interchange business hub and Saint Peter and Paul Assyrian Primary School. Provided potential construction air quality impacts from the Proposed Modification are appropriately managed in accordance with mitigation measures listed in **Section 8.0** no significant cumulative impacts are anticipated.

7.0 Operational impact assessment

This section provides an assessment of operational air quality impacts from the Proposed Modification.

7.1 Air quality assessment of pollutants

The following section provides a discussion of the change in concentrations for predicted pollutants between modelled scenarios for both the southern and northern modelling domains. The relative change in ground level pollutant contribution has been discussed within the context of:

- Change in predicted ground level concentrations for the following future scenarios compared to the existing baseline scenario (Scenario 1) and the:
  - 'Do Nothing' design opening year 2026 (Scenario 2).
  - Proposed Modification design opening year 2026 (Scenario 3)
  - 'Do Nothing' ten years after design opening year 2036 (Scenario 4).
  - Proposed Modification ten years after design opening year 2036 (Scenario 5)
- Change in predicted ground level concentrations between:
  - 'Do Nothing' (Scenario 2) and the Proposed Modification (Scenario 3) for 2026.
  - 'Do Nothing' (Scenario 4) and the Proposed Modification (Scenario 5) for 2036.

Existing ground level concentrations for some pollutants (NO_2, PM_{10} and $PM_{2.5}$) are predicted to result in high concentrations at sensitive receptors close to the road and in some instances elevated background concentrations further exacerbate the elevated concentration. The assessment considered the relative change in ground level pollution concentrations compared to existing levels because of the Proposal. Assessment of the results have been discussed in the context of the change in predicted ground level contribution to:

a. Distinguish between existing and future changes in ground level pollution concentrations that are not directly tied to the Proposed Modification but are a direct result of changing emission standards as discussed in **Section 4.2.5**.

b. Distinguish between predicted ground level pollution concentrations for 2026 and 2036 with and without the Proposed Modification; to understand the potential impacts directly associated with the Proposed Modification.

Predicted road contributions (or incremental contributions) from road traffic in isolation for all pollutants as well as cumulative concentrations for pollutants NO_2, CO, PM_{10} and $PM_{2.5}$ for all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

7.1.1 Nitrogen dioxide

The following section provides a discussion on predicted change in maximum 1-hour and annual average NO_2 ground level concentrations at sensitive receptors. Predicted NO_2 ground level concentrations are discussed within the context of the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposed Modification for the design opening year (2026) and ten years after opening (2036.)

Section 7.1.1.1 provides a detailed discussion on the predicted changes in maximum 1-hour and annual average NO_2 concentrations within the Southern Domain and **Section 7.1.1.2**. discusses predicted pollutant ground level concentrations in the northern domain. A comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to the 1-hour maximum and annual average criteria. This includes a discussion based on the differences at sensitive receptors and based on concentration contours for gridded receptors within the study area. A summary of the change in predicted changes in NO_2 concentrations at sensitive receptors for the study area is also provided in the text box below.

NO_2 concentrations were based on the concentration of NO_X and the conversion ratio outlined in **Section 4.2.8**.

Predicted road contributions (or incremental contributions) from traffic in isolation for NO_2 along with cumulative concentrations for all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

The predicted ground level NO_2 concertation (1-hour maximum and annual average) in 2026 and 2036 are predicted to decrease when compared to existing ground level concentrations. This is due to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emission standards, and reduced number of aging vehicles with lower emission standards. This is evident between 2026 and 2036 modelled scenarios with a smaller difference in predicted ground level concentrations between the Proposed Modification and 'do nothing scenario' due to the weighting of emission factors on the results.

The Proposed Modification may result in 1 hour maximum and annual average NO_2 concentrations at sensitive receptors than predicted scenarios without the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential areas of Oakhurst and Glendenning. In general, the changes between with and without project scenarios were relatively small when compared to the EPA criteria.

Despite potential slight increase in NO_2 concentrations in 2026 and 2036 for the Proposed Modification predicted roadside concentrations are expected to decrease when compared to existing operations. These changes are discussed further in **Appendix I**. Differences in the baseline and future scenarios are greater than any differences noted as a result of 2026 and 2036 emissions with and without project scenarios.

7.1.1.1 Southern domain

Predicted changes in 1-hour maximum and annual average NO_2 concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-1** and **Figure 7-2** for the Southern Domain.

Figure 7-1 shows that predicted 1-hour maximum concentrations at sensitive receptors in 2026 and 2036 both with and without the Proposed Modification are generally lower than existing concentrations with some minor increases observed at a few locations.

Like the predicted 1-hour maximum NO_2 concentrations **Figure 7-2** shows that annual average concentrations at sensitive receptors are expected to be lower than modelled baseline conditions. It can be seen from **Figure 7-2** that predicted annual average NO_2 concentrations for 2026 and 2036 with and without the Proposed Modification are lower at all sensitive receptors when compared to existing concentrations.

The predicted decreases in 1-hour maximum and annual average NO_2 concentrations observed in **Figure 7-1** and **Figure 7-2** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**. This is further demonstrated by the greater reduction in predicted NO_2 concentrations observed across most sensitive receptors between 2026 and 2036 scenarios shown in **Figure 7-1** and **Figure 7-2**.

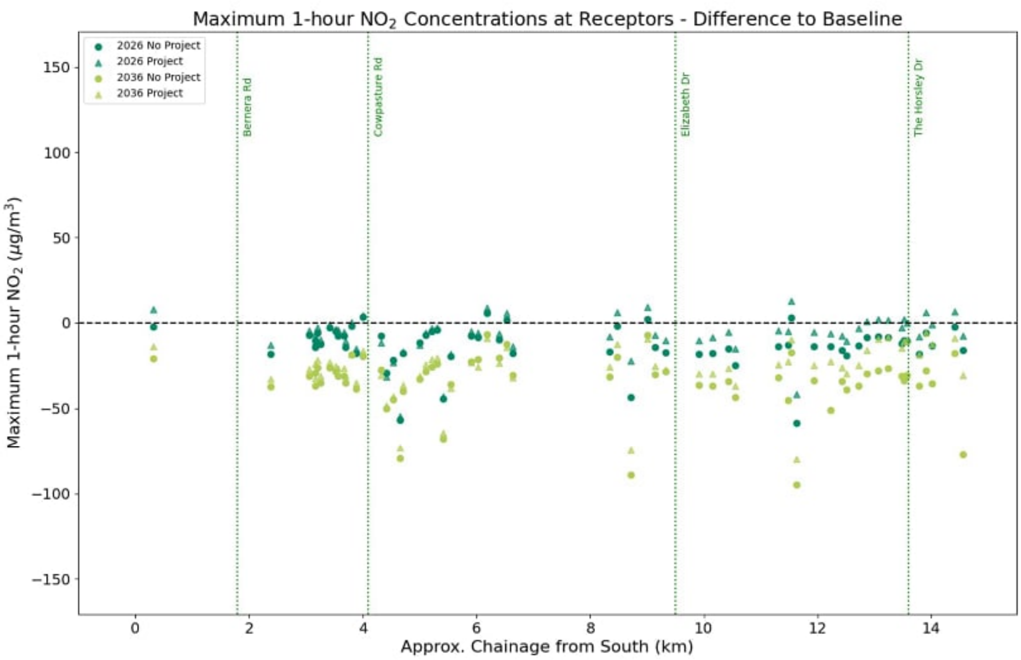


Figure 7-1 South Domain: predicted changes in maximum 1-hour NO_2 contribution from baseline

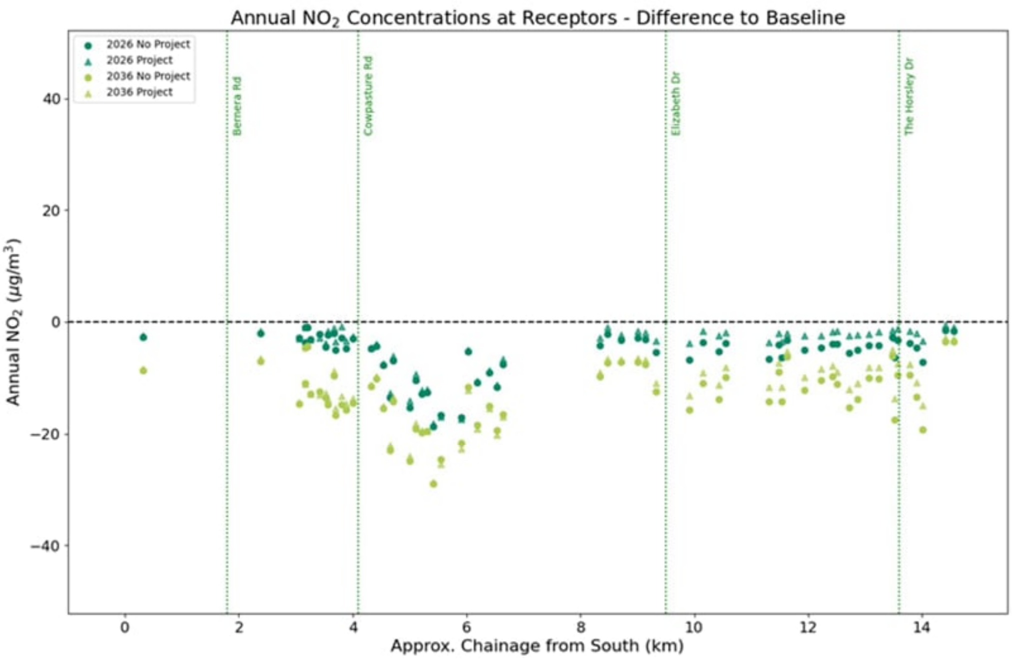


Figure 7-2 South Domain: predicted changes in annual average NO_2 contribution from baseline

As the predicted decreases in 1-hour maximum and annual average NO_2 concentrations compared to the baseline are largely attributed to lower emission factors used for future vehicle fleets, further examination of predicted NO_2 concentrations with and without the Proposed Modification was required. **Figure 7-3** and **Figure 7-4** shows the difference in 1 hour maximum and annual average NO_2 concentrations at sensitive receptors in the southern domain with and without the Proposed Modification. Predicted differences in in 1-hour maximum NO_2 concentrations for the southern modelling domain are also presented as contour plots in **Figure 7-5** for 2026 and 2036.

Figure 7-3 shows that for the first 8km predicted 1-hour maximum concentrations at sensitive receptors are generally unchanged for the Proposed Modification in both 2026 and 2036. This is consistent with the contours shown in **Figure 7-5**. From 8km to around 14km (just before the intersection with Elizabeth Drive to just after where the Westlink M7 intersects with The Horsley Drive) predicted 1-hour maximum concentrations at sensitive receptors are generally slightly higher for the Proposed Modification in both 2026 and 2036. These results are also consistent with observed concentration contours shown in **Figure 7-5**.

Observed differences between with project and without project modelled scenarios are relatively minor when compared to the EPA criterion of 246µg/m^3, with the highest difference in concentration between Proposed Modification and the 'Do-nothing' scenario equated to about 18 percent of the criterion. In general, the difference between the with and without project scenarios was within two or three percent of the criteria. The differences in concentrations between the Proposed Modification and "do-nothing" scenario are likely attributed to several factors including vehicle speed and increased vehicle numbers as part of the Proposed Modification.

Difference in the predicted annual average NO_2 concentrations in **Figure 7-4** indicate that predicted ground level concentrations are generally a little higher for the Proposed Modification at almost all receptor locations.

Observed differences in annual average concentrations between the Proposed Modification and "Do-nothing" modelled scenarios are relatively small within the context of the EPA annual average criteria of 62 µg/m^3. The highest difference in concentration was found to be around eight percent; while most difference between the Proposed Modification and the 'Do-nothing' scenarios at sensitive receptors were less than five percent of the criterion.

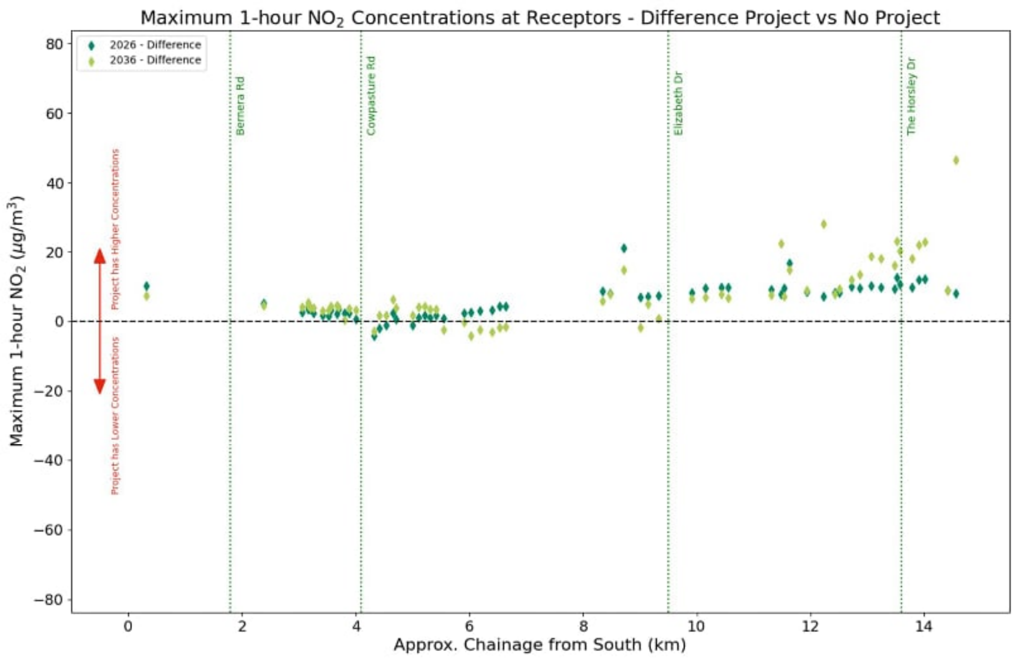


Figure 7-3 South Domain: predicted difference between project and no project maximum 1-hour NO_2 contributions

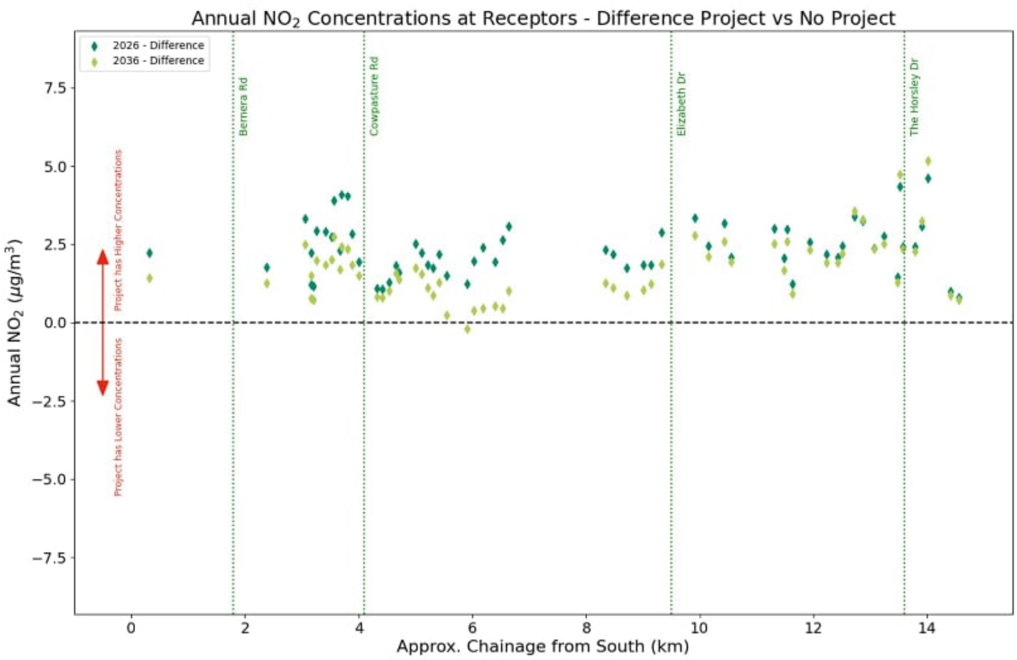


Figure 7-4 South Domain: predicted difference between project and no project annual average NO_2 contributions

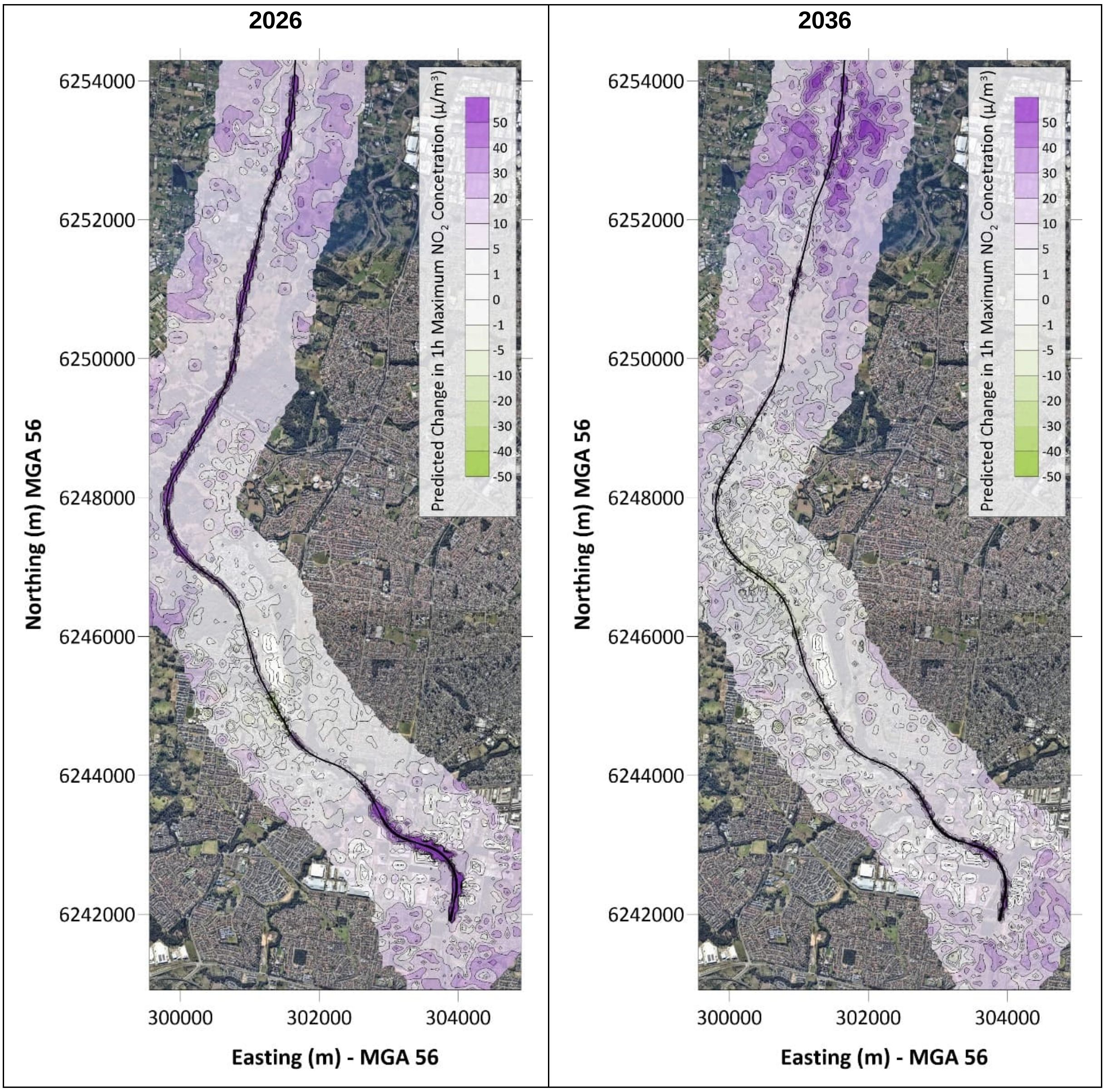


Figure 7-5 Predicted change in maximum 1-hour NO_2 concertation contours for South Domain

7.1.1.2 Northern domain

Predicted changes in 1-hour maximum and annual average NO_2 concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-6** and **Figure 7-7** for the Northern Domain.

Figure 7-6 shows that predicted 1-hour maximum concentrations at sensitive receptors for 2026 and 2036 both with and without the Proposed Modification are lower than existing concentrations. Significant reductions in the NO_2 concentration compared to the baseline were observed for towards the northern extent of the alignment in the high urban residential areas of Oakhurst and Glendenning, north of the Power Street intersection. Predicted 1-hour maximum NO_2 concentrations at sensitive receptors for 2036 both with and without the Proposed Modification generally indicate lower concentrations than both the existing and 2026 scenarios.

Like the predicted 1-hour maximum NO_2 concentrations **Figure 7-7** shows that annual average concentrations at sensitive receptors are expected to be lower than modelled baseline conditions. It can be seen from **Figure 7-7** that predicted annual average NO_2 concentrations for 2026 and 2036 with and without the Proposed Modification are lower at all sensitive receptors when compared to existing concentrations. Again, annual average NO_2 concentrations predicted at sensitive receptors for 2036 both with and without the Proposed Modification generally indicate lower concentrations than both the existing and 2026 scenarios.

Predicted decreases in 1-hour maximum and annual average NO_2 concentrations in **Figure 7-6** and **Figure 7-7** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**. This improvement in predicted NO_2 concentrations increases with time as shown between the 2026 and 2036 changes predicted concentrations compared to the baseline in **Figure 7-6** and **Figure 7-7**.

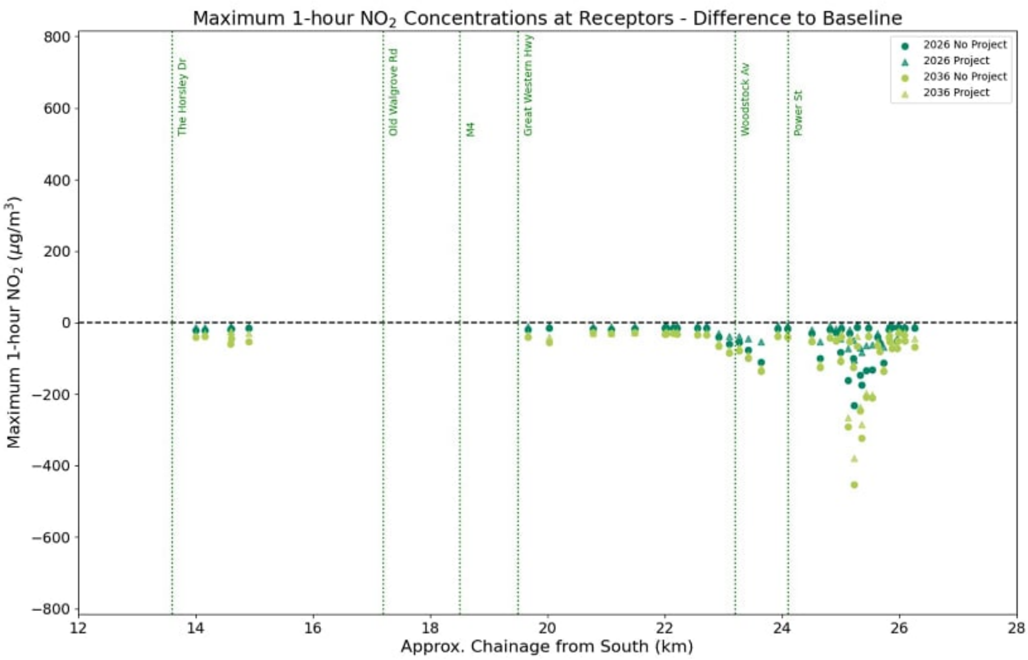


Figure 7-6 North Domain: predicted changes in maximum 1-hour NO_2 contribution from baseline

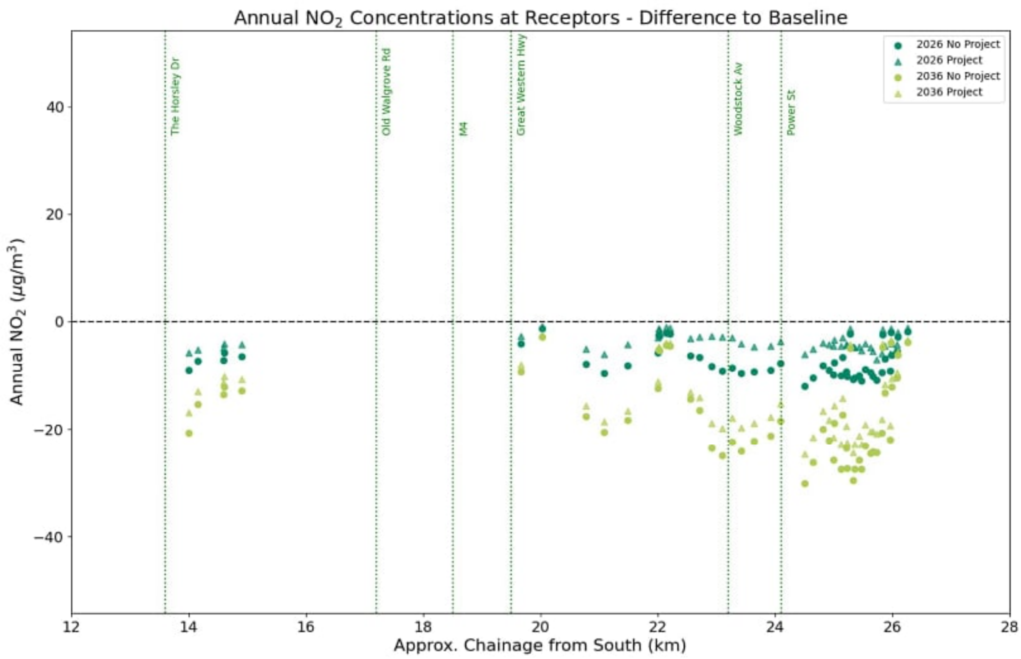


Figure 7-7 North Domain: Predicted changes in annual average NO_2 contribution from baseline

As the predicted decreases in 1-hour maximum and annual average NO_2 concentrations compared to the baseline are largely attributed to lower emission factors used for future vehicle fleets, further examination of predicted NO_2 concentrations with and without the Proposed Modification was required. **Figure 7-8** and **Figure 7-9** shows the difference in 1 hour maximum and annual average NO_2 concentrations at sensitive receptors in the northern domain with and without the Proposed Modification. Predicted differences in in 1-hour maximum NO_2 concentrations for the northern modelling domain are also presented as contour plots in **Figure 7-10** for 2026 and 2036.

Predicted differences in in 1-hour maximum NO_2 concentrations in **Figure 7-10** indicate that for 2026 the Proposed Modification would generally result in higher roadside ground level concentrations than without the Proposed Modification. A similar trend in **Figure 7-10** is observed in 2036; where 1-hour maximum NO_2 concentrations for the Proposed Modification would generally be higher than without the Proposed Modification, however the difference between with project and without scenarios is predicted to be smaller.

Figure 7-8 provides further detail relating to predicted differences in 1-hour maximum NO_2 concentrations at sensitive receptors within the Northern Domain. **Figure 7-8** shows that the predicted changes in ground level concentration at sensitive receptors are relatively similar or slightly higher for the Proposed Modification in 2026 and 2036; with exception to north of Power Street. Here predicted maximum ground level concentrations are higher at urban residential receptors at Oakhurst and Glendenning. This is likely attributed to higher vehicle numbers for the Proposed Modification. At the worst affected sensitive receptor, the difference in predicted concentration equates to 51% and 30% of the EPA criteria of 246µg/m^3 for 2026 and 2036 modelled scenarios respectively. For most sensitive receptors, the difference in concentration between with and without project scenarios; relative to the EPA criteria is only minor within five percent of each other. Predicted maximum 1-hour concentrations for the Proposed Modification in 2026 and 2036 are also still lower than existing conditions as discussed above and in the detail results analysis in **Appendix I**.

Difference in the predicted annual average NO_2 concentrations in **Figure 7-9** indicate that predicted annual average NO_2 concentrations are only slightly higher for the Proposed Modification. Similar to **Figure 7-8** predicted sensitive receptor concentrations are notably higher at urban residential receptors at Oakhurst and Glendenning; and likely attributed mostly to higher vehicle numbers.

Differences between annual average contributions between with and without project scenarios are minor; with an observable difference of under nine percent at the worst affected receptor between both 2026 and 2036 scenarios. Modelled annual average NO_2 concentrations for the Proposed Modification in 2026 and 2036 are also still lower than existing conditions as discussed above and in the detail results analysis in **Figure 7-8**.

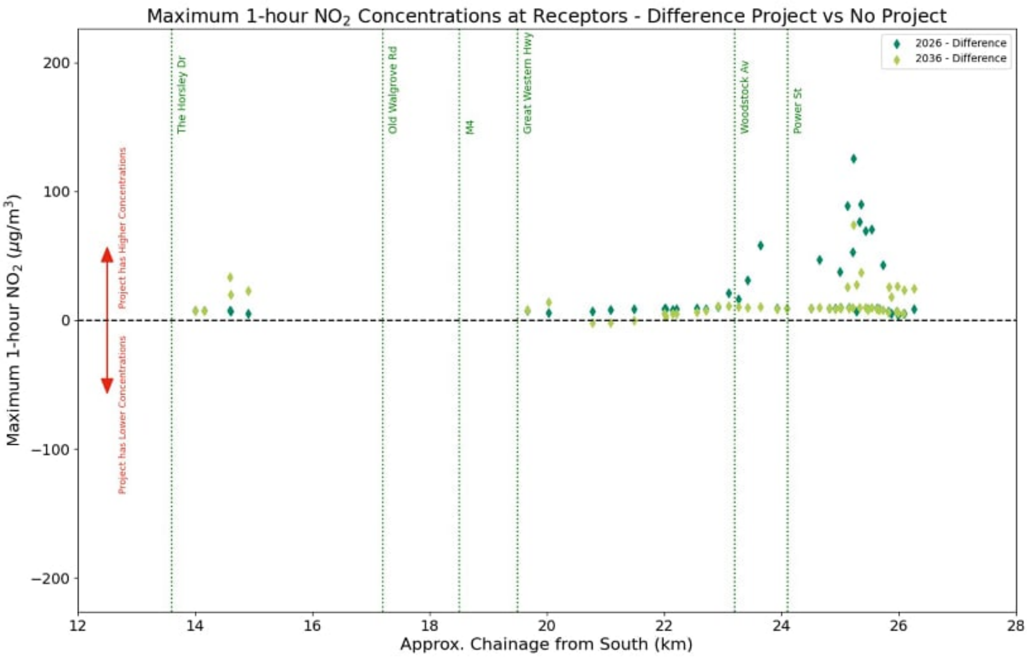


Figure 7-8 North Domain: predicted difference between project and no project maximum 1-hour NO_2 contributions

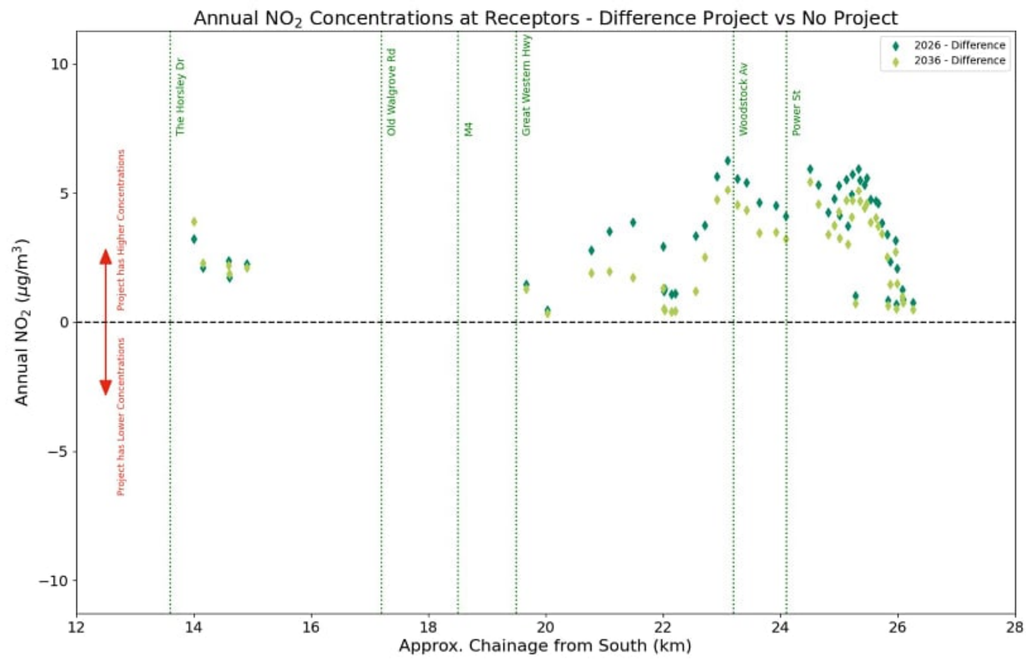


Figure 7-9 North Domain: predicted difference between project and no project annual average NO_2 contributions

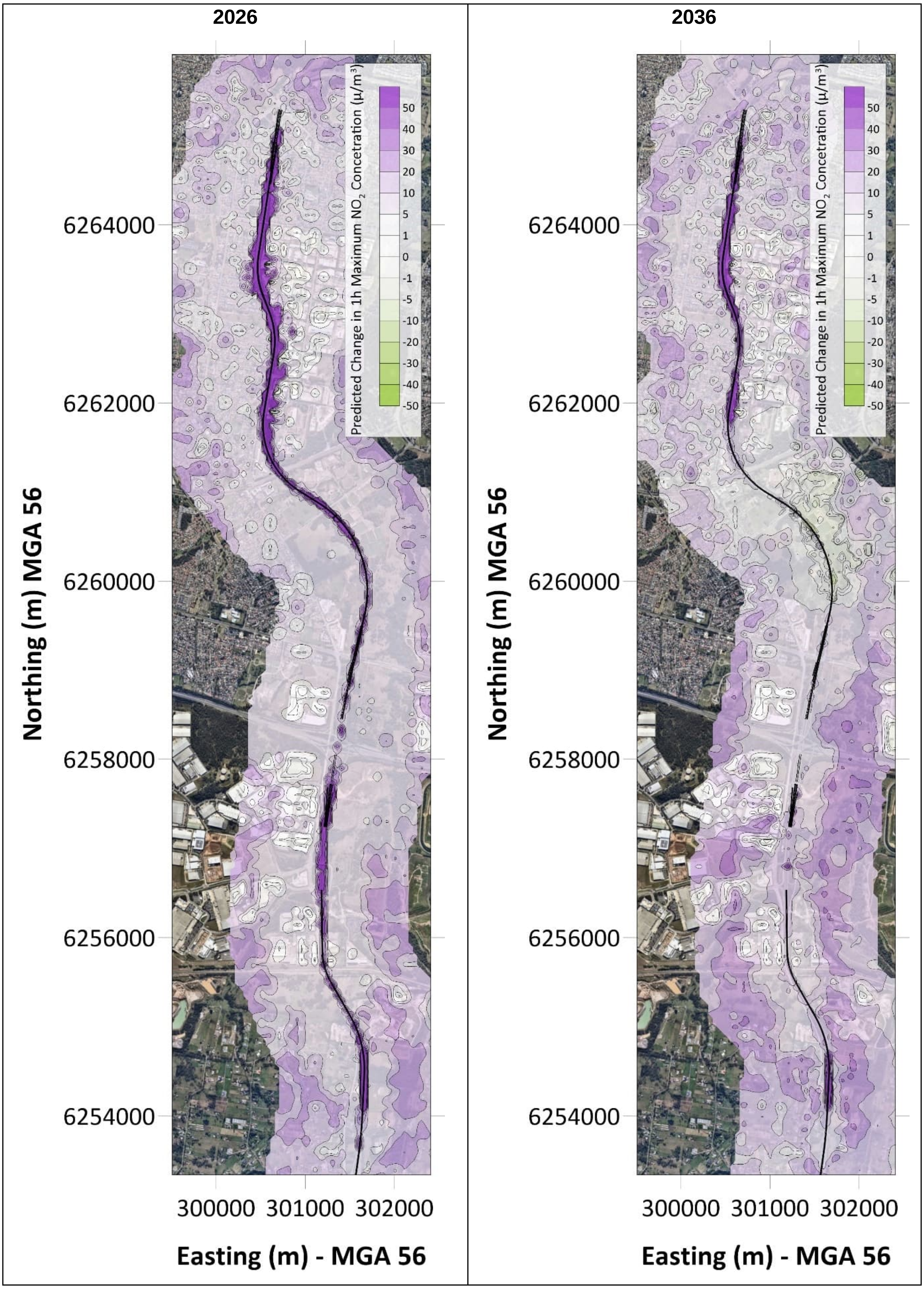


Figure 7-10 Predicted change in maximum 1-hour NO_2 concertation contours for North Domain

7.1.2 Carbon monoxide

The following section provides a discussion on predicted change in maximum 1-hour and 8-hour CO ground level concentrations at sensitive receptors. Predicted CO ground level concentrations are discussed within the context of the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposal; for the design opening year (2026) and ten years after opening (2036).

Section 7.1.2.1 provides a detailed discussion on the predicted changes in maximum 1-hour and 8-hour CO concentrations within the Southern Domain and **Section 7.1.2.2**. discussed predicted pollutant ground level concentrations in the northern domain. Comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to the 1-hour and 8-hour maximum criteria. A summary of the change in predicted changes in maximum 1-hour and 8-hour CO concentrations at sensitive receptors for the study area is also provided in the text box below.

Predicted road contributions (or incremental contributions) from road traffic in isolation for CO as well as cumulative concentrations all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

Ground level CO concentrations (1 hour maximum and 8 hour maximum) in 2026 and 2036 are predicted to decrease when compared to existing roadside concentrations. This is due to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emission standards, and reduced number of aging vehicles with lower emission standards. This is evident between 2026 and 2036 modelled scenarios with a smaller difference in predicted ground level concentrations between the Proposed Modification and 'do nothing' scenario due to the weighting of emission factors on the results

Predicted incremental and cumulative CO 1-hour and 8-hour maximum concentrations within the northern domain are well below EPA criteria at all sensitive receptors and is discussed further in **Appendix I**.

The Proposed Modification may result in higher 1-hour and 8-hour maximum CO concentrations at sensitive receptors than predicted scenarios without the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential premises in Oakhurst and Glendenning. These changes are relatively minor within the context of the EPA criteria of 30,000µg/m^3 and 10,000µg/m^3; and equate to less than three percent at the worst affected sensitive receptors.

7.1.2.1 Southern domain

Predicted changes in 1-hour and 8-hour maximum and annual average CO concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-11** and **Figure 7-12** for the Southern Domain.

Figure 7-11 shows that predicted 1-hour maximum CO concentrations at sensitive receptors for 2026 both with and without the Proposed Modification are generally lower than existing concentrations. Predicted 1-hour maximum concentrations at sensitive receptors for 2036 both with and without the Proposed Modification indicate lower than existing concentrations at most sensitive receptor locations.

Predicted 8-hour maximum CO concentrations **Figure 7-12 also** shows that concentrations at sensitive receptors are generally expected to be lower than existing baseline conditions. It can be seen from **Figure 7-12** predicted 8-hour maximum CO concentrations both with and without the Proposed Modification are lower in 2036 when compared with both 2026 modelled scenarios.

The predicted decreases in 1-hour and 8-hour maximum CO_2 concentrations observed in **Figure 7-11** and **Figure 7-12** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**. This is further demonstrated by the increased reduction in predicted CO concentrations observed across all sensitive receptors between 2026 and 2036 scenarios shown in **Figure 7-11** and **Figure 7-12**

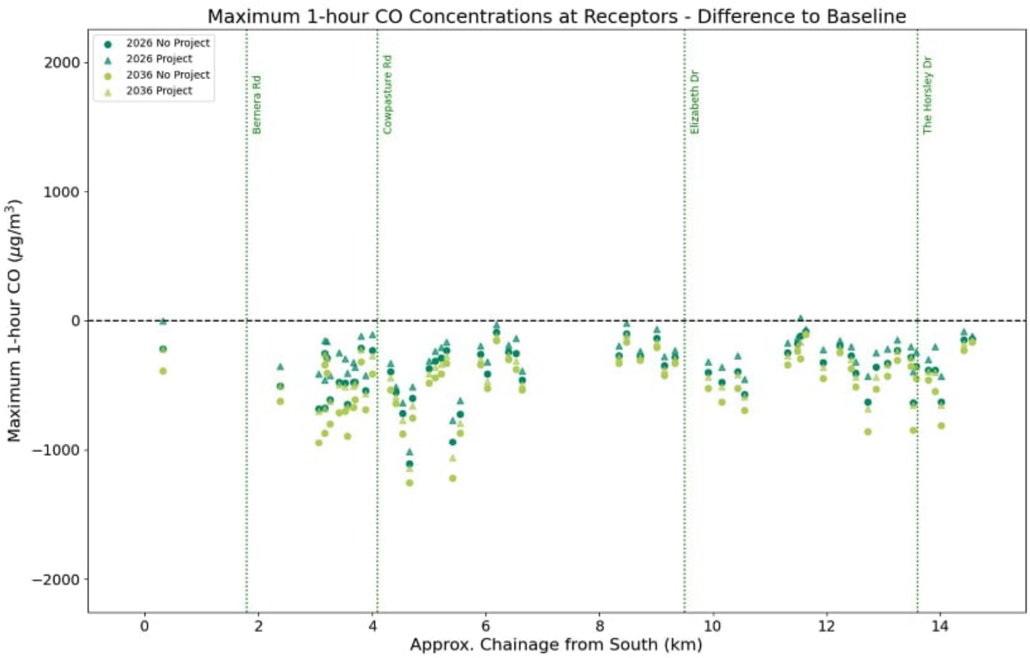


Figure 7-11 **South Domain: predicted changes in maximum 1-hour CO contribution from baseline**

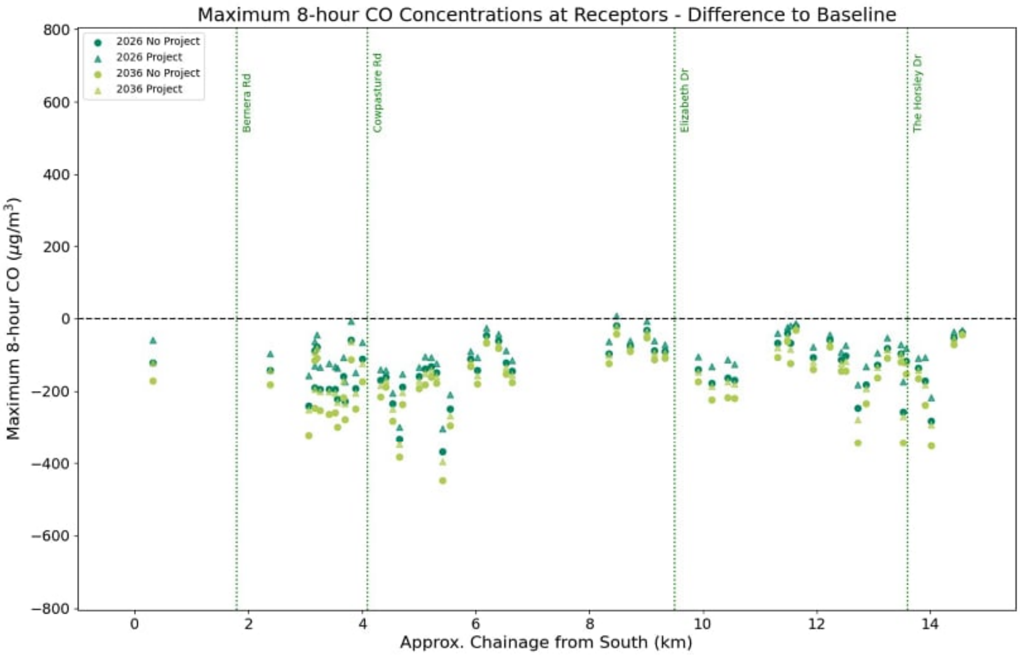


Figure 7-12 South Domain: predicted changes in maximum 8-hour CO contribution from baseline

As the predicted decreases in 1-hour and 8-hour maximum CO concentrations when compared to the baseline are largely attributed lower emission factors used for future vehicle fleets further examination of predicted CO concentrations with and without the Proposed Modification was required. **Figure 7-13** and **Figure 7-14** shows the difference in 1 hour and 8-hour maximum CO concentrations at sensitive receptors in the southern domain with and without the Proposed Modification.

Figure 7-13 and **Figure 7-14** show that there are some increases in the predicted maximum 1-hour and 8-hour maximum CO concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. These changes are relatively minor within the context of the EPA criteria of 30,000µg/m^3 and 10,000µg/m^3; and equate to less than one percent at the worst affected sensitive receptors.

Predicted incremental and cumulative concentrations at all sensitive receptors for CO within the southern domain were well below 1-hour and 8-hour maximum EPA criteria and is discussed further in **Appendix I**.

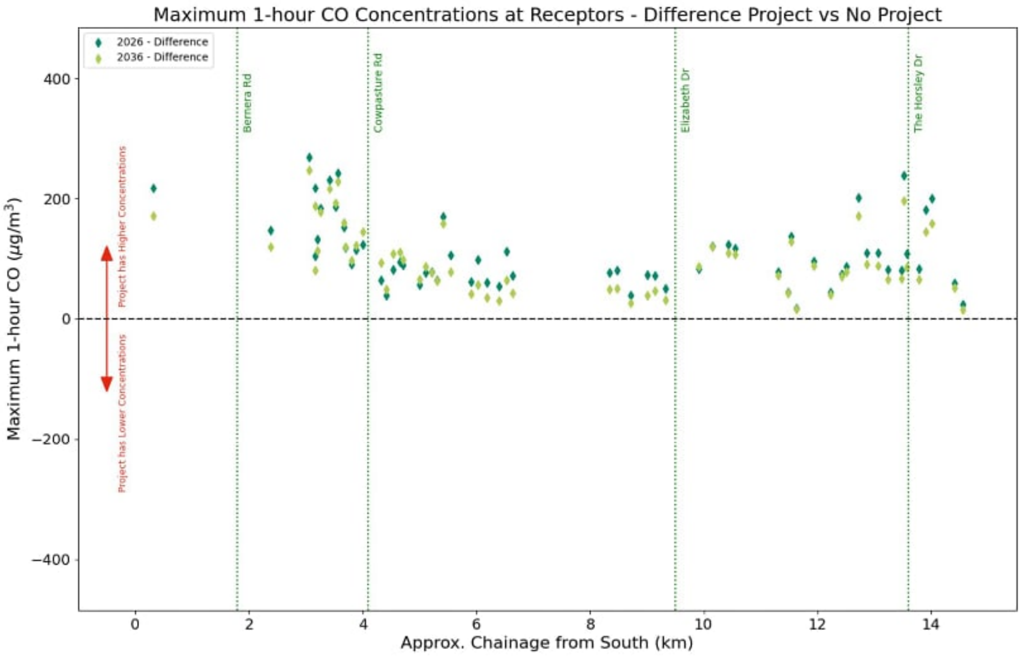


Figure 7-13 **South Domain: predicted difference between project and no project maximum 1-hour CO contributions**

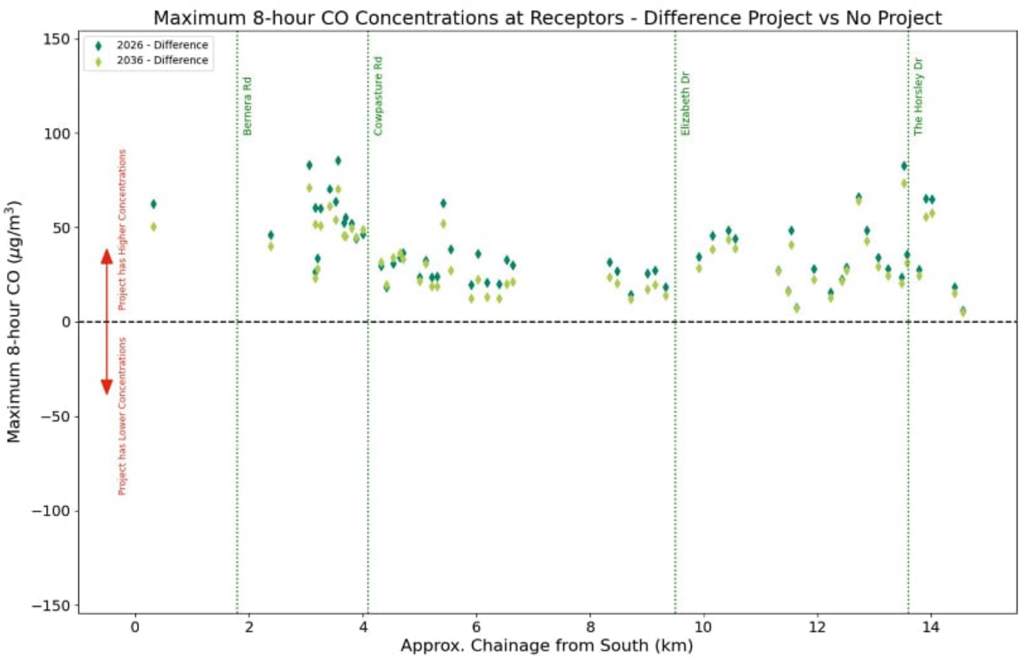


Figure 7-14 **South Domain: predicted difference between project and no project maximum 8-hour CO contributions**

7.1.2.2 Northern domain

For the Northern Domain predicted changes in 1-hour and 8-hour maximum CO concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-15** and **Figure 7-16**.

The predicted 1-hour maximum CO concentrations in **Figure 7-15** shows sensitive receptors for 2026 both with and without the Proposed Modification are lower than existing concentrations. Further minor reductions in 1-hour maximum CO concentrations at sensitive receptors are observed for the 2036 modelled scenarios both with and without the Proposed Modification. The highest reductions are observed north of Power Street, urban residential areas of Oakhurst and Glendenning.

Predicted 8-hour maximum CO concentrations **Figure 7-16 also** shows that concentrations at sensitive receptors are generally expected to be lower than modelled baseline conditions. It can be seen from **Figure 7-16** predicted 8-hour maximum CO concentrations both with and without the Proposed Modification are lower in 2036 when compared with both 2026 modelled scenarios.

The predicted decreases in 1-hour and 8-hour maximum CO concentrations observed in **Figure 7-15** and **Figure 7-16** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**. This is further demonstrated by the increased reduction in predicted CO concentrations observed across all sensitive receptors between 2026 and 2036 scenarios shown in **Figure 7-15** and **Figure 7-16**.

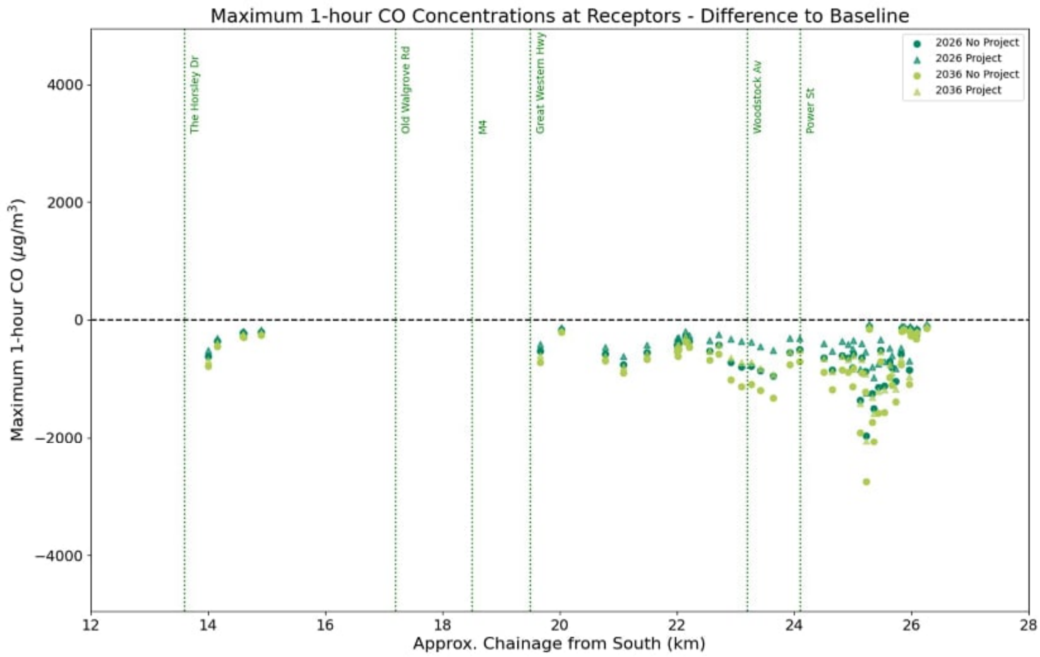


Figure 7-15 **North Domain: predicted changes in maximum 1-hour CO contribution from baseline**

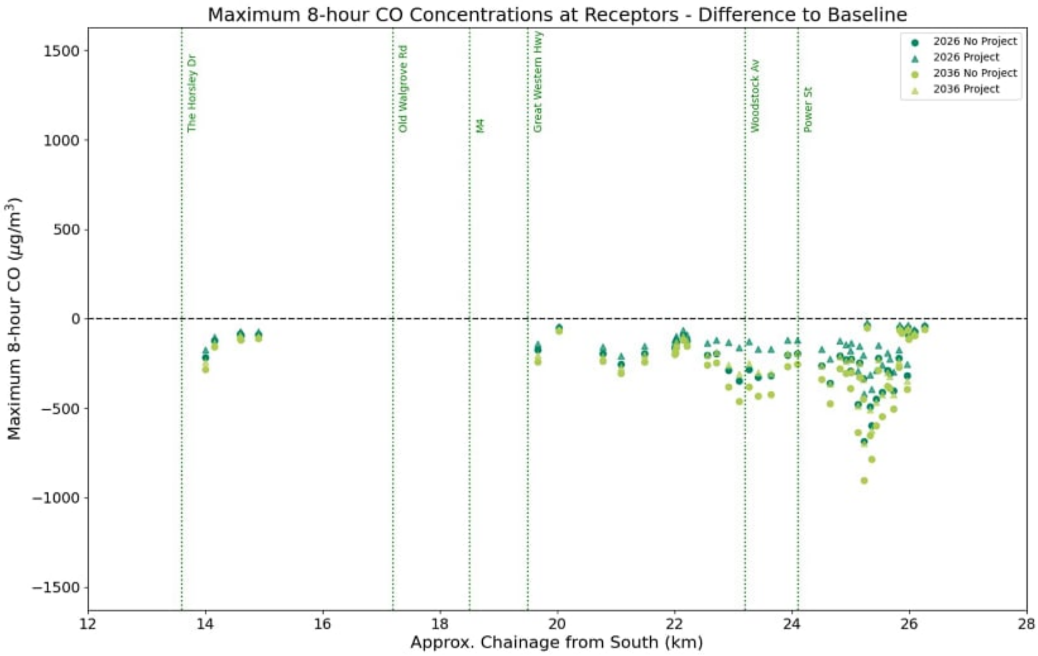


Figure 7-16 North Domain: predicted changes in maximum 8-hour CO contribution from baseline

Given decreases in predicted 1-hour and 8-hour maximum CO concentrations for 2026 and 2036 are largely attributed to lower emission factors used for future vehicle fleets, further examination of predicted CO concentrations with and without the Proposed Modification was required. For the northern domain **Figure 7-17** and **Figure 7-18** shows the difference in 1 hour and 8-hour maximum CO concentrations at sensitive receptors with and without the Proposed Modification.

Figure 7-17 and **Figure 7-18** show that there are some increases in the predicted maximum 1-hour and 8-hour maximum CO concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. The highest differences predicted between the Proposed Modification and without the Proposed Modification occur within the urban residential areas north of Power Street. Increased traffic volumes for the Proposed Modification is likely the primary driver of the difference between the with and without project scenarios. These changes are relatively minor within the context of the EPA criteria of 30,000μg/m^3 and 10,000μg/m^3; and equate to less than three percent at the worst affected sensitive receptors.

Predicted incremental and cumulative CO 1-hour and 8-hour maximum concentrations within the northern domain are well below EPA criteria at all sensitive receptors and is discussed further in **Appendix I**.

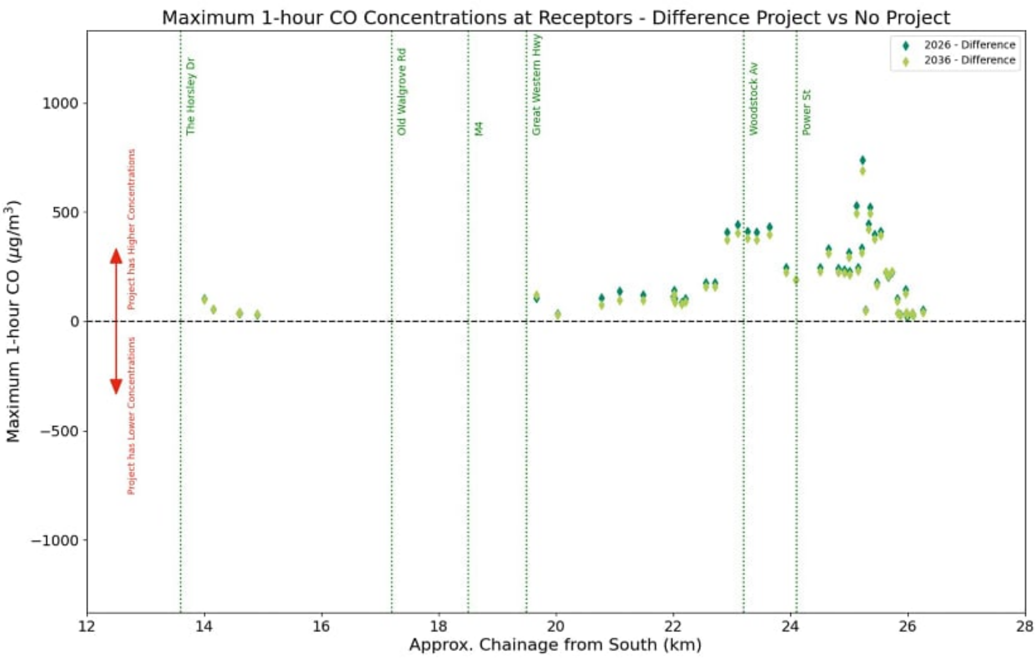


Figure 7-17 North Domain: predicted difference between project and no project maximum 1-hour CO contributions

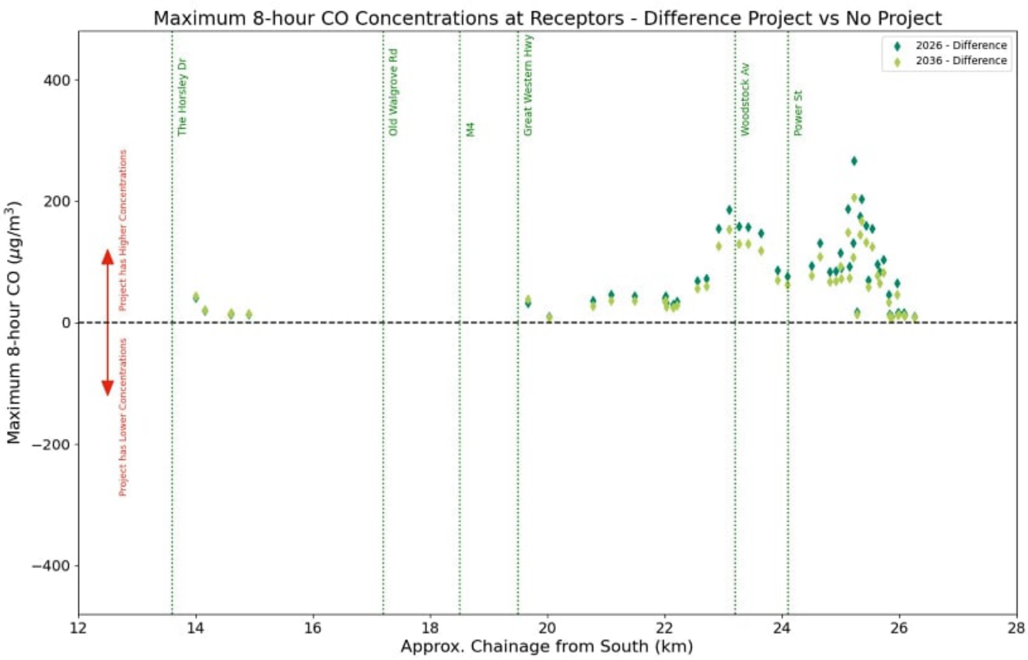


Figure 7-18 North Domain: predicted difference between project and no project maximum 8-hour CO contributions

7.1.3 Particulate matter (PM_{10})

The following section provides a discussion on predicted change in maximum 24-hour and annual average PM_{10} ground level concentrations at sensitive receptors. Predicted PM_{10} ground level concentrations are discussed within the context of the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposal; for the design opening year (2026) and ten years after opening (2036.)

Section 7.1.3.1 provides a detailed discussion on the predicted changes in maximum 24-hour and annual average PM_{10} concentrations within the Southern Domain and **Section 7.1.3.2**. discussed predicted pollutant ground level concentrations in the northern domain. Comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to the 24-hour maximum and annual average criteria. A summary of the change in predicted changes in PM_{10} concentrations at sensitive receptors for the study area is also provided in the text below.

Predicted road contributions (or incremental contributions) from road traffic in isolation for PM_{10} as well as cumulative concentrations all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

Ground level PM_{10} concentrations (24 hour maximum and annual average concentrations) in 2026 and 2036 are predicted to decrease when compared to the existing roadside concentrations. This is due to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emissions standards and reduced number of aging vehicles with lower emission standards.

Analysis of changes in contribution of 24 hour maximum and annual average PM_{10} concentrations indicate that the Proposed Modification may result in slightly higher concentrations at sensitive receptors than without the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential premises in Oakhurst and Glendenning. In generally however observable changes between with and without project scenarios were relatively small when compared to the EPA criteria. These changes are discussed further in **Appendix I**.

7.1.3.1 Southern domain

Predicted changes in 24-hour maximum and annual average PM_{10} concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-19** and **Figure 7-20** for the Southern Domain.

Figure 7-19 shows that predicted 24-hour maximum concentrations at sensitive receptors for 2026 and 2036 both with and without the Proposed Modification are slightly lower than existing concentrations. Similarly, **Figure 7-20** shows that annual average concentrations for 2026 and 2036 at sensitive receptors are predicted to be lower than modelled baseline conditions both with and without the Proposed Modification.

The predicted decreases in 24-hour maximum and annual average PM_{10} concentrations observed in **Figure 7-19** and **Figure 7-20** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

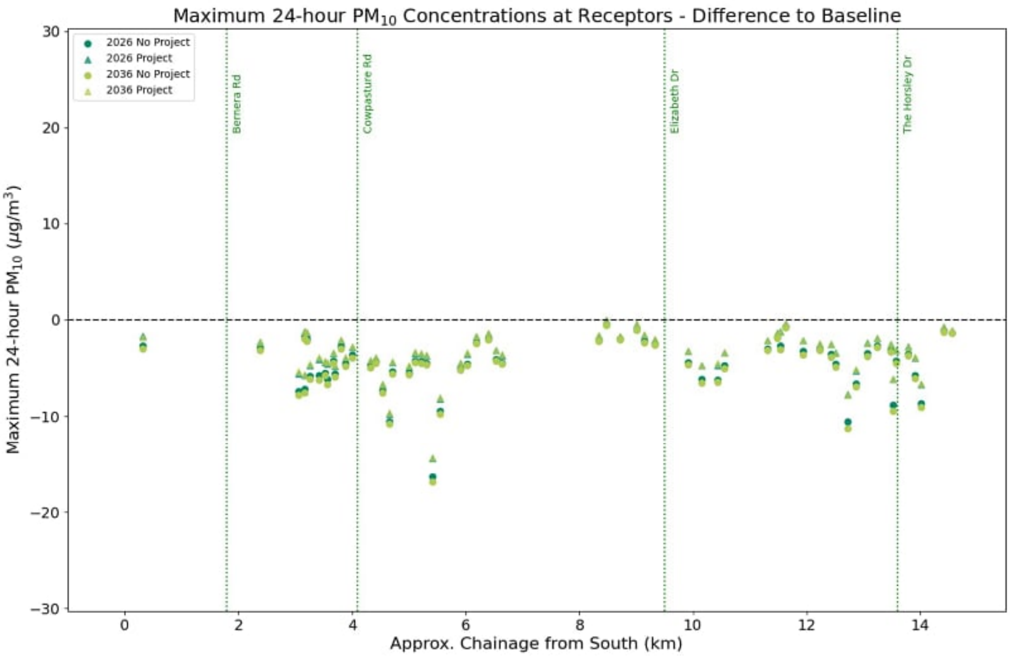


Figure 7-19 South Domain: predicted changes in maximum 24-hour PM_{10} contribution from baseline

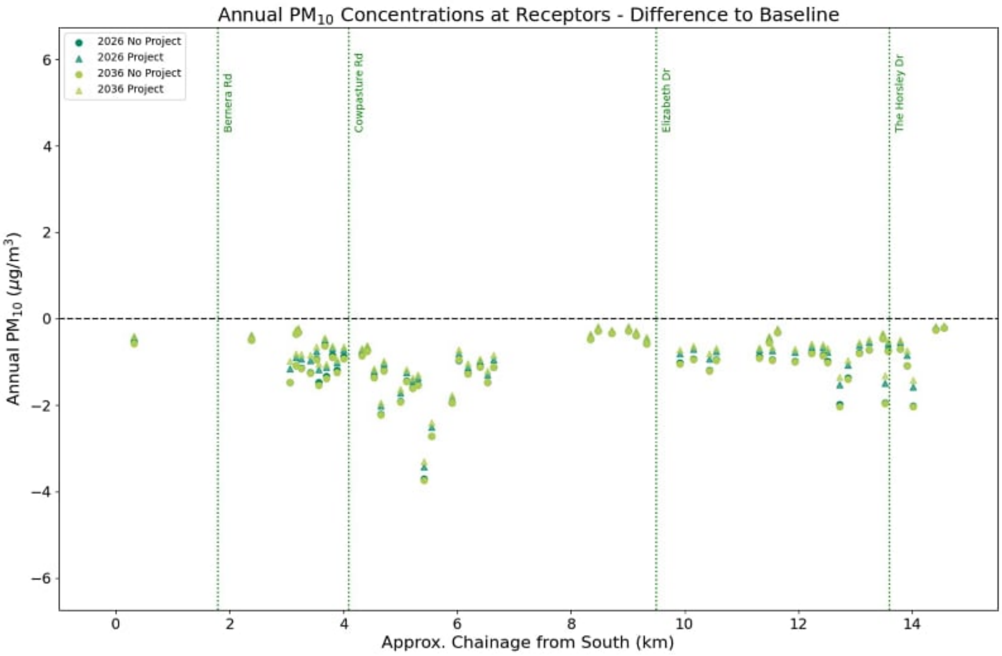


Figure 7-20 South Domain: predicted changes in annual average PM_{10} contribution from baseline

As the predicted decreases in 24-hour maximum and annual average PM_{10} concentrations when compared to the baseline are generally attributed lower emission factors used for future vehicle fleets further examination of predicted PM_{10} concentrations with and without the Proposed Modification was required. **Figure 7-21** and **Figure 7-22** shows the difference in 24-hour maximum and annual average PM_{10} concentrations at sensitive receptors in the southern domain with and without the Proposed Modification.

Figure 7-21 and **Figure 7-22** show that there are some increases in the predicted maximum 24-hour and annual average PM_{10} concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. The highest difference was observed within around 1km of The Horsley Drive intersection. These changes are relatively minor equating to around eight percent of the 24-hour criterion of 50 µg/m^3 and around three percent of the annual average criterion of 25 µg/m^3.

Predicted incremental and cumulative concentrations at all sensitive receptors for 24 hour maximum and annual average PM_{10} concentrations are discussed further in **Appendix I**.

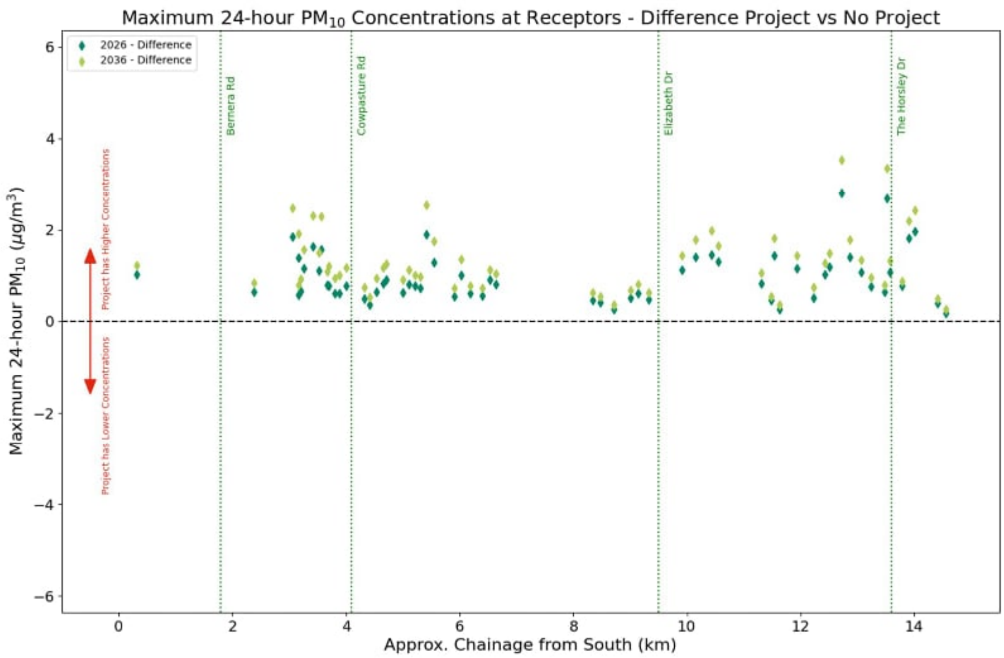


Figure 7-21 **South Domain: predicted difference between project and no project maximum 24-hour PM_{10} contributions**

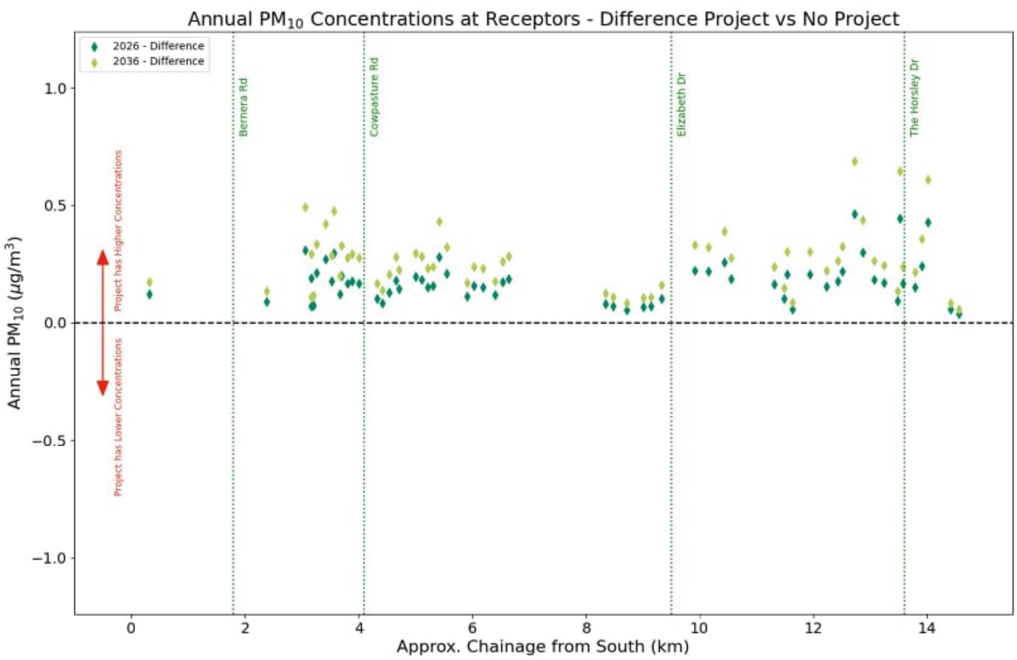


Figure 7-22 **South Domain: predicted difference between project and no project annual average PM_{10} contributions**

7.1.3.2 Northern domain

For the Northern Domain predicted changes in 24-hour and annual average PM_{10} concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-23** and **Figure 7-24**.

Modelled 24-hour maximum PM_{10} concentrations in **Figure 7-23** show sensitive receptors for 2026 and 2036 both with and without the Proposed Modification are lower than the baseline scenario. The highest reductions are observed north of Power Street, urban residential areas of Oakhurst and Glendenning.

Predicted annual average PM_{10} concentrations **Figure 7-24** also shows that annual average concentrations at sensitive receptors for 2026 and 2036 are predicted at lower ground level concentrations than modelled existing conditions both with and without the Proposed Modification. The largest annual average concentration reductions are observed north of Power Street, urban residential areas of Oakhurst and Glendenning.

The predicted decreases in 24-hour and annual average PM_{10} concentrations observed in **Figure 7-23** and **Figure 7-24** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

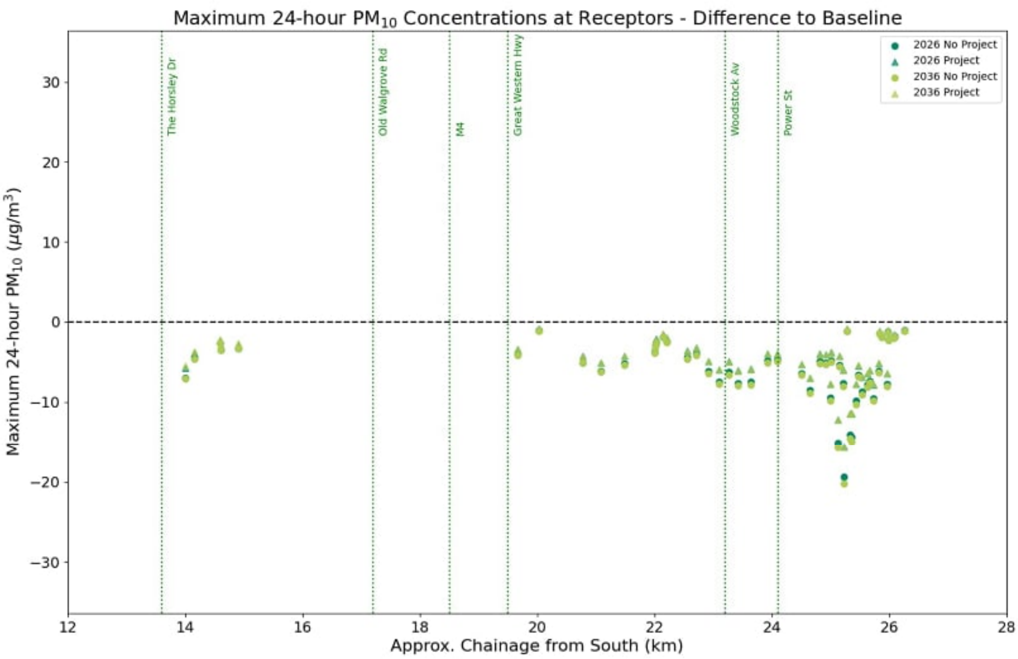


Figure 7-23 **North Domain: predicted changes in maximum 24-hour PM_{10} contribution from baseline**

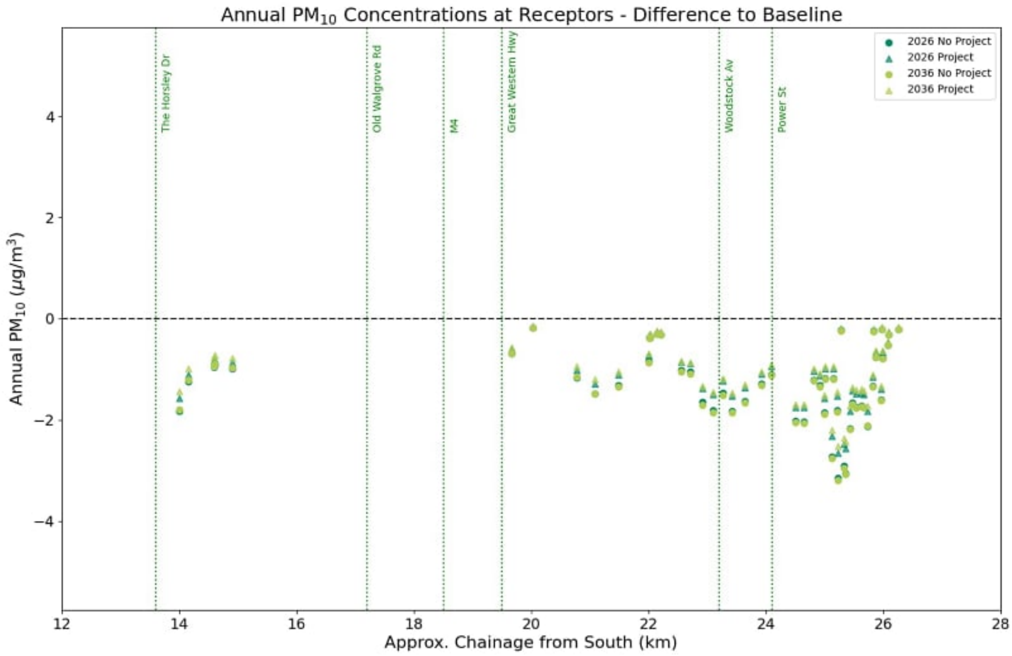


Figure 7-24 North Domain: predicted changes in annual average PM_{10} contribution from baseline

As decreases in predicted 24-hour and annual average PM_{10} concentrations for 2026 and 2036 would primarily be attributed lower emission factors used for future vehicle fleets further examination of predicted PM_{10} concentrations with and without the Proposed Modification was required. For the northern domain **Figure 7-25** and **Figure 7-26** shows the difference in 24-hour and annual average PM_{10} concentrations at sensitive receptors with and without the Proposed Modification.

Figure 7-25 and **Figure 7-26** show that there are some increases in the predicted 24-hour and annual average PM_{10} concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. The highest differences predicted between the Proposed Modification and without the Proposed Modification occur within the urban residential areas north of Power Street; where the minimum road speed for the Proposed Modification was lower than the 'Do nothing' Scenarios. Combined with increased traffic volumes these potential impacts are likely attributed to the difference between the with and without project scenarios. These changes are relatively minor within the context of the EPA criteria. The difference between worst affected receptors were in the order of ten percent of the maximum 24-hour concentration EPA criterion of 50 µg/m^3 and around three percent of the annual average criterion of 25 µg/m^3.

Predicted incremental and cumulative concentrations at all sensitive receptors for maximum 24-hour and annual average PM_{10} concentrations are discussed further in **Appendix I**.

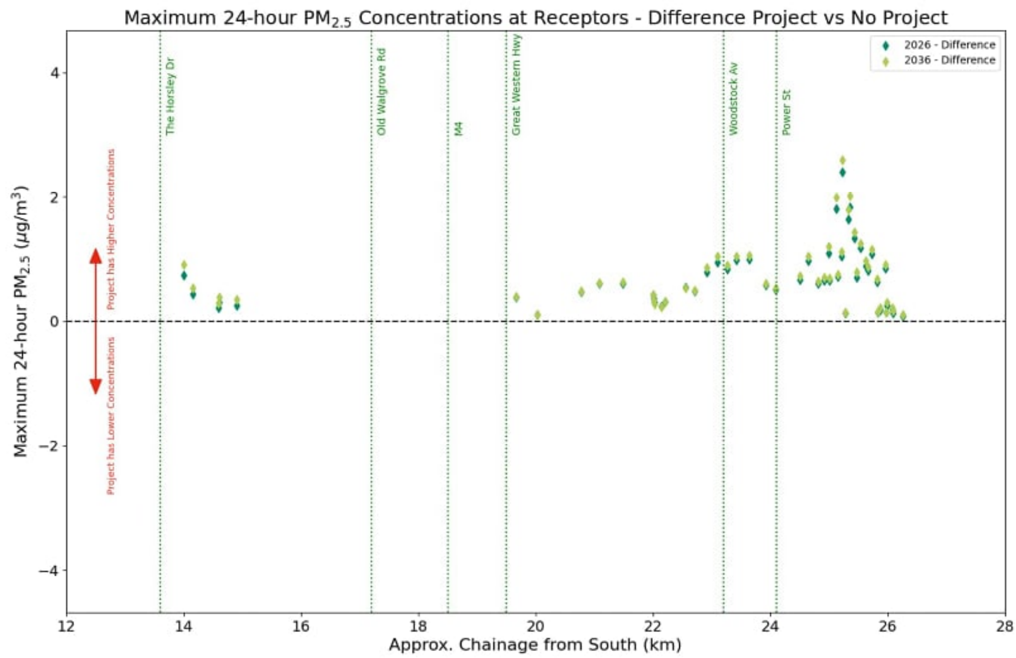


Figure 7-25 North Domain: predicted difference between project and no project maximum 24-hour PM_{10} contributions

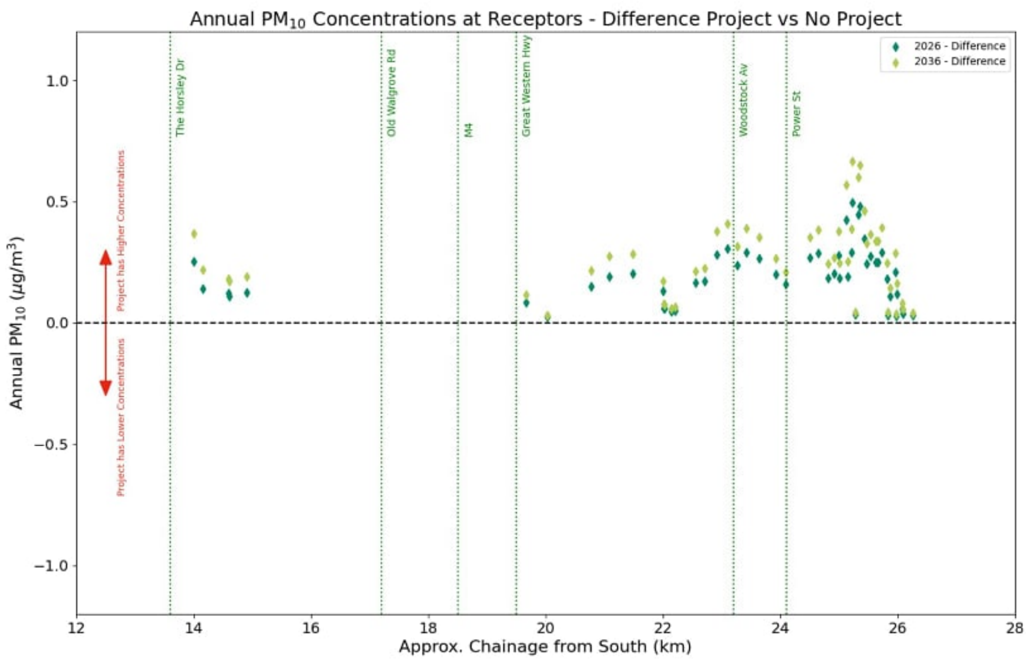


Figure 7-26 North Domain: predicted difference between project and no project annual average PM_{10} contributions

7.1.4 Particulate matter ($PM_{2.5}$)

The following section provides a discussion on predicted change in maximum 24-hour and annual average $PM_{2.5}$ ground level concentrations at sensitive receptors. Predicted $PM_{2.5}$ ground level concentrations are discussed within the context of the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposal; for the design opening year (2026) and ten years after opening (2036).

Section 7.1.4.1 provides a detailed discussion on the predicted changes in maximum 24-hour and annual average $PM_{2.5}$ concentrations within the Southern Domain and **Section 7.1.4.2**. discussed predicted pollutant ground level concentrations in the northern domain. Comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to the 24-hour maximum and annual average criteria. A summary of the change in predicted changes in $PM_{2.5}$ concentrations at sensitive receptors for the study area is also provided in the text box below.

As discussed in **Section 5.2.4.2** existing annual average $PM_{2.5}$ concentrations within the study area are already elevated. Modelling results with and without for $PM_{2.5}$ have also been assessed against recommended $\Delta PM_{2.5}$ health assessment criteria (see **Section 3.4.3**). Assessment of incremental annual average $\Delta PM_{2.5}$ are discussed in **Section 7.1.4.3**.

Predicted road contributions (or incremental contributions) from road traffic in isolation for $PM_{2.5}$ as well as cumulative concentrations all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

Ground level $PM_{2.5}$ concentrations (24 hour maximum and annual average) in 2026 and 2036 are predicted to decrease when compared to the existing roadside concentrations. This is due to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emissions standards and reduced number of aging vehicles with lower emission standards.

Analysis of changes in contribution of 24 hour maximum and annual average $PM_{2.5}$ concentrations indicate that the Proposed Modification may result in slightly higher concentrations at sensitive receptors than without the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential premises in Oakhurst and Glendenning. In generally the predicted changes between with and without project scenarios were relatively small when compared to the EPA criteria. These changes are discussed further in **Appendix I**

Predicted annual average $\Delta PM_{2.5}$ values for the Proposed Modification were also examined for future scenarios; and compared against recommended guidelines to assess incremental health risk. At the worst affected sensitive receptors annual average $\Delta PM_{2.5}$ indicated changes to $PM_{2.5}$ concentrations would be considered tolerable; with most sensitive receptors lying within the acceptable risk category. There were no sensitive receptors with an annual $\Delta PM_{2.5}$ value deemed an unacceptable risk.

7.1.4.1 Southern domain

Predicted changes in 24-hour maximum and annual average $PM_{2.5}$ concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-27** and **Figure 7-28** for the Southern Domain.

Figure 7-27 shows that predicted 24-hour maximum concentrations at sensitive receptors for 2026 and 2036 both with and without the Proposed Modification are slightly lower than existing concentrations. Similarly, **Figure 7-28** shows that annual average concentrations for 2026 and 2036 at sensitive receptors are predicted to be lower than modelled baseline conditions both with and without the Proposed Modification.

The predicted decreases in 24-hour maximum and annual average $PM_{2.5}$ concentrations observed in **Figure 7-27** and **Figure 7-28** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

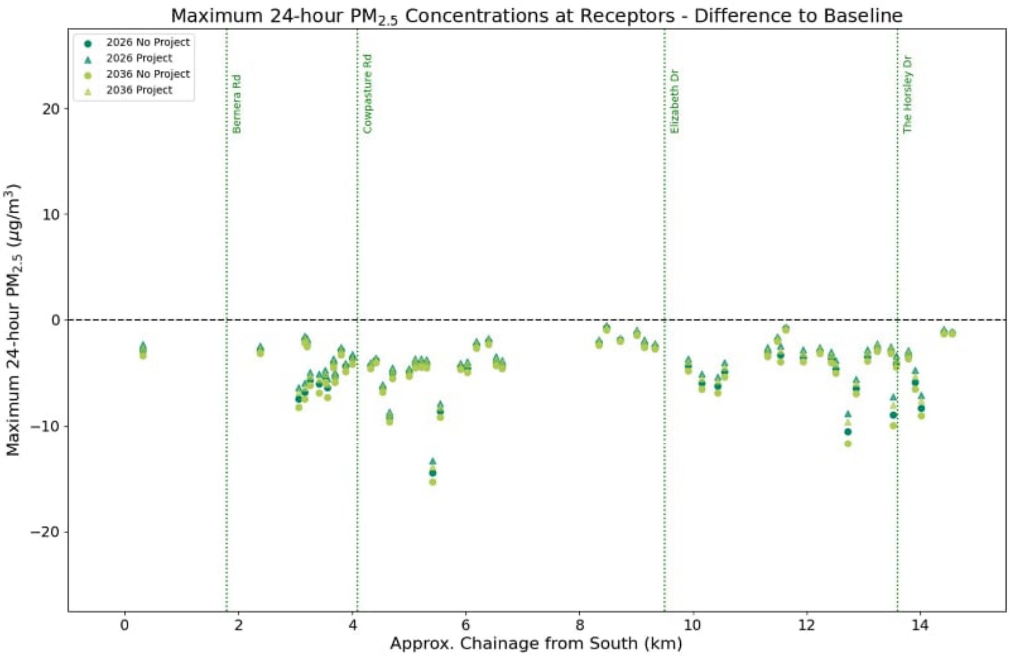


Figure 7-27 **South Domain: predicted changes in maximum 24-hour $PM_{2.5}$ contribution from baseline**

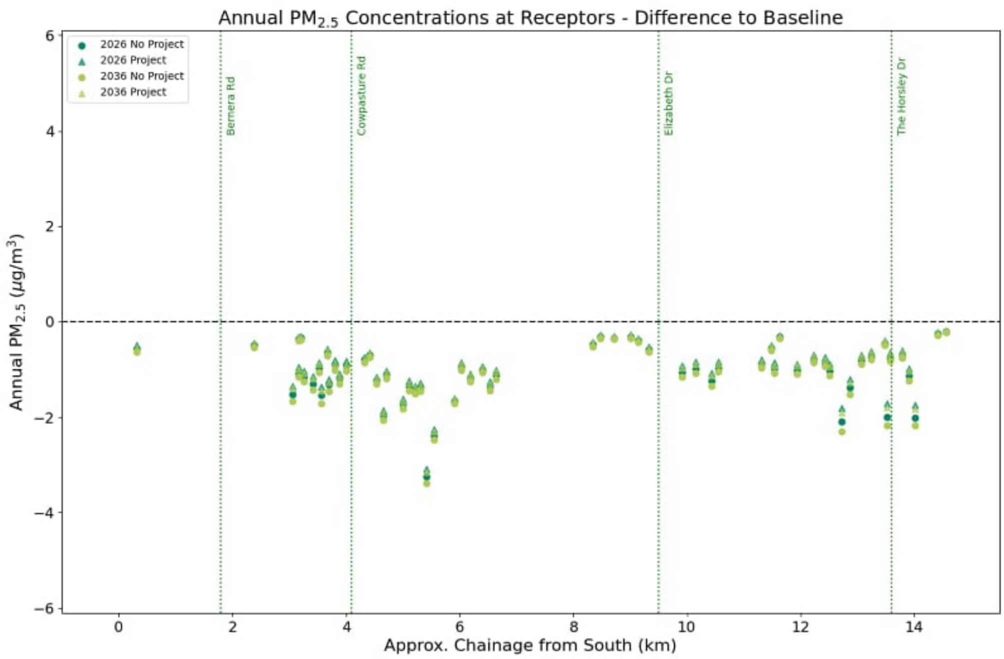


Figure 7-28 **South Domain: predicted changes in annual average $PM_{2.5}$ contribution from baseline**

As the predicted decreases in 24-hour maximum and annual average $PM_{2.5}$ concentrations when compared to the baseline are generally attributed lower emission factors used for future vehicle fleets further examination of predicted $PM_{2.5}$ concentrations with and without the Proposed Modification was required. **Figure 7-29** and **Figure 7-30** shows the difference in 24-hour maximum and annual average $PM_{2.5}$ concentrations at sensitive receptors in the southern domain with and without the Proposed Modification.

Figure 7-29 and **Figure 7-30** show that there are some increases in the predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. The highest difference was observed within around 1km of The Horsley Drive intersection. These changes are relatively minor equating to around eight percent of the 24-hour criterion of 25 µg/m^3 and around five percent of the annual average criterion of 8 µg/m^3.

Elaborating on **Figure 7-30** the predicted annual average $\Delta PM_{2.5}$ for 2026 and 2036 modelled scenario are discussed within the context of the recommended guidelines for health assessment criteria in **Section 7.1.4.3**. Predicted incremental and cumulative concentrations at all sensitive receptors for 24 hours maximum and annual average $PM_{2.5}$ concentrations are discussed further in **Appendix I**.

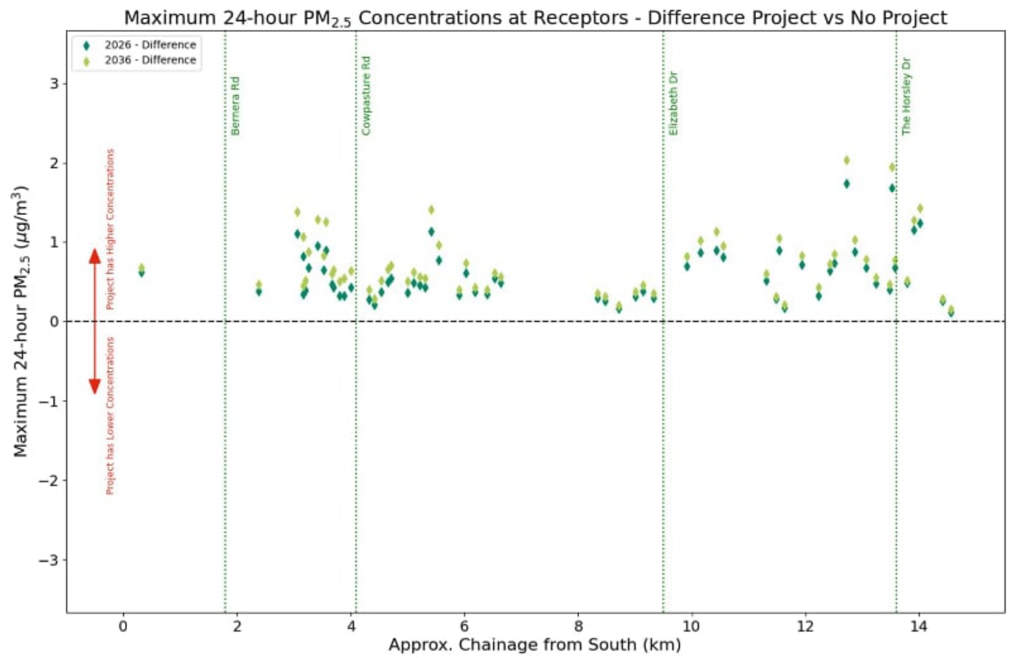


Figure 7-29 South Domain: predicted difference between project and no project maximum 24-hour $PM_{2.5}$ contributions

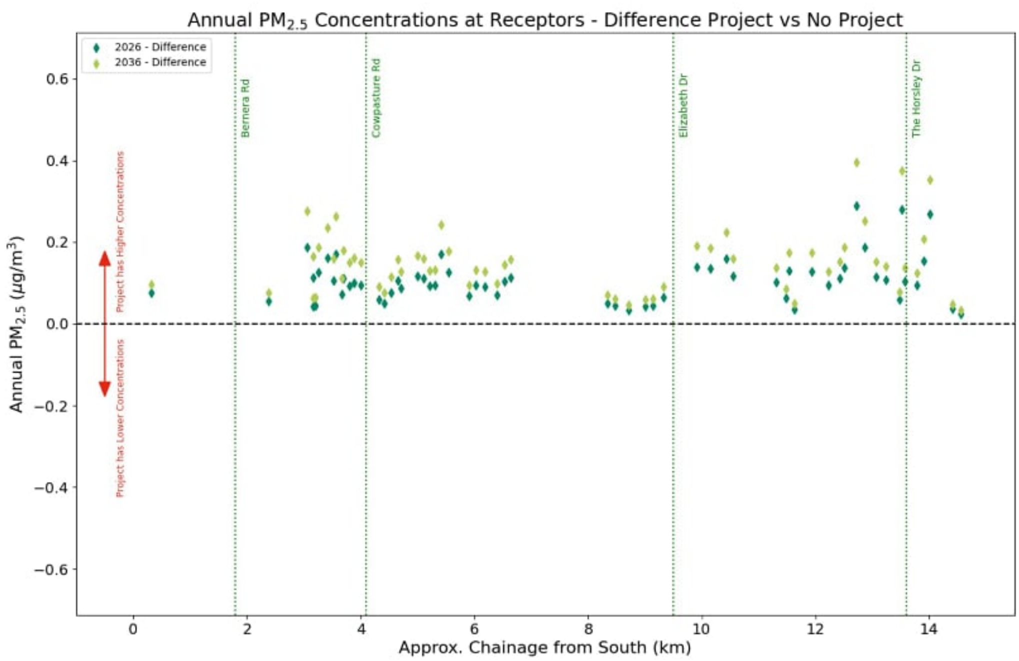


Figure 7-30 South Domain: predicted difference between project and no project annual average $PM_{2.5}$ contributions

7.1.4.2 Northern domain

For the Northern Domain predicted changes in 24-hour and annual average $PM_{2.5}$ concentrations for 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-31** and **Figure 7-32**.

Modelled 24-hour maximum $PM_{2.5}$ concentrations in **Figure 7-31** show sensitive receptors for 2026 and 2036 both with and without the Proposed Modification are lower than the baseline scenario. The highest reductions are observed north of Power Street, urban residential areas of Oakhurst and Glendenning.

Predicted annual average $PM_{2.5}$ concentrations **Figure 7-32** also shows that annual average concentrations at sensitive receptors for 2026 and 2036 are predicted at lower ground level concentrations than modelled existing conditions both with and without the Proposed Modification. The annual average concentration reductions are observed north of Power Street, urban residential areas of Oakhurst and Glendenning.

The predicted decreases in 24-hour and annual average $PM_{2.5}$ concentrations observed in **Figure 7-31** and **Figure 7-32** are largely attributed to lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

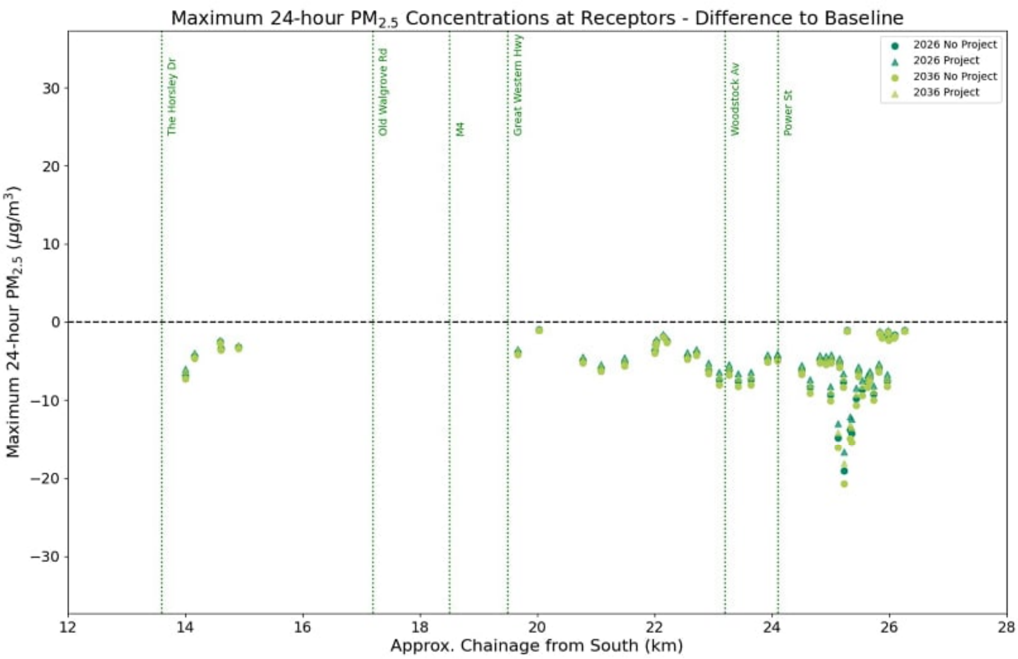


Figure 7-31 North Domain: predicted changes in maximum 24-hour $PM_{2.5}$ contribution from baseline

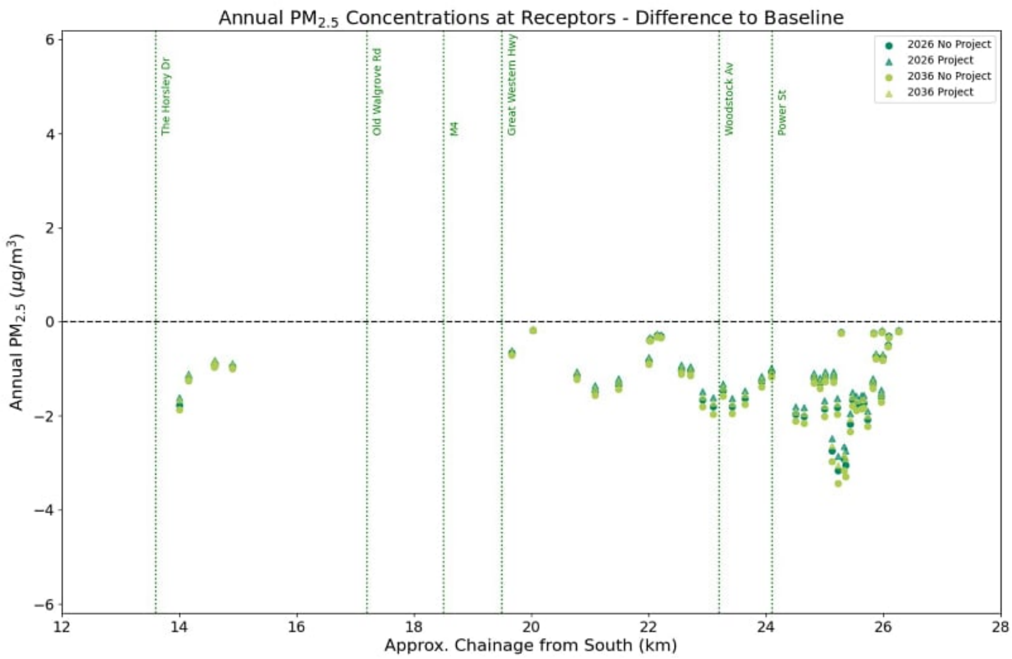


Figure 7-32 North Domain: predicted changes in annual average $PM_{2.5}$ contribution from baseline

As decreases in predicted 24-hour and annual average $PM_{2.5}$ concentrations for 2026 and 2036 would primarily be attributed lower emission factors used for future vehicle fleets further examination of predicted $PM_{2.5}$ concentrations with and without the Proposed Modification was required. For the northern domain **Figure 7-33** and **Figure 7-34** shows the difference in 24-hour and annual average $PM_{2.5}$ concentrations at sensitive receptors with and without the Proposed Modification.

Figure 7-33 and **Figure 7-34** show that there are some increases in the predicted 24-hour and annual average $PM_{2.5}$ concentrations for 2026 and 2036 when the Proposed Modification is compared to the 'Do nothing' scenarios. The highest differences predicted between the Proposed Modification and without the Proposed Modification occur within the urban residential areas north of Power Street; where the minimum road speed for the Proposed Modification was lower than the 'Do nothing' Scenarios. Combined with increased traffic volumes these potential impacts are likely attributed to the difference between the with and without project scenarios. These changes are relatively minor within the context of the EPA criteria. The difference between worst affected receptors were in the order of 11 percent of the maximum 24-hour concentration EPA criterion of 25 µg/m^3 and around five percent of the annual average criterion of 8 µg/m^3.

Elaborating on **Figure 7-26** the predicted annual average $\Delta PM_{2.5}$ for 2026 and 2036 modelled scenario are discussed within the context of the recommended guidelines for health assessment criteria in **Section 7.1.4.3**. Predicted incremental and cumulative concentrations at all sensitive receptors for maximum 24-hour and annual average PM_{10} concentrations are discussed further in **Appendix I**.

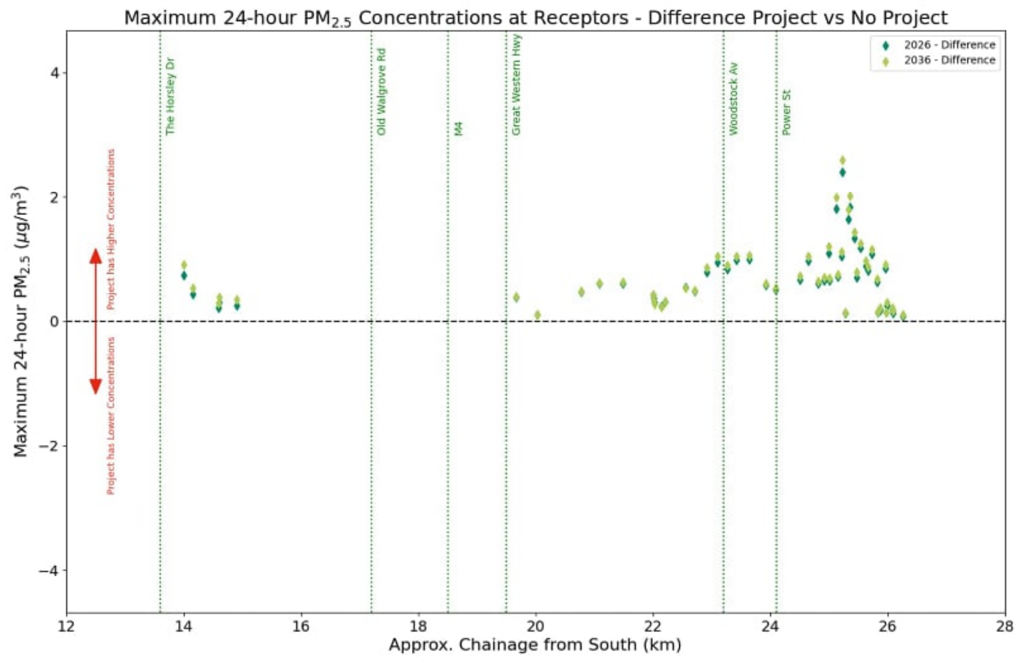


Figure 7-33 North Domain: predicted difference between project and no project maximum 24-hour $PM_{2.5}$ contributions

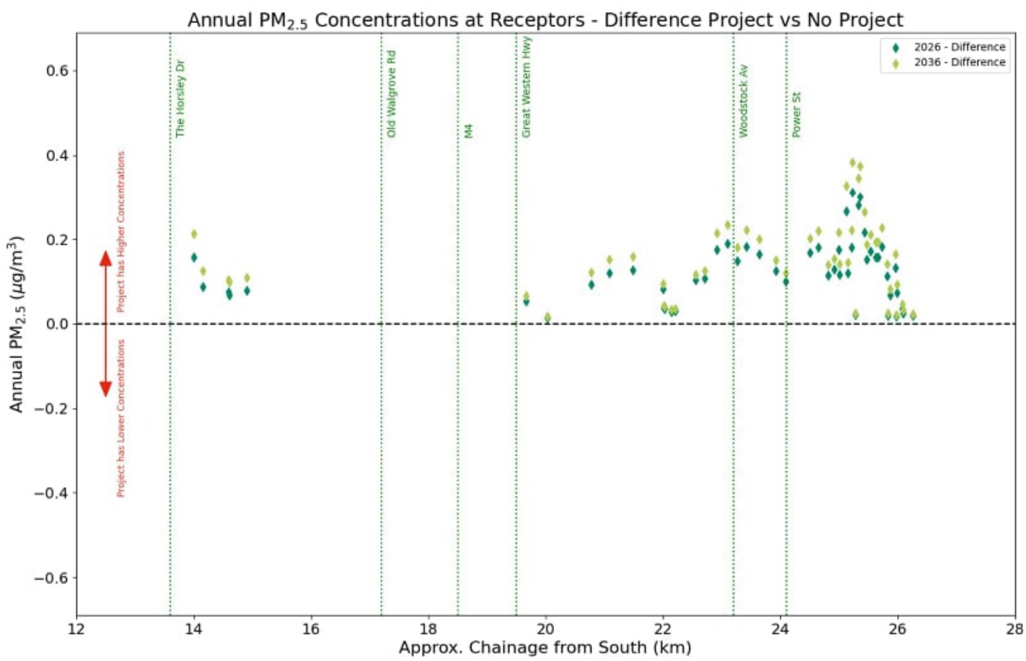


Figure 7-34 North Domain: predicted difference between project and no project annual average $PM_{2.5}$ contributions

7.1.4.3 Incremental health assessment ($\Delta PM_{2.5}$)

As discussed in Section 5.2.4.2 existing annual average $PM_{2.5}$ concentrations are already elevated within the study area. As such recommended incremental guidelines in *An Australian incremental* *guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions* (Capon, A. & Wright J. 2019) have been used to assess the impact of $PM_{2.5}$ from the Proposed Modification.

Based on the guidelines as described in **Table 3-6** the following $\Delta PM_{2.5}$ categories have been used to define the level of risk from the Proposed Modification:

- **Negligible Risk** for $\Delta PM_{2.5}$ < 0.02µg
- **Acceptable Risk** for $\Delta PM_{2.5}$ between 0.02 - 0.17µg
- **Tolerable Risk** for $\Delta PM_{2.5}$ between 0.17 – 1.7µg
- **Unacceptable Risk** for $\Delta PM_{2.5}$ between >1.7µg

Figure 7-30 and **Figure 7-34** above show changes in predicted annual $PM_{2.5}$ concentrations for the Proposed Modification for 2026 and 2036 at sensitive receptors; also referred to as the predicted $\Delta PM_{2.5}$. Both **Figure 7-30** and **Figure 7-34** show that the at the worst affected sensitive receptors occur in 2036 with an annual $\Delta PM_{2.5}$ just under 0.4 µg putting them at the lower end of the tolerable risk category. Most sensitive receptors for both 2026 and 2036 have a predicted annual $\Delta PM_{2.5}$ of less than 0.2 µg and are more likely to experience annual average $PM_{2.5}$ concentrations changes within the acceptable risk category. There are no sensitive receptors with an annual $\Delta PM_{2.5}$ value that places it within the unacceptable risk category.

Predicted annual $\Delta PM_{2.5}$ values for gridded receptors for 2026 and 2036 shown in **Figure 7-35** for the southern domain and **Figure 7-36** for the northern domain with contours based on the four risk categories. Within the study area most ground level annual average $\Delta PM_{2.5}$ values fall within the negligible risk category; with higher annual $\Delta PM_{2.5}$ values closer to the kerb of the Westlink M7 classified as acceptable risk. While not easily visible in **Figure 7-30** and **Figure 7-34** due to the scale of the study area shown some smaller areas close to the road corridor fall within the tolerable risk category as discussed for sensitive receptors above. For most of the study area however the potential health risk associated with the Proposed Modification in relation annual average $\Delta PM_{2.5}$ negligible to acceptable.

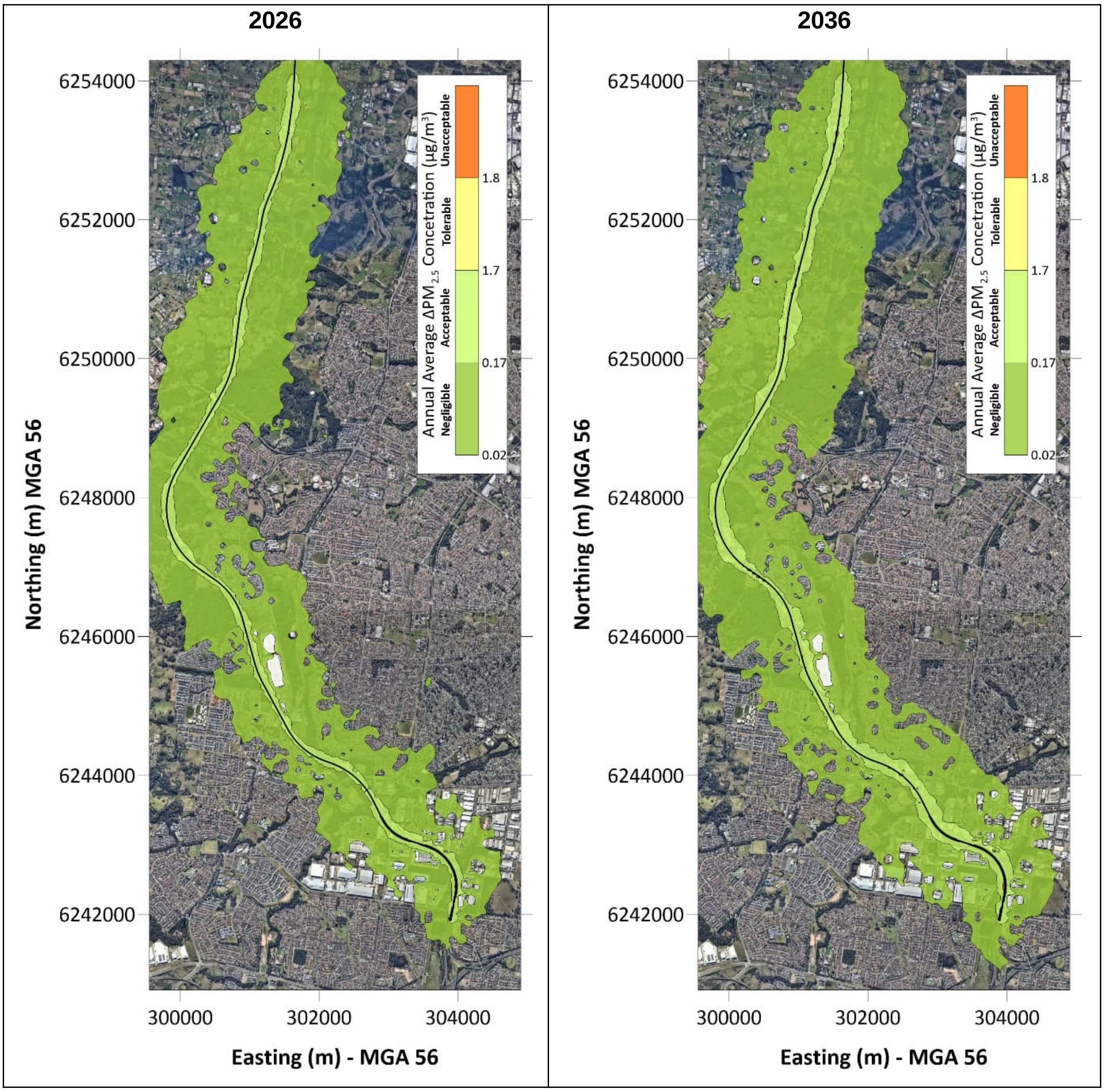


Figure 7-35 Predicted annual delta $PM_{2.5}$ contours for South Domain

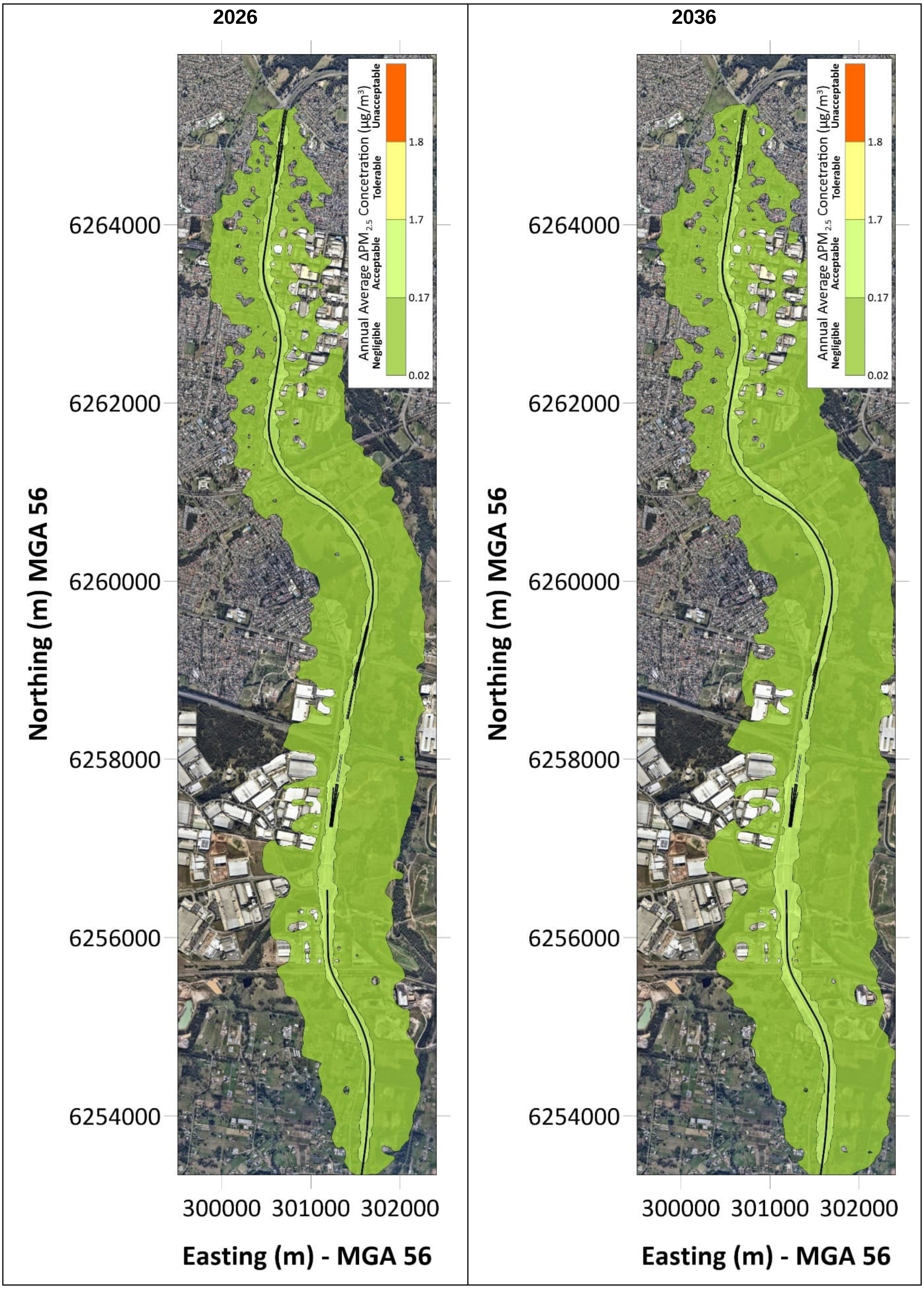


Figure 7-36 Predicted annual delta $PM_{2.5}$ contours for North Domain

7.1.5 Volatile organic compounds (VOCs)

The following section provides a discussion on predicted change in the 1 hour 99.9th percentile ground level concentrations for VOCs at sensitive receptors. Predicted VOC ground level concentrations are discussed within the context of the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposal; for the design opening year (2026) and ten years after opening (2036.)

Of the VOC's listed key pollutants of interest listed in **Section 2.2.2** benzene and formaldehyde have the lowest 1-hour 99th percentile criteria of 29µg/m^3 and 20µg/m^3 respectively of all the VOC's. For brevity results analysis is focused on these pollutants in this Section with results for toluene, acetaldehyde, xylene and 1,3 butadiene reported in **Appendix I**.

Section 7.1.5.1 provides a detailed discussion on the predicted changes 1 hour 99.9th percentile concentrations for benzene and formaldehyde within the Southern Domain and **Section 7.1.5.2**. discussed predicted VOC ground level concentrations in the northern domain. Comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to EPA criteria for benzene and formaldehyde. A summary of the change in predicted changes in VOC ground level concentrations at sensitive receptors for the study area is also provided in the text box below.

Predicted road contributions (incremental contributions) for VOCs for all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

Analysis of changes in contribution of predicted 1-hour 99.9th percentile benzene and formaldehyde concentrations indicate there is no significant difference in predicted ground level VOC concentrations at sensitive receptors with or without the Proposed Modification for 2026 and 2036. Predicted changes in contribution for both benzene and formaldehyde were found to be less than one percent of the individual VOC species criteria.

Potential decreases for all future scenarios when compared to exiting baseline VOC concentrations at sensitive receptors were also observed. These changes are discussed are attributed to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emission standards, and reduced number of aging vehicles with lower emission standards. Predicted incremental 1-hour 99.9th percentile benzene and formaldehyde concentrations within the northern domain are well below EPA criteria at all sensitive receptors and is discussed further in **Appendix I**. Predicted incremental 1-hour 99.9th percentiles for toluene, acetaldehyde, xylene and 1,3 butadiene are also presented in **Appendix I**

7.1.5.1 Southern domain

Benzene

Predicted changes in 1-hour 99.9th percentile concentrations for benzene 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-37** for the Southern Domain.

Figure 7-37 shows that predicted 1-hour 99.9th percentile concentrations for benzene at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled baseline concentrations. Projected ground level concentrations for 2036 are also slightly lower for both Scenario 4 and Scenario 5. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

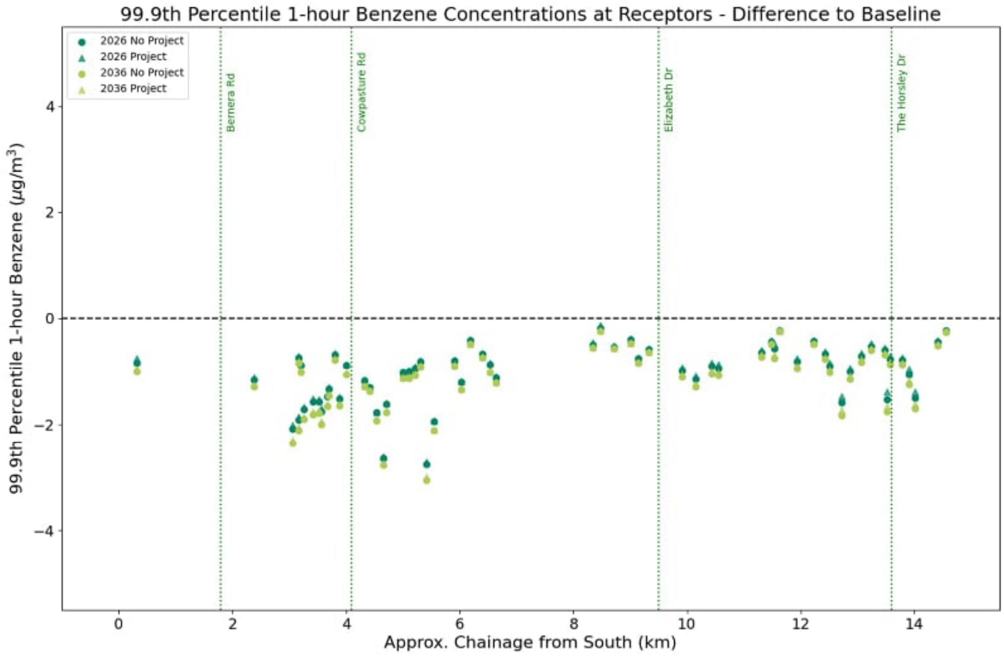


Figure 7-37 South Domain: predicted changes in 99.9th%ile 1-hour benzene contribution from baseline

Predicted changes in the 1-hour 99.9th percentile benzene contributions between the Proposed Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-38 shows that predicted change in benzene concentration between the Proposed Modification and without the Proposed Modification are generally in the order of ±0.1µg/m^3, which equates to less than one percent of the EPA criterion of 29 µg/m^3. The predicted change in benzene contribution associated with the Proposed Modification at sensitive receptors is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile benzene concentrations at sensitive receptors within the southern domain were well below EPA criteria and is discussed further in **Appendix I**.

Figure 7-38 South Domain: predicted difference between project and no project 99.9th%ile 1-hour benzene contributions

Formaldehyde

Predicted changes in 1-hour 99.9th percentile concentrations for formaldehyde 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against existing concentrations (Scenario 1) in **Figure 7-39** for the Southern Domain.

Figure 7-39 shows that predicted 1-hour 99.9th percentile concentrations for formaldehyde at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled existing concentrations. Projected ground level concentrations for 2036 are also slightly lower both with and without the Proposed Modification. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

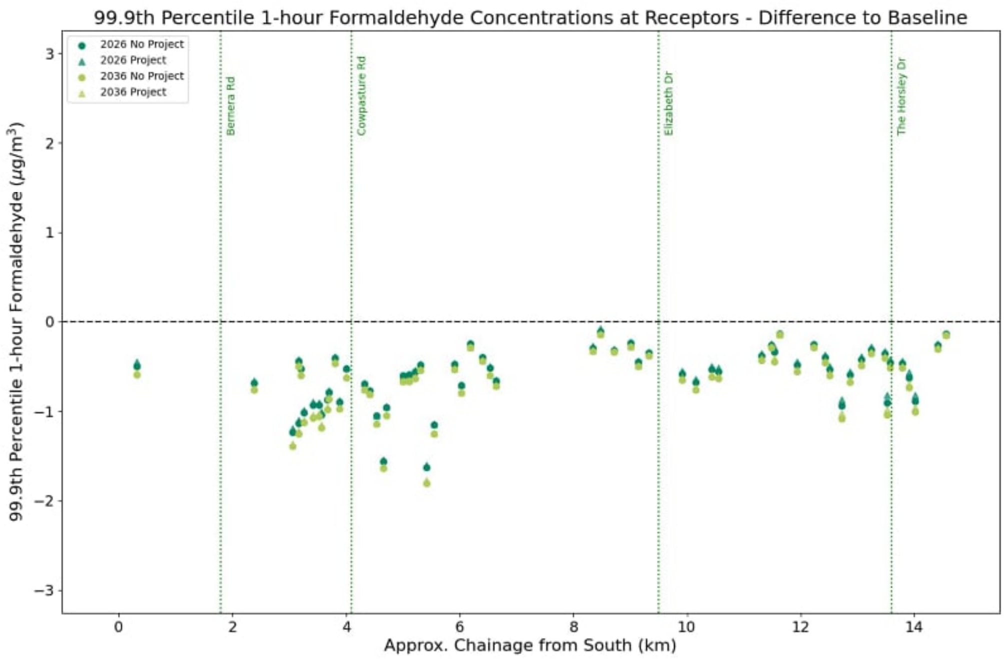


Figure 7-39 South Domain: predicted changes in 99.9th%ile 1-hour formaldehyde contribution from baseline

Predicted changes in the 1-hour 99.9th percentile formaldehyde contributions between the Proposed Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-40 shows that predicted change in formaldehyde concentration between the Proposed Modification and without the Proposed Modification are generally in the order of ±0.1µg/m^3, which equates to less than one percent of the EPA criterion of 20 µg/m^3. The predicted change in formaldehyde contribution associated with the Proposed Modification at sensitive receptors is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile formaldehyde concentrations at sensitive receptors within the southern domain were well below EPA criteria and is discussed further in **Appendix I**.

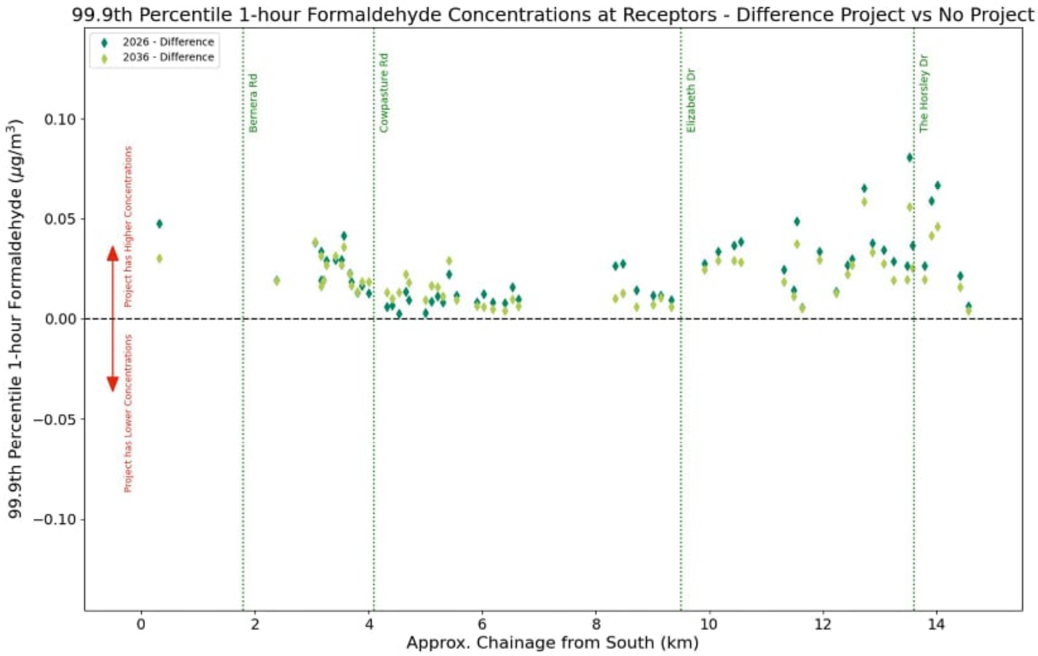


Figure 7-40 South Domain: predicted difference between project and no project 99.9th%ile 1-hour formaldehyde contributions

7.1.5.2 Northern domain

Benzene

Predicted changes in 1-hour 99.9th percentile concentrations for benzene 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-41** for the Northern Domain.

Figure 7-41 shows that predicted 1-hour 99.9th percentile concentrations for benzene at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled baseline concentrations. Projected ground level concentrations for 2036 are also slightly lower for both Scenario 4 and Scenario 5. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

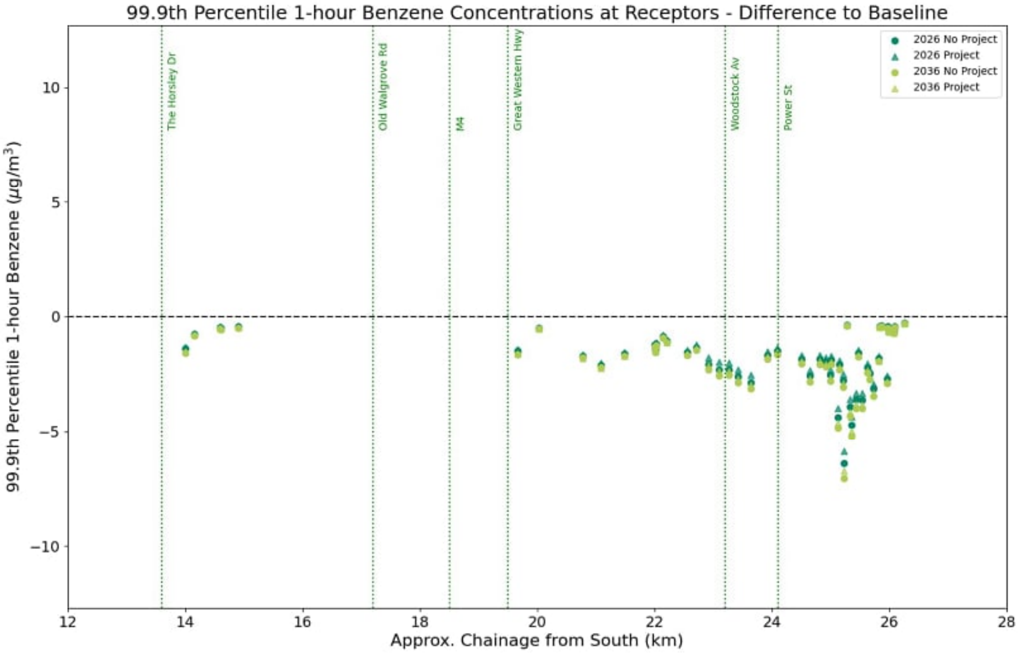


Figure 7-41 North Domain: predicted changes in 99.9th%ile 1-hour benzene contribution from baseline

Predicted changes in the 1-hour 99.9th percentile benzene contributions between the Proposed Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-42 shows that predicted change in benzene concentration between the Proposed Modification and without the Proposed Modification are generally in the order of ±0.2µg/m^3, which equates to less than one percent of the EPA criterion of 29 µg/m^3. The predicted change in benzene contribution associated with the Proposed Modification at sensitive receptors in the northern domain is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile benzene concentrations at sensitive receptors within the northern domain were well below EPA criteria and is discussed further in **Appendix I**.

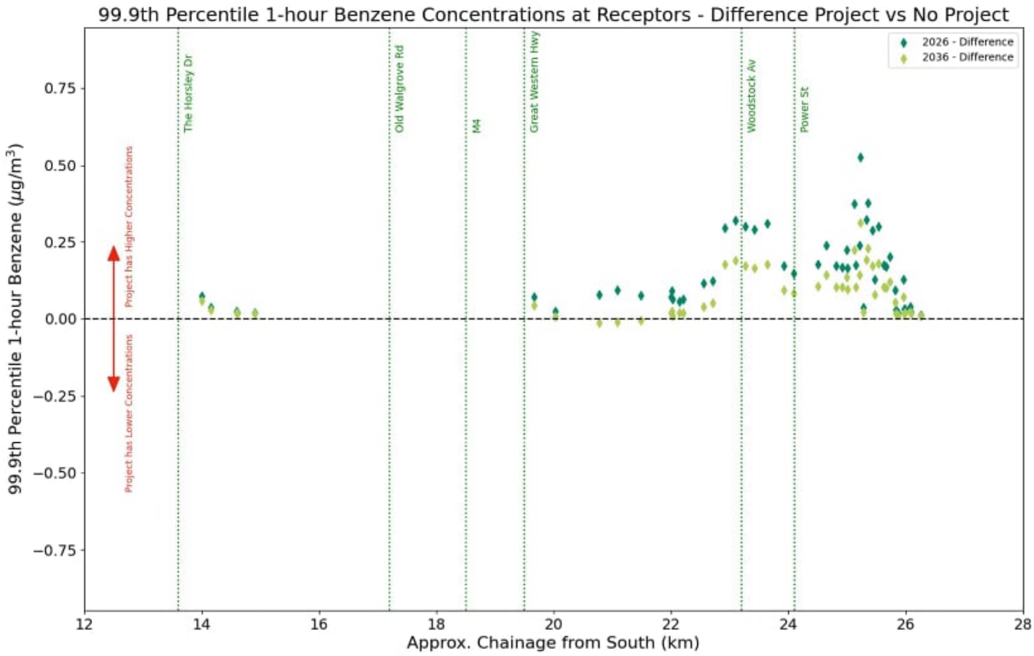


Figure 7-42 North Domain: predicted difference between project and no project 99.9th%ile 1-hour benzene contributions

Formaldehyde

Predicted changes in 1-hour 99.9th percentile concentrations for formaldehyde 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against existing concentrations (Scenario 1) in **Figure 7-43** for the Southern Domain.

Figure 7-43 shows that predicted 1-hour 99.9th percentile concentrations for formaldehyde at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled existing concentrations. Projected ground level concentrations for 2036 are also slightly lower both with and without the Proposed Modification. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

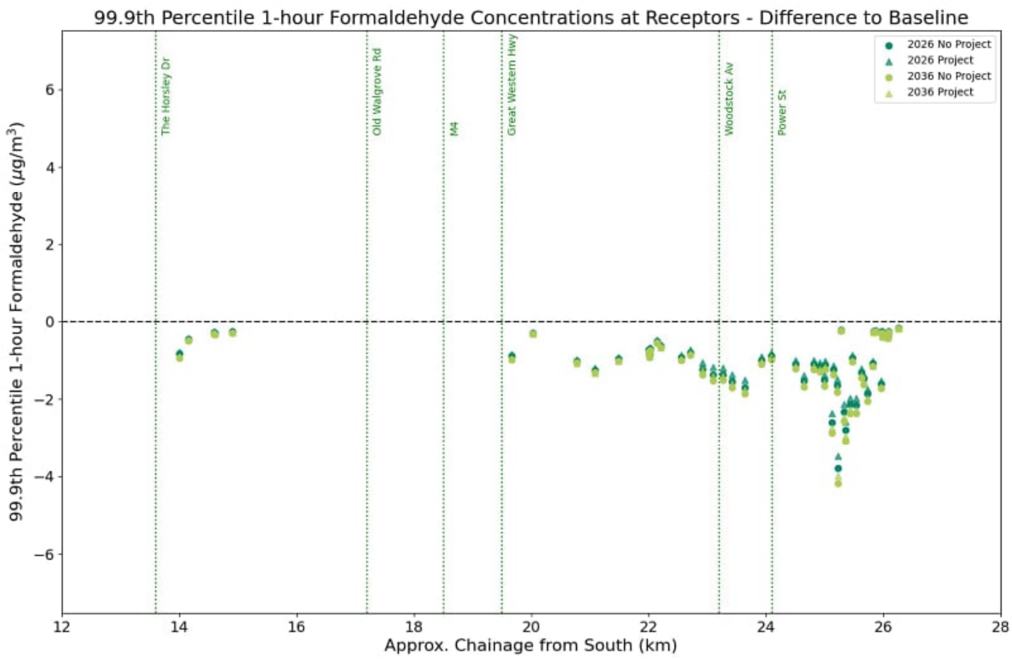


Figure 7-43 **North Domain: predicted changes in 99.9th%ile 1-hour formaldehyde contribution from baseline**

Predicted changes in the 1-hour 99.9th percentile formaldehyde contributions between the Proposed Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-44 shows that predicted change in formaldehyde concentration between the Proposed Modification and without the Proposed Modification are generally in the order of ±0.15µg/m^3, which equates to less than one percent of the EPA criterion of 20 µg/m^3. The predicted change in benzene contribution associated with the Proposed Modification at sensitive receptors is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile formaldehyde concentrations at sensitive receptors within the southern domain were well below EPA criteria and is discussed further in **Appendix I**.

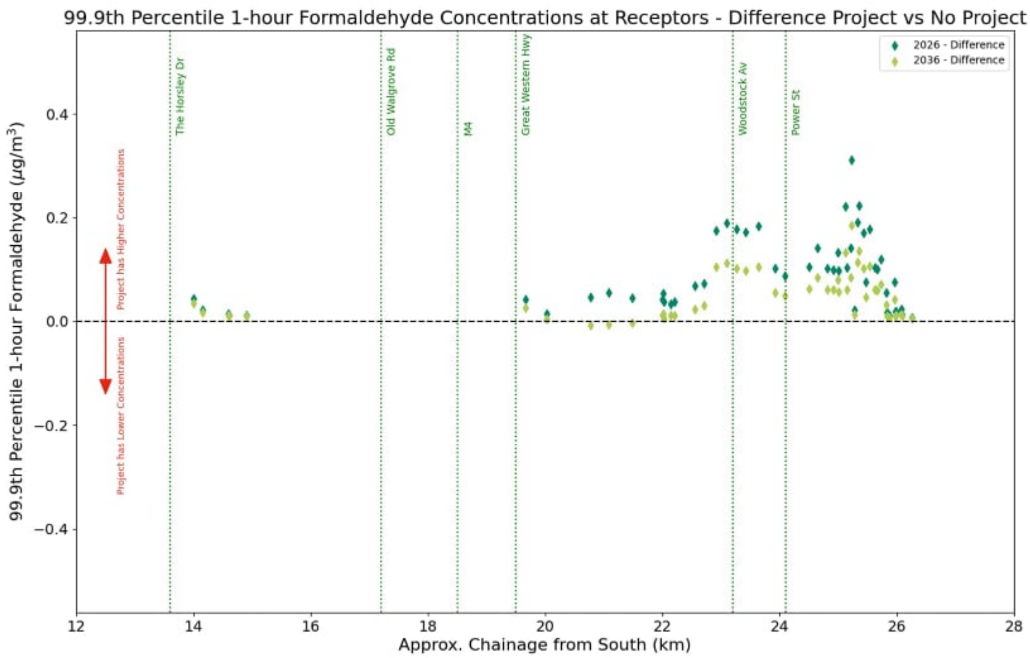


Figure 7-44 North Domain: predicted difference between project and no project 99.9th%ile 1-hour formaldehyde contributions

7.1.6 Polycyclic aromatic hydrocarbons (PAHs)

The following section provides a discussion on predicted change in the 1 hour 99.9th percentile ground level concentrations for total PAHs at sensitive receptors. Total PAHs reported have been expressed as benzo[a]pyrene (BaP) calculated using the potency equivalency factors for PAHs as described in **Section 4.2.5.2**. Modelled PAH ground level concentrations are discussed based on the difference between the Proposed Modification and existing baseline conditions; as well as the differences with and without the Proposal; for the design opening year (2026) and ten years after opening (2036).

Section 7.1.6.1 provides a detailed discussion on the predicted changes 1 hour 99.9th percentile concentrations for benzene and formaldehyde within the Southern Domain and **Section 7.1.6.2**. discussed predicted PAH ground level concentrations in the northern domain. Comparison of predicted ground level concentrations with and without the Proposed Modification are assessed based on the relative percentage change in relation to EPA criteria for PAHs (as BaP).

Predicted road contributions (incremental contributions) for PAHs for all modelled scenarios are assessed against relevant EPA criteria in **Appendix I**.

Summary of potential impacts

Analysis of changes in contribution of predicted 1-hour 99.9th percentile benzene and formaldehyde concentrations indicate there is no significant difference in predicted ground level total PAH concentrations (as BaP equivalent) at sensitive receptors with or without the Proposed Modification for 2026 and 2036. Predicted changes in contribution for total PAHs were found to be less than one percent of the EPA criteria.

Potential decreases for all future scenarios when compared to exiting baseline PAH concentrations at sensitive receptors were also observed. These changes are discussed are attributed to anticipated changes in vehicle fleets, with expected increased uptake in vehicles with more stringent emission standards, and reduced number of aging vehicles with lower emission standards. Predicted incremental 1-hour 99.9th percentile PAH concentrations within the northern domain are well below EPA criteria at all sensitive receptors and is discussed further in **Appendix I** of this report.

7.1.6.1 Southern domain

Predicted changes in 1-hour 99.9th percentile concentrations for PAHs (as BaP) 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-45** for the Southern Domain.

Figure 7-45 shows that predicted 1-hour 99.9th percentile concentrations for PAHs at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled baseline concentrations. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

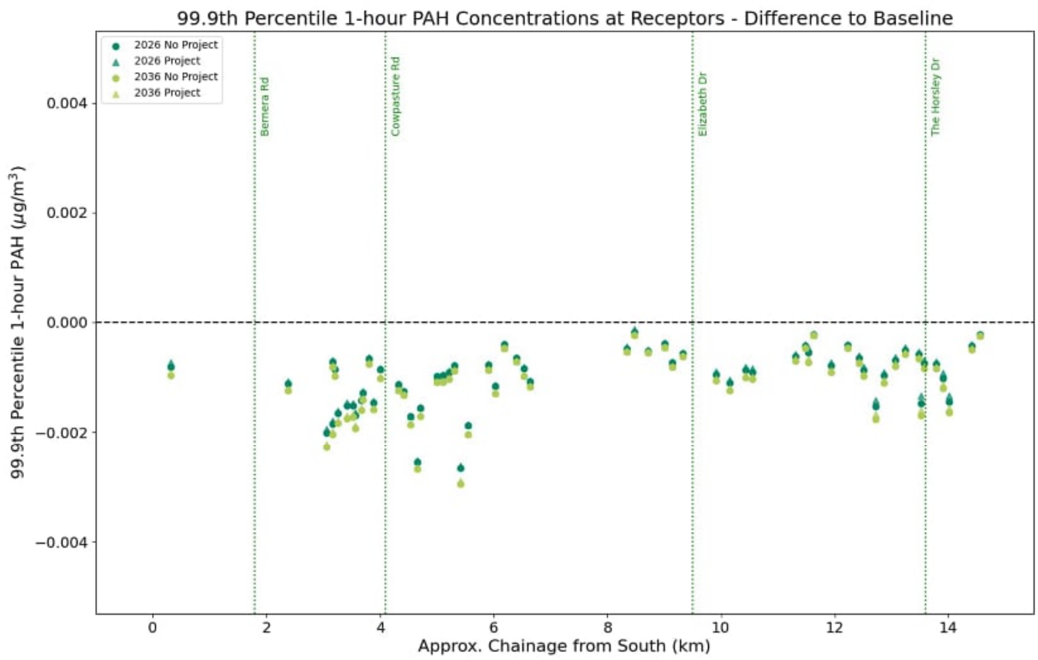


Figure 7-45 **South Domain: predicted changes in 99.9th%ile 1-hour PAH (as BaP) contribution from baseline**

Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-46 shows that predicted change in total PAH (as BaP) concentration between the Proposed Modification and without the Proposed Modification are generally in the order of 0.0001µg/m^3, which equates to less than one percent of the EPA criterion of 0.4 µg/m^3. The predicted change in PAH contribution associated with the Proposed Modification at sensitive receptors is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile total PAH concentrations at sensitive receptors within the southern domain were well below EPA criteria and is discussed further in **Appendix I**.

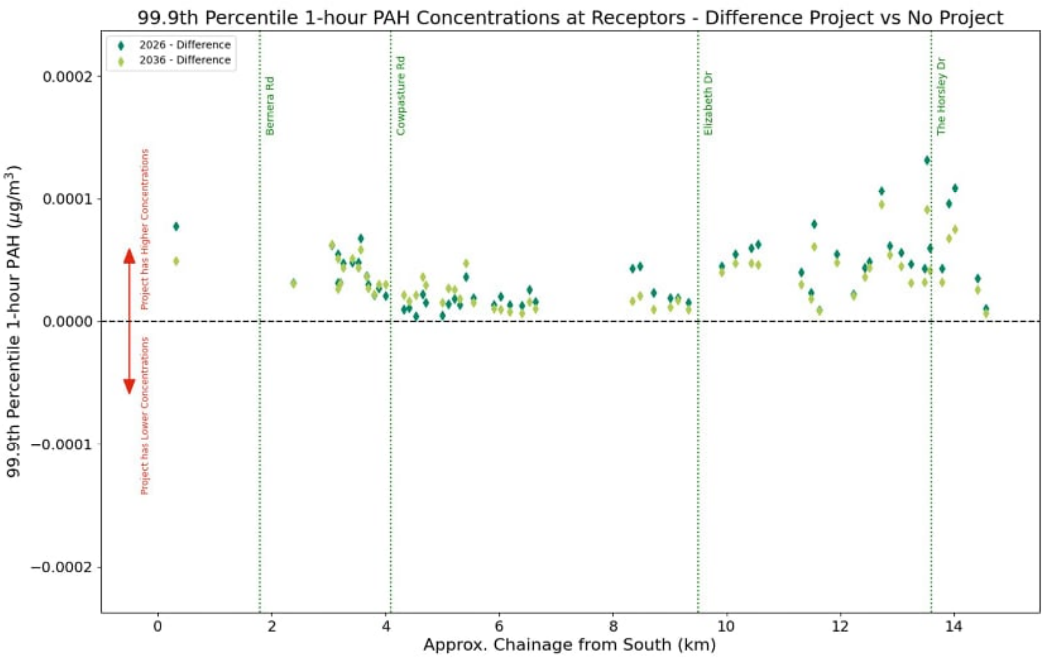


Figure 7-46 **South Domain: predicted difference between project and no project 99.9th%ile 1-hour PAH (as BaP) contributions**

7.1.6.2 Northern Domain

Predicted changes in 1-hour 99.9th percentile concentrations for total PAH (as BaP) 2026 and 2036 with and without the Proposed Modification at sensitive receptors have been plotted against baseline concentrations (Scenario 1) in **Figure 7-47** for the Northern Domain.

Figure 7-47 shows that predicted 1-hour 99.9th percentile concentrations for total PAH at sensitive receptors for 2026 and 2036 with and without the Proposed Modification are lower than modelled baseline concentrations. Predicted decreases in future scenarios are primarily associated with lower emission factors associated with uptake of vehicles which adhere to more stringent emission standards as discussed in **Section 4.2.5**.

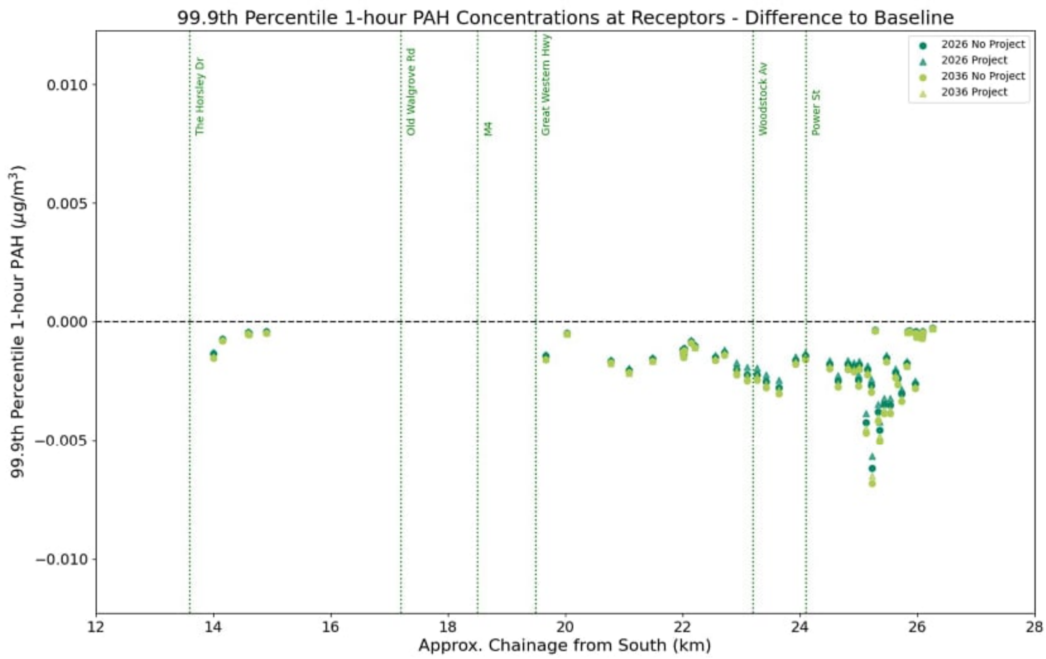


Figure 7-47 **North Domain: predicted changes in 99.9th%ile 1-hour PAH (as BaP) contribution from baseline**

Predicted changes in the 1-hour 99.9th percentile benzene contributions between the Proposed Modification and 'Do nothing' option for 2026 and 2036; were also reviewed to assess the potential impacts from the Proposed Modification.

Figure 7-48 shows that predicted change in total PAHs (as BaP equivalent) concentration between the Proposed Modification and without the Proposed Modification are generally in the order of 0.0005 µg/m^3, which equates to less than one percent of the EPA criterion of 0.4 µg/m^3. The predicted change in PAH contribution associated with the Proposed Modification at sensitive receptors in the northern domain is therefore considered negligible.

Predicted incremental 1-hour 99.9th percentile PAH concentrations at sensitive receptors within the northern domain were well below EPA criteria and is discussed further in **Appendix I**.

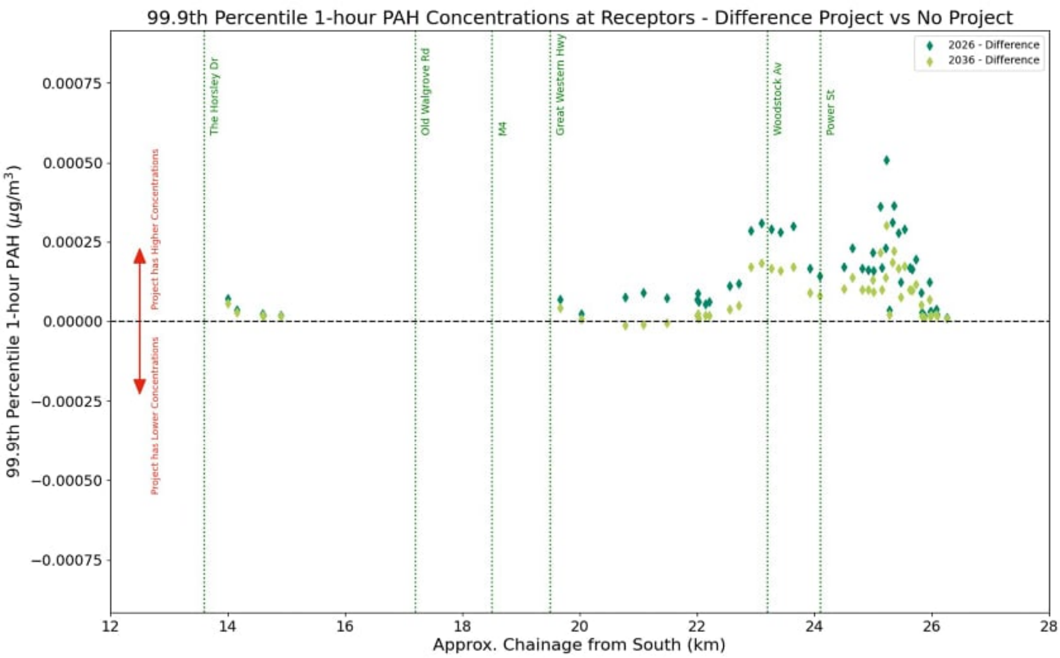


Figure 7-48 North Domain: predicted difference between project and no project 99.9th%ile 1-hour PAH (as BaP) contributions

7.2 Traffic Network Analysis

The results of the air dispersion modelling conducted for the Proposed Modification as discussed in **Section 7.1** and Appendix I are based on estimated vehicle emissions from traffic along the mainline of the M7 motorway along with the emissions associated with the onramp and off-ramps. This section provides a qualitative analysis of changes to the road network surrounding the M7 as discussed in **Section 4.2.6**.

A key objective of the Proposed Modification as well as for other approved (or proposed) road upgrade projects within the surrounding network as discussed in **Section 4.3** and **Section 7.3** is to improve network efficiency. Upgrading or improving the existing road network; can reduce congestion and associated vehicle emissions within some areas of the network. Changes in traffic numbers as part of road infrastructure upgrades may also influence the spatial distribution of air pollutants within a local air shed.

Traffic modelling has predicted that there would be an increase in road traffic on the Westlink M7 as a direct result of the widening of the M7 as discussed in **Section 4.2.5**. This increase in traffic has resulted in the air pollutant predictions at several locations showing a negligible to small increase in pollutant concentrations at sensitive receptors (despite an increase in vehicle speed and efficiency) as discussed in **Section 7.1** and **Appendix I.** This is purely due to increased traffic numbers on the M7 close to these receptor locations (speed changes were examined to understand the sensitivity of the predictions to speed, which showed only a minor effect on the overall findings).

The modelled results which show a negligible to small increase in pollutant concentrations does not include the potentially beneficial changes in road traffic volumes in the surrounding road network which may be influenced by the proposed widening of the Westlink M7. It would be expected that in the airshed immediately surrounding the Westlink M7, that the distribution of air pollutant emissions would change as a result of the proposed modification. These changes would be expected to result in some areas experiencing higher traffic volumes and hence higher impacts while other locations would experience lower traffic numbers and hence lower pollutant concentrations as vehicles which may have used parallel routes instead use the more free-flowing Westlink M7. The effect of the proposed modification across the airshed would be expected to be broadly balanced with some areas experiencing increases while other experiencing decreases. As such, the modelling results presented above are considered conservative and actual air pollutants in some areas along the Westlink M7 would be lower than existing and modelled levels.

7.3 Cumulative impact assessment

7.3.1 Scoping assessment

Table 6-7 provides a qualitative cumulative assessment of operational impacts associated with other projects as listed in **Table 4-18** and in the modification report. It should be noted that the operational cumulative assessment should not be confused with the reporting of cumulative impacts from the Proposed Modification in Section 7.1 which refers to the incremental impacts from the Westlink M7 and background air quality concentrations.

Table 7-1 Cumulative assessment of operational Air Quality impacts with other projects

Project Name and ID	Pollutants of Interest	Cumulative Assessment
The Sydney Zoo Modification SSD-7228	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Extension of zoo operational hours is considered a traffic generating development. Any increased traffic emissions from the MOD are unlikely to result in significant cumulative impacts during operation of the Proposed Modification to Westlink M7.

Project Name and ID	Pollutants of Interest	Cumulative Assessment
Light Horse Interchange Business Hub Eastern Creek SSD-9667	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Potential traffic generating development adjacent to West link M7. Minor cumulative impacts associated with vehicle emissions. • Future businesses would be considered future sensitive receptors. • Future businesses would be considered future sensitive receptors.
Saint Peter and Paul Assyrian Primary school SSD-9210	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Potential traffic generating development adjacent to West link M7. Minor cumulative impacts associated with vehicle emissions. • School would be considered future highly sensitive receptor.
Gazorp Industrial Estate SSD-5248	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Potential traffic generating development adjacent to West link M7. Minor cumulative impacts associated with vehicle emissions. • Potential emissions from industrial activities at the estate currently unknown. • Future businesses would be considered future sensitive receptors.
M12 Motorway SSI-9364	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Assessment of potential impacts from Proposed Modification in **Section 7.1** and **Appendix I** included on and off-ramps to M12 as described in **Section 4.2** and **Appendix H**. • Growth factor assumptions used to calculate traffic data for the Proposed Modification for future 2026 and 2036 modelled scenarios include road upgrades at intersection approaches including the M12. Further assessment of cumulative impacts is not required.
Mamre Road Upgrade	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Mamre Road is located 7km to the west of Westlink M7 at its closest point; cumulative impacts associated with the Mamre Upgrade would be negligible.
Sydney Metro - Western Sydney Airport SSI-10051	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Growth factor assumptions used to calculate traffic data for the Proposed Modification for future 2026 and 2036 modelled scenarios include major changes to the surrounding transport network that would affect traffic volumes on the Westlink M7.
Western Sydney Airport	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Growth factor assumptions for future 2026 and 2036 modelled scenarios used to calculate traffic data for the Proposed Modification would account for major traffic generating developments thus further assessment of cumulative impacts is not required.

Project Name and ID	Pollutants of Interest	Cumulative Assessment
Major land releases, including: • Western Sydney Aerotropolis • Southwest Growth Area • Western Sydney Employment Area. Future strategic government project	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Growth factor assumptions used to calculate traffic data for the Proposed Modification for future 2026 and 2036 modelled scenarios would account for major traffic generating developments thus further assessment of cumulative impacts is not required.
Horsley Drive upgrade	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Assessment of potential impacts from Proposed Modification in **Section 7.1** and **Appendix I** included on and off-ramps to Horsley Drive as described in **Section 4.2** and **Appendix H**. • Growth factor assumptions used to calculate traffic data for the Proposed Modification for future 2026 and 2036 modelled scenarios include road upgrades at intersection approaches. Further assessment of cumulative impacts is not required.
The Northern Road upgrade (approved and under construction) SSI-7127	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• The Northern Road is located 15km to the west of Westlink M7; cumulative impacts associated with the Mamre Upgrade would be negligible.
Horsley Drive Business Park SSD-7664-Mod-1	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Potential traffic generating development adjacent to West link M7. Minor cumulative impacts associated with vehicle emissions. • Potential emissions from industrial activities at the estate currently unknown. • Future businesses would be considered future sensitive receptors.
Moorebank Intermodal Precinct West - Stage 2 SSD-7709	NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs	• Growth factor assumptions used to calculate traffic data for the Proposed Modification for future 2026 and 2036 modelled scenarios would account for major traffic generating developments thus further assessment of cumulative impacts is not required.

<table>
<tr><th>Project Name and ID</th><th>Pollutants of Interest</th><th>Cumulative Assessment</th></tr>
<tr><td>Sydney International Speedway SSI-10048</td><td>NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs</td><td>Located approximately 1.2km east of the Westlink M7. In 2020. The Jacobs 2020 AQIA for the Speedway undertook dispersion modelling using CALPUFF to predict dust impacts from speedway racing. Particulate ground level concentrations estimated from contour plot for PM_{10} and $PM_{2.5}$ at the Westlink M7 are provided in the table below.
<table>
<tr><th>Pollutant</th><th>Averaging Period</th><th>Speedway Contribution (µg/m^3)</th></tr>
<tr><td rowspan="2">PM_{10}</td><td>24h Maximum</td><td>0.1</td></tr>
<tr><td>Annual Average</td><td>1</td></tr>
<tr><td rowspan="2">$PM_{2.5}$</td><td>24h Maximum</td><td>0.1</td></tr>
<tr><td>Annual Average</td><td>0.01</td></tr>
</table>
Of the predicted speedway contributions at Westlink M7 the most critical parameter is annual $PM_{2.5}$ ground level concentrations; from a potential health risk perspective. The incremental contribution from the Speedway at Westlink M7 is approximately 0.01µg/m^3. This equates to 0.1% of the EPA criteria of 8 µg/m^3 and from a cumulative perspective would not make a material difference to ambient air quality concentrations.</td></tr>
<tr><td>Momentum Industrial estate Modification 1 Revised Layout and Earthworks SSD-5248-Mod-1</td><td>NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs</td><td>• Potential traffic generating development adjacent to West link M7. Minor cumulative impacts associated with vehicle emissions.
• Potential emissions from industrial activities at the estate currently unknown.
• Future businesses would be considered future sensitive receptors.</td></tr>
<tr><td>Elizabeth Drive Upgrade</td><td>NO_2, CO, PM_{10}, $PM_{2.5}$, VOCs & PAHs</td><td>• Potential cumulative impacts from vehicle emissions with operation of Proposed Elizabeth Drive Upgrade.</td></tr>
</table>

7.3.2 Key project analysis

Of the above projects listed in **Table 6-7**; most are located at a distance far enough away from the Proposed Modification to not result in a material difference in cumulative ground level concentrations. Larger traffic generating developments including approved road upgrades which would influence future traffic numbers on the Westlink M7 such as the M12 have been accounted for within traffic growth factors assumptions for 2026 and 2036 modelled scenarios. Put simply changes to vehicle numbers on the Westlink M7 due to approved development that may have a significant influence on traffic numbers on the Westlink M7 both with and without the Proposed Modification have been accounted for in Modelled Scenarios described in **Section 4.2.2**. As such further assessment is not required.

The Proposed Elizabeth Drive Upgrade which intersects with the Westlink M7 may also result in potential cumulative impacts from vehicle emissions. Assessment of cumulative impacts from the Proposed Elizabeth Drive Upgrade would need to be included as part of the EIS for Elizabeth Drive as lodgement of the development application for this project is expected to occur after the Westlink M7 Proposed Modification goes on exhibition. Both the Proposed Modification of Westlink M7 and the Proposed Upgrade to Elizabeth Drive are aimed at *about improving traffic efficiency across the wider* network.

Following construction of the Momentum and Gazorp industrial estates, Light Horse Interchange business hub and Saint Peter and Paul Assyrian Primary school these facilities would be considered sensitive receptors. Predicted ground level concentrations at existing receptors for the Proposed Modification are discussed in **Section 7.1** and **Appendix I** and would be indicative of potential impacts at future receptors along the alignment. Furthermore as noted in **Section 7.1** and **Appendix I** ground level impacts for 2026 and 2036 modelled scenarios are expected to decrease when compared to existing baseline conditions.

8.0 Mitigation and management measures

This section describes performance outcomes related to air quality, and mitigation and management measures to manage potential air quality impacts from the Proposed Modification.

8.1 Performance outcomes

The performance outcomes for air quality for the Proposed Modification are as follows:

- *Air quality impacts at sensitive receptors during the construction phase would not be of unacceptable levels*
- *The operation of the Proposed Modification would generally improve existing air quality at existing hotspots*
- *The operation of the Proposed Modification would not decrease air quality by unacceptable levels at sensitive receptors*

The Proposed Modification would be designed, constructed and operated with the aim of achieving these performance outcomes.

8.2 Mitigation measures

The current Conditions of Approval (CoA) that apply to the approved project require mitigation and management measures to be implemented (either directly in the conditions or through reference to environmental management plans required).

The mitigation and management measures described in Table 8-1 have been identified to address the impacts identified as a direct result of the assessment undertaken in this report. These measures would be incorporated into existing environmental management plans where they have not been accounted for already. Proposed amendments to the CoA for the Proposed Modification are described in Chapter 7 of the modification report.

Table 8-1 Mitigation and management measures

Impact	ID	Mitigation measure	Responsibility	Timing
Complaints	AQ1	A communications plan will be displayed at each construction zone, including a duty phone number so stakeholders and community members can get in contact regarding the construction activities. All complaints will be recorded and investigated, and measures taken in response.	Construction contractor	Construction
Cumulative impacts with other projects	AQ2	On a regular basis the stages of other major constructions within 500 metres of the proposed modification will be assessed, to determine any cumulative air quality impacts. The possibility of co-ordinating activities between sites will be assessed to avoid potentially high dust impact activities occurring at the same time.	Construction contractor	Construction
Combustion emissions	AQ3	Use of diesel- or petrol-powered generators will be avoided where practicable and mains electricity or battery powered equipment will be used where practicable.	Construction contractor	Construction

Impact	ID	Mitigation measure	Responsibility	Timing
	AQ4	All vehicles and plant will be switched off engines when stationary - no idling vehicles.	Construction contractor	Construction
Dust emissions	AQ5	During periods of high potential for increased air quality impacts and/or prolonged dry or windy conditions the frequency of site inspections will be increased by the person accountable for air quality and dust issues.	Construction contractor	Construction
	AQ6	At each construction zone, the site arrangement will be planned so that dust generating activities are undertaken to minimise dust at nearby receptors. Measures may include stockpiles located as far away from receptors as possible; dust barriers being erected around dusty activities/site boundary, or similar.	Construction contractor	Construction
	AQ7	A maximum speed limit of 15 km/h on unsurfaced roads and construction work areas will be imposed and signposted.	Construction contractor	Construction
	AQ8	Adequate water supply will be provided on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Construction contractor	Construction
	AQ9	Earthworks and exposed areas/soil stockpiles will be re-vegetated or stabilised as soon as practicable.	Construction contractor	Construction
	AQ10	Water-assisted dust sweeper(s) will be used on access and local roads, to remove, as necessary, any material tracked out of the site.	Construction contractor	Construction
	AQ11	Vehicles entering and leaving sites will be covered to prevent escape of materials during transport.	Construction contractor	Construction
	AQ12	A wheel washing system will be implemented at relevant construction ancillary facilities (with rumble grids to dislodge accumulated dust and mud prior to leaving the site), where reasonably practicable.	Construction contractor	Construction
Odour	AQ13	Any acid sulphate soils encountered during earthworks will be managed in accordance with the with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998) and *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (NSW Roads and Traffic Authority 2005).	Construction contractor	Construction

9.0 Conclusion

An air quality assessment has been prepared to support the modification report and to address the relevant SEARs issued for the Proposed Modification. This report assesses the potential impacts of construction and operation of the Proposed Modification on ground level air quality concentrations at nearby sensitive receptors and identifies appropriate mitigation and management measures to address identified impacts.

Construction impact assessment

A qualitative assessment of construction impacts from the project was undertaken to assess potential impacts from construction dust, combustion emissions and odour. The qualitative dust risk assessment undertaken in accordance with the IAQM UK 2014 methodology found that unmitigated dust risks at different points along the Westlink M7 for demolition, earthworks, construction and track out were rated as medium to high for dust soiling and human health and negligible to high for ecological risks. Specific activity-based dust mitigation measures recommended to reduce dust generation should be incorporated into the construction environmental management plans. Residual dust impacts are not anticipated to be significant with the application of mitigation measures.

Qualitative assessment of combustion emissions from the projects found that given the typically transitory nature of construction traffic, as well as use of mobile and stationary plant equipment exhaust emissions it is unlikely to make a significant impact on local air quality. Typical mitigation measures for maintenance and minimising combustion emissions from construction vehicles is also recommended as part of the construction environmental management plans. A qualitative assessment of odour impacts from earthworks found that the potential for odour impacts from construction would not be significant due to the low probability of encountering acid sulphate soils.

A cumulative assessment of construction impacts identified with several nearby approved projects was also undertaken. The assessment found that most are located at a distance far enough away from the Proposed Modification construction footprint that potential cumulative impacts are expected to be negligible. Projects where there is the potential for cumulative air quality impacts include road construction works that intersect with the Westlink M7 Proposed Modification and developments adjoining the construction of commercial and industrial business parks and a primary school. Scheduled construction work for these developments may coincide with construction work for the proposed modification. Provided potential construction air quality impacts from the Proposed Modification are appropriately managed in accordance with recommend mitigation measures no significant cumulative impacts are anticipated.

Operational impact assessment

Quantitative assessment of construction impacts was undertaken as a Level 2 Assessment in accordance with the Approved Methods using the dispersion model GRAL. Modelled scenarios were included which considered both existing traffic volumes and future traffic volumes for the design opening year and ten years after opening with projected growth in traffic vehicles accounting for approved intersection upgrades including the new M12.

Modelled scenarios included:

- One ‘Baseline Scenario’ based on the 2021 existing Westlink M7 traffic operations with the existing freeway traffic lane layout
- Two ‘Do Nothing Scenarios’ for 2026 and 2036, which considered traffic volumes without the Proposed Modification and assumed an unchanged freeway traffic lane layout.
- Two ‘Proposed Modification Scenarios’ for 2026 and 2036 which included traffic volumes with the Proposed Modification and an upgraded freeway traffic lane layout (3 lanes for most of the length of the Westlink M7).

Analysis of the modelled results found that for the baseline scenario, predicted existing incremental and/or cumulative ground level concentrations at some sensitive receptors were elevated for some pollutants and in some instances exceeding the EPA criterion. Elevated pollutant concentrations included existing predicted 1-hour maximum and annual average NO_2, 24-hour maximum and annual average PM_{10} and $PM_{2.5}$ concentrations, with the highest predicted levels generally observed at the northern end of the alignment, particularly close to urban residential premises in Oakhurst and Glendenning. Existing predicted ground level concentrations for all other pollutants and averaging periods were below relevant EPA criterion.

Given that this assessment examines an upgrade to an existing roadway, the assessment of the Proposed Modification was undertaken based on a comparison between predicted existing ground level concentrations and the future ‘do-nothing’ and ‘do something’ scenarios. Results for all 2026 and 2036 scenarios showed ground level concentrations at sensitive receptors for all pollutants at lower levels than existing ground level concentrations. This overall reduction is due to the anticipated changes in vehicle fleet mix with an expected increased proportion of vehicles with more stringent emission standards and reduced number of aging vehicles with lower emission standards.

Analysis of the expected change in future pollutant concentrations show that the Proposed Modification may result in higher concentrations at sensitive receptors than are expected due to the Proposed Modification. The highest differences were observed in the northern portion of the study area, particularly near urban residential premises in Oakhurst and Glendenning. In general, however, observable changes between the ‘do-nothing’ and ‘do something’ project scenarios were relatively small when compared to the EPA criteria. Differences in the baseline and future scenarios greatly outweigh any difference between 2026 and 2036 for the ‘do-nothing’ and ‘do something’ project scenarios due to anticipated changes in vehicle fleets. This is also evident between 2026 and 2036 modelled years which show smaller difference in predicted ground level concentrations observed between the ‘do something’ and ‘do nothing’ scenario.

The Proposed Elizabeth Drive Upgrade which intersects with the Westlink M7 may result in potential cumulative impacts from vehicle emissions. Assessment of cumulative impacts from the Proposed Elizabeth Drive Upgrade would need to be included as part of the EIS for Elizabeth Drive as lodgement of the development application for this project is expected to occur after the Westlink M7 Proposed Modification goes on exhibition. Both the Proposed Modification of Westlink M7 and the Proposed Upgrade to Elizabeth Drive are aimed at about improving traffic efficiency across the wider network.

Closure

Potential air quality impacts from the Proposed Modification are considered to be minor when predicted pollutant ground level concentrations are compared with and without the Proposed Modification in 2026 and 2036. Potential impacts from construction; including cumulative impacts with construction work at adjoining intersections can also be appropriately managed though standard mitigation measures are not expected to result in significant impacts. In conclusion, construction and operational air quality impacts from the Proposed Modification of Westlink M7 are unlikely to have a significant impact of ground level air quality concentrations.

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Appendix A

Pollutants of Interest and their Effects

Appendix A Pollutants of interest and their effects

Table A-1 provides a description of the acute (short term) and chronic (long term) human and ecological health effects for the following idented pollutants of interest for the Proposed Modification:

- 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
  - Xylene
  - 1,3 butadiene
- Polycyclic Aromatic Hydrocarbons (PAHs).

Table A-1 Human and ecological health effects of ambient air pollution

Pollutant	Human Health Impacts	Environmental Impacts
Nitrogen dioxide (NO_2)	Nitrogen oxides (NOx) emitted from combustion sources are comprised mainly of nitric oxide (NO, approximately 95% at the point of emission) and nitrogen dioxide (NO2, approximately 5% at the point of emission). Nitric oxide is much less harmful to humans than NO2 and is not generally considered a pollutant with health impacts. NOx may be inhaled or absorbed through the skin. People who live in areas of high motor vehicle usage may be exposed to higher levels of nitrogen oxides. Acute exposure to low levels of NO2 can irritate eyes, nose, throat, and lungs, possibly leading to coughing, shortness of breath, tiredness and nausea. Exposure can also result in a build-up of fluid in the lungs for 1-2 days after exposure. Breathing high levels of NO2 can cause rapid burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, a build-up of fluid in the lungs, and in extreme cases death.	Excessive levels of the NOx, particularly NO2, can cause death in plants and roots and damage the leaves of many agricultural crops. NO2 is the damaging component of photochemical smog. Excessive levels increase the acidity of rain (lower the pH), and thus lower the pH of surface and ground waters and soil. The lowered pH can have harmful effects, possibly even death, on a variety of biological systems. In the atmosphere, NOx is rapidly equilibrated to NO2, which eventually forms acid rain. In the stratosphere, oxides of nitrogen play a crucial role in maintaining the levels of ozone. Concern with nitric oxide relates to its transformation to nitrogen dioxide and its role in the formation of photochemical smog.
Carbon monoxide (CO)	Carbon monoxide can enter the body by inhalation and be rapidly absorbed by the bloodstream from the lungs. Typical levels in urban and rural areas are however, unlikely to cause ill effects. People can be exposed to CO through using malfunctioning equipment and using poorly vented vehicles. Acute exposure to levels of 200 parts per million (ppm) or more for 2 to 3 hours can lead to headache, dizziness, light-headedness and fatigue. Exposure to higher concentrations (say, 400 ppm or more) of CO can cause sleepiness, hallucinations, convulsions, collapse, loss of consciousness and even death. It can also cause personality and memory changes, mental confusion and loss of vision. Extremely high exposures to carbon monoxide can cause the formation of carboxyhaemoglobin and decrease the body's ability to transport oxygen. This can cause a bright	Carbon monoxide, through complex atmospheric chemical reactions, can affect the amount of other greenhouse gases, which are linked to climate change. Additionally, high levels of CO may cause adverse health impacts for birds and animals, similar to the effects are experienced by humans, although high levels are unlikely to be experienced in rural environments, except in extreme events such as bushfires.

Pollutant	Human Health Impacts	Environmental Impacts
	red colour to the skin and mucous membranes causing trouble breathing, collapse, convulsions, coma and possibly death. Long term (chronic) health effects can occur from exposure to low levels of carbon monoxide. These effects may produce heart disease and damage to the nervous system. Exposure of pregnant women to carbon monoxide may result in low birth weights and other defects in the offspring.	
Particulate matter	Particles within the PM_{10} fraction generally enter the body via inhalation. In the lungs particles can have a direct physical effect and/or be absorbed into the blood. Airborne particulate matter can be generated by vehicles from direct emissions from the burning of fuels (especially diesel-powered vehicles) and from wear of tyres or vehicle-generated air turbulence on roadways. Particles may also be generated from earthworks, wind erosion, and construction activities. The factors that may influence the health effects of exposure to particles include: • The chemical composition and physical properties of the particles. • The mass concentration of the airborne particles. • The size of the particles (smaller particles may be associated with more adverse effects due to increased likelihood of deep inhalation into the lungs). • The duration of exposure (acute and long term). Recent epidemiological research suggests that there is no threshold at which health effects do not occur. The health effects include irritation of mucous membranes, toxic effects by absorption of the toxic material into the blood and increased respiratory symptoms, aggravation of asthma and premature death.	Particles are easily entrained into the air by wind or disturbances. Airborne particulate matter may also react with other substances in the atmosphere, reduce visibility, increase the possibility of precipitation, fog and clouds and reduce solar radiation. Additionally, particulate matter may cause similar respiratory impacts in animals as to humans. High levels of prolonged dust deposition may lead to plant physical stress and reduced photosynthesis, respiration, and transpiration through smothering. Dust deposition may also lead to chemical changes to soils or watercourses may lead to a loss of plants or animals for example via changes in acidity

Pollutant	Human Health Impacts	Environmental Impacts
Benzene	Benzene is a VOC released into the air from sources including car exhaust, Evaporation of vehicle fuels from motors and vehicle fuel tank, smoke from tobacco and bushfires and from industry. Most people are exposed outdoors to low levels of benzene from tobacco smoke and car exhaust. Worksafe Australia classifies benzene as a toxic health hazard. Exposure can result in symptoms such as skin and eye irritations, drowsiness, dizziness, headaches, and vomiting and even death at high levels of exposure. Benzene is carcinogenic and has been linked to leukemia. Chronic exposure at various levels can affect normal blood production and can be harmful to the immune system. Benzene has also been linked with birth defects in animals and humans.	Benzene has a high acute toxic effect on aquatic life. Long-term effects on marine life can mean shortened lifespan, reproductive problems, lower fertility and changes in appearance or behaviour. It can cause death in plants and roots and damage to the leaves of many agricultural crops. Benzene is a precursor to hydrocarbon leading to the formation of photochemical smog. It generally breaks down in the atmosphere over a few days and reacts with other chemicals in the atmosphere to produce phenol, nitrophenol, nitrobenzene, formic acid and peroxyacetyl nitrate. Precipitation can also remove benzene from the air before evaporating, continuing to pollute the air
Formaldehyde	Vehicle exhaust is a major source of formaldehyde. Acute exposure to low levels of formaldehyde can cause eyes, nose and throat irritation and allergies affecting the skin and lungs. Higher exposure levels can cause throat spasms and a build-up of fluid in the lungs, leading to death. Formaldehyde can cause an asthma-like respiratory allergy causing shortness of breath, wheezing, cough and/or chest tightness. Repeated exposures may cause bronchitis, with coughing and shortness of breath. Formaldehyde has also been identified as a potential carcinogen.	In air, formaldehyde decomposes relatively quickly (within 24 hours) to form formic acid and carbon monoxide. Formaldehyde does not bioaccumulate in plants and animals. Chronic effects in animals may include shortened lifespan, reproductive problems, lower fertility and changes in appearance or behaviour. Chronic effects can be seen a long time after first exposure to a toxic chemical. Formaldehyde has high chronic toxicity to aquatic life. Formaldehyde may cause cancer and other chronic illnesses in rodents. Birds and terrestrial animals exposed to formaldehyde could contract similar diseases. Insufficient data are available to evaluate or predict the long-term effects of formaldehyde in plants.

Pollutant	Human Health Impacts	Environmental Impacts
Toluene	Toluene is VOC used as a component of petrol and in paints and cleaning agents. Exposure to toluene is most likely to occur through vehicle emissions, cigarette smoke or use of consumer products such as paint or varnish. Toluene generally breaks down in the atmosphere after a few days. Acute exposure to toluene results first in light-headedness and euphoria, followed by dizziness, sleepiness, unconsciousness, and in some cases death. Long-term exposures at low levels can result in kidney damage and permanent brain damage including problems with speech, vision, and hearing, loss of muscle control, loss of memory and balance and reduced scores of psychological tests.	Toluene is moderate acute and chronic toxicity to aquatic organisms. Chronic and acute effects on birds or land animals have not been determined. Toluene is expected to minimally bioaccumulate. Toluene can also cause membrane damage to the leaves in plants.
Acetaldehyde	Acetaldehyde is a VOC and sources of acetaldehyde include fuel combustion emissions from stationary internal combustion engines and power plants that burn fossil fuels, wood, or trash, oil and gas extraction, refineries, cement kilns, lumber and wood mills and paper mills. Acetaldehyde in the air degrades rapidly in a matter of hours due to photochemical oxidation and reaction with hydroxyl radicles and is therefore unlikely to be transported far from the emission source. Acetaldehyde is an irritant of the skin, eyes, mucous membranes, throat and respiratory tract. Symptoms of exposure to this compound include nausea, vomiting, headache, dermatitis and pulmonary oedema. It has a general narcotic action and large doses cause death by respiratory paralysis. It may also cause drowsiness, delirium, hallucinations and loss of intelligence. Exposure may also cause slow mental response, severe damage to the mouth, throat and stomach; accumulation of fluid in the lungs, chronic respiratory disease, kidney and liver damage, throat irritation, dizziness, reddening and swelling of the skin and sensitisation. It may cause photophobia and is a potential carcinogen.	In sufficient concentrations acetaldehyde can affect animals in a similar way to humans.

Pollutant	Human Health Impacts	Environmental Impacts
Xylene	Xylene is an aromatic volatile organic compound chemicals produced during incomplete combustion of fossil fuels. Other sources include commercial and household painting and woodfire heaters. Xylenes may irritate the eyes, nose and throat. They may cause stomach problems, drowsiness, loss of memory, poor concentration, nausea, vomiting, abdominal pain and incoordination. High levels may cause dizziness, passing out, and death. Repeated exposures may damage bone marrow, which causes a low blood cell count. Xylenes may damage a developing foetus.	Xylene has high acute (short-term) and chronic (long-term) toxicity to aquatic life and can bioaccumulate in fish. There is not sufficient data to predict the acute or chronic toxicity of xylene on birds or land animals. Xylene can also cause injury to various agricultural and ornamental crops
1,3 butadiene	1-3 butadiene is a volatile organic compound and is formed as a product of incomplete combustion of fossil fuels and biomass. The main sources of 1-3 butadiene are from vehicle emissions and cigarette smoke. Although 1,3-butadiene breaks down quickly in the atmosphere, it is usually found in ambient air at low levels in urban and suburban areas. Acute exposure at low levels can lead to irritation of the eyes, throat, nose, and lungs and at high levels can cause damage to the central nervous system or cause symptoms such as distorted blurred vision, vertigo, general tiredness, decreased blood pressure, headache, nausea, decreased pulse rate, and fainting. Long term exposure to 1,3-butadiene may lead to increased risk of cardiovascular diseases and cancer.	1-3-Butadiene has moderate acute (short-term) and slight chronic (long term) toxicity to aquatic life. Long term exposure to 1-3 butadiene may cause adverse health impacts for birds and animals, like the effects are experienced by humans,

Pollutant	Human Health Impacts	Environmental Impacts
Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs comprise of over 100 different chemicals produced during incomplete combustion of fossil fuels, garbage or other organic material. Key sources of PAHs include vehicle emissions, cigarette smoke and residential woodfires and bushfires. PAHs in air are usually not found singularly, but as mixtures with many different types present at the same time. This makes assessing the health effects of individual PAHs very difficult. Short term exposure effects from PAHs include eye and skin irritation, nausea and vomiting, diarrhoea and confusion. Long term exposure effects from chronic or long-term exposure to PAHs include cataracts, kidney and liver damage and skin damage and photosensitisation (sensitisation to light). Long term exposure also increases the risk of skin, lung and bladder cancer as well as gastrointestinal issues.	PAHs can be toxic for aquatic organisms and birds. Studies have shown animals exposed to levels of some PAHs over long periods long term have developed lung cancer from inhalation, stomach cancer from ingesting PAHs in food and skin cancer from skin contact. PAH contamination also has an adverse effect on water and nutrient uptake by plants by impacting seed germination, plant establishment and growth.

Appendix B

Vehicle Emission Regulation and Strategies

Appendix B Vehicle emission regulation and strategies

Overview

This annexure provides a description of the relevant government strategies and legislation used to regulate vehicle emissions in Australia. Specifically, it provides:

- a description of important federal and NSW state government strategies to promote reductions in vehicle emissions through cleaner transport, engines, and fuels.
- a list of key federal legislation, regulations, and standards used to regulate light and heavy on-road vehicle emission standards in Australia.

Strategies

Future Fuels and Vehicles Strategy: Powering Choice 2021 (Cth)

The Australian Governments Department of Industry, Science, Energy and Resources (DISER) released the *Future Fuels and Vehicles Strategy: Powering Choice* (DISER 2021) in November 2021. The strategy sets out how the Australian Government aim to support a technology-led approach to reduce emissions in the transport sector by enabling the private sector to commercially deploy low emissions road transport technologies at scale. The government aims to leverage more private sector investment by focusing on the following four streams of key infrastructure and technology investment:

- Public electric vehicle charging and hydrogen refuelling infrastructure
- Heavy and long-distance vehicle fleets
- Light vehicle commercial fleets
- Household smart charging.

In partnership with the private sector the strategy focuses on five priority initiatives to address barriers and provide confidence to consumers to support the uptake of low emission vehicles including:

- Electric vehicle charging and hydrogen refuelling infrastructure where it is needed to:
- Early focus on commercial fleets.
- Improving information for motorists
- Integrating battery electric vehicles into the electricity grid
- Supporting Australian innovation and manufacturing.

The five initiatives support the uptake of low emissions road transport technologies, which would intern alter the future fleet makeup on Australian Roads and support *Australia's Long Term Emission Reduction Plan 2021*

NSW Clean Air Strategy 2021-2030 (NSW)

The *NSW Clean Air Strategy 2021-2030* (DPE 2022) aims to promote ongoing reductions in air quality impacts in NSW by:

- Setting out the evidence that underpins and guides NSW Government action on air quality
- Outlining existing policy, regulatory framework and the measures aimed at managing air quality
- Proposing actions to achieve further health gains for communities across NSW.

The strategy identifies five key actions to improve outcomes for air quality and health including:

1. Better preparedness for pollution events.
2. Cleaner industry
3. Cleaner transport, engines, and fuels

4. Healthier households
5. Better places.

Proposed actions relating to the transport sector under Action 3 include:

- Integrating air quality improvements into transport planning, programs, and projects.
- Progress policies and incentives to increase uptake of zero and low exhaust emission vehicles
- Support sustainable, healthy, and smart travel choices
- Improve regulation of vehicle and fuel emissions
- Drive emission reductions from non-road diesel vehicles and equipment.

NSW Electric Vehicle Strategy 2021-2030 (NSW)

The *NSW Electric Vehicle Strategy 2021* (DPE 2021) was developed by the NSW government to accelerate the states vehicle fleet of the future. The strategy outlines the NSW's governments key strategies to increase the uptake of electric vehicles. These include:

- Reducing upfront costs of electric vehicles by introducing rebates, removal of stamp duty and providing fleet incentives
- Developing a world class electric vehicle charging network by investing in ultra-fast charging infrastructure and destination infrastructure near commuter carparks, transport hubs and regional tourist locations
- Updating policies and legislation to allow electric vehicle drivers to use transit lanes (such as T2 and T3 lanes) for a limited time to increase uptake.
- Promote investment in minerals required to produce electric vehicle batteries
- Support continued growth of regional tourism by catering for increased electric vehicle volumes and roll pout of 'EV Tourist Drives' across the state to promote scenic regional driving routes.

Legislation, regulations and standards

Fuel Quality Standards Act 2000

The *Fuel Quality Standards Act 2000* (Cth) as amended in June 2021 provides the legislative framework for setting national fuel quality and fuel quality information standards in Australia for petrol, diesel, biodiesel and Autogas. The aim of the Fuel Quality Standards act is to regulate the quality of fuel supplied in Australia to reduce air emissions associated with fuel use and facilitate adoption of emission control technology.

Under the *Fuel Quality Standards Act 2000* (Cth) the following legislative instruments set specifications for fuel standards in Australia:

- *Fuel Quality Standards (Autogas) Determination 2019* (Cth)
- *Fuel Quality Standards (Automotive Diesel) Determination 2019* (Cth)
- *Fuel Quality Standards (Biodiesel Diesel) Determination 2019* (Cth)
- *Fuel Quality Standards (Ethanol) Determination 2019* (Cth).

The Fuel Quality Standards set specifications for a range of pollutants such as sulphur content, PAHs and heavy metals.

Road Vehicles Standards Act 2018

The *Road Vehicles Standards Act 2018* (RVSA) (Cth) which commenced on 1 July 2021 supersedes the *Motor Vehicle Standards Act 1989* (Cth) (MVSA) and was introduced to improve the safety, environmental and anti-theft performance of all road vehicles.

New on-road motor vehicle emissions are determined by the Commonwealth Government via the Australian Design Rules (ADRs). National road vehicle standards relating to road emissions originally made under Section 7 of the MVSA continue in force as if were a national road vehicle standard under Section 12 of the RVSA[9].

Third Edition Australian Design Rules (ADRs) (Cth)

Exhaust and evaporative emission requirements for new on-road vehicles are administered under:

- *Vehicle Standard (Australian Design Rule 79/00 – Emission Control for Light Vehicles) 2005*
- *Vehicle Standard (Australian Design Rule 80/00 – Emission Control for Heavy Vehicles) 2005*

Australia currently mandates the following emission standards:

- Euro IV emission standards for newly approved models first manufactured from 1 November 2013 and for all light vehicles manufactured from 1 November 2016; and
- Euro V emission standards for newly approved heavy vehicle models manufactured from 1 January 2010 and for all heavy vehicles manufactured from January 2011.

While Euro IV light vehicle emission standards and Euro V heavy vehicle emission standards has and is continuing to reduce air emissions from new light vehicles entering the Australian fleet, many other countries have introduced increasingly stringent vehicle emission standards. The Commonwealth Government is currently evaluating the implementation of more stringent emission standards to achieve a reduction in transport related air pollution and ensure the Australian vehicle market keeps pace with international technological developments. Draft regulatory impact statements for the implementation of more stringent light and heavy vehicle emission standards are discussed below.

Light Vehicle Emission Standards for Cleaner Air Draft RIS 2020 (Cth)

Australia currently mandates the Euro 5 emission standards for newly approved vehicle models manufactured from 1 November 2012, and for all light vehicles manufactured from November 2016. The draft Regulatory Impact Statement (RIS) for Light Vehicle Emission Standards proposed by the Commonwealth Government in October 2020 evaluates whether the Australian Government should mandate more stringent standards (Euro 6) to reduce noxious emissions from light road vehicles (Commonwealth of Australia 2020).

The key changes under the Euro 6 emission standards when compared to Euro 5 are:

- 55% reduction in emission limits for NOx for light diesel vehicles
- A particle limit number to reduce fine particulates from direct injection petrol vehicles; and
- Tighter thresholds for on-board diagnostic systems that monitor the performance of emission control systems

The draft RIS found that the mandating Euro 6d emission standards for light vehicles would bring Australian vehicle standards closer to international standards and provide significant benefits to the Australian community through improved air quality by mandating Euro 6d for new light vehicles. The Draft RIS recommends phasing in of Euro 6d standards from 1 July 2027 for new model light vehicles and from July 2028 for all new light vehicles.

A final recommendation to Government on the implementation of new light vehicle emission standards will be made following consideration of feedback received during the targeted consultation period with key stakeholders which closed in February 2021.

Projects emission factors for 2026 and 2036 discussed in **Section 4.2.5.2** of this technical report account for changes in the vehicle fleet including mandated vehicle emission standards. Consideration of future mandates such as the draft Regulatory Impact Statement (RIS) for Light Vehicle Emission Standards have not been accounted for. Implementation of this mandate would result in a lowering of emission rates for NO_2 and particulates; thus, modelled emission factors for light vehicles in this technical report are considered conservative.

[9] See Schedule 3, Part 2, item 2 of the Road Vehicle Standards (Consequential and Transitional Provisions) Act 2018

Heavy Vehicle Emission Standards for Cleaner Air Draft RIS 2020 (Cth)

Australia currently mandates the Euro V emission standards for newly approved heavy vehicle models manufactured from 1 January 2010, and for all heavy vehicles manufactured from January 2011. The draft Regulatory Impact Statement (RIS) for Heavy Vehicle Emission Standards proposed by the Commonwealth Government in October 2020 evaluates whether the Australian Government should mandate more stringent standards to reduce noxious emissions from heavy road vehicles (Commonwealth of Australia 2020a).

The key changes under the Euro VI emission standards when compared to Euro V are:

- A reduction in emission limits for NOx of up to 80%
- A reduction in emission limits for particulate by up to 60%
- A new particulate number limit to reduce ultrafine particle emissions; and
- A new more representative engine bench test and new on-road emissions test.

The draft RIS found that the mandating VI emission standards for heavy vehicle models manufactured from July 2027 and for all new heavy vehicles manufactured from July 2028 would result in significant health benefits from the reduction in diesel emissions. The Draft RIS recommends mandating Euro VI standards in Australia for new heavy vehicle models from 1 July 2027 and from 1 July 2018 all new heavy vehicles.

A final recommendation to Government on the implementation of new heavy vehicle emission standards will be made following consideration of feedback received during the targeted consultation period with key stakeholders which closed in February 2021.

Projects emission factors for 2026 and 2036 discussed in **Section 4.2.5.2** of this technical report account for changes in the vehicle fleet including mandated vehicle emission standards. Consideration of future mandates such as the draft Regulatory Impact Statement (RIS) for Heavy Vehicle Emission Standards have not been accounted for. Implementation of this mandate would result in a lowering of emission rates for NO_2 and particulates; thus, modelled emission factors for heavy vehicles in this technical report are considered conservative.

Appendix C

Meteorological Data Analysis

Appendix C Meteorological data analysis

Meteorology from a dispersion modelling perspective is a critical component to get as representative as possible. As outlined in Section 4.2, the meteorology for the GRAL model is provided by a meteorological data pre-processor called GRAMM. This model takes meteorological data from the modelling domain and processes it into a format compatible with the GRAL model. As detailed in Section 4.2.4, there are several stages of data preparation required for GRAMM. One of the inputs needed for this study was the stability class data used as input to the Match to Observation function. CALMET data identification and inputs for the stability class calculations are summarised in this appendix, which outlines the following:

1. The methodology and outcomes from the analysis to identify the representative meteorological years for use in the dispersion modelling.
2. Identification of candidate meteorological stations for use in the dispersion modelling
3. Details of the CALMET settings adopted

Representative data year selection

A three-year meteorological data set was developed based on surface observations at nearby weather stations for the 2016-2018 calendar years. When selecting a period of meteorological data for use in the modelling, care must be taken to ensure the source data's suitability for modelling purposes.

An analysis of weather data from nearby weather stations covering the period 2010 to 2019 was undertaken to select the most appropriate three-year period for the assessment. Consideration was given to parameters such as Southern Oscillation Index, data availability, weather parameters and pollutant concentrations from nearby air quality monitoring stations.

For each parameter, the calendar years from 2010 to 2019 were ranked based on how closely the year matched the long-term trends. A combined ranking was developed for each station based on the suitability of the parameters for each calendar year. Three-year rankings were then developed based on the individual year rankings to determine the most appropriate three-year period for use in the assessment.

Based on the M7 Project boundaries, the stations selected for analysis include:

1. Badgerys Creek BoM Station – south-western extent of M7 upgrade project
2. Holsworthy Aerodrome BoM Station - southern extent of CALMET Region
3. Horsley Park BoM Station – centre of M7 upgrade project
4. Liverpool DPE Station – close to southern extent of M7 upgrade project
5. Prospect DPE Station – north-eastern extent M7 upgrade project
6. Richmond RAAF BoM Station - northern extent of CALMET Region
7. St Marys DPE Station – north-western extent of M7 upgrade project.

The location of these seven stations are presented in **Figure C-1**.

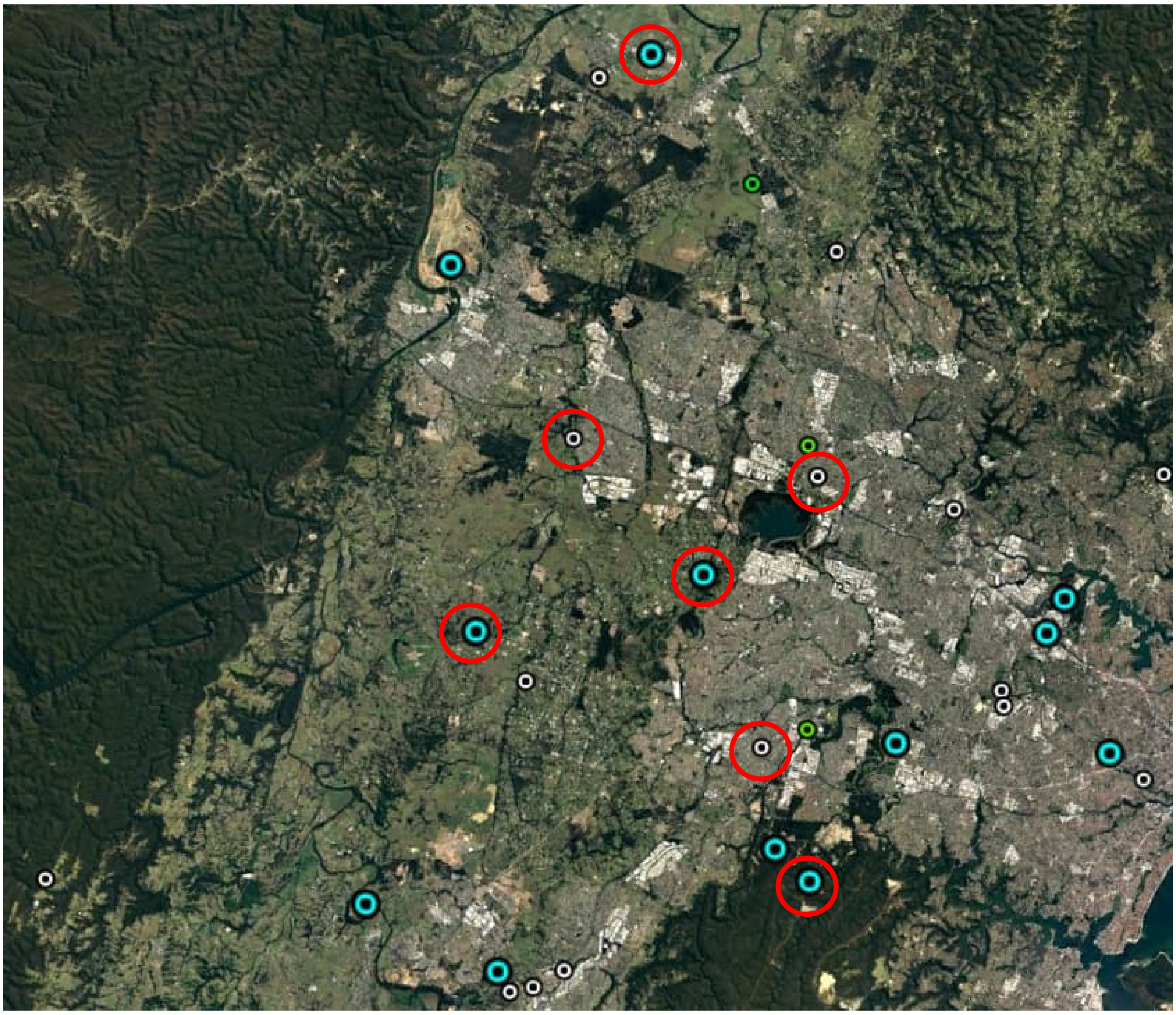


Figure C-1 Monitoring station locations

The assessment looked at the following parameters when assessing each calendar year:

- Southern Oscillation Index
- Meteorology data availability
- Wind Speed
- Wind Direction
- Calms (across whole data set and at 9am and 3pm)
- PM_{10}, $PM_{2.5}$ and NO_2 concentrations
- Temperature
- Humidity
- Pressure.

Each of the above parameters were assessed differently according to their different parameter characteristics. The parameters and their assessment method have been provided in **Table C-2**.

Table C-2 Met and pollutant parameter assessment methodology

Parameter	Assessment Methodology	Comments
Southern Oscillation Index	Divergence of annual SOI from neutral setting (value of zero).	If SOI was >7 or <7, the met year was not considered acceptable for use.
Meteorology Data Availability	Data ranked according to data availability. Lowest rank attributed to highest data availability.	If <90% availability, met year was considered acceptable for use.
Wind Speed	Probability density function used to determine which annual met year was closest to 10-year data set[1]	
Wind Direction	Frequency of occurrence and variation from the long-term frequency of occurrence was used to determine which met year was most appropriate	
Calms (across whole data set and at 9am and 3pm)	Given how higher calms provide more conservative results, the ranking was attributed based on which met year had the highest calms percentages.	It may be arguable that this is overly conservative, but has been adopted for this study.
PM_{10}, $PM_{2.5}$ and NO_2 concentrations	Probability density function used to determine which pollutant data set was closest to 10-year data set[1]	
Temperature	Probability density function used to determine which annual Temperature data set was closest to 10-year data set[1]	
Humidity	Probability density function used to determine which annual Humidity data set was closest to 10-year data set[1]	
Pressure	Probability density function used to determine which pollutant data set was closest to 10-year data set[1]	
[1] 10-year data set represents the PDF analysis of all 10 years of data, not an average.		

Southern Oscillation Index

Figure C-2 shows the SOI data between 2010 and 2019. Four years (2010, 2011, 2015 and 2019) were strongly El Nino or La Nina. The remaining years had a neutral average SOI value.

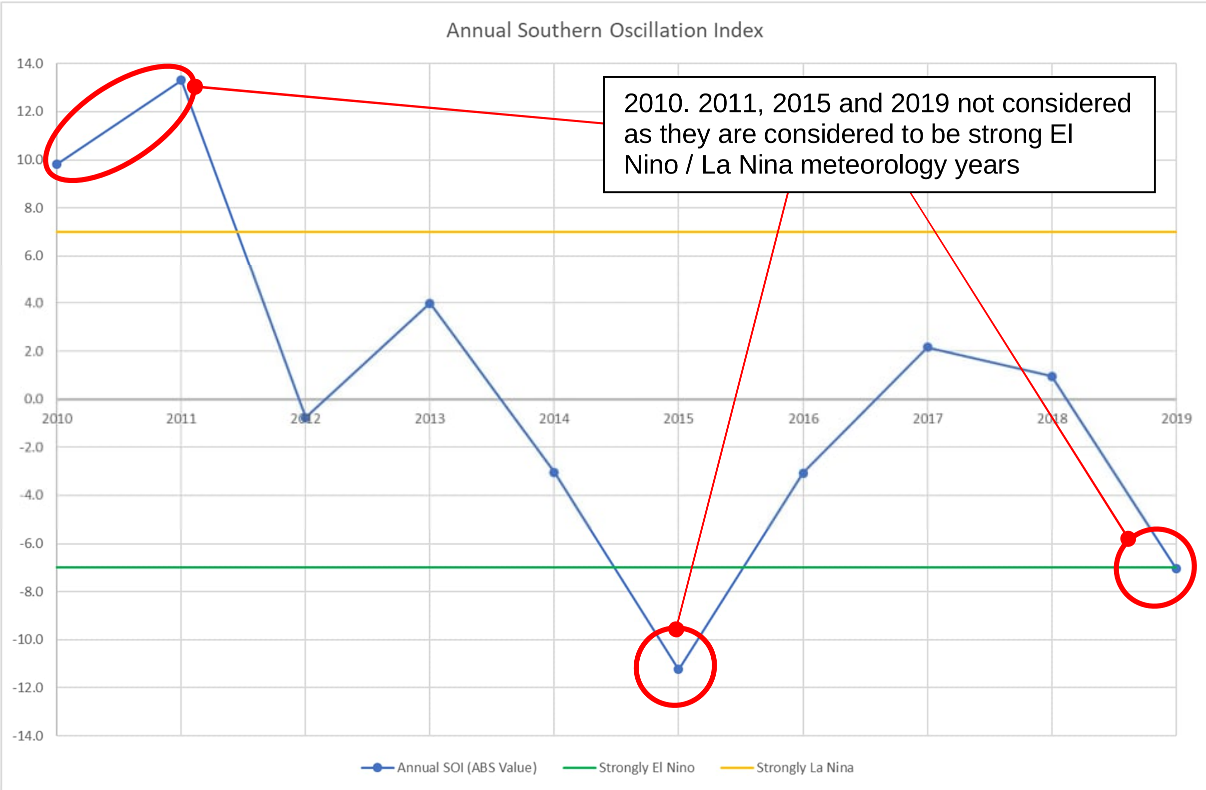


Figure C-2 SOI data from 2010-2019

Meteorology data availability

Met data and pollutant data availability are shown below in **Table C-3**.

Table C-3 Data availability

Station	Parameter	Availability (%)	Comments
Badgerys Creek	Wind Speed / Wind Direction	98.1%	All met years had availability greater than 90% for all parameters. No years excluded.
	Humidity	96.7%	
	Pressure	94.0%	
	Temperature	98.1%	
Holsworthy	Wind Speed / Wind Direction	73.3% (100% for 2013-19)	Holsworthy monitoring did not start until August 2012, meaning 2010, 2011 and 2012 were excluded from the analysis.
	Humidity	73.3% (100% for 2013-19)	
	Pressure	73.3% (100% for 2013-19)	
	Temperature	73.3% (100% for 2013-19)	
Horsley Park	Wind Speed / Wind Direction	98.8%	
	Humidity	99.7%	
	Pressure	No Data	Not monitored
	Temperature	99.7%	
Liverpool	Wind Speed / Wind Direction	99.0%	
	Humidity	98.8%	
	Pressure	99.6%	
	Temperature	98.9%	

Station	Parameter	Availability (%)	Comments
Prospect	Wind Speed / Wind Direction	99.2%	
	Humidity	99.0%	
	Pressure	No Data	Not monitored
	Temperature	99.1%	
Richmond	Wind Speed / Wind Direction	98.2%	
	Humidity	98.6%	
	Pressure	99.7%	
	Temperature	98.6%	
St Marys	Wind Speed / Wind Direction	98.6%	
	Humidity	97.8%	
	Pressure	No Data	Not monitored
	Temperature	98.9%	

Missing data is represented annually for a range of meteorological parameters for each of the seven stations in **Figure C-3** to **Figure C-9**. Due to the very large amount of data available, only the proportion of missing wind speed data was taken into account when developing the rankings.

Figure C-3 Missing data by year – Badgerys Creek

Figure C-4 Missing data by year – Holsworthy

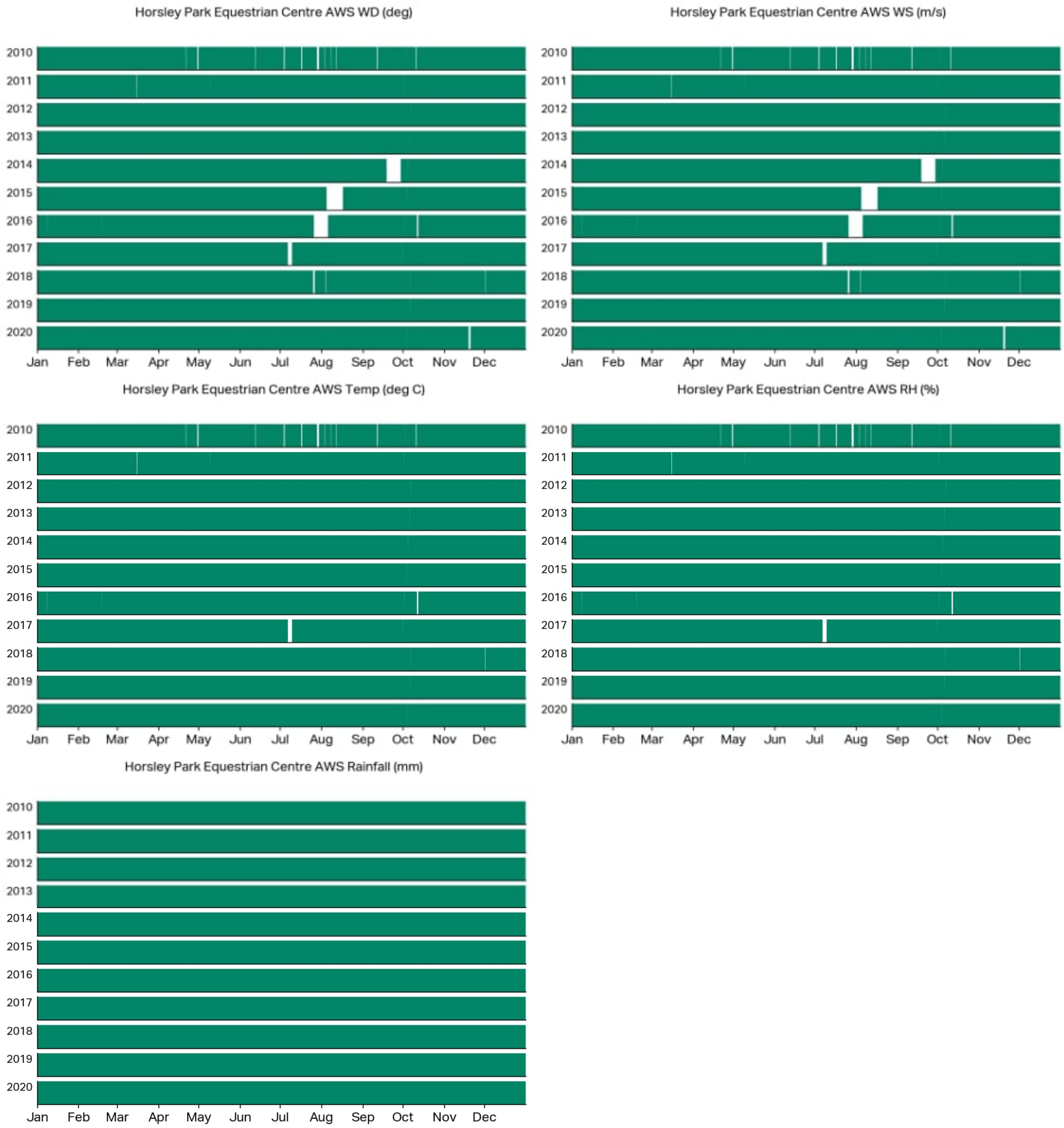


Figure C-5 Missing data by year – Horsley Park

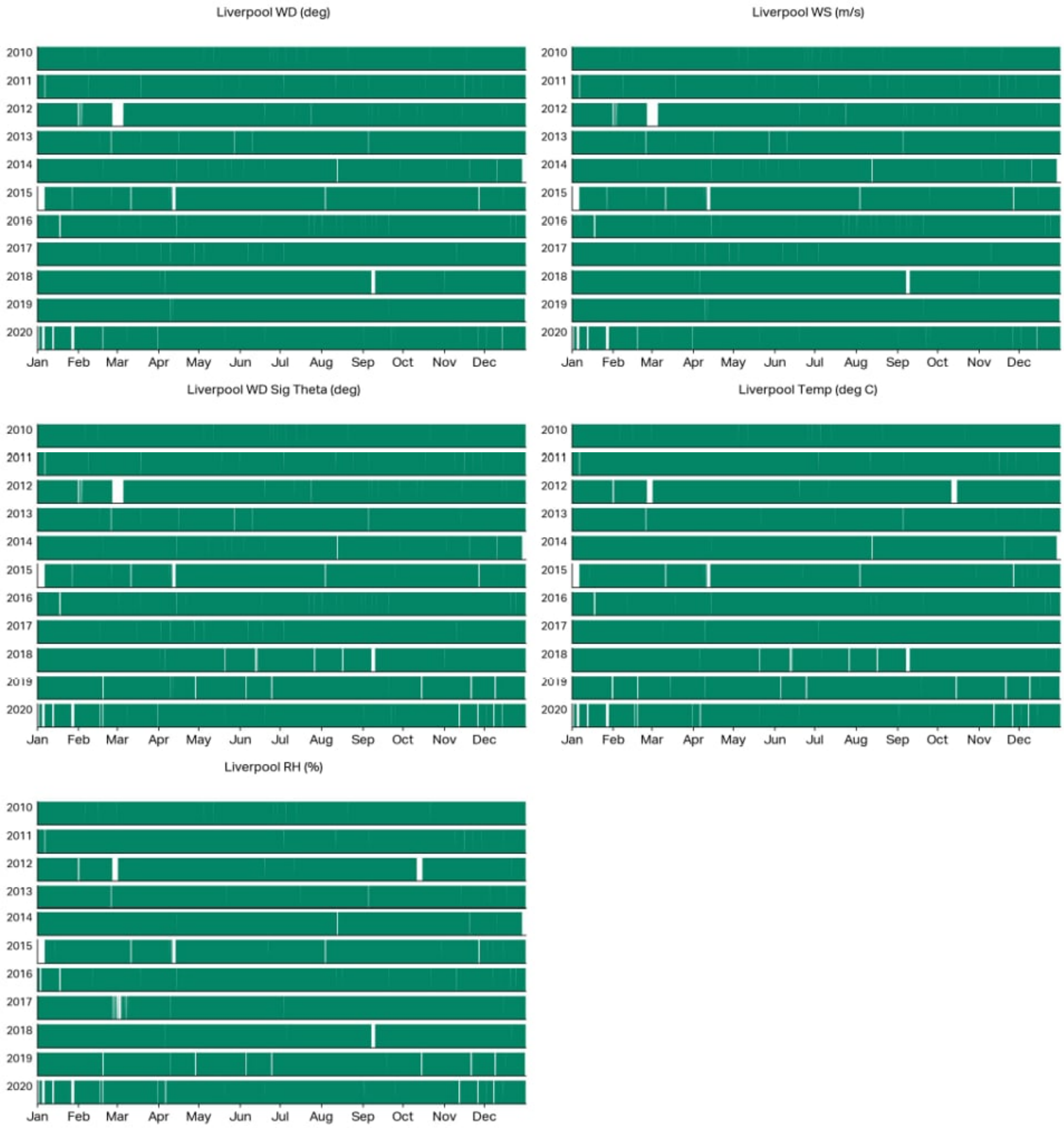


Figure C-6 Missing data by year – Liverpool

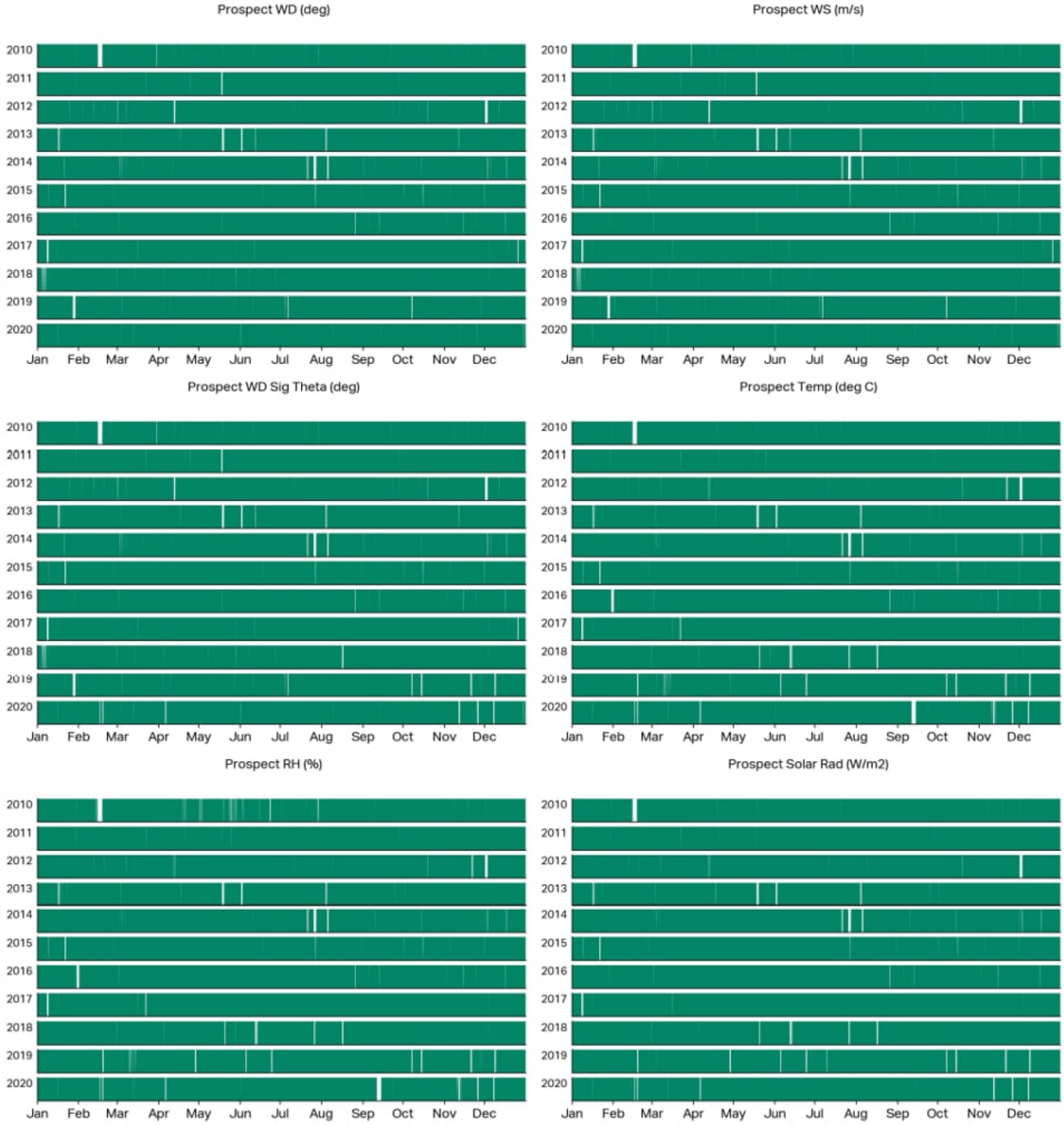


Figure C-7 Missing data by year – Prospect

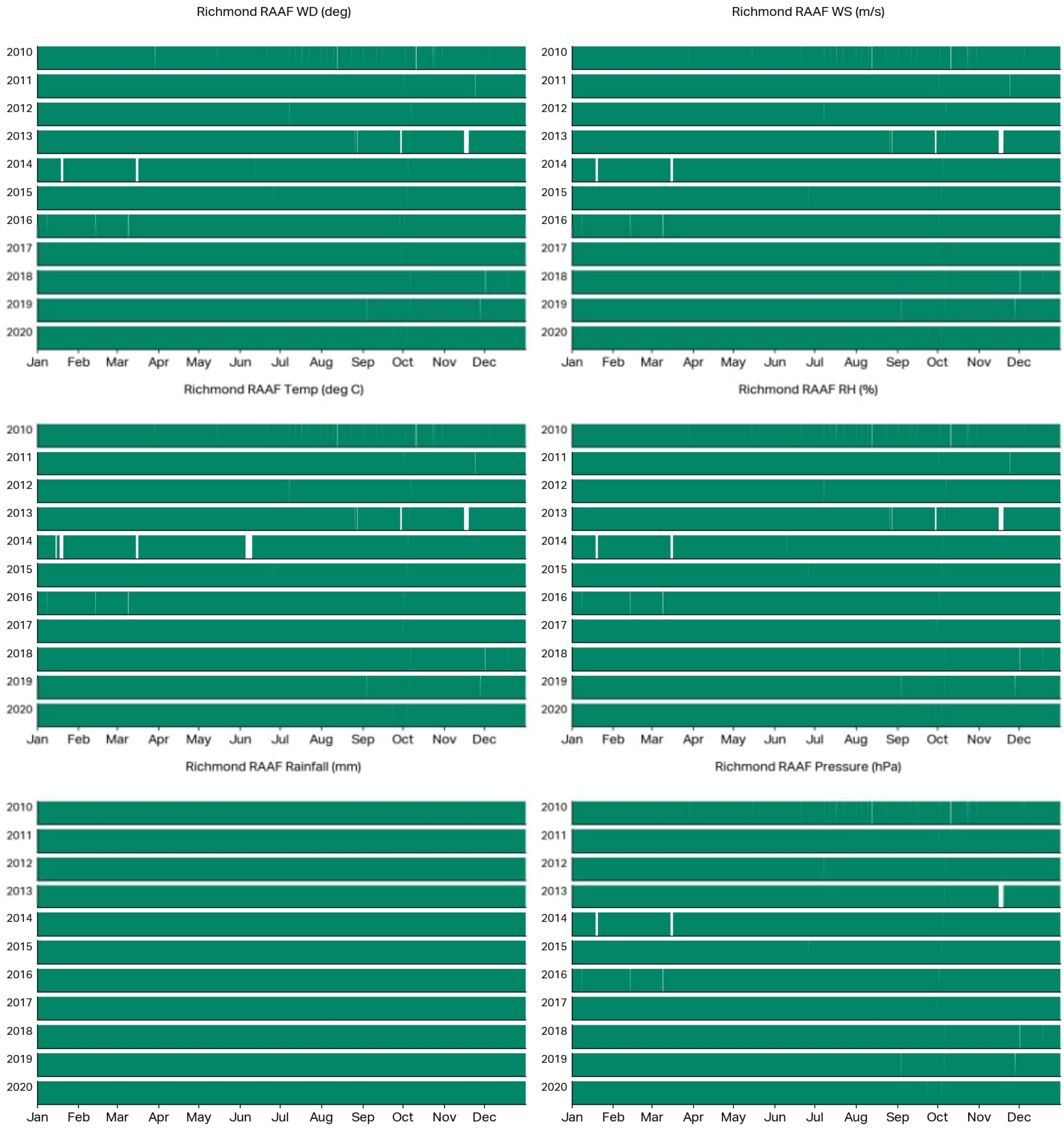


Figure C-8 Missing data by year – Richmond

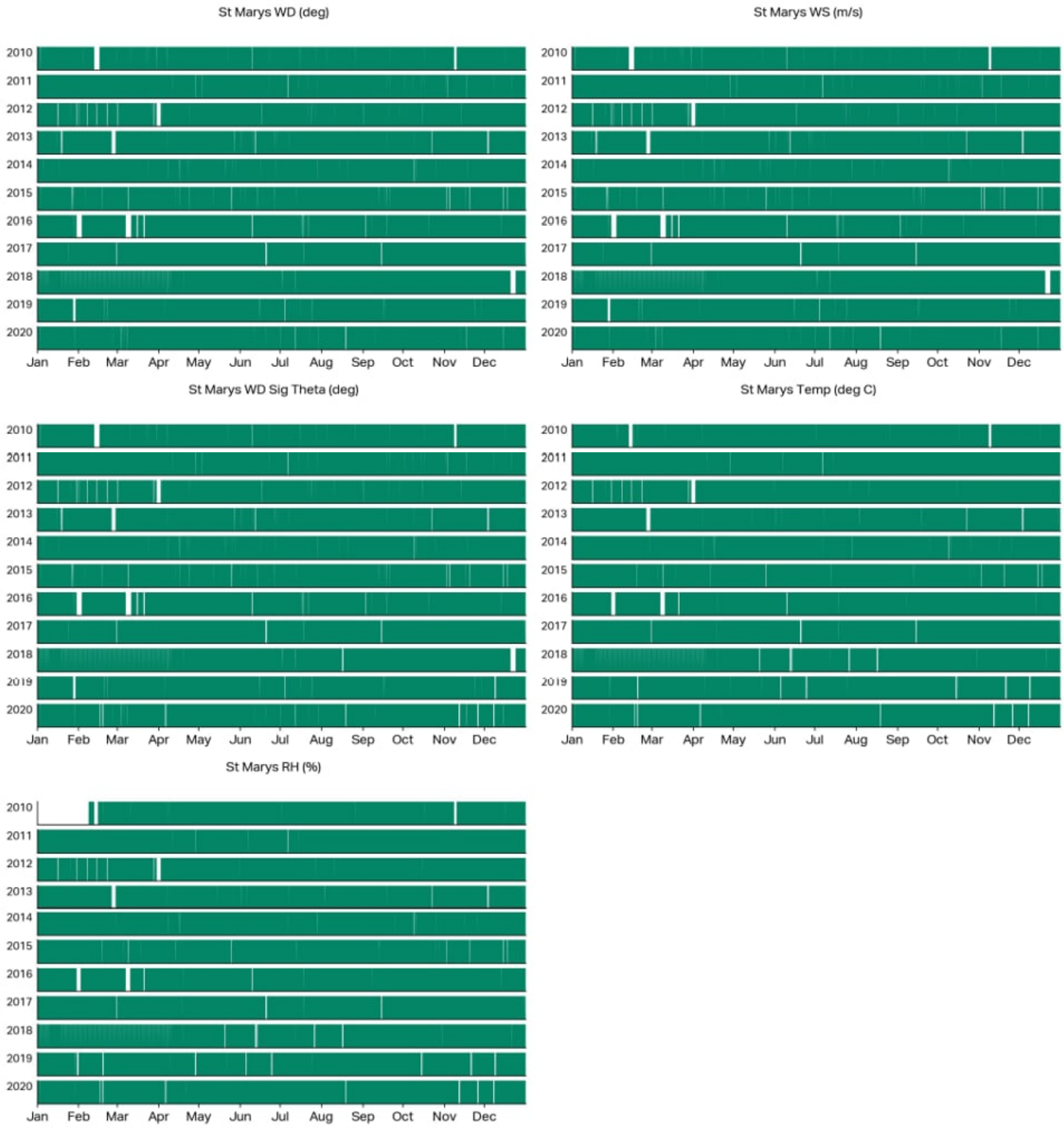
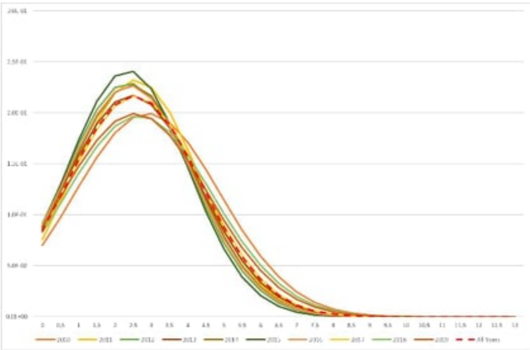


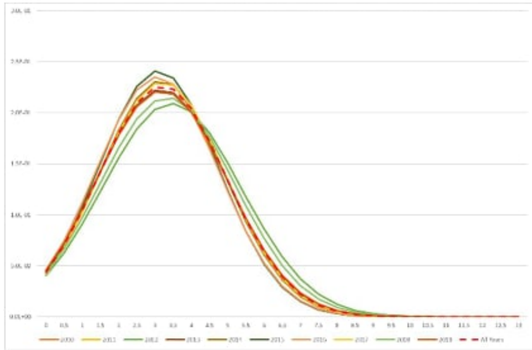
Figure C-9 Missing data by year – St Marys

Wind speed

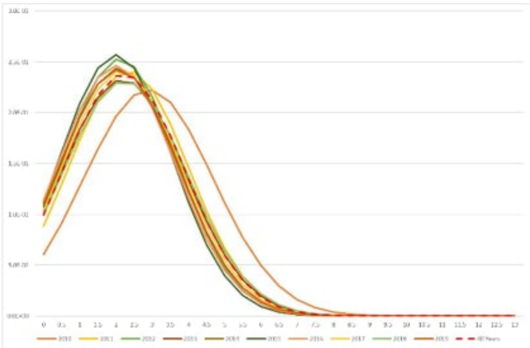
Wind Speed data is presented using PDF plots which show variation away from the long term mean data values. PDF plots for the different stations are shown in **Figure C-10**. In general, there was not a large variation in wind speeds between each year.



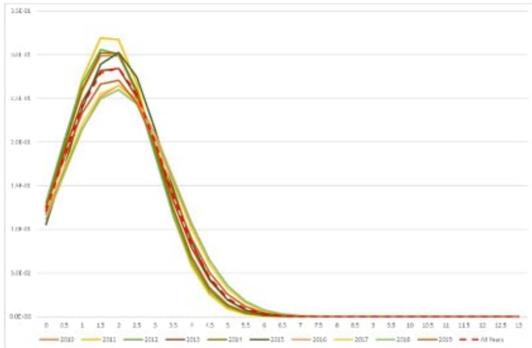
Badgerys Creek



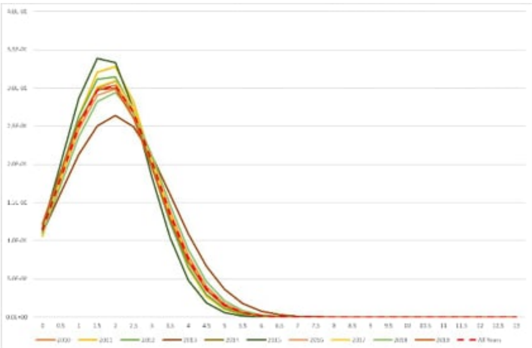
Holsworthy



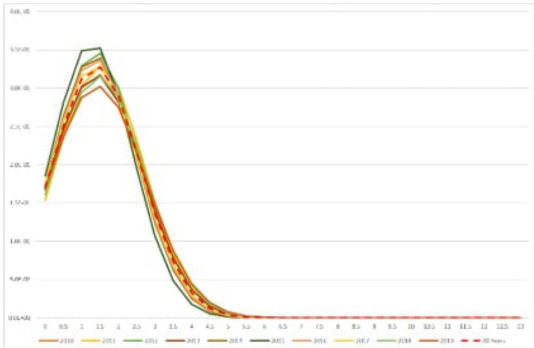
Horsley Park



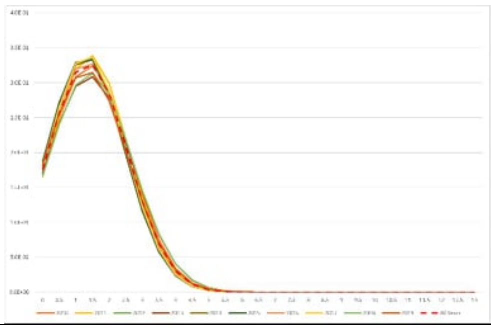
Liverpool



Prospect



Richmond



St Marys

Figure C-10 Wind speed PDF plots

Wind direction

Wind Direction has been analysed using frequency of occurrence plots which are shown in **Figure C-11**. In general, there was only minor variation in wind direction frequency from year to year at each of the stations.

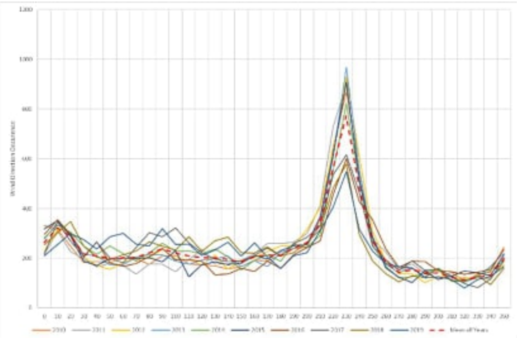
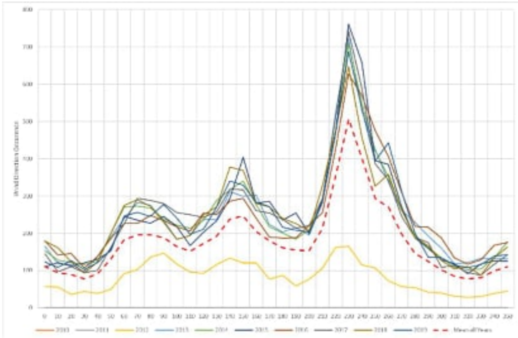
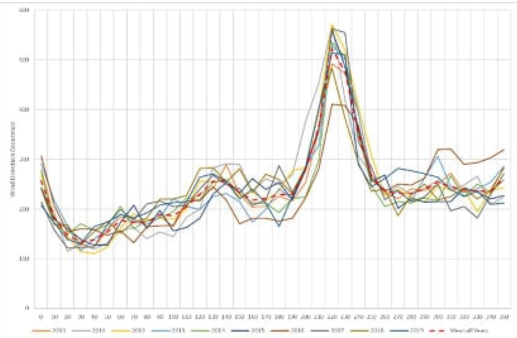
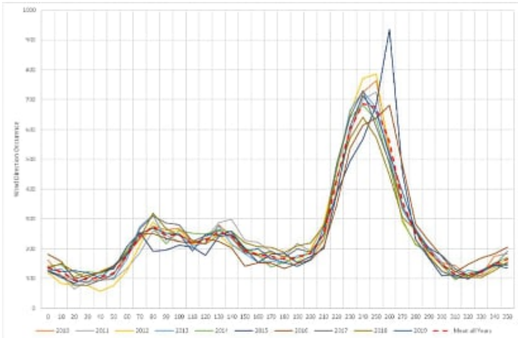
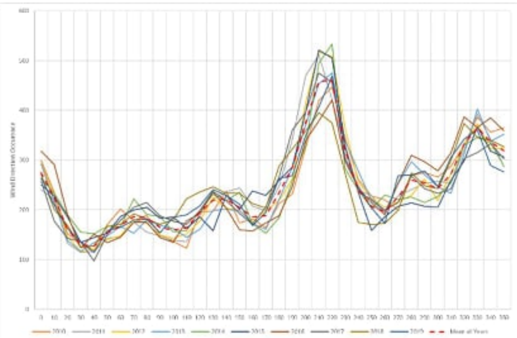
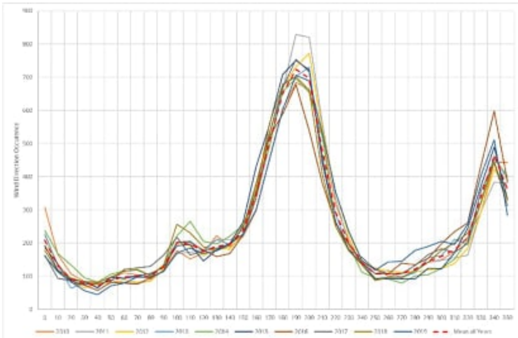
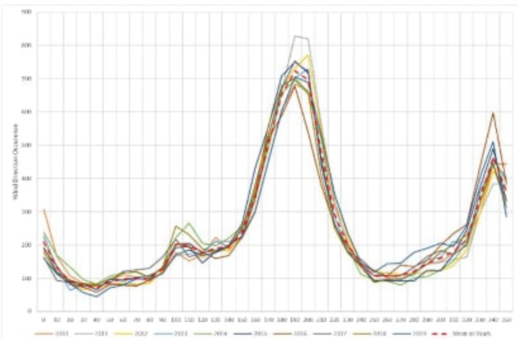
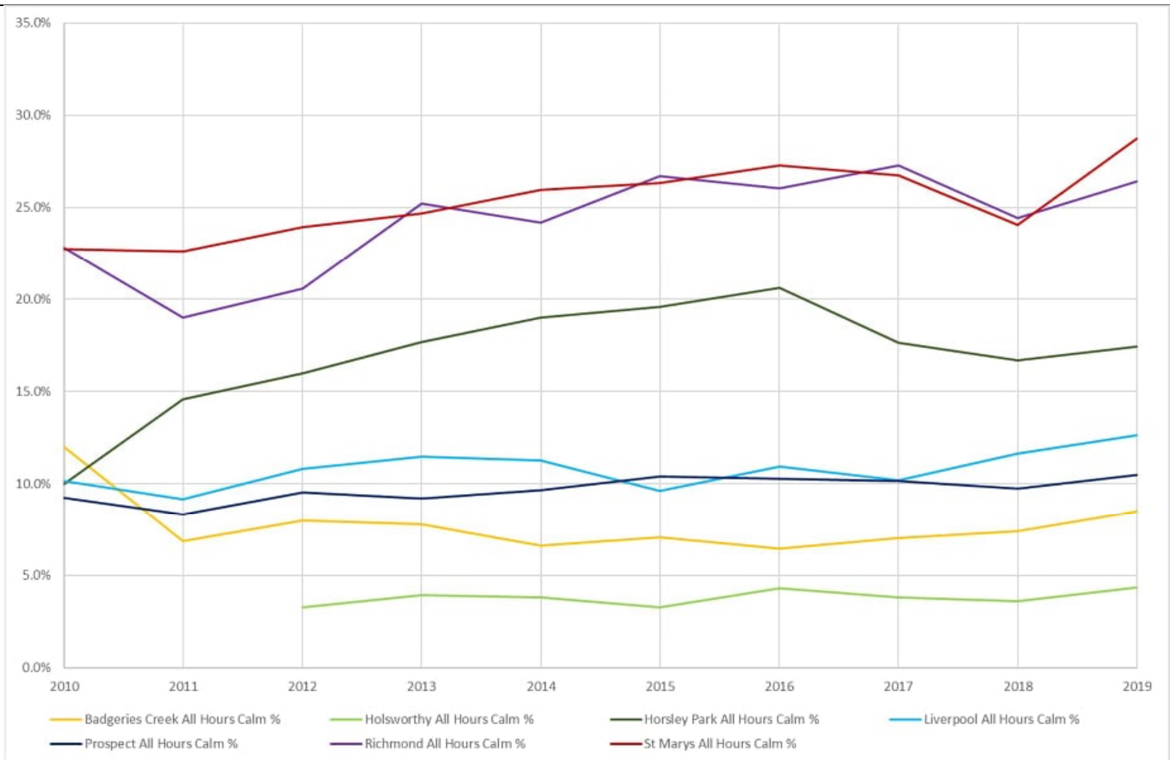
	
Badgerys Creek	Holsworthy (**<u>biased by limited 2012 data</u>**)
	
Horsley Park	Liverpool
	
Prospect	Richmond
	
St Marys	

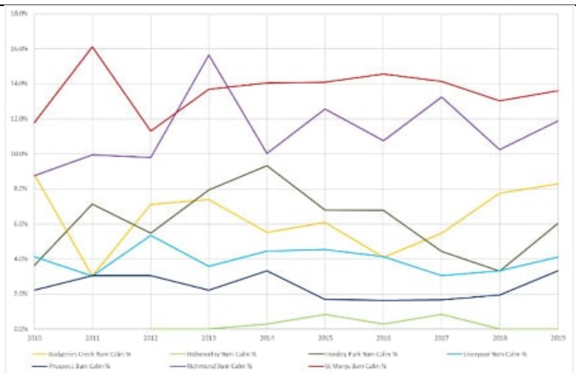
Figure C-11 Wind direction occurrence plots

Calms (across whole data set and at 9am and 3pm)

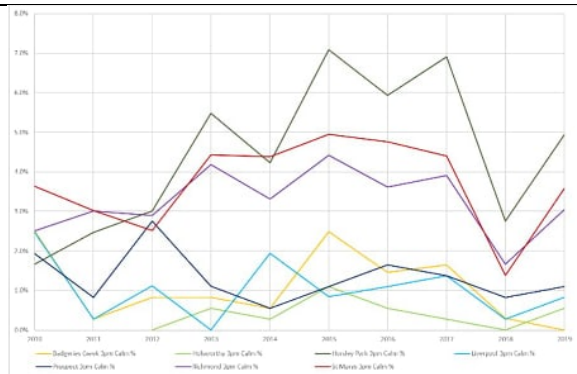
Analysis of the frequency of calm conditions (wind speeds less than 0.5 m/s) was undertaken with the data presented in **Figure C-12**. There was a high variance in calm frequencies spatially across the seven different sites, with the highest all-hours calms occurring at St Marys and Richmond, and the lowest at Holsworthy. These differences are likely due to differences in station location in terms of terrain and nearby obstacles to wind flow. Temporal variation at the individual stations is also obvious with Horsley Park in particular ranging from about 10 % calms in 2010, to over 20% calms in 2016. Calm frequencies at 3pm varied considerably at Horsley Park as well, with less than 2% in 2010 and over 7% in 2015. There was slightly less annual variation at the other stations.



All Hours Calms



9am Calms



3pm Calms

Figure C-12 **Calm percentage occurrence plots**

PM_{10}, $PM_{2.5}$ and NO_2 concentrations

Pollutants are assessed using PDF plots as shown in **Figure C-13**, **Figure C-14** and **Figure C-15**.

It is obvious from the PM_{10} and $PM_{2.5}$ plots that the year 2019 was very different to the long-term trend at all stations. This was due to the very high PM_{10} and $PM_{2.5}$ concentrations across the Sydney area during the latter part of 2019 caused by the bushfire event. The NO_2 data did not show a significant difference in 2019, with only minor variation between each analysed year.

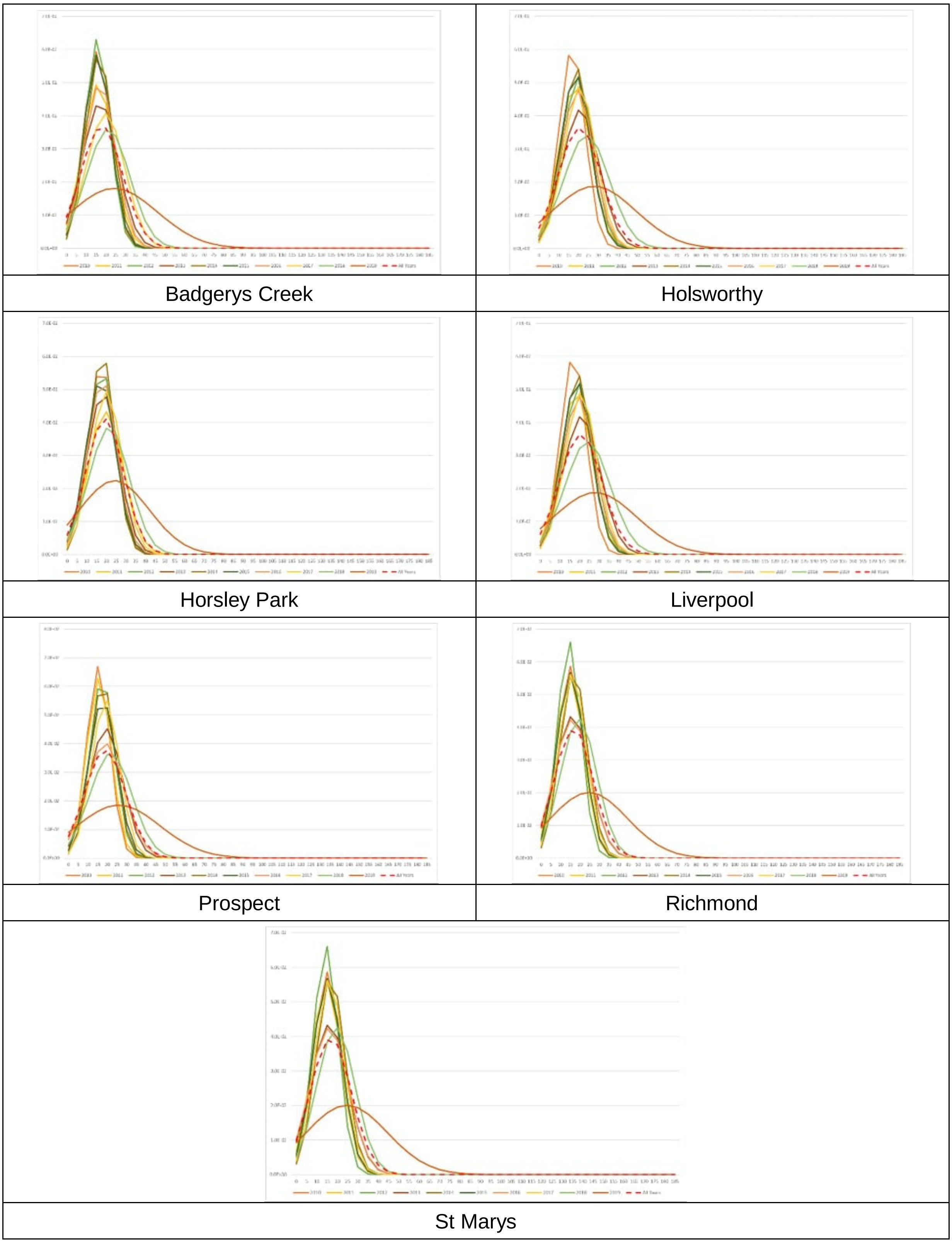
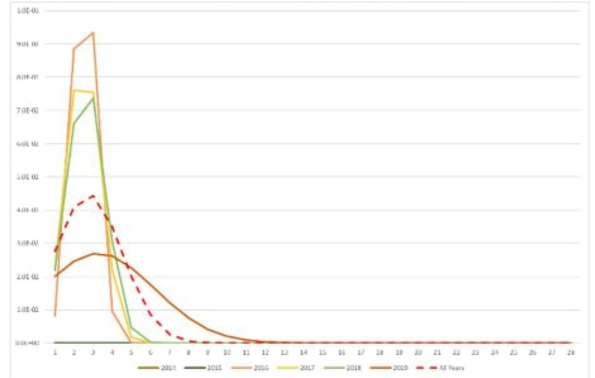
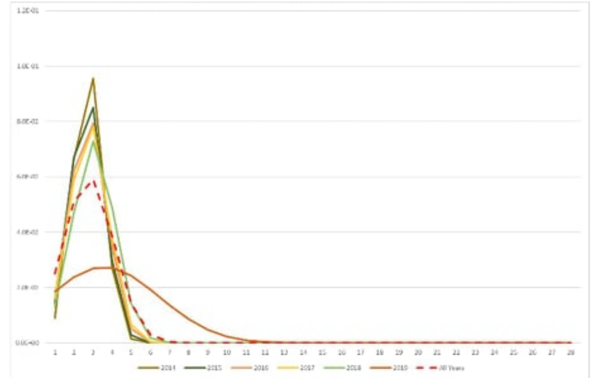


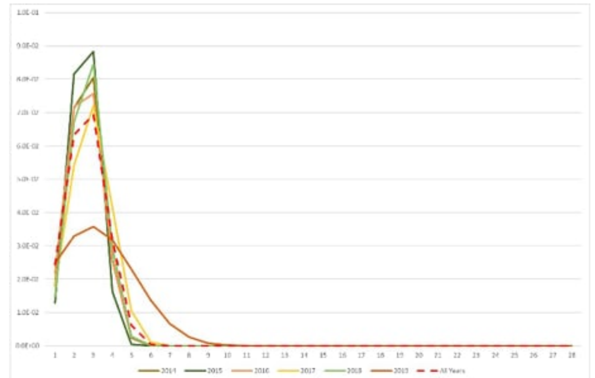
Figure C-13 PM_{10} PDF plots



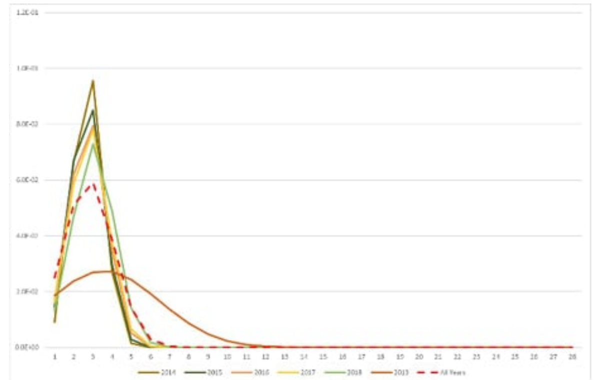
Badgerys Creek



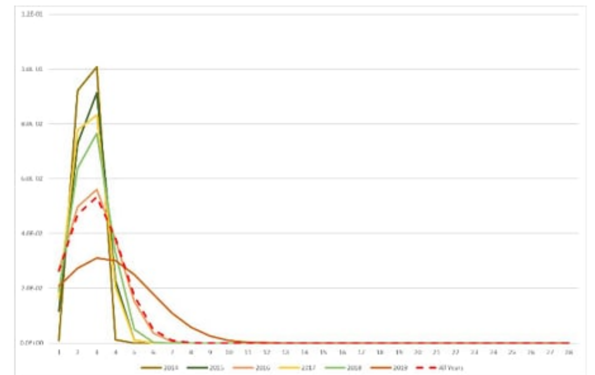
Holsworthy



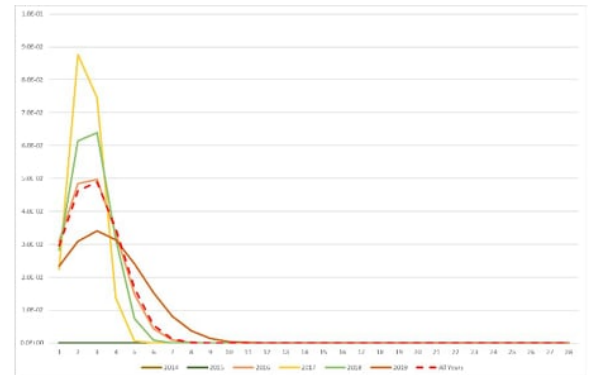
Horsley Park



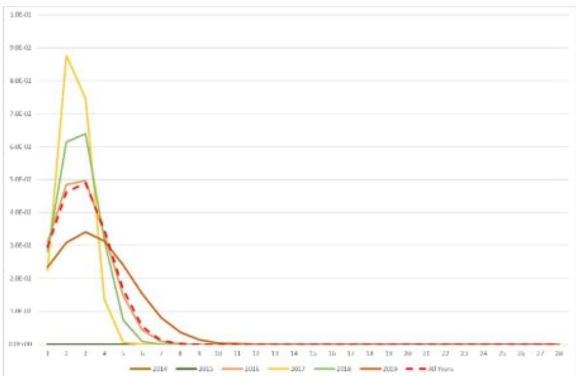
Liverpool



Prospect

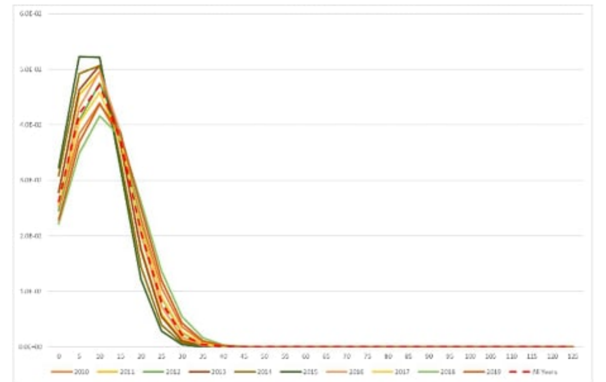


Richmond

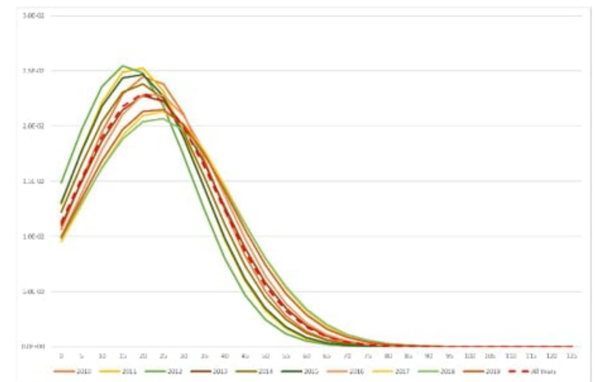


St Mary

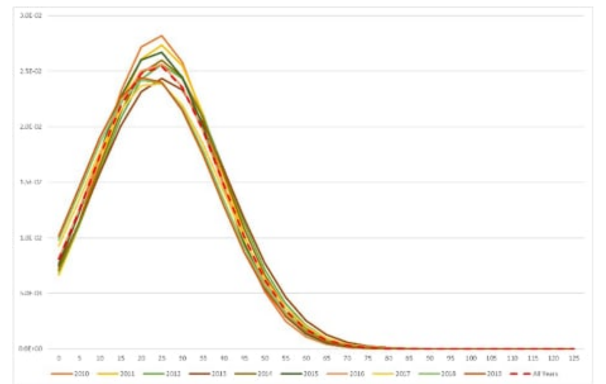
Figure C-14 PM2.5 PDF plots



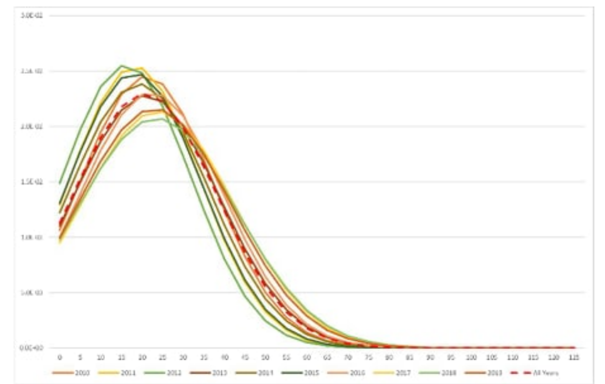
Badgerys Creek



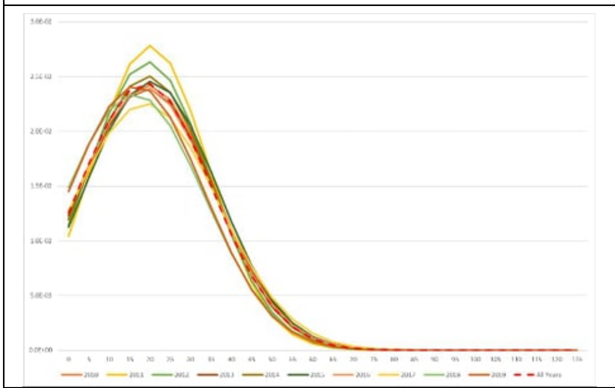
Holsworthy



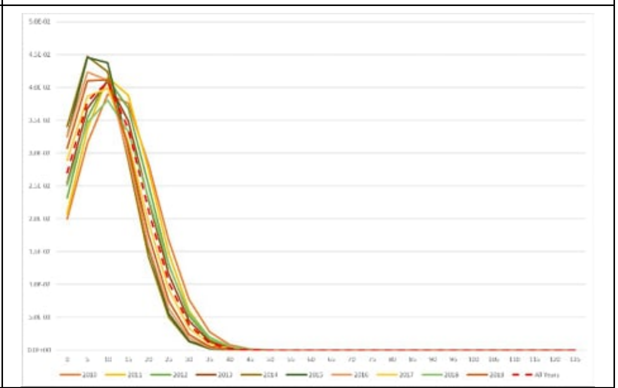
Horsley Park



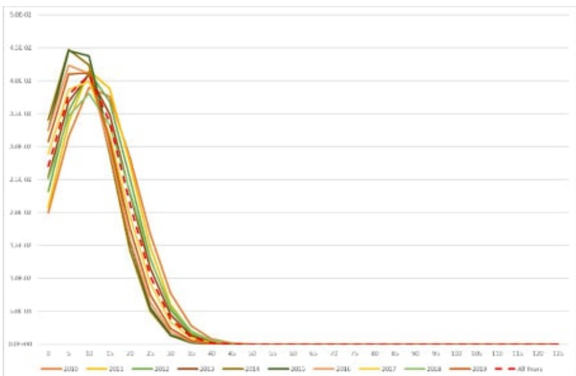
Liverpool



Prospect



Richmond

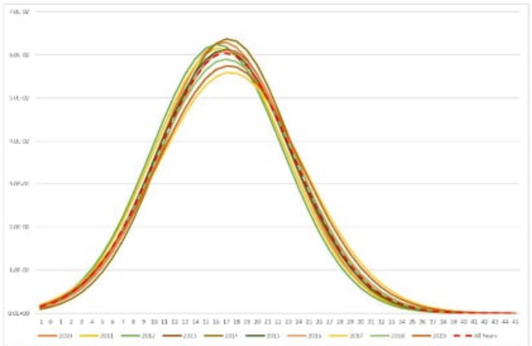


St Mary

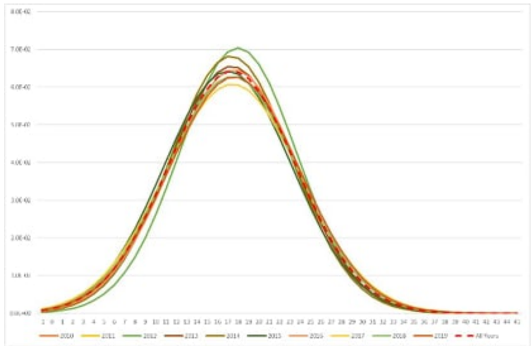
Figure C-15 NO2 PDF plots

Temperature

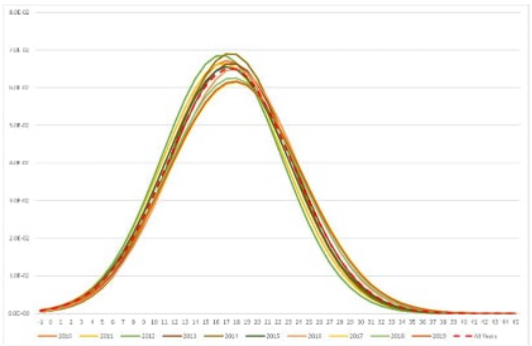
Temperature data are assessed using PDF plots as shown in **Figure C-16**. As expected, there was not a significant variation in temperature across the different years.



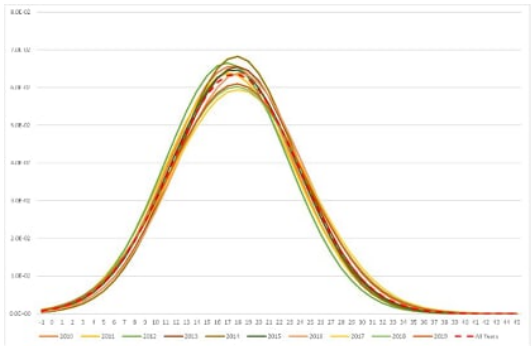
Badgerys Creek



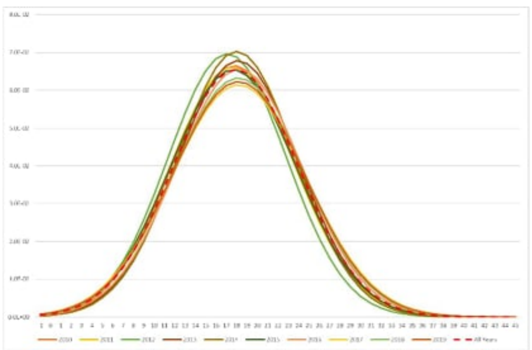
Holsworthy



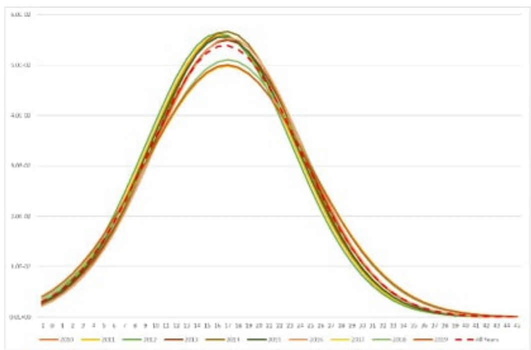
Horsley Park



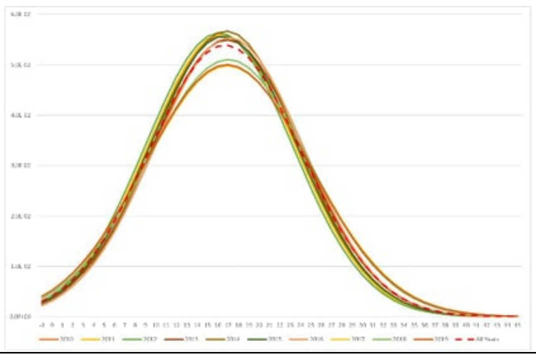
Liverpool



Prospect



Richmond



St Mary

Figure C-16 Temperature PDF plots

Humidity

Humidity data are assessed using PDF plots as shown in Figure C-17. As expected, there was not a significant variation in humidity across the different years.

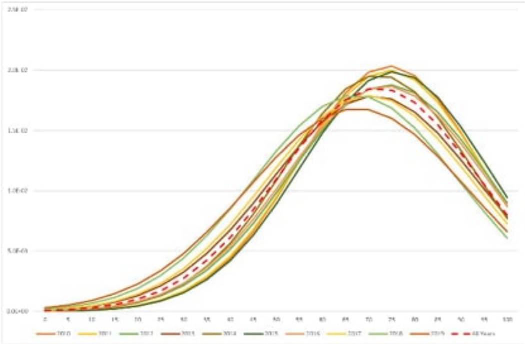
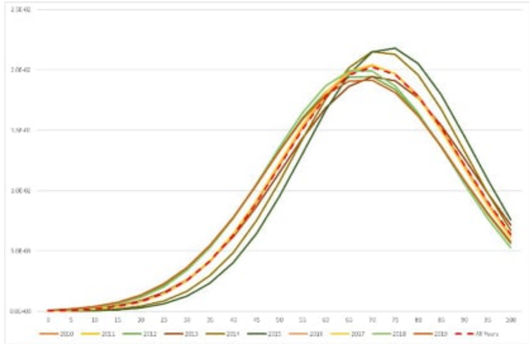
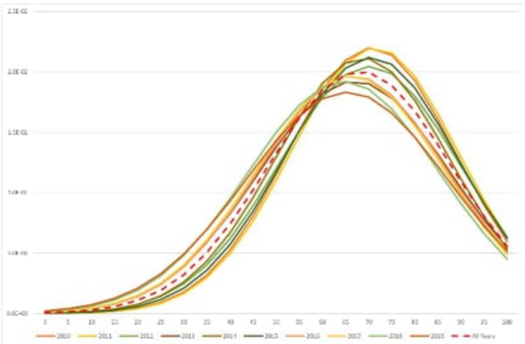
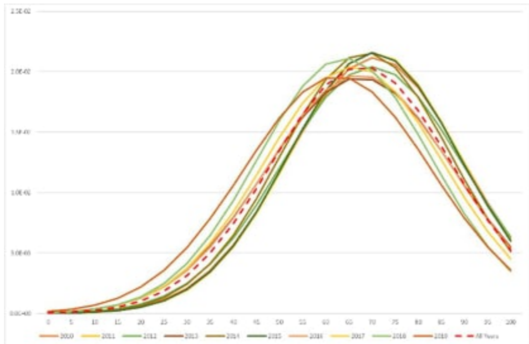
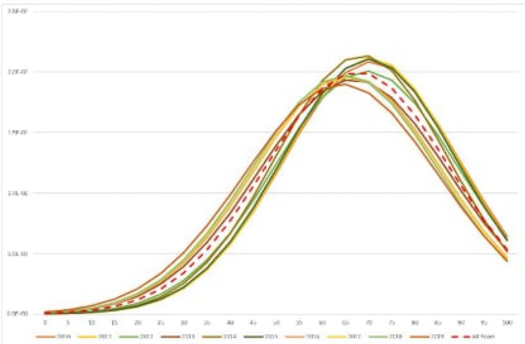
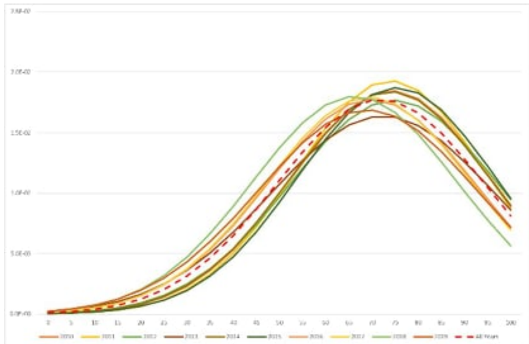
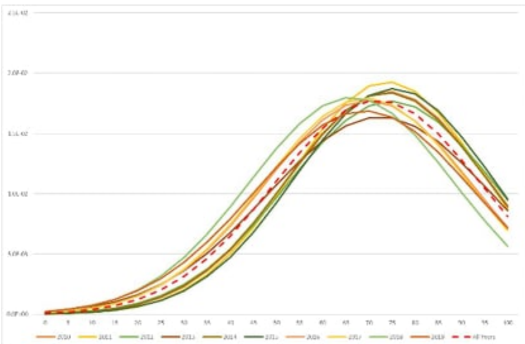
	
Badgerys Creek	Holsworthy
	
Horsley Park	Liverpool
	
Prospect	Richmond
	
St Mary	

Figure C-17 Humidity PDF plots

Pressure

Pressure data are assessed using PDF plots as shown in **Figure C-18**. Only three stations monitor pressure, all of which showed a slightly higher curve in 2012. This means 2012 experienced a higher frequency of average air pressure hours (i.e. a slight squashing of the curve towards the mean air pressure value) and suggest that 2012 was perhaps more stable in terms of fluctuations in air pressure.

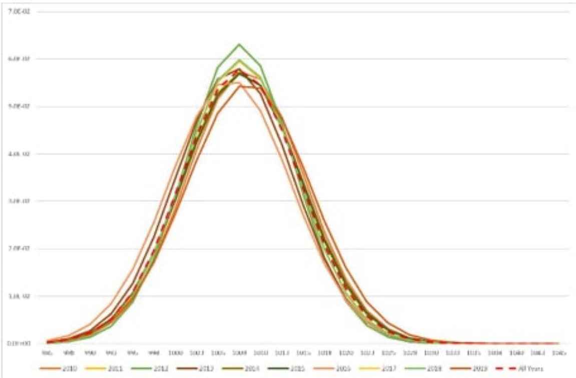
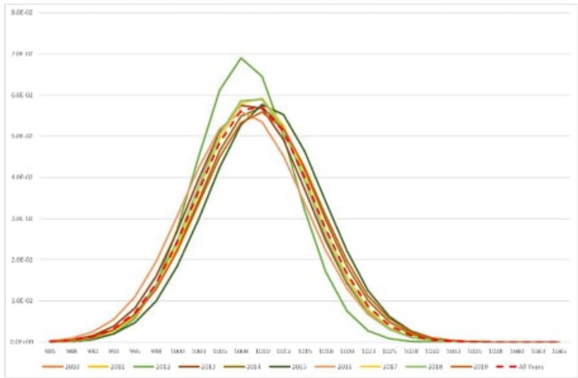
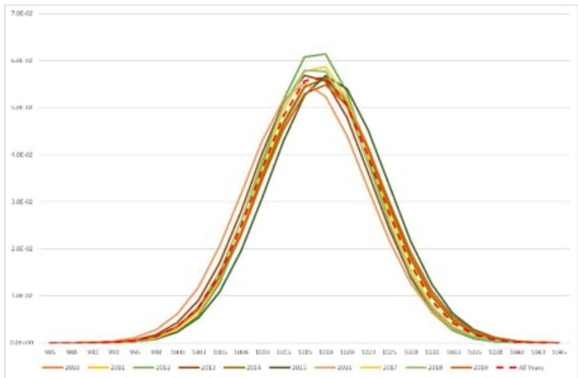
	
Badgerys Creek	Holsworthy
No Pressure Data	
Horsley Park	Liverpool (Bankstown Pressure Data)
No Pressure Data	**No Pressure Data**
Prospect	Richmond
No Pressure Data	
St Marys	

Figure C-18 Pressure PDF plots

Ranking of met parameters and pollutants

A summary of the raw ranks applied to each parameter for each station is presented in **Table C-5**. The lower the rank, the better matched that year is to the long term meteorological trends at that station.

The effect that each parameter has on dispersion modelling is not uniform with some parameters having a much higher impact on the modelling and can vary more significantly than others. To try and obtain a more meaningful rank of different parameters, a weighting was applied to the raw ranks presented in **Table C-5** depending on the importance of the parameter in terms of its effect on dispersion the model. The weightings for the parameters are shown in **Table C-3**.

Table C-4 Weighting of met and pollutant parameters

Parameter	Weighting
Southern Oscillation Index, Data Availability	Rank x1
Wind Speed and Direction	Rank x1.5
Calm Percentages (all data, 9am and 3pm), PM_{10}, $PM_{2.5}$ and NO_2 concentrations	Rank x2
Temperature, Humidity and Pressure	Rank x4

A summary of the weighted ranks for each year the seven stations is presented in **Table C-6**. Based on the rankings and analysis of the meteorology, the meteorology year that most closely matched long term trends at all stations was 2017. The 2016 and 2018 calendar years were also fairly good matches, ranked 5th and 4th respectively.

Table C-5 Raw rank of met and pollutant parameters (all 7 stations)

Calendar Year	Badgerys Creek	Holsworthy	Horsley Park	Liverpool	Prospect	Richmond	St Marys	Sum of Ranks	Combined Rank
2010	7	ND	7	7	10	9	9	49	8
2011	8	ND	7	8	8	8	7	46	7
2012	1	1	1	2	2	4	3	14	1
2013	6	6	6	6	6	6	4	40	6
2014	5	2	2	4	3	2	5	23	4
2015	9	7	9	10	7	7	8	57	9
2016	3	5	3	5	5	5	6	32	5
2017	3	3	4	1	1	1	2	15	2
2018	2	4	5	3	4	3	1	22	3
2019	10	8	10	9	9	10	10	66	10

Table C-6 Weighted final rank of met and pollutant parameters (all 7 stations)

Calendar Year	Badgerys Creek	Holsworthy	Horsley Park	Liverpool	Prospect	Richmond	St Marys	Sum of Ranks	Combined Rank
2010	7	ND	9	7	10	10	9	52	8
2011	8	ND	7	8	7	8	7	45	7
2012	1	3	1	1	1	4	3	14	2
2013	5	6	6	6	6	6	5	40	6
2014	4	1	3	3	3	3	4	21	3
2015	10	7	8	10	9	7	8	59	9
2016	6	5	4	5	5	5	6	36	5
2017	3	2	2	2	2	1	1	13	1
2018	2	4	5	4	4	2	2	23	4
2019	9	8	10	9	7	9	10	62	10

Further building on the above analysis, the ranking and data presented above was extended to define which three-year consecutive data set is most representative of long term conditions. To achieve the ranking the following three-year periods were considered:

- 2010-2012
- 2011-2013
- 2012-2014
- 2013-2015
- 2014-2016
- 2015-2017
- 2016-2018
- 2017-2019

The scaled station values for each year were summed according to the year combinations above and the lowest value chosen as the best year for the three-calendar year met data file for use. The ranking for the six closest stations to the M7 are shown in **Table C-7**.

Table C-7 3 Year datar Ranking combination

Calendar Years	BoM Badgerys Creek	BoM Horsley park	DPE Bringelly	DPE Liverpool	DPE Prospect	DPE St Marys	Combined Rankings	Final Rank
2010-2012	5	6	6	4	5	6	32	5
2011-2013	4	3	4	5	4	4	24	4
2012-2014	2	2	2	2	1	2	11	2
2013-2015	7	8	8	8	8	7	46	8
2014-2016	8	7	7	7	7	8	44	7
2015-2017	6	5	5	6	6	5	33	6
2016-2018	1	1	1	1	2	1	7	1
2017-2019	3	4	3	3	3	3	19	3

Based on the rankings in **Table C-7**, the best three-year met data combination was for 2016-2018. On this basis, the CALMET and GRAMM / GRAL runs were based on this three-year time period.

Meteorological station selection for CALMET

Once the representative / conservative three-year meteorological period was selected, the next stage of assessment was to ascertain which of the available met stations should be used in the CALMET run. The available met stations for the M7 region include the following:

1. Badgerys Creek BoM Station (67108)
2. Bankstown Airport BoM Station (66137)
3. Camden Airport BoM Station (68192)
4. Campbelltown (Mount Annan) BoM Station (68257)
5. Canterbury Racetrack (66194)
6. Holsworthy Aerodrome BoM Station (66161)
7. Holsworthy Defence BoM Station (68263)
8. Horsley Park BoM Station (67119)

9. Mangrove Mountain BoM Station
10. Mount Boyce BoM Station
11. Penrith Lakes BoM Station (67113)
12. Richmond RAAF BoM Station (67105)
13. Sydney Olympic Park (Archery Centre) BoM Station (66212)
14. Bargo DPE Station
15. Bringelly DPE Station
16. Camden DPE Station
17. Campbelltown West DPE Station
18. Chullora DPE Station
19. Liverpool DPE Station
20. Prospect DPE Station
21. Randwick DPE Station
22. Richmond DPE Station
23. St Marys DPE Station.

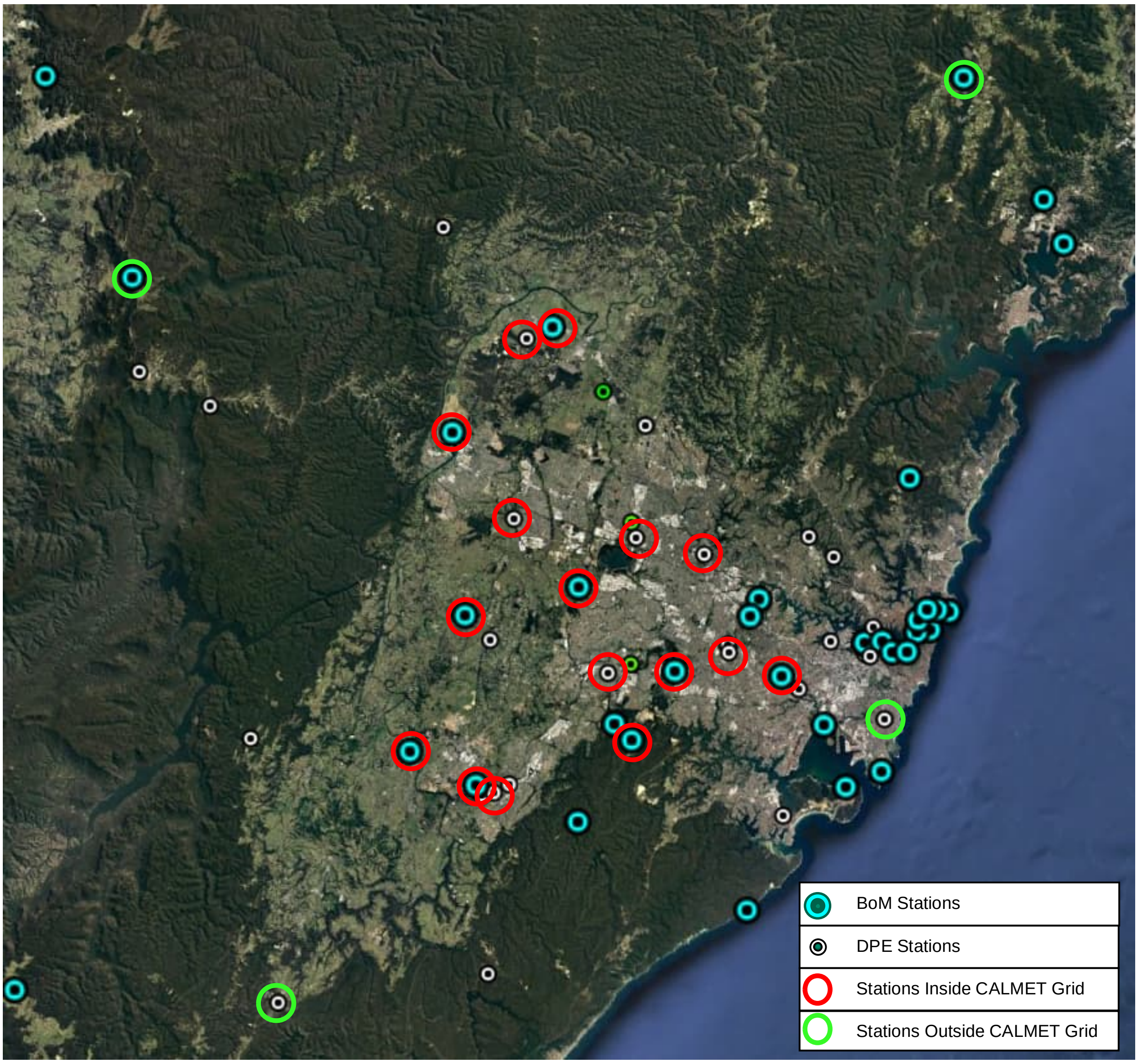


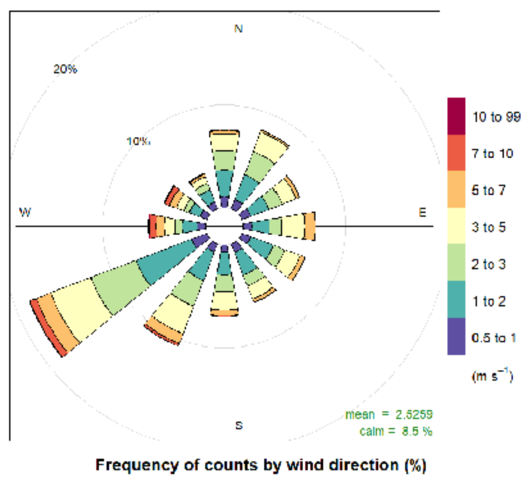
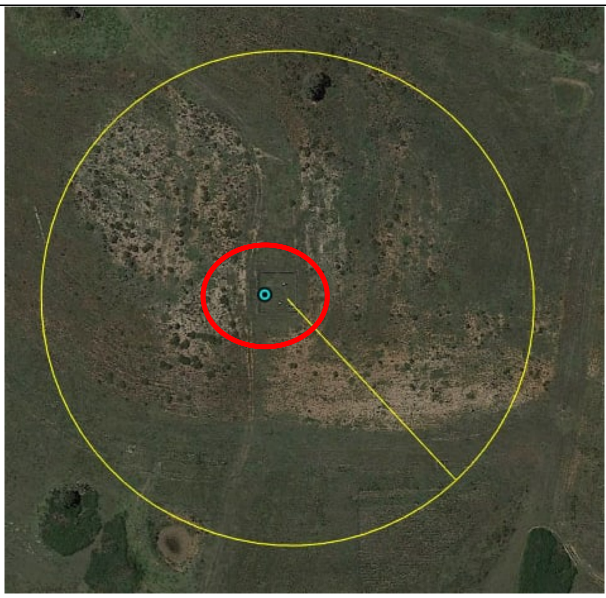
Figure C-19 CALMET surface station locations

Station analysis

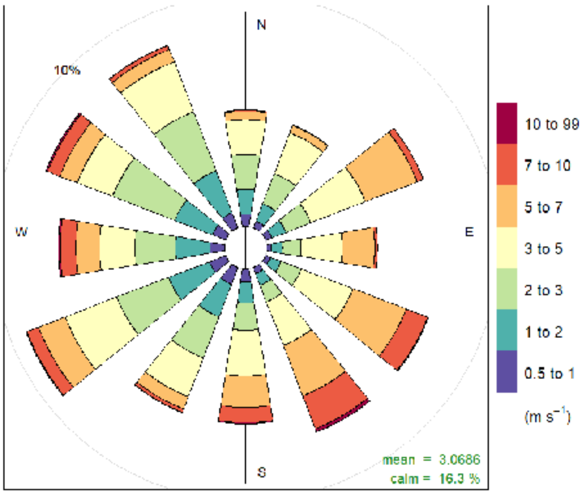
An analysis has been undertaken examining the following:

- Compliance of the station with Australian Standard AS/NZS 3580.1.1:2007 - Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment
- Whether there are any indications of bias in the wind roses

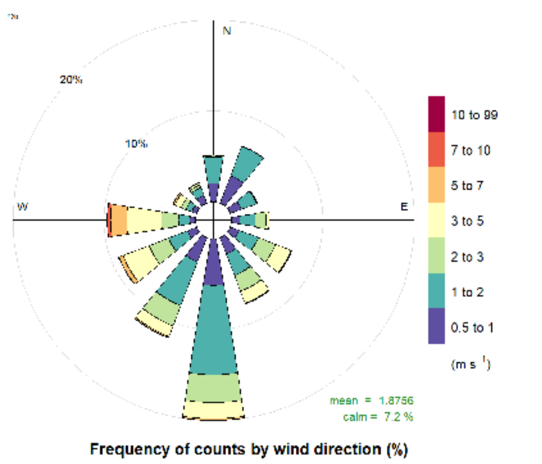
Badgerys Creek BoM Station (67108)

	
Wind rose, 2010-2019	Aerial view of station
No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).	

Bankstown Airport BoM station (66137)

	
Wind rose, 2010-2019	Aerial view of station
This station is in the centre of the airfield. No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).	

Bargo DPE station



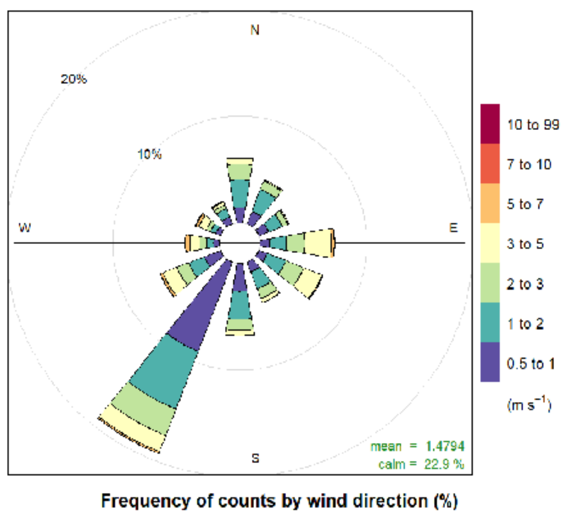
Wind rose, 2010-2019

Aerial view of station

This station is position in an empty field adjacent to a long stand of trees. There are some trees to the north which may affect winds from that direction. The wind rose does show a lower proportion of winds from the northerly sectors suggesting a blocking effect due to the trees.

Despite the potential for obstacle effects, the Randwick station will still be included in the CALMET model as it represents an "off-met-grid" met station, which only provides boundary condition winds for the CALMET run. As its contributions to the overall winds are minor, it has been used for the development of the overall meteorology for the Proposed Modification.

Bringelly DPE station

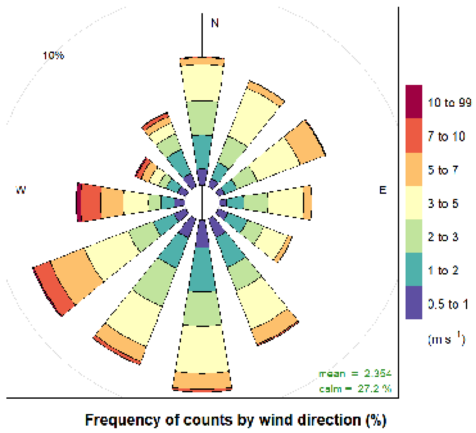


Wind rose, 2010-2019

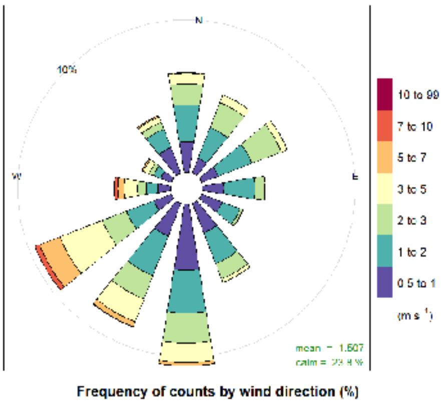
Aerial view of station

Couple of minor trees observed from the aerial photograph close to the station (within 5m of the station fence line). Close trees when viewed horizontally are very low and well below the elevation of the anemometer. Close trees not a problem for WS/WD. Stand of trees observed ~15m to the SE of the station. Trees are ~10-20m tall. May affect the winds slightly, but unlikely to be too badly affected.

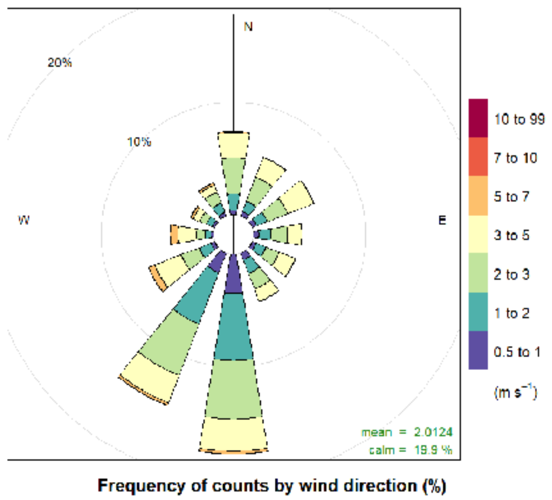
Camden Airport BoM station (68192)

	
Wind rose, 2010-2019	Aerial view of station
This station is situated off the edge of the airfield. No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).	

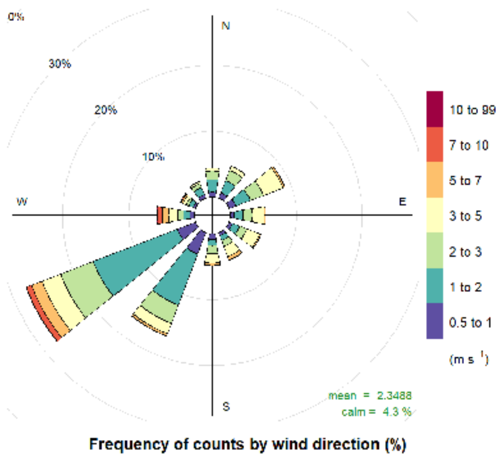
Camden DPE Station

	
Wind rose, 2010-2019	Aerial view of station
Met station is situated very close to a single storey building to the west and south of the station and a large tree to the SW of the station. Based on the wind rose, the building and tree may be affecting the meteorology with a lower than expected westerly portion of winds with a higher SW proportion of winds potentially suggesting winds being channelled around the building to the west. No notes were included on the DPE website in relation to proximity to buildings or trees.	

Campbelltown (Mount Annan) BoM station (68257)

	
Wind rose, 2010-2019	Aerial view of station
No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height). This location is likely to be heavily affected by local terrain, with the station positioned in a NWE-SSW oriented valley formation.	

Campbelltown West DPE Station

	
Wind rose, 2010-2019	Aerial view of station
No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height)	

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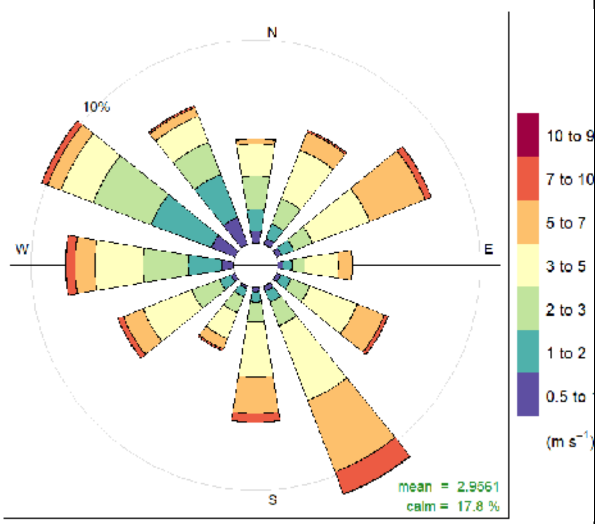
Canterbury BoM Station (66194)

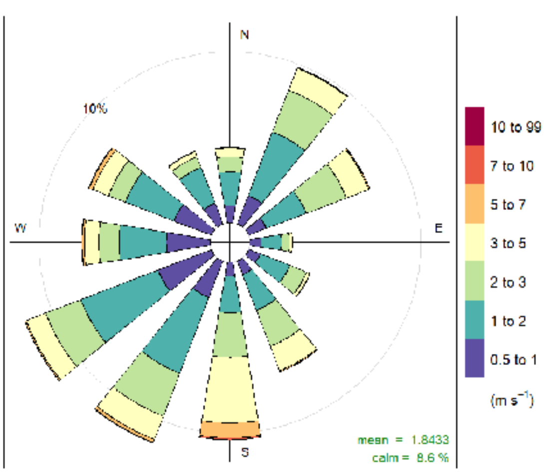


Wind rose, 2010-2019

Aerial view of station

This station is in the centre of the racetrack with no obstructions or concerns. Should be very reliable.

Chullora DPE Station



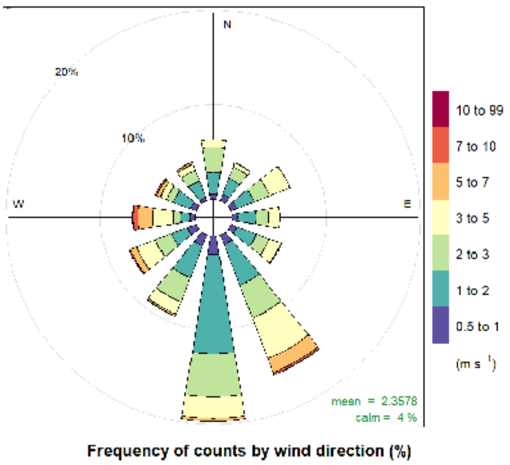
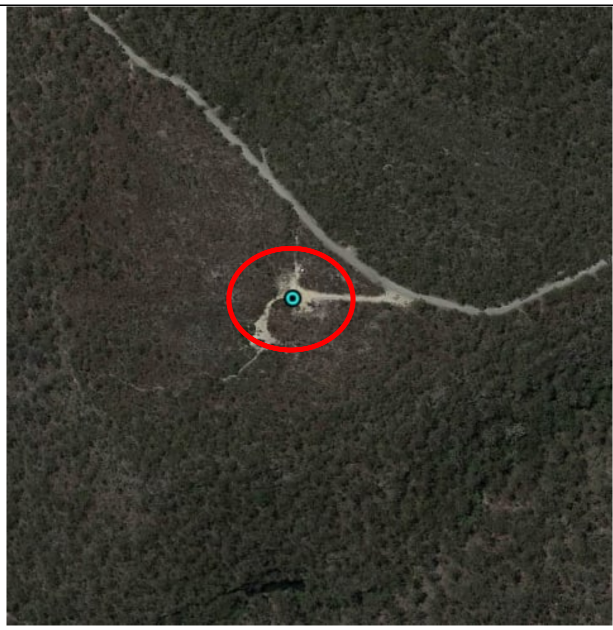
Wind rose, 2010-2019

Aerial view of station

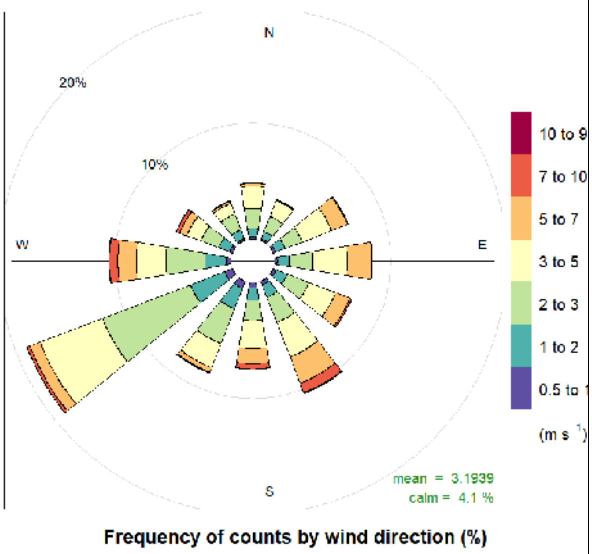
There are several large trees around the station, particularly to the east of the station. These may have affected the westerly portion of winds, but overall the station seems OK.

Note on the ESS Website - The site does not currently comply with Australian Standard AS/NZS 3580.1.1:2007 - Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment as the clear sky angle is < 120° due to trees within 20 metres to the north-east and east of the monitoring site

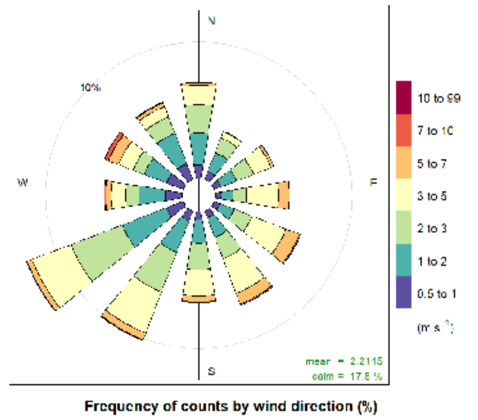
Holsworthy Defence BoM Station (68263)

	
Wind rose, 2010-2019	Aerial view of station
There are low shrubs and trees close to the boundary of the met station enclosure. Although there are obstacles within the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height), the wind direction is not expected to be affected by the vegetation surrounding the station.	

Holsworthy Aerodrome BoM Station (66161)

	
Wind rose, 2010-2019	Aerial view of station
No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).	

Horsley Park BoM station (67119)

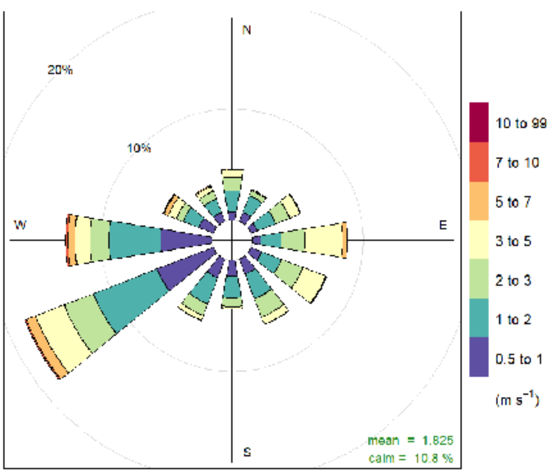


Wind rose, 2010-2019

Aerial view of station

No there are several single trees along a road ~40m – 60m to the NW of the met tower. The spacing of the trees and nature of the trees (white thinly leafed variety) suggest that they are unlikely to significantly affect the wind measurements. The shipping containers to the SW of the tower are unlikely to be high enough to affect the air flow measured at the tower.

Liverpool DPE station



Wind rose, 2010-2019

Aerial view of station

Minor buildings to the south and a small tree to the south. Unlikely to affect the station. Station reflects the topography in which the station is installed i.e. SW-NE valley. Should be OK if needed.

Mangrove Mountain BoM station (63292)

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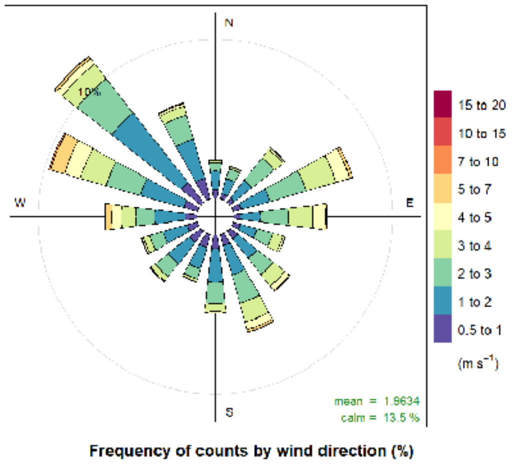
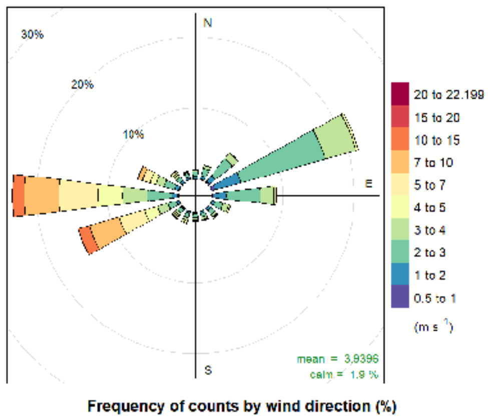
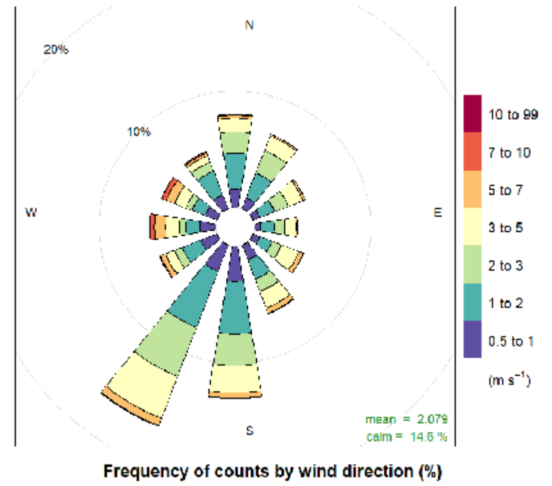
<tr><td>
</td><td></td></tr>
<tr><td>Wind rose, 2010-2019</td><td>Aerial view of station</td></tr>
<tr><td colspan="2">There are several low shrubs / trees in the immediate area surrounding the met tower. Given the predominantly low shrubs / trees in the area around the station, the location should be representative of meteorology in the area without any major obstruction bias.</td></tr>
</table>

Mount Boyce BoM station (63292)

<table>
<tr><td>
</td><td></td></tr>
<tr><td>Wind rose, 2010-2019</td><td>Aerial view of station</td></tr>
<tr><td colspan="2">There are several low trees in the immediate area surrounding the met tower. There are a few trees to the south at a distance of >30m which are equal to or taller than the met tower. Given the predominantly low trees the station should be representative of meteorology in the area without any major obstruction bias.</td></tr>
</table>

Penrith Lakes BoM station (67113)

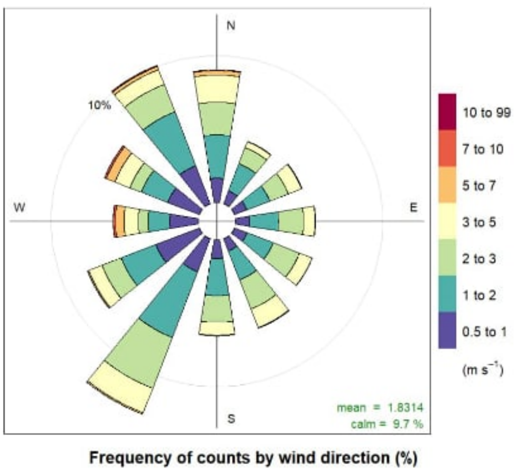


Wind Rose, 2010-2019

Aerial View

No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).

Prospect DPE station

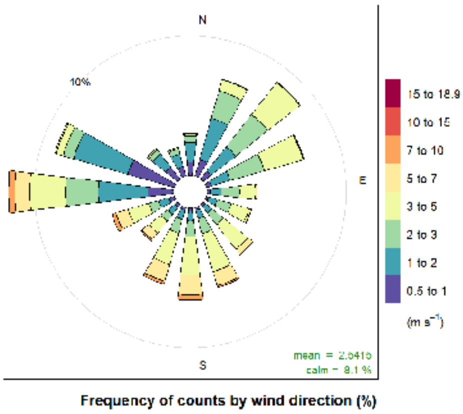


Wind Rose, 2010-2019

Aerial View of station

There are a couple of minor trees around the station. Trees are well below the height of the anemometer and unlikely to drastically affect the meteorology at the station.

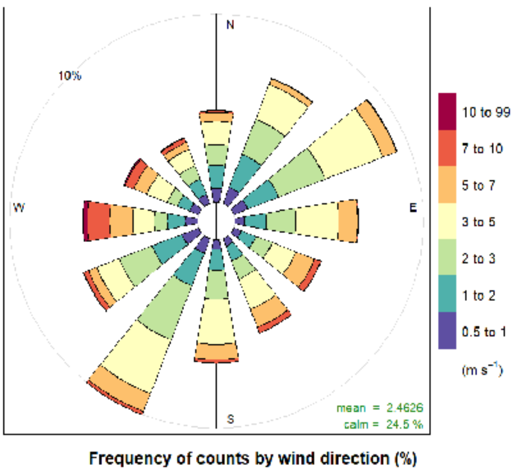
Randwick ESS station

	
Wind Rose, 2010-2019	Aerial View

There are several large trees to the immediate vicinity of the station to the north of the met tower. It is likely there are significant obstructions within the recommended distance from the met tower which may affect the wind direction (10x Tree height or 10x Building height). There is evidence that there may be an effect from the north with the wind rose showing a lower proportion of wind from that sector. This may be coincidental, but also may be reflective of an obstacle effect.

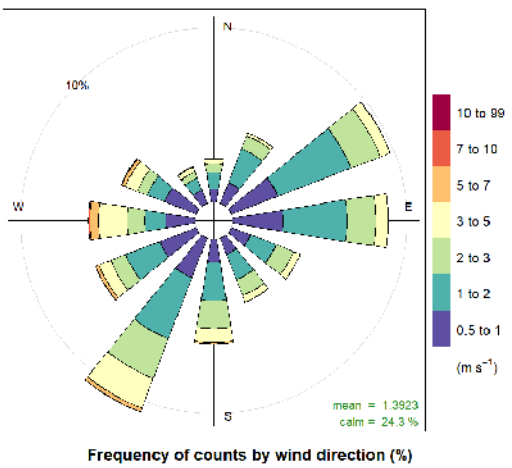
Despite the potential for obstacle effects, the Randwick station will still be included in the CALMET model as it represents an “off-met-grid” met station, which only provides boundary condition winds for the CALMET run. As its contributions to the overall winds are minor, it has been used for the development of the overall meteorology for the Proposed Modification.

Richmond RAAF BoM station (67105)

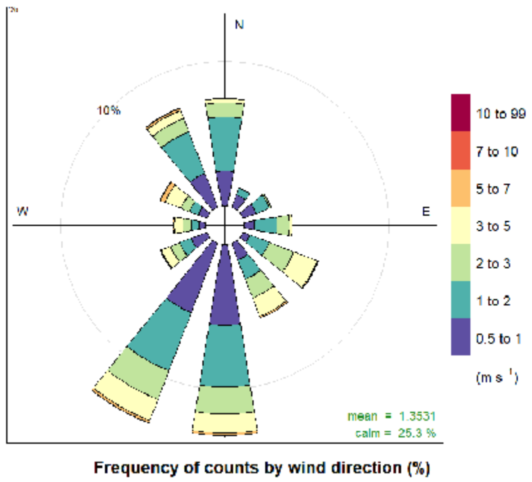
	
Wind Rose, 2010-2019	Aerial View

No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).

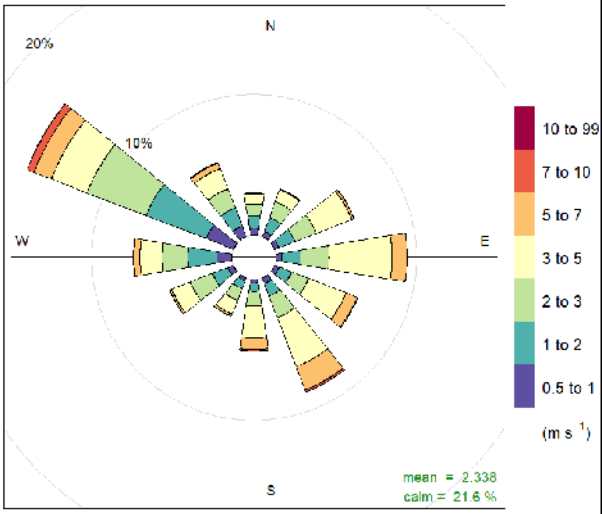
Richmond DPE station

<table>
<tr><td>
</td><td></td></tr>
<tr><td>Wind Rose, 2010-2019</td><td>Aerial View of station</td></tr>
<tr><td colspan="2">No trees or obstacles close to the met station. All obstacles well outside the siting distance recommended by AS3580-14 (10x Tree height or 10x Building height).</td></tr>
</table>

St Marys DPE station

<table>
<tr><td>
</td><td></td></tr>
<tr><td>Wind Rose, 2010-2019</td><td>Aerial View of station</td></tr>
<tr><td colspan="2">No there is a large stand of tall trees ~40m to the NE of the met tower. These trees are all likely to be much taller than the tower and may affect the wind direction in the NE sector. There is a smaller frequency of winds from the NE for the St Marys met tower which may suggest an influence by the tree line in that direction. There are some large buildings to the south, however wind patterns suggest significant winds from the south which appear unaffected by the buildings.</td></tr>
</table>

Sydney Olympic Park (Archery Centre) BoM station (66212)

	
Wind Rose, 2010-2019	Aerial View of station
A stand of trees is located to the NW of the station which is otherwise unobstructed. The trees are medium height mangroves which are not expected to overly affect the station readings at 10m	

Overall station assessment

The station analysis has been summarised below in **Table C-8**.

Table C-8 Station analysis summary

Station	BoM / DPE	Comments	Rank[1]
Badgerys Creek	BoM	No limitations	1
Bankstown Airport	BoM	No limitations	1
Bargo	DPE	Possibly affected by trees / buildings to north	
Bringelly	DPE	Possibly affected by trees to the SE of station	3
Camden Airport	BoM	No limitations	1
Camden	DPE	Buildings close to station, may be affected	3
Campbelltown (Mount Annan)	BoM	No obstacles, possibly terrain skewed	2
Campbelltown West	DPE	No limitations	1
Canterbury Racecourse	BoM	No limitations	1
Chullora	DPE	Possibly affected by trees / buildings to east	3
Holsworthy Defence	BoM	Only data from Dec 2017-2019	3
Holsworthy Aerodrome	BoM	No limitations	1
Horsley Park	BoM	No limitations	1
Liverpool	DPE	No obstacles, possibly terrain skewed	2

Station	BoM / DPE	Comments	Rank[1]
Mangrove Mountain	BoM	No limitations	1
Mount Boyce	BoM	No limitations	1
Penrith Lakes	BoM	No limitations	1
Prospect	DPE	No limitations	1
Randwick	DPE	Possible obstructions, still usable	2
Richmond RAAF	BoM	No limitations	1
Richmond	DPE	No limitations	1
St Marys	DPE	Minor tree obstacles, possibly terrain skewed	2
Sydney Olympic Park (Archery)	BoM	No limitations	1
[1] Ranking are: (1) No limitations, (2) Possibly Skewed by Terrain, and (3) Likely affected by obstacles or insufficient data and not considered usable			

Of the stations examined, the only stations that have been omitted due to problems with the siting or data were:

- Bringelly DPE station (not of concern due to the proximity of the Badgerys Creek BoM station)
- Camden DPE station (not of concern due to the proximity of the Camden Airport BoM station)
- Holsworthy defence has limited data for the 3-year time-period and has been omitted from the analysis. Holsworthy Defence is close to the Holsworthy Aerodrome that is considered representative of the area, so no loss in data reliability in that area.

Note that Chullora data has been included despite a rating of 3. Analysis of this station suggests that the data is accurate and is not adversely affected by trees or buildings in the surrounding environment. On this basis it has been included in the assessment.

CALMET settings

The CALMET settings are summarised in **Table C-9**. Critical settings used within CALMET have been explained below along with details of all general settings used in CALMET.

Table C-9 CALMET settings

Parameter	Value
Meteorological grid domain	50 km x 50 km
Meteorological grid resolution	250 metre resolution (200 x 200 grid cells)
Reference grid coordinate (SW corner)	281.100 km E, 6231.700 km S
Cell face heights in vertical grid (m)	0,20,40,80,160,320,640,1200,2000,3000,4000
Simulation length	3 years (2016-2018)
Surface meteorological stations	BoM Stations Badgerys Creek (Station 67108) Bankstown Airport (Station 66137) Camden Airport (Station 68192) Campbelltown (Mount Annan) (Station 68257) Canterbury Racetrack (Station 66194) Holsworthy Aerodrome (Station 66161) Horsley Park (Station 67119) Penrith Lakes (Station 67113) Richmond RAAF (Station 67105) Sydney Olympic Park (Archery Centre) (Station 66212) DPE Stations Campbelltown West Chullora Liverpool Prospect Richmond St Marys Boundary Condition Stations (outside of Met Domain) Mount Boyce (Station 63292) Mangrove Mountain (Station 66059) Randwick DPE Bargo DPE
Upper air meteorology	5 TAPM derived up.dat files
CALMET Modelling Mode	Observations mode
Terrain data	Terrain elevations were extracted from NASA Shuttle Radar Topography Mission Version 3 data set (SRTM1 30 metre resolution).
Land use Data	USGS 1km GLCC land use dataset
Wind field guess	Computed internally
Seven critical CALMET parameters	TERRAD = 5 km RMAX1 = 5 km R1 = 5 km RMAX2 = 10 km R2 = 10 km IEXTRP = -4 BIAS = -1,-0.5,0,0.5,1,1,1,1,1,1

TERRAD

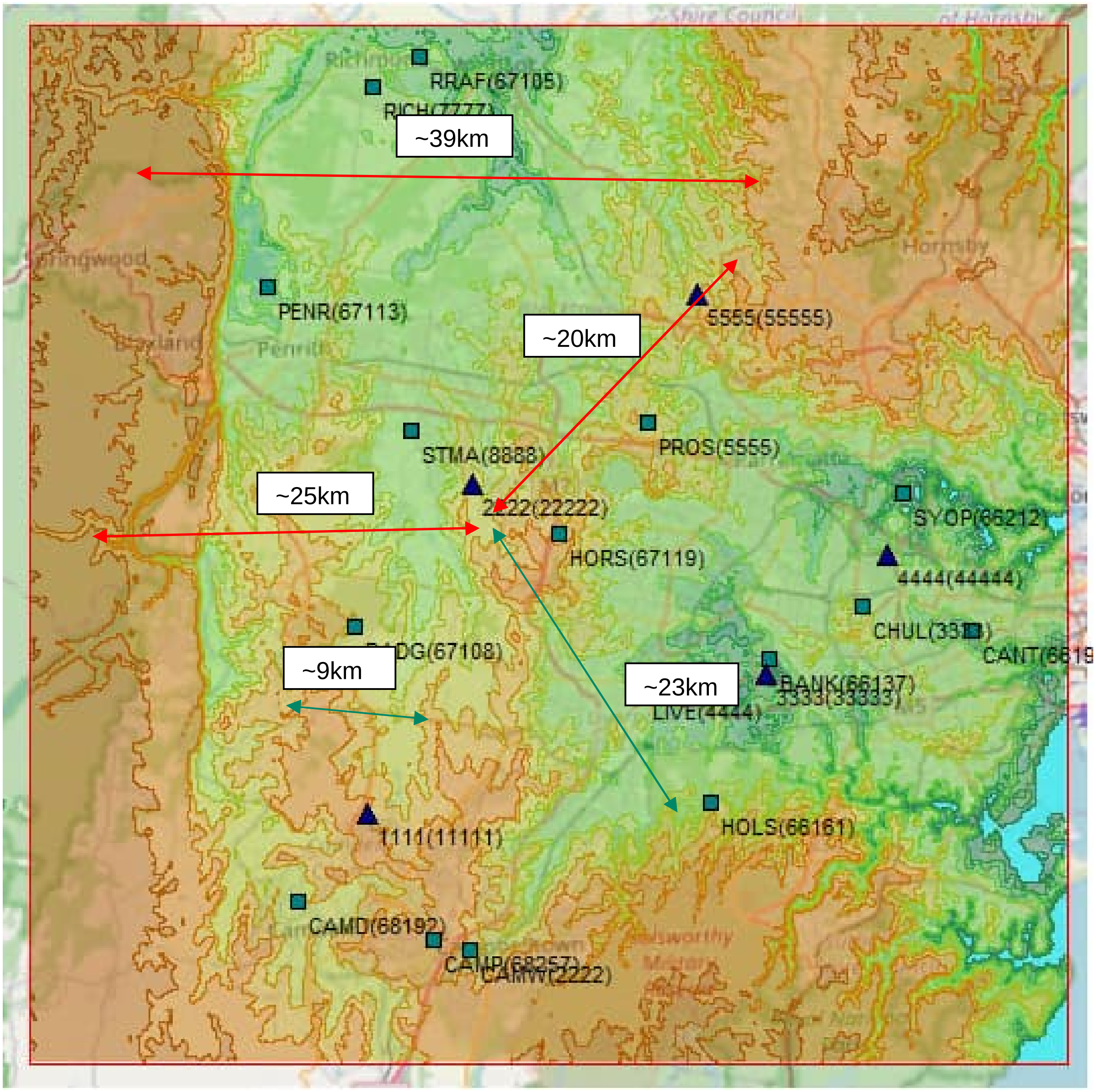


Figure C-20 Ridge-to-ridge locations used in calculating TERRAD

Given the location of the M7 Roadway the TERRAD should be based on an average of the 4 closest ridge to ridge distances plotted in **Figure C-20**.

Average = 23.2km (39km, 20km, 25km, 9km and 23km). TERRAD = ½ the ridge-to-ridge distance, therefore the **TERRAD value for this run = 23.2 ÷ 2 = 11.6km = 12km** (typically rounded up to the nearest km as per CALPUFF guidelines).

IEXTRP

Default is ‘to extrapolate using similarity theory” and to exclude upper air observations from Layer 1

This switch affects whether the model allows vertical extrapolation of surface data or not. This switch was developed since upper air observations are typically only taken every 12 hours. The vertical extrapolation of surface wind observations allows for the hourly surface data to impact layers above the surface layer.

The default of this value is set to -4, which means similarity theory is used to extrapolate the surface winds into the layers aloft, which provides more information on the observed local effects to the upper layers.

IEXTRP affects vertical extrapolation of surface winds, and whether layer 1 data from upper air stations are ignored, and is normally is set to -4. Setting IEXTRP < 0, means that the lowest layer of the upper-air observation will not be considered in any interpolations. Since upper-air observations are only taken every 12-hours, the time-interpolated surface wind values from the upper-air observations are usually of no use. When IEXTRP is set to -4, similarity theory is used to extrapolate the surface winds into the layers aloft, which provides more information on observed local effects to the upper layers. Setting IEXTRP to 0 means that no vertical extrapolation from the surface wind data is used.

A value of IEXTRP < 0 means that upper-air observations will not be considered in the Layer 1.

<u>Setting assumed for this run was -4</u>

BIAS

The BIAS parameter is most often used in complex terrain situations. The BIAS value ranges from -1 to +1, and a value is input by the user for each vertical layer. A value of -1 means the surface station has 100% weight, while a value of +1 means the upper air station has 100% weight. In simple terrain situation, BIAS is often set to zero (0) for each vertical layer which means the upper air and surface wind and temperature observations are given equal weight in the 1/r2 interpolations used to initialize the computational domain.

The BIAS affects how the initial Step 1 winds will be interpolated to each grid cell in each vertical layer based on upper air and surface observations. By setting BIAS to -1, we eliminate upper-air observations in the interpolations for this layer. Conversely by setting BIAS to +1, we eliminate the surface observations in the interpolations for this layer.

An example where non-default settings for BIAS may be used is for a narrow, twisting valley, where the only upper-air observations were 100 km to the west, and the only local surface wind observations were in one location in the valley. For this example, we might set BIAS to -1 within the valley forcing surface data only to be used for the lowest layers, and BIAS to +1 above the valley forcing upper air data only to be used aloft, and BIAS might go from -1 to +1 in the transitional layers at the top of the valley.

From the guidance:

- Default (NZ * 0) is to not change the 1/R2 weighting given equally to surface and upper air data
- Not used in No-Obs mode
- Requires user input, depending on validity of surface and upper air stations

<u>BIAS Settings adopted in this study were = -1,-0.5,0,0.5,1,1,1,1,1,1</u>

The intent here is to bias the surface data more heavily in the first two layers with the third layer neutral and stronger bias toward upper air data from 4^{th} layer upwards. This was based on the widespread, good quality surface data available for the dispersion model across the domain. Extrapolating the upper air down to the surface layers was not necessary or desirable for this run.

R1 & R2

The value of R1 and R2 are used in the construction of the Step 2 wind field, where the observed winds are 'blended' in with the Step 1 winds and observations. R1 represents the distance from a surface observation station at which the surface observation and the Step 1 wind field are weighted equally.

R2 represents the comparable distance for winds in layers 2 and above. It is important to note that all the results of the diagnostic wind model (kinematics, slope and blocking effects) are contained in the Step 1 wind field, thus if too much weight is given to the observations, then you will essentially erase all the information generated in creating the Step 1 winds. Rule of thumb is to start with small R1 and R2 values and slowly increase these values if you do not believe the surface stations are showing enough weight.

Typically for observation sites in flat terrain values of R1 and R2 are larger than in mountainous terrain where a station's flow is limited by the valley segment.

From the guidance:

- No Default.
- Requires user input. Value in km specific to each model domain 1 value represents all stations.
- Not used in No-Obs model.

Looking at the R1 Value, we can look at the minimum distance from any individual station to another station as a first pass at defining the R1 value. The minimum value is ~2.3km with the largest distance ~11.6km. While this technically doesn't have anything to do with "*the distance from a surface observation station at which the surface observation and the Step 1 wind field are weighted equally*" it gives a bit of a hint as to the distance between observation stations and how far the R1 value may need to be before the Step 1 wind field is weighted equally to the surface observations.

R1 Value assumed for this CALMET run is 5km

R2 Value assumed for this CALMET run in 10km

RMAX1 & RMAX2

The values of RMAX are also used in the construction of the Step 2 wind field, where the observed winds are 'blended' in with the Step 1 winds. Any observation for which R_k (the distance from the grid cell to the k-th observation location) is greater than RMAX1 in the surface layer, or RMAX2 aloft is excluded from the above 'blending' formula. We can use RMAX1 and RMAX2 to exclude observations from being inappropriately included (as they are in the next valley, on the other side of a mountain, etc.). Note, if you are using RMAX1 and RMAX2 to exclude observations, then you do not want to set LVARY to T, as then CALMET will increase the values of RMAX1 and RMAX2 to at least capture the nearest observation, regardless of whether this makes sense.

Typically values of RMAX1 and RMAX2 are smaller than R1 and R2, this way ‘sharp’ boundaries between the Step 1 wind field and the weighted observation station are prevented.

From the guidance:

- No Default
- Requires user input. Value in km specific to each model domain 1 value represents all stations
- Not used in No-Obs model

These values have been set slightly smaller than the R1 and R2 values to prevent the sharp boundaries between the Step 1 wind field and the weighted observation data.

RMAX1 Value assumed for this CALMET run is 3km

RMAX2 Value assumed for this CALMET run in 5km

Other settings in CALMET

The additional settings adopted by the assessment are presented in **Table C-10.**

Table C-10 Additional CALMET settings

Option	Parameter	Adopted Value	Notes
Meteorology Options (Group 1 of CALMET inputs)			
This switch determines whether you use just observational data, or, a combination of surface and prognostic data, or, prognostic data only	NOOBS	0	NOOBS can be any of 0, 1 or 2, depending on whether CALMET is run with observation data only (0), a combination of prognostic and surface data (1) or, just prognostic model data (2)
Cloud data options; 0, 1, 2, 3, 4	ICLOUD	4	Compute the gridded cloud cover from relative humidity profile using all levels of data (“*MM5toGrads*” algorithm)
Wind Field Model Options (Group 5 of CALMET inputs)			
Wind field model selection variable	IWFCOD	1	Use of the diagnostic wind module is recommended
Compute Froude number adjustment effects	IFRADJ	1	Used to evaluate thermodynamic blocking effects of the terrain on

Option	Parameter	Adopted Value	Notes
			the wind flow and are described using the critical Froude number (see CRITFN to define)
Compute kinematic effects	IKINE	0	Do not calculate a terrain-forced vertical velocity in the initial guess wind field. (This option is normally turned off, especially at when using fine resolution due to occasional non-convergence of algorithm producing anomalous wind speeds in Layer 2
O'Brien procedure for adjustment of the vertical velocity	IOBR	0	No adjustment required to the vertical velocity profile at the top of the model domain
Compute slope flows	ISLOPE	1	Yes, compute upslope and downslope flows which are calculated as a function of sensible heat flux, distance to the crest or valley bottom and slope angle
Extrapolate calm winds aloft (0=no, 1=yes)	ICALM	0	Selection depends on whether adequate upper air data are available to determine winds in Layer 2 and above. Normally ICALM=0 when using gridded prognostic data. Extrapolating calms in a steep valley may be appropriate. A (1) for ICALM will extend calm conditions to the top of the boundary layer.
Minimum distance between upper air station and surface station for which extrapolation of surface winds will be allowed	RMIN2	-1	This option is designed to avoid extrapolated surface data "competing" with actual upper air measurements when both surface and upper air measurements are co-located. However, the better time resolution of the surface data (hourly) suggests extrapolating may be appropriate. RMIN2 defined the distance between measurements defining "co-located". Using -1 when IEXTRP = +/- 4 will ensure extrapolation of all surface stations
Gridded prognostic wind field model output fields as initial guess wind field	IPROG	0	This option refers to the use of gridded prognostic meteorological model output as the initial guess wind field in CALMET.
Time step (seconds) of the prognostic model input data	ISTEPPG	3600	Usually this is an hourly time step. Some gridded prognostic data may be available only every 3 hours (ISTEPPG=3)

Option	Parameter	Adopted Value	Notes
Use coarse CALMET fields as initial guess fields	IGFMET	0	Default is off (0), but useful option if you do not have prognostic model data. When switch is on (1) the coarse CALMET fields from an earlier run will be used to define the IGF
Radius of influence Parameters			
Use varying radius of influence	LVARY	F	The recommended value is F which turns off the varying radius of influence option. LVARY=T may be used when using objective analysis rather than the diagnostic wind module (IWFCOD=0). LVARY=T results in the radius of influence being expanded when no stations are within the fixed radius of influence value. Caution is warranted because when LVARY=T, the model effectively enlarges RMAX to incorporate the 'nearest' station regardless of whether it is suitable or not
Other Wind Field Input Parameters			
Minimum radius of influence used in the wind field interpolation	RMIN	0.1	Recommendation is a very small value (0.1 km). Used to prevent a divide by zero error when a grid point and station are co-located
Relative weighting of the prognostic wind field	RPROG	0	Only change this value if CSUMM winds are used in the Step 1 wind field. CSUMM model data is very rarely used and outdated format of entering prognostic wind speeds and direction into the model
Maximum acceptable divergence in the divergence minimization procedure	DIVLIM	$5x10^{-6}$	No need to change this default value which has been rigorously tested
Maximum number of iterations in the divergence minimization procedure	NITER	50	Recommended default value (50) is normally used
Number of passes in the smoothing procedure	NSMTH (NZ)	2, 9*4	Recommended values are 2 passes in the lowest layer, 4 passes in the higher layers. More passes will result in more smoothing of the final wind field. But rarely altered
Maximum number of stations used in each layer for the interpolation of data to a grid point	NINTR2	99	Normally, recommended default value (99) is used

Option	Parameter	Adopted Value	Notes
Critical Froude Number	CRITFN	1	Terrain blocking occurs when Froude number < CRITFN. Default value should be used except when justified by data
Empirical factor controlling the influence of kinematic effects	ALPHA	0.1	Use default
Multiplicative scaling factor for extrapolation of surface observations to upper layers	FEXTR2 (NZ)	NZ x 0.0	Seldom used and not used when IEXTRP = +/- 4
Barrier Information			
Number of barriers to interpolation of the wind fields	NBAR	0	Usually not used. Use barriers to block out a certain station effects. Barriers can extend from the surface layer to user-defined upper layer limit
X and Y coordinates of barriers	XBBAR, YBBAR, XEBAR, YEBAR	Not Used	Used only if NBAR > 0 to define the coordinates of the barrier
Level (1 to NZ) up to which barriers apply	KBAR	Not Used	Used only if NBAR > 0. User defined switch to control vertical extent of barriers. This requires careful examination of the resulting wind field at each level
Diagnostic Module Data Input Options			
Surface temperature	IDIOPT1	0	Compute the surface temperature internally from hourly surface observations or prognostic model data. DIAG.DAT file is no longer used
Surface station to use for the surface temperature	ISURFT	-1	Use 2-D spatially varying surface temperatures
Diagnostic module domain-averaged lapse rate option	IDIOPT2	0	Computed internally using twice daily upper air data or, prognostic fields. DIAG.DAT file is no longer used
Upper air station to use for domain scale lapse rate	IUPT	-1	Use spatially varying potential temperature lapse rate
Depth through which the domain scale lapse rate is computed	ZUPT	200m	Only used when temperature lapse rate is computed internally from available upper air or gridded prognostic data. Recommended ZUPT value is based on model testing and should not be changed without supporting data
Initial Guess Wind Field	IDIOPT3	0	Computed internally from observations and or prognostic winds
Upper air station to use for initial guess field (IGF).	IUPWND	-1	Use 3-D varying initial guess field. Only used if when using observational data to define the IGF (i.e., NOOBS=0). Default

Option	Parameter	Adopted Value	Notes
			means use the 3-D initial guess field
Bottom and top of layer through which the domain-scale winds are computed	ZUPWND	Not Used	Option not used with 3-D IGF
Observed surface wind components for wind field module	IDIOPT4	0	Keep at recommended value. DIAG.DAT file is no longer used
Observed upper air wind components	IDIOPT5	0	Keep at recommended value. DIAG.DAT file is no longer used
Overwater Surface Fluxes Method and Parameters			
COARE (Coupled Ocean Atmosphere Response Experiment) with no wave parameterization (JWAVE=0), Charnock	ICOARE	10	Recent COARE overwater flux module improves model performance over the previous Overwater Coastal Dispersion (OCD) model algorithm. The US EPA default of ICOARE = 0, which is to use the original deltaT method of OCD model is not recommended because MMS-sponsored model evaluations have demonstrated better performance with the COARE algorithm
Coastal/Shallow water length scale	DSHELF	0 km	Used for COARE fluxes. Default value is 0 km assumes deep water. User can enter a different value in km, to represent the length scale of the shallow water which is then modified for roughness (zo). However, MMS-sponsored model evaluations have demonstrated similar performance with the
COARE warm layer computation	IWARM	0	Used for COARE fluxes. Default value is 0 assuming deep water and well mixed ocean layer. Warm layer computation must be off (IWARM=0) if sea surface temperature is measured with an IR radiometer
COARE cool skin layer computation	ICOOL	0	Used for COARE fluxes. Default value is 0 assuming deep water and well mixed ocean layer. Cool skin layer computation off (ICOOL=0) if sea surface temperature is measured with an IR radiometer

Option	Parameter	Adopted Value	Notes
Mixing Height – Input Group 6 – Empirical Mixing Height Constants			
Neutral mechanical equation	CONSTB	1.41	Value based on empirical data - no need to change
Convective mixing height equation	CONSTE	0.15	Value based on empirical data - no need to change
Stable mixing height equation	CONSTN	2400	Value based on empirical data - no need to change
Overwater mixing height equation	CONSTW	0.16	Value based on empirical data in Gulf of Mexico. May be a function of locations
Absolute value of Coriolis	FCORIOL	1.0E-04 s^{-1}	Suitable default for mid-latitudes, will need to be changed if in higher or lower latitudes accordingly
Spatial Averaging of Mixing Heights	IAVEZI	1	Conduct spatial averaging which is recommended to smooth mixing heights between grid cells
Maximum search radius in averaging process (in grid cells)	MNMDAV	1 grid cell	Typical value is several (1-10) km, but must be expressed in terms of number of grid cells (MNMDAV = X km/DGRIDKM). Note, default value of 1 cell is not the recommended value. MNMDAV must be computed (in grid cell units) from the search radius in km divided by the grid cell size (km)
Half-angle of upwind looking cone for averaging	HAFANG	30 deg	Default value based on model testing
Layer of winds used in upwind averaging	ILEVZI	1	Default value based on model testing
Mixing Height – Input Group 6 – Convective Mixing Height Options			
Method to compute the convective mixing height	IMIXH	1	Maul-Carson for land and water cells. The recommendation reflects the recent research findings of the study sponsored by the MMS. The US EPA default of IMIXH=-1 (Maul-Carson mixing height for over land only and the OCD mixing height overwater) is not recommended because it does not reflect the findings of the MMS-sponsored model evaluation work
Threshold buoyancy flux required to sustain convective mixing height growth overland	THRESHL	0.0 W/m^3	

Option	Parameter	Adopted Value	Notes
Threshold buoyancy flux required to sustain convective mixing height growth overwater	THRESHW	0.05 W/m^3	Recommended value based on testing sponsored by MMS over the Gulf of Mexico
Mixing Height – Input Group 6 – Other Mixing Height Variables			
Minimum potential temperature lapse rate in stable layer above the current convective mixing height	DPTMIN	0.001 deg K/m	Based on empirical testing, do not change unless have data to prove otherwise
Depth of layer above current convective mixing height (ZI) through which potential temperature lapse rate is computed	DZZI	200m	Based on empirical testing, do not change unless have data to justify alternative setting
Minimum overland mixing height	ZIMIN	50m	Reflects presence of typical surface roughness elements, such as vegetation, structures, trees and shear-induced mixing near the ground. User can modify ZIMIN, but do so with caution
Maximum overland mixing height	ZIMAX	3000m	In Australia ZIMAX should typically be 3000m or more
Minimum overwater mixing height	ZIMINW	50m	Based on testing, modify only with supporting data
Maximum overwater mixing height	ZIMAXW	3000m	Based on testing, modify only with supporting data

Appendix D

Methodology for Interpolation of Background Data

Appendix D Methodology for interpolation of background data

Regional availability of DPE data

The proposed Westlink M7 Modification covers a large study area of about 30 km in length. It is therefore reasonable to expect that background concentrations of pollutants of interest would vary spatially along the study area. The location of regionally operating DPE ambient air quality stations is provided in **Figure D-21**. The northern and southern modelling GRAL domains are also shown in **Figure D-21**, noting the closest DPE stations are Bringelly, St Marys, Prospect and Liverpool though none are within the modelling domain.

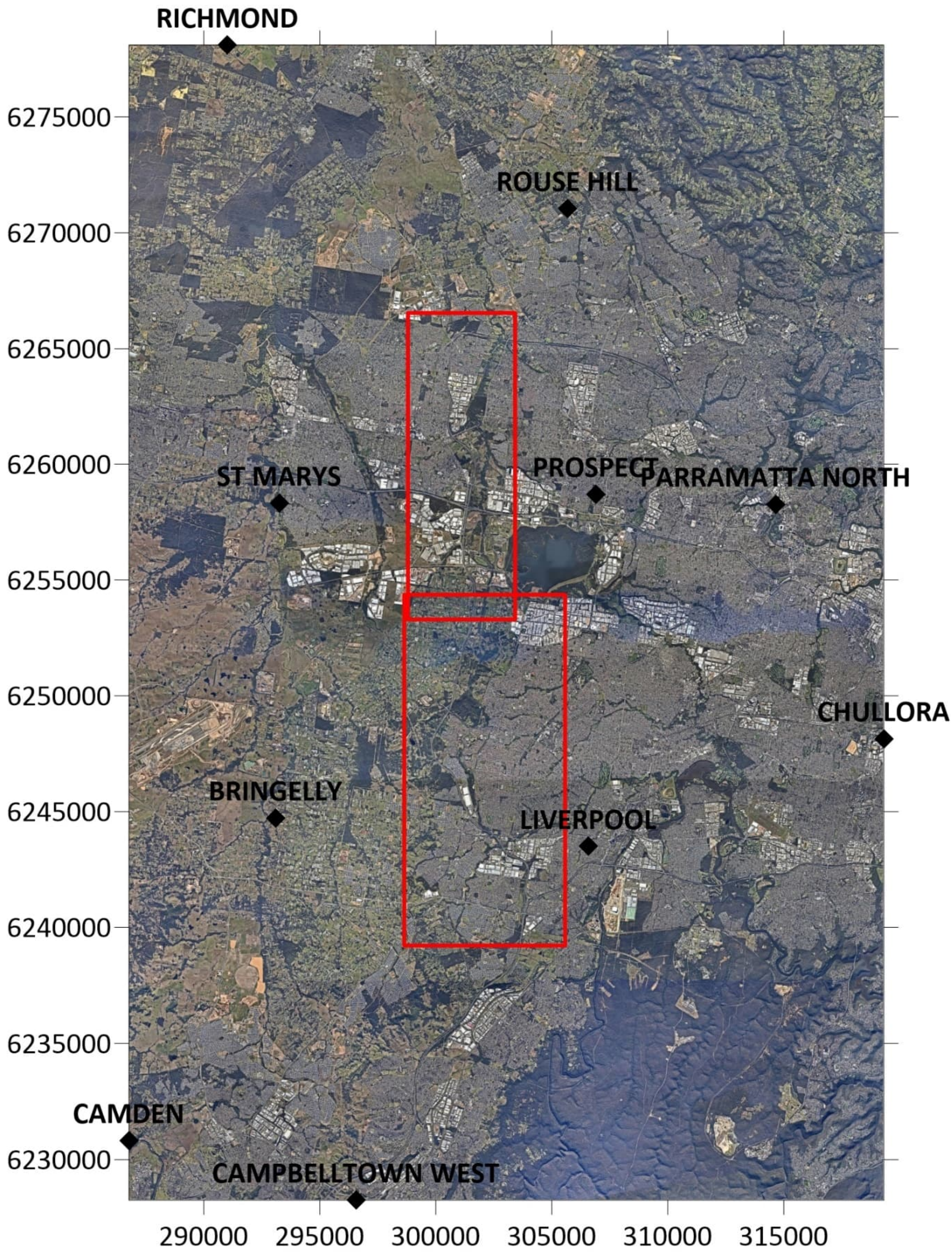


Figure D-21 Regional DPE Air Quality monitoring network surrounding the study area.

Cumulative (Project plus background) concentrations of pollutants were estimated by spatially interpolating concentration measurements for NO_2, PM_{10} and $PM_{2.5.}$ Other pollutants were not included as quality measured concentration data is not available in the study area.

Data availability was generally high for each station included in the interpolation, with most of the stations having over 95 % data availability. The stations with full coverage for the 2017 calendar year with the best and worst data availability are presented in **Figure D-22** (Richmond – worst) and **Figure D-23** (Liverpool – best).

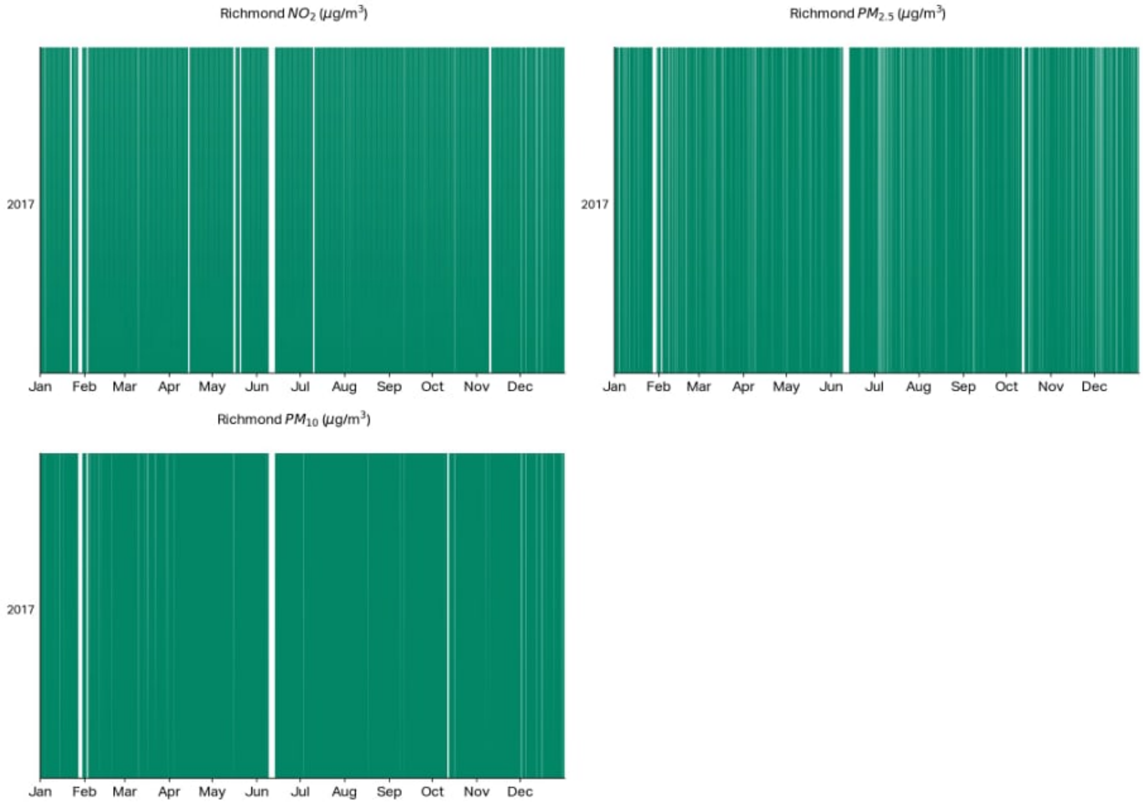


Figure D-22 DPE Data for 2017 at Richmond for NO_2, $PM_{2.5}$ and PM_{10} – green indicates available data

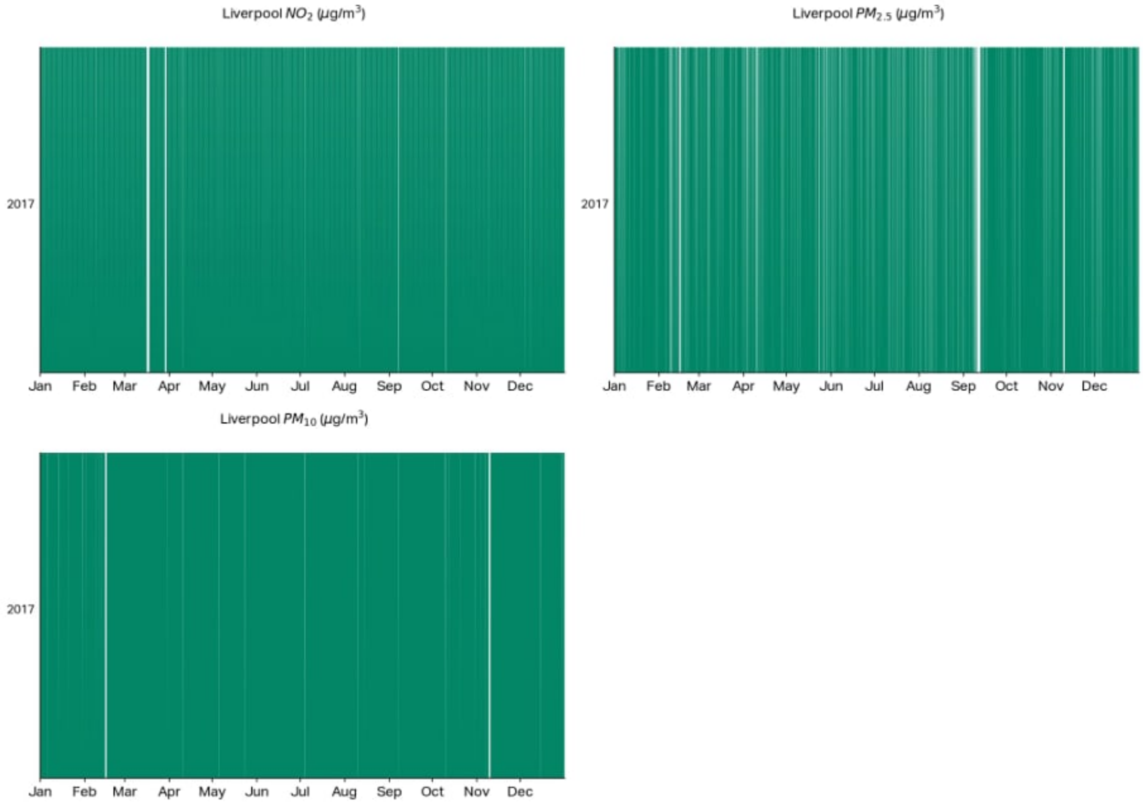


Figure D-23 DPE data for 2017 at Liverpool for NO_2, $PM_{2.5}$ and PM_{10} – green indicates available data

Data interpolation

Hourly recorded monitoring data at each identified monitoring station was interpolated into a grid covering the extent of the monitoring stations using the Python programming language. MGA 56 easting and northing coordinates in metres for each DPE Station were assigned x and y values respectively and hourly background concentrations are assigned z values.

Hourly data was gridded using radial basis function (RBF) interpolation method to create a spatially varying gridded data from the formerly unstructured background air quality data. A multiquadric basis kernel function was used for interpolating grid nodes.

A 500m grid resolution was used for the RBF interpolation. The RBF-interpolated grid was then used to generate concentrations at each of the modelled sensitive receptors. This step was undertaken using a simple linear interpolation.

An overview of the interpolation process is presented in **Figure D-24**.

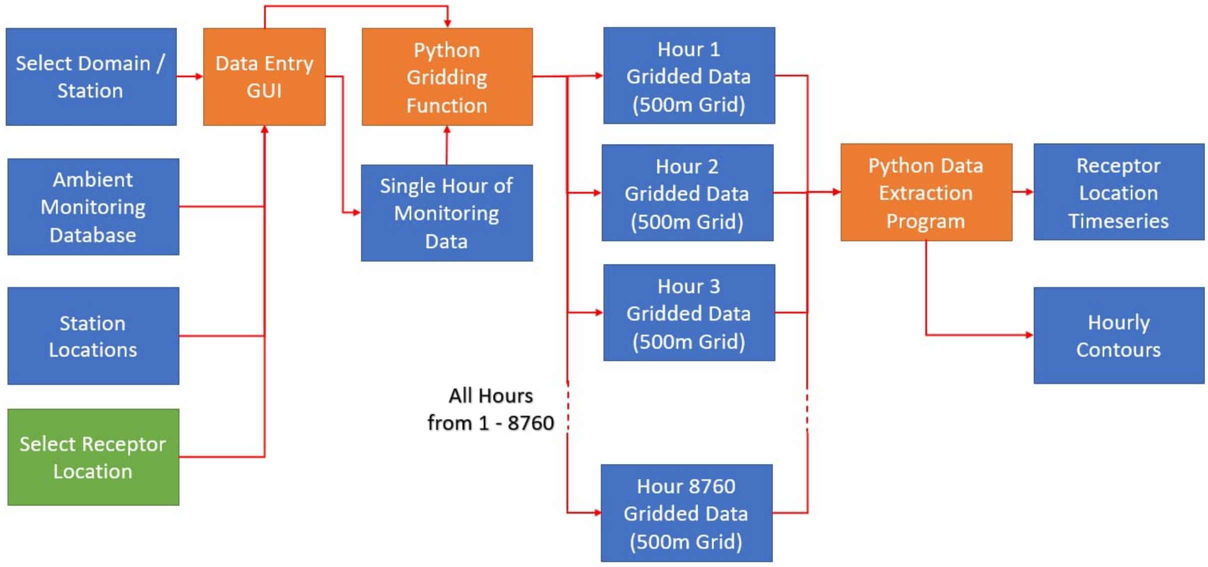


Figure D-24 **Background Air Quality Interpolation methodology flow chart.**

A timeseries covering each hour in the modelled year for each pollutant and each sensitive receptor location was generated from the interpolated data. The timeseries data was combined with hourly predicted concentrations from the GRAL model to generate a contemporaneous data set of cumulative pollutant concentrations (Project plus background).

A sample of the interpolated grid data is presented in **Figure D-25**. This represents interpolated PM_{10} concentrations for the first hour of the background data (January 1st 2017 00:00). For this hour, the highest PM_{10} concentration was measured at Prospect, and the lowest measured at Campbelltown West. Modelled receptors nearest to Prospect for that hour would have a higher background concentration applied to the contemporaneous data set.

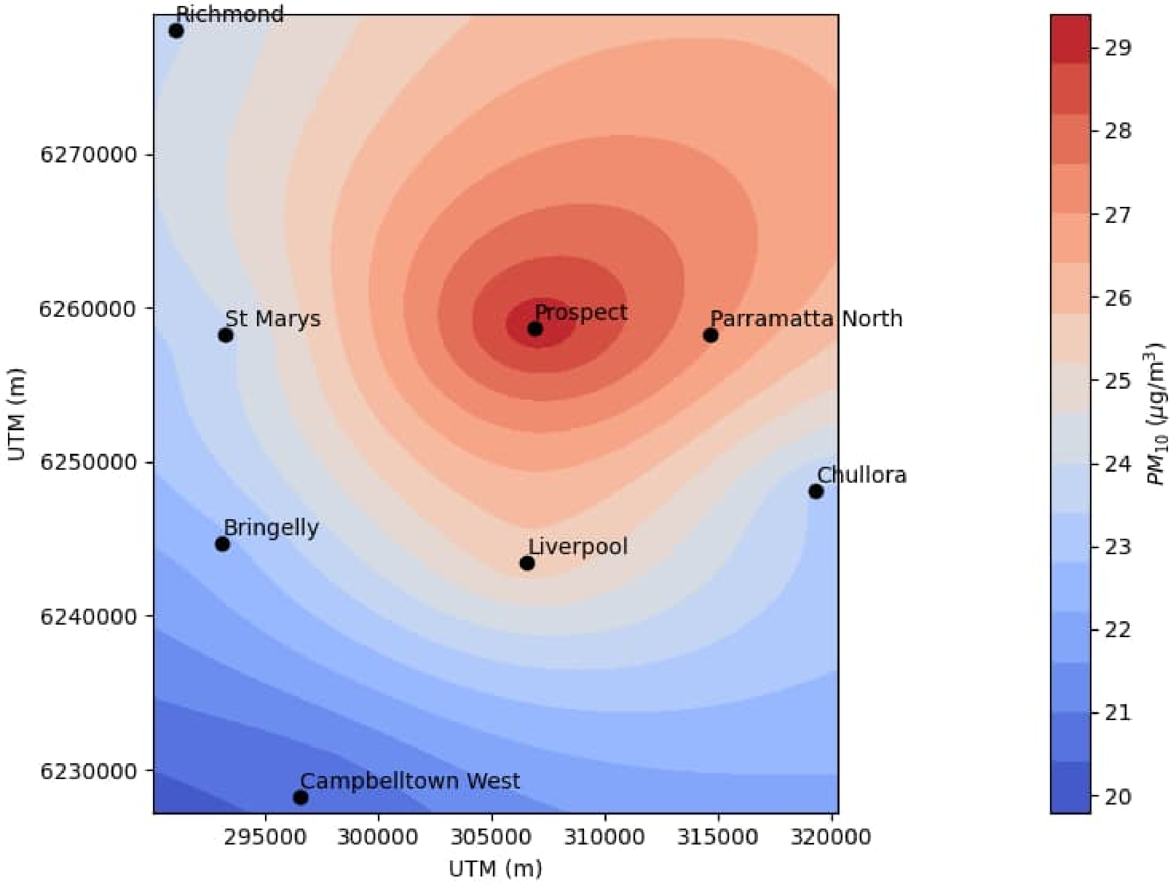


Figure D-25 Sample interpolated grid data for a single hour – PM_{10} January 1st 2017 12 am

Appendix E

Sensitive Receptors

Appendix E Sensitive receptors

Sensitive receptor locations

The coordinates for all sensitive receptors used in the southern and northern modelling domains are provided in **Table E-11**.

Table E-11 Sensitive receptor locations for southern and northern modelling domains

Southern Domain Receptor ID	MGA 56 (m)		Northern Domain Receptor ID	MGA 56 (m)	
	Easting	Northing		Easting	Northing
S1	303709	6242252	N1	301001	6264326
S2	302475	6243546	N2	301258	6259359
S3	302106	6244059	N3	300987	6264889
S4	301180	6244857	N4	300391	6261024
S5	301279	6253284	N5	300290	6261130
S6	301363	6253374	N6	300251	6261191
S7	301920	6243884	N7	300923	6265054
S8	301987	6243879	N8	300605	6261106
S9	301921	6244238	N9	300759	6259815
S10	301788	6244325	N10	300352	6261014
S11	301688	6244406	N11	300630	6265085
S12	301611	6244488	N12	300629	6264953
S13	301541	6244542	N13	300620	6264828
S14	301472	6244637	N14	300610	6264750
S15	302141	6244346	N15	300564	6264442
S16	301992	6244465	N16	300534	6264314
S17	301967	6244616	N17	300481	6264256
S18	302318	6244224	N18	300573	6264525
S19	301142	6245208	N19	300588	6264624
S20	301129	6245074	N20	300491	6264099
S21	301111	6244918	N21	300466	6264022
S22	301038	6245229	N22	300454	6263912
S23	301033	6245548	N23	300437	6263751
S24	301000	6245644	N24	300587	6264069
S25	300953	6245738	N25	300601	6264200
S26	300943	6245834	N26	300617	6264324
S27	300917	6245958	N27	300628	6264419
S28	300885	6246075	N28	300659	6264552
S29	300876	6246448	N29	300676	6264704
S30	300813	6246559	N30	300715	6264899

Southern Domain Receptor ID	MGA 56 (m)		Northern Domain Receptor ID	MGA 56 (m)	
	Easting	Northing		Easting	Northing
S31	300721	6246704	N31	300747	6265032
S32	300568	6246861	N32	300777	6265147
S33	300462	6246930	N33	300796	6265322
S34	300396	6247034	N34	300466	6265205
S35	300248	6248286	N35	300429	6263598
S36	300292	6248421	N36	300477	6263166
S37	300483	6248590	N37	300537	6263022
S38	300582	6248828	N38	300611	6262761
S39	300664	6248971	N39	300587	6262556
S40	300592	6249208	N40	300558	6262415
S41	300618	6249817	N41	300529	6262248
S42	300666	6250030	N42	300500	6262065
S43	300901	6250295	N43	300469	6261858
S44	300651	6250438	N44	300443	6261694
S45	300922	6251397	N45	301556	6254635
S46	300883	6251189	N46	301587	6254342
S47	300889	6251334	N47	301545	6253758
S48	301341	6251430	N48	301759	6253893
S49	301050	6251783	N49	301822	6254330
S50	301095	6252074	N50	301664	6260387
S51	301141	6252272	N51	301489	6260646
S52	301183	6252352	N52	301191	6260944
S53	301296	6252533			
S54	301409	6253030			
S55	301343	6252666			
S56	301307	6252878			
S57	301480	6253304			
S58	301408	6253571			
S59	301564	6253782			
S60	301774	6253651			
S61	301819	6254319			
S62	301472	6254181			

Highly sensitive receptor locations

The location of highly sensitive receptors, including model identification number, property name, coordinates, and distance from the Westlink M7 is provided in **Table E-12**. This is a subset of the sensitive receptors reported in **Table E-11**.

Table E-12 Highly sensitive receptor locations

Sensitive Land Use Type	ID	Property Name	MGA 56 (m)		Distance (m)
			Easting	Northing	
Schools and Childcare Facilities	S1	Amenity College, Preston's Campus	303695	6242262	244
	S2	Good Shepard Catholic Primary School	302467	6243560	200
	S3	Good Samaritan Catholic College	302150	6244021	120
	N1	Glendening Public School	301001	6264326	406
	S4	Middleton Grange Public School	301162	6244864	230
	S5	Marion Catholic Primary School	301251	6253271	372
	S6	Horsley Park Public School	301306	6253381	250
	N2	Eastern Creek Public School	301258	6259359	338
	N3	St Francis of Assisi Primary School Glendenning	300987	6264889	310
Hospitals, Medical Clinics and Facilities	S7	Hoxton Park Family Health Point Medical Centre	301919	6243870	370
	S8	Community Health Centres, Huxton Park	301982	6243860	350
	N4	Saints Medical Centre	300391	6261024	384
	N5	iFamily Medical Centre	300290	6261130	397
	N6	Rooty Hill Medical and Dental Centre	300251	6261191	394
	N7	Richmond Road Family Practice	300923	6265054	219
Retirement Villages and Aged Care Facilities	N8	Anglicare Rooty Hill Village	300605	6261106	127
	N9	Our Lady of Consolation Aged Care Facility	300759	6259815	330
	N10	Vserve Australia Disability and Aged Care Services	300352	6261014	392

Sensitive receptor location maps

The spatial location of each receptor relative to the Westlink M7 is presented in **Figure E-26** to **Figure E-34**.

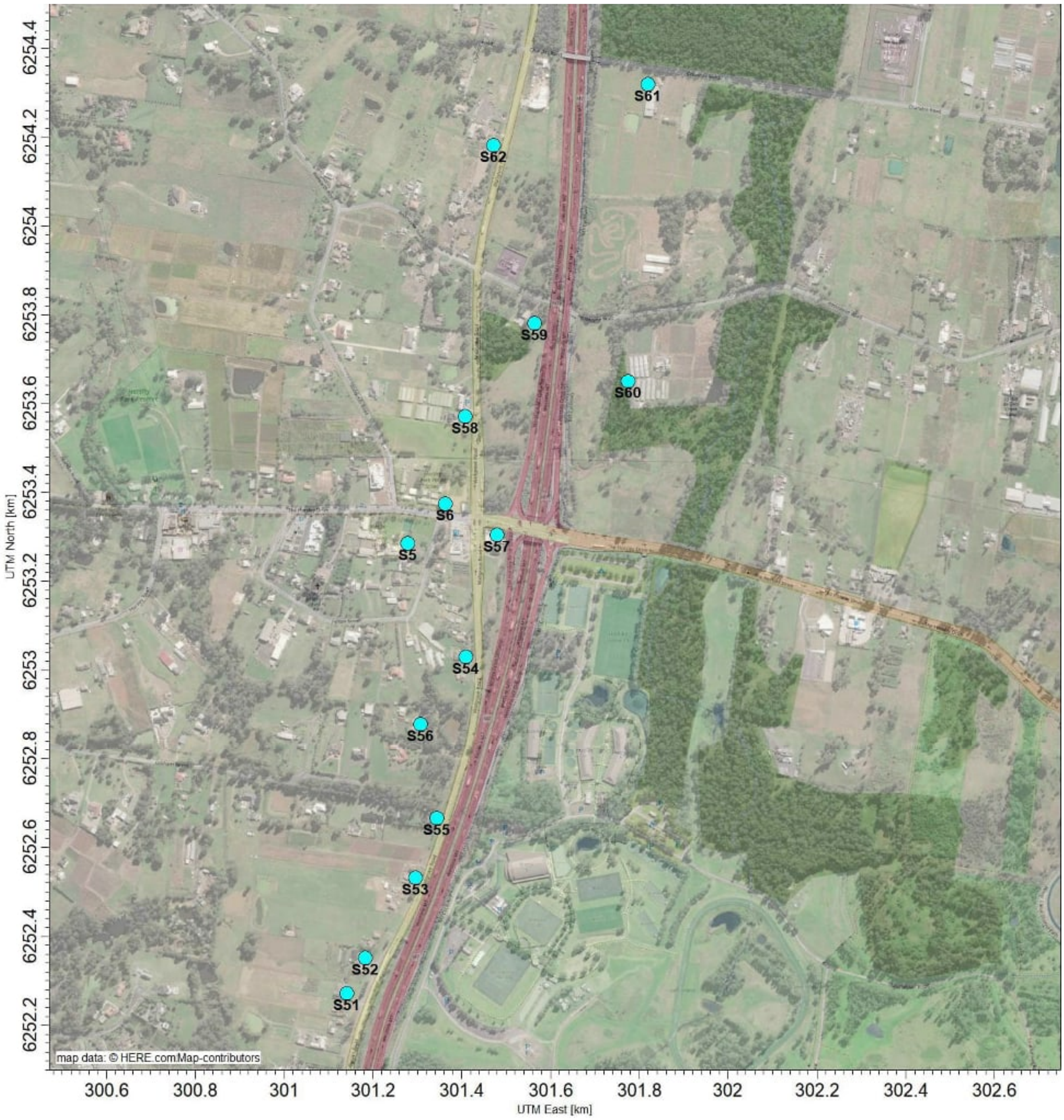


Figure E-26 Sensitive receptors in the Southern Domain (1 of 5)

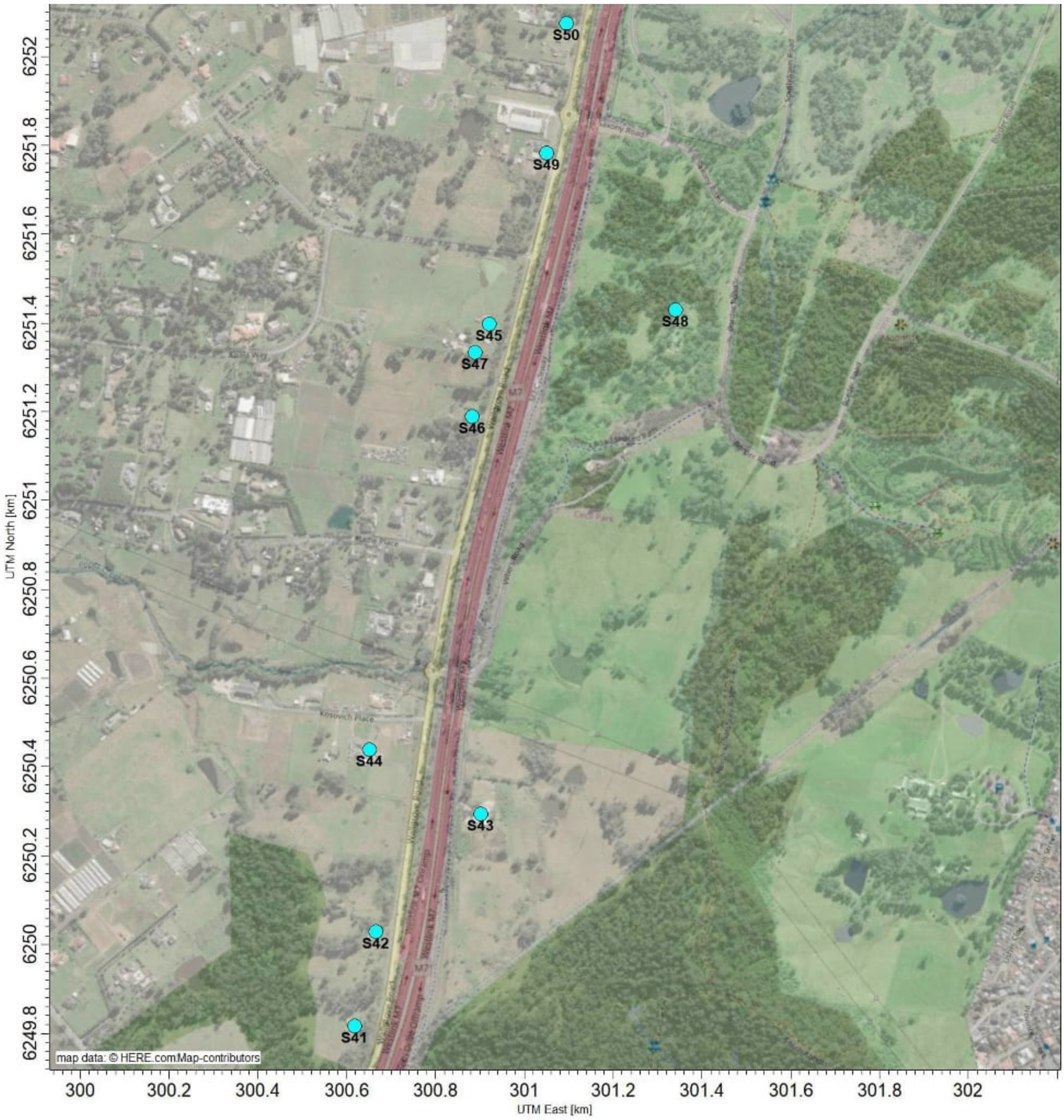


Figure E-27 Sensitive receptors in the Southern Domain (2 of 5)

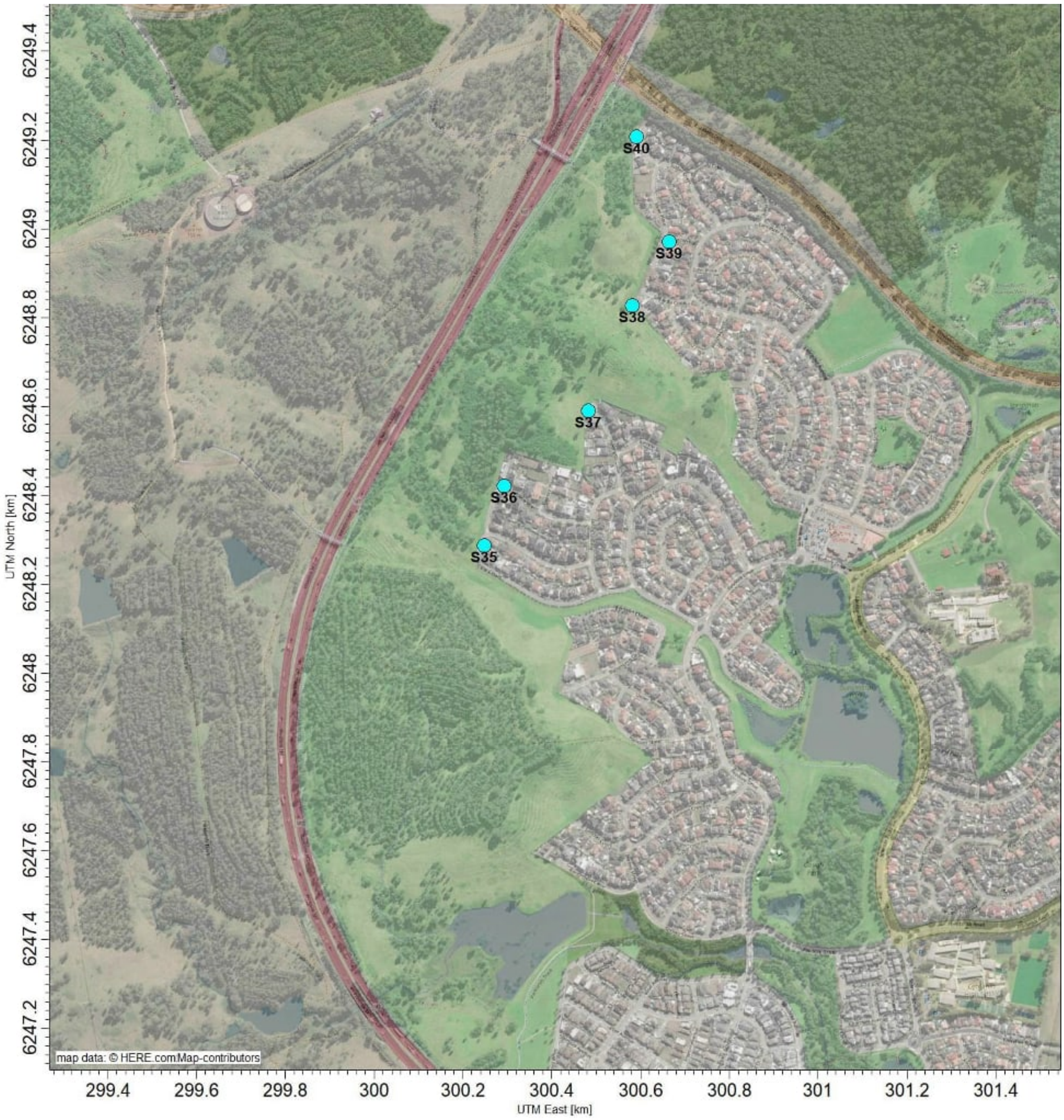


Figure E-28 Sensitive receptors in the Southern Domain (3 of 5)

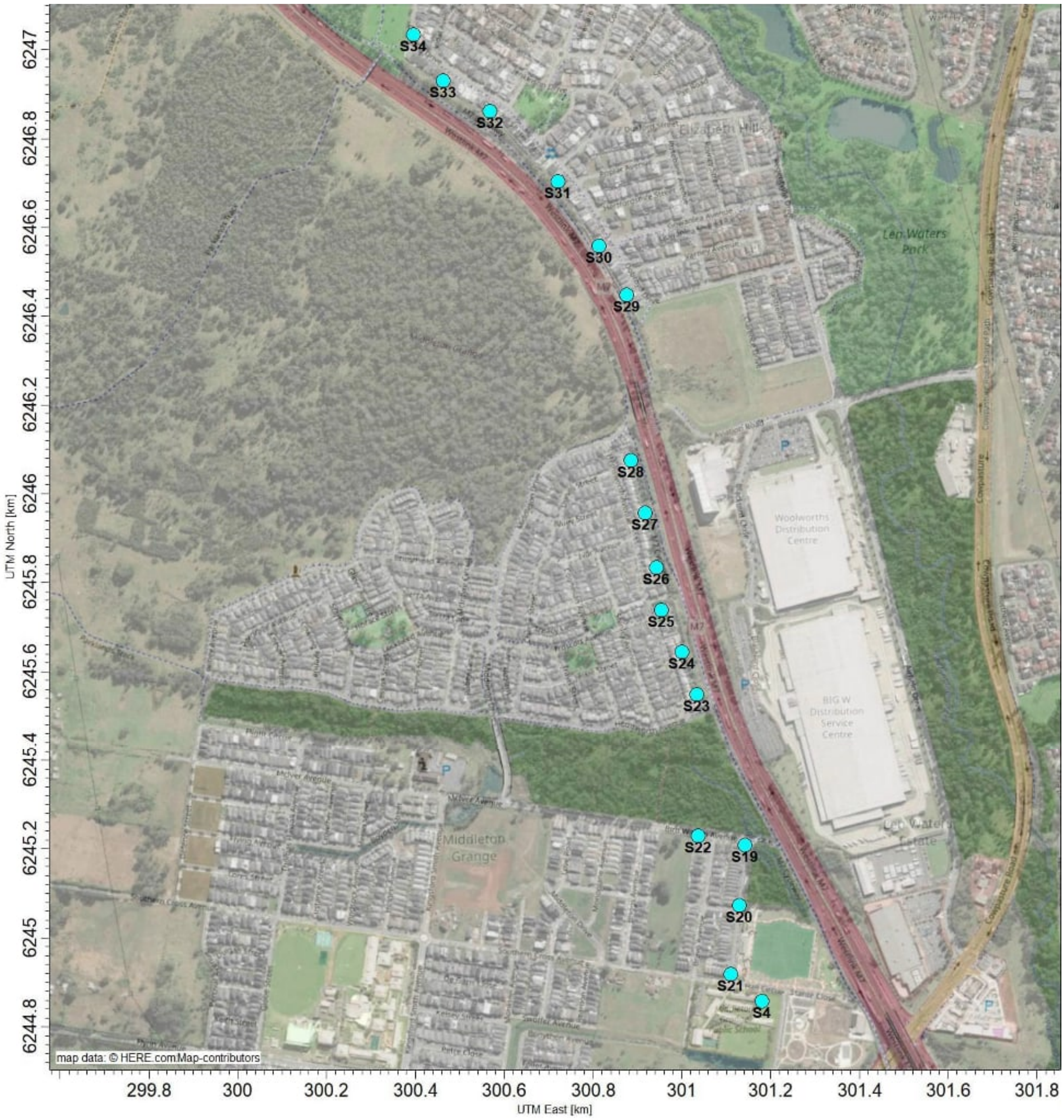


Figure E-29 Sensitive receptors in the Southern Domain (4 of 5)

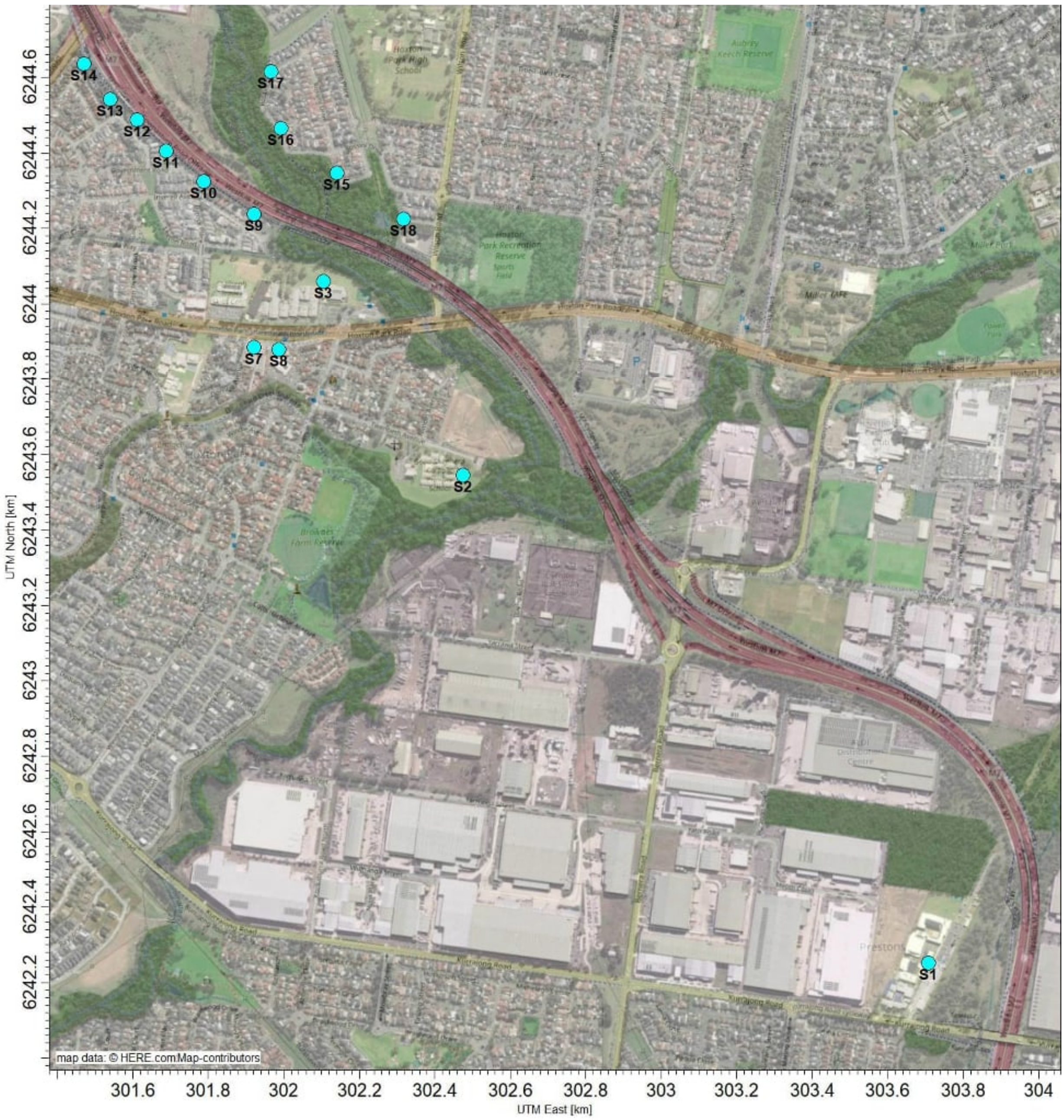


Figure E-30 Sensitive receptors in the Southern Domain (5 of 5)

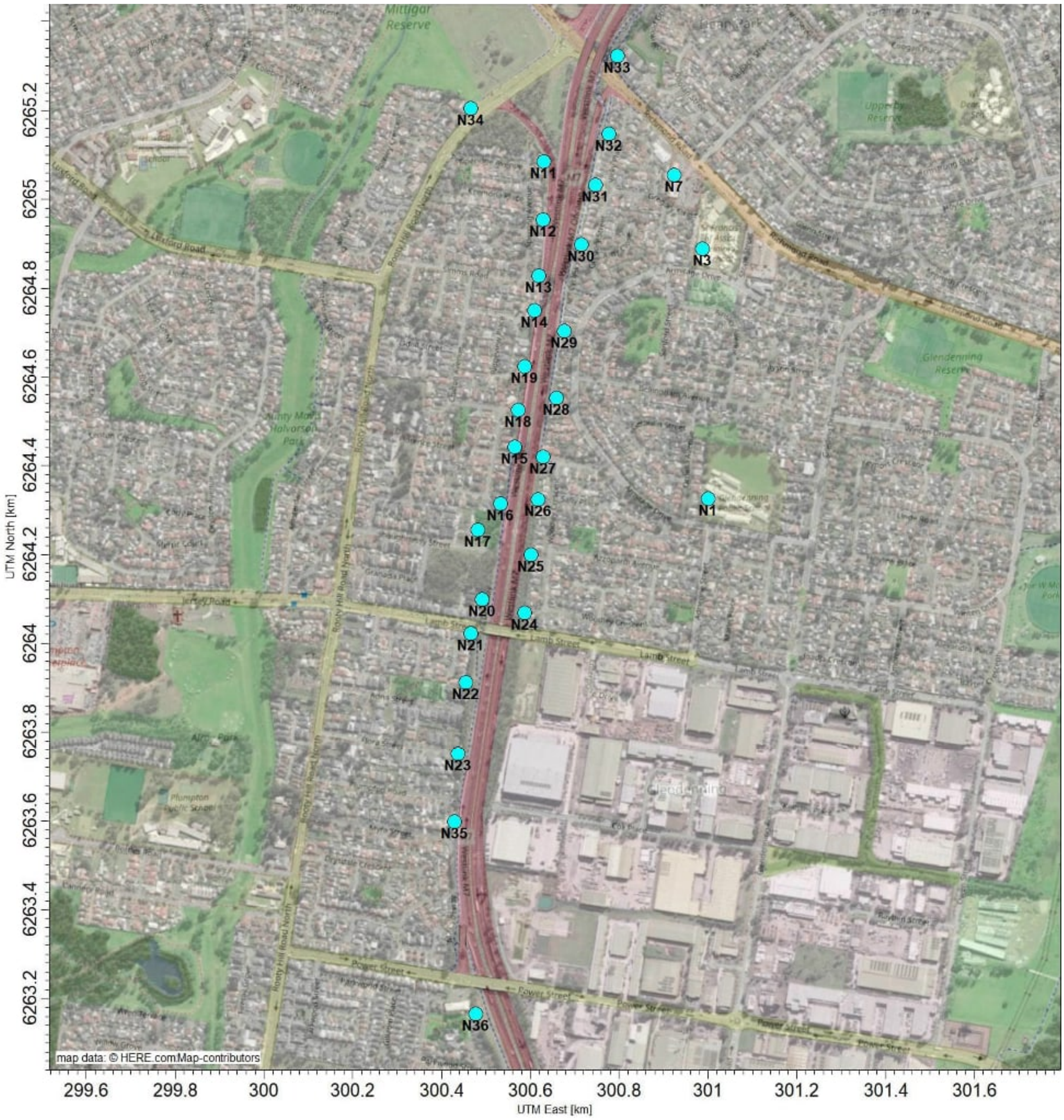


Figure E-31 Sensitive receptors in the Northern Domain (1 of 4)

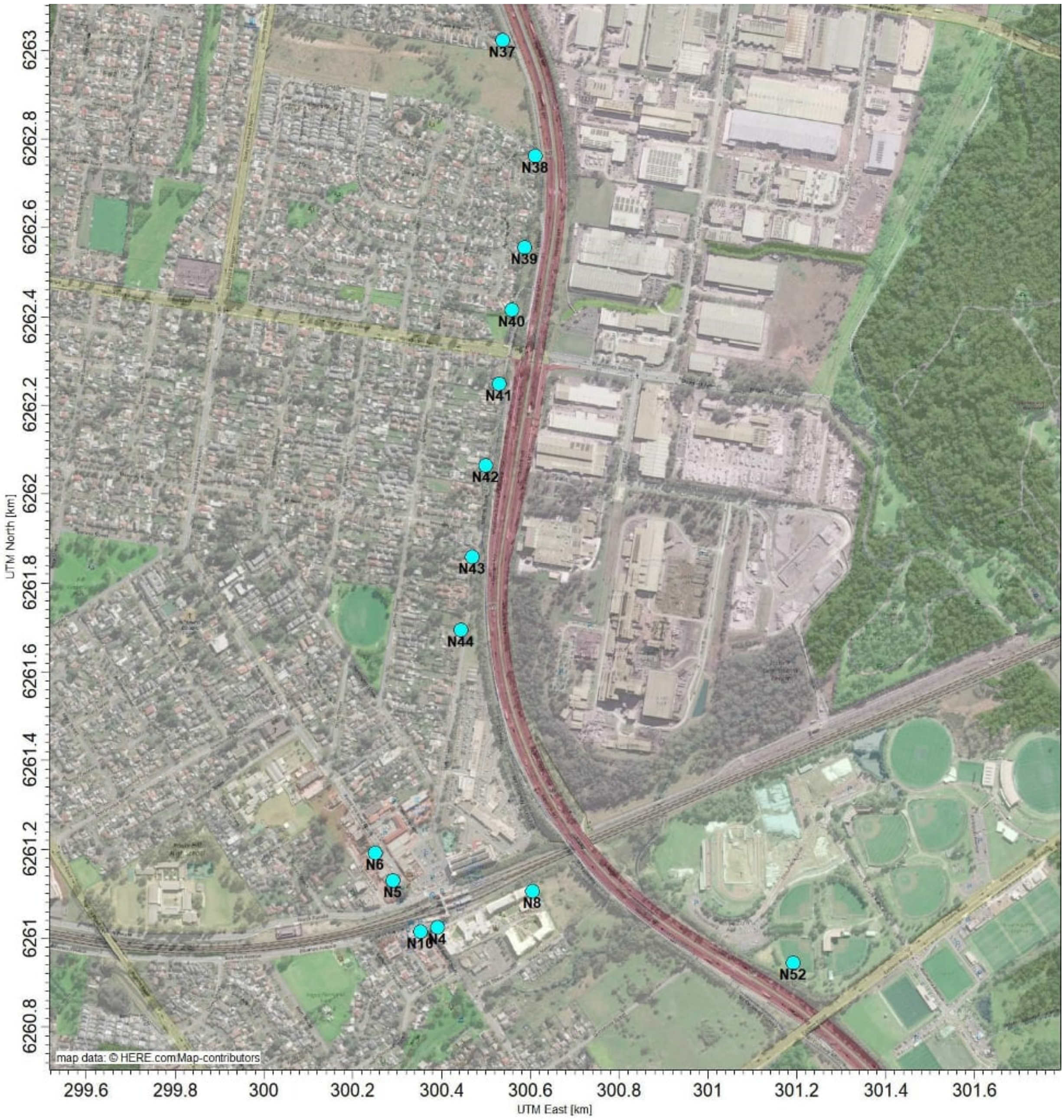


Figure E-32 Sensitive receptors in the Northern Domain (2 of 4)

Figure E-33 Sensitive receptors in the Northern Domain (3 of 4)

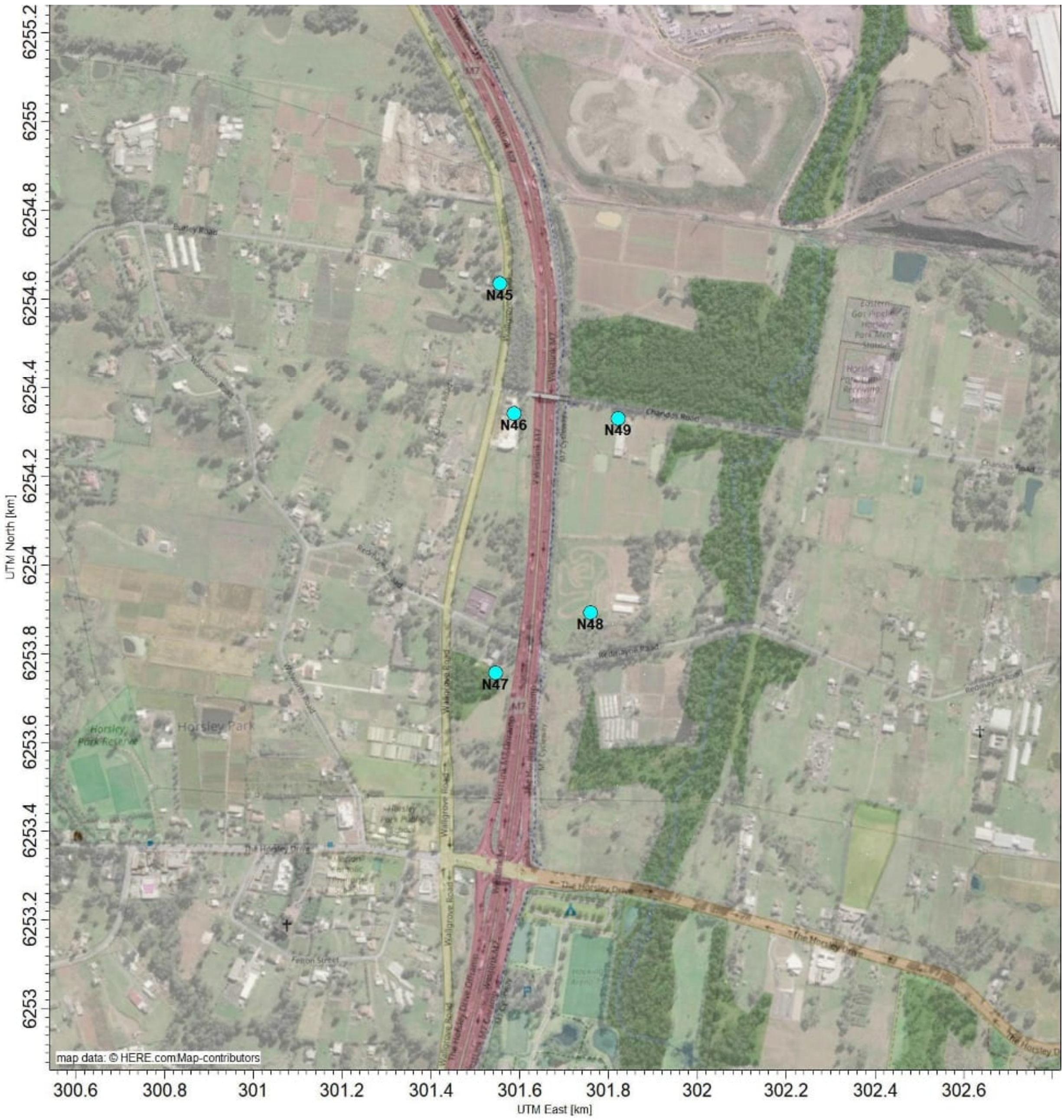


Figure E-34 Sensitive receptors in the Northern Domain (4 of 4)

Appendix F

MTO Analysis

Appendix F MTO analysis

The GRAMM Match to observation (MTO) function was used to ensure the wind fields used for the GRAL modelling are as representative of local wind conditions as possible. The following section outlines the data from the iterative MTO analysis and a brief discussion of the performance of the MTO calculations.

The performance of the MTO function is displayed in the GRAMM model GUI through the calculation of the degree of fit for the wind fields for different vectoral errors. The table below show the percent of situations that fit within a vectorial error of 10%, 20%, 40% and 60% and a stability class error of 0 or ±1 classes. As a rule of thumb, the higher the percent of situations that fall within a vectoral error, the better the fit has occurred.

The different scenarios examined reflect different weighting factors used for the different modelling possibilities considered.

Due to the length of the M7 alignment, the GRAMM MTO process was split into two domains that were examined separately:

- Domain 1: Southern Domain
- Domain 2: Northern Domain.

Southern Domain

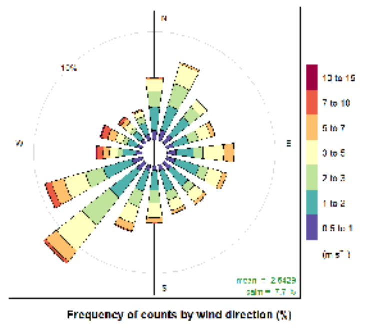
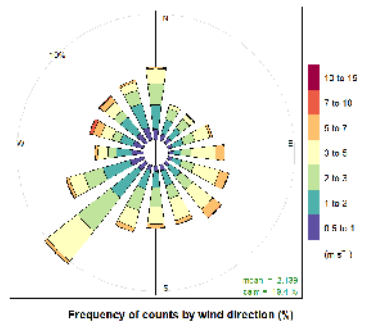
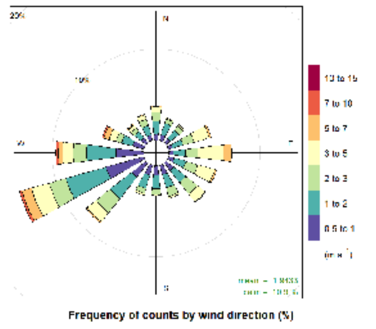
The stations used for the MTO analysis in the Southern Domain were:

- BoM Badgerys Creek
- BoM Horsley Park, and
- DPE Liverpool.

Four MTO options, each with different weighting factors and direction factors, were investigated. The options with the best results (i.e. the best matching winds at each of the three stations) selected for use in GRAL. A summary of the settings used for each option is presented in **Table F-13**.

Option 1 had a good fit in terms of the vectorial and stability class errors at each of the three station locations. Option 1 performed better than Option 2 or 4 at Horsley Park, which is perhaps the most important of the stations to match well, given its proximity to the M7 motorway. Option 3 matched well (even better than Option 1) at Horsley Park; however, it did not match as well as Option 1 at the other two stations. Overall, the MTO Option 1 appeared to match best for the Southern Domain and was selected for use in the GRAL.

Table F-13 MTO options and settings for the Southern Domain – Option 1 selected for use in GRAL

Badgerys Creek		Horsley Park		Liverpool	
2016-2018 Measured					
					
Option 1: WF = 0.5,1,0.5, DF = 0.5,1,0.5 (Order = Badgerys Creek, Horsley Park, Liverpool)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
9	24	49	65	66	92
45	67	86	94	59	87
5	16	42	63	54	81
Option 2: WF = 1,1,1, DF = 1,1,1 (Order = Badgerys Creek, Horsley Park, Liverpool)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
21	40	63	76	61	87
22	44	71	84	54	83
11	26	53	72	50	78
Option 3: WF = 0.25,1,0.25, DF = 0.25,1,0.25 (Order = Badgerys Creek, Horsley Park, Liverpool)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
5	17	41	58	69	94
61	77	89	96	61	89
3	12	36	57	56	83
Option 4: WF = 1,0.5,1, DF = 1,0.5,1 (Order = Badgerys Creek, Horsley Park, Liverpool)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
27	48	69	80	64	90
10	27	56	73	55	85
11	27	55	75	53	81
WF = Station Weighting Factor, DF = Station Direction Weighting Factor					

Wind Roses

Wind rose for each of the four options are presented in **Figure F-35** to **Figure F-38**.

Predicted wind direction was similar for each of the four options at the three locations. The matched wind roses at Horsley Park station looked best with a reasonable correlation with the observed winds for both Option 1, Option 2 and Option 3.

Wind speeds and calms are discussed separately below.

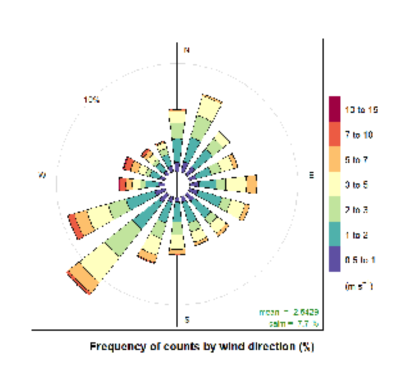
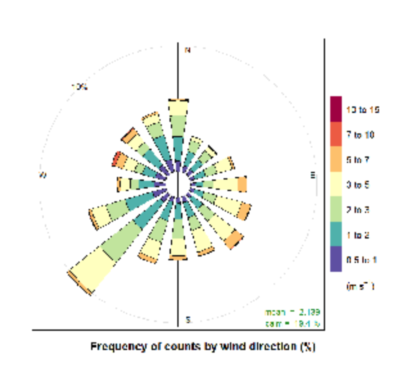
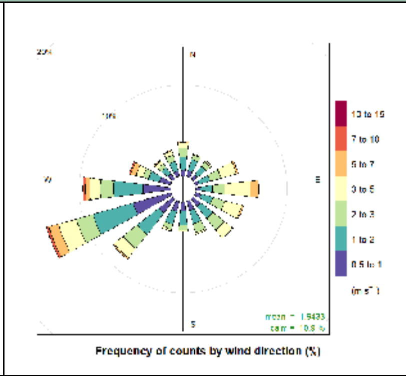
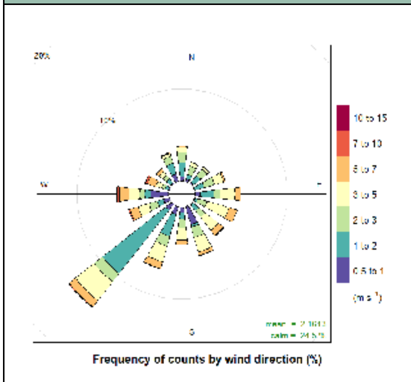
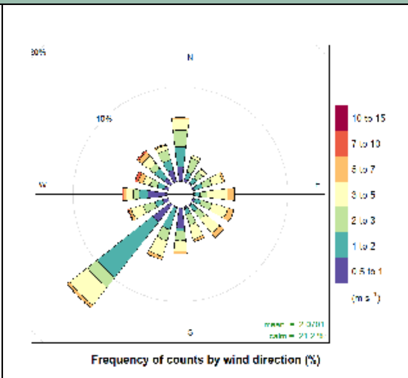
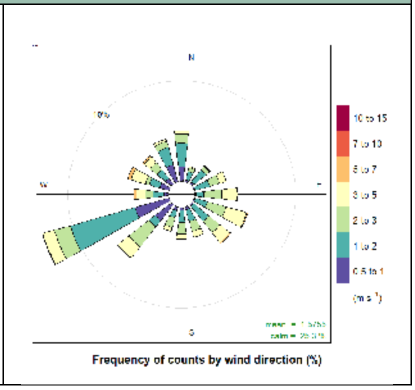
Badgerys Creek	Horsley Park	Liverpool
2016-2018 Measured		
		
2016-2018 MTO Data		
		

Figure F-35 Option 1: WF = 0.5,1,0.5, DF = 0.5,1,0.5 (Order = Badgerys Creek, Horsley Park, Liverpool)

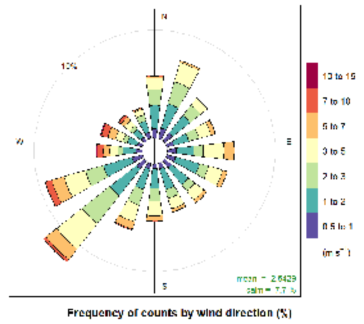
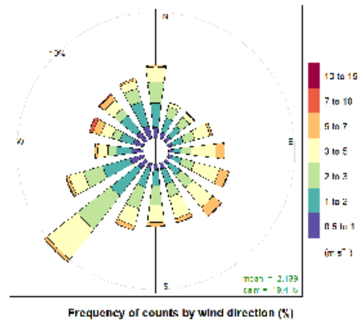
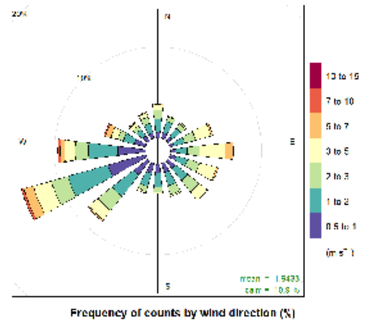
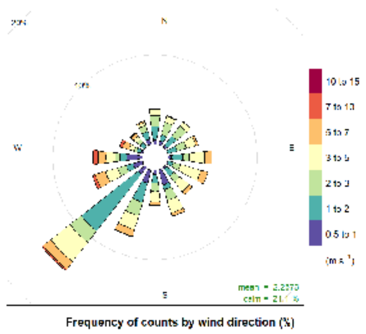
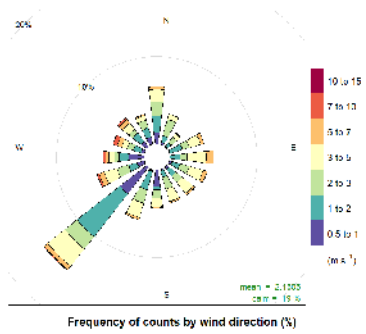
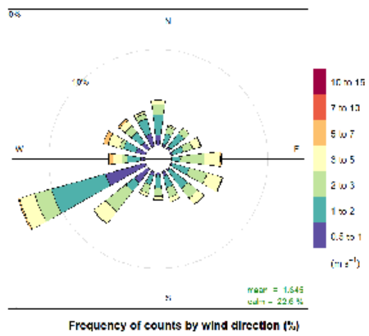
Badgerys Creek	Horsley Park	Liverpool
2016-2018 Measured		
		
2016-2018 MTO Data		
		

Figure F-36 **Option 2: WF = 1,1,1, DF = 1,1,1 (Order = Badgerys Creek, Horsley Park, Liverpool)**

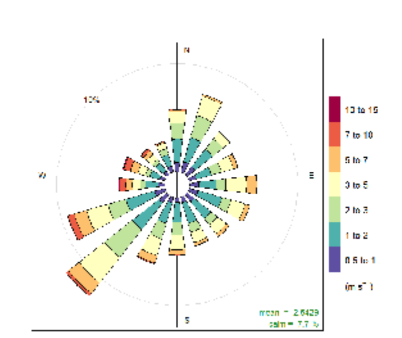
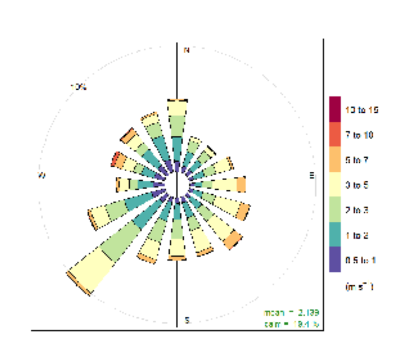
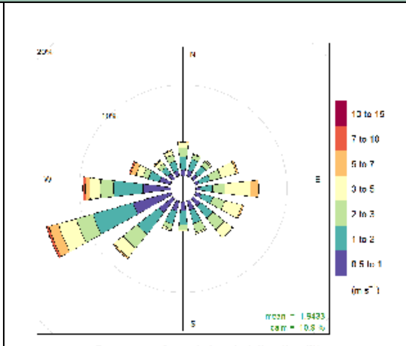
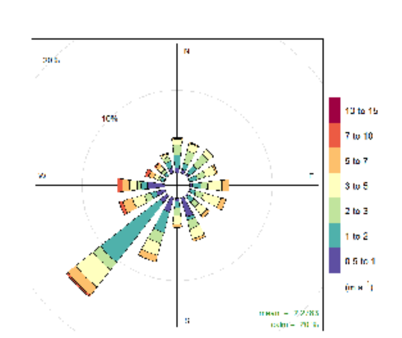
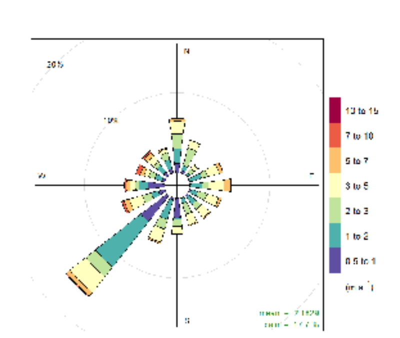
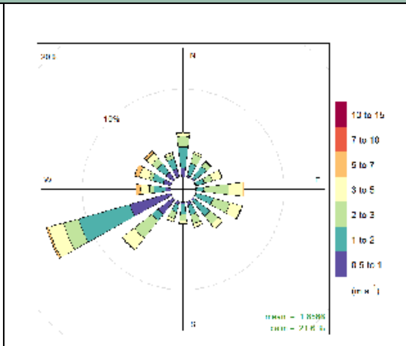
<table>
<tr><th>Badgerys Creek</th><th>Horsley Park</th><th>Liverpool</th></tr>
<tr><td colspan="3">2016-2018 Measured</td></tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr><td colspan="3">2016-2018 MTO Data</td></tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</table>

Figure F-37 **Option 3: WF = 0.25,1,0.25, DF = 0.25,1,0.25 (Order = Badgerys Creek, Horsley Park, Liverpool)**

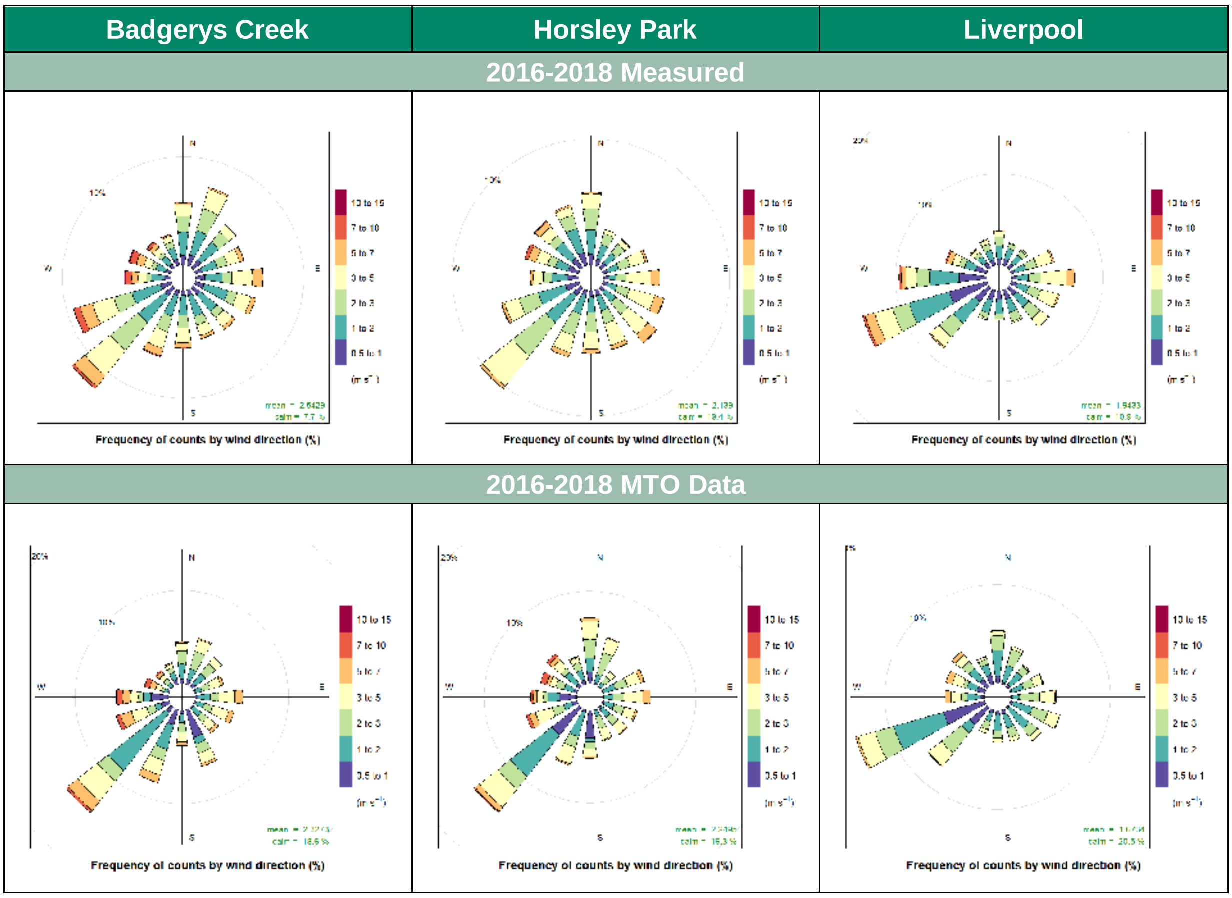


Figure F-38 **Option 4: WF = 1,0.5,1, DF = 1, 0.5, 1 (Order = Badgerys Creek, Horsley Park, Liverpool)**

Stability class analysis

An analysis of the MTO GRAMM-predicted stability classes compared with stability classes predicted by CALMET are presented for each station location in **Figure F-39**, **Figure F-40** and **Figure F-41**. Overall, there was not a large difference between the stability classes predicted by each option in the GRAMM MTO process.

GRAMM tended to predict Class 4 stability over Class 3, with a higher frequency of Class 4 predicted at each location compared with CALMET. Important to note however, is that Class 3 and 4 both indicate relatively neutral stability, and the combined Class 3 and Class 4 frequency is similar between both CALMET and all the MTO options.

GRAMM tended to underpredict the frequency of Class 6 stability compared with CALMET. It is noted that the stability classes from CALMET are also predicted values, and a perfect match is not expected between CALMET and GRAMM.

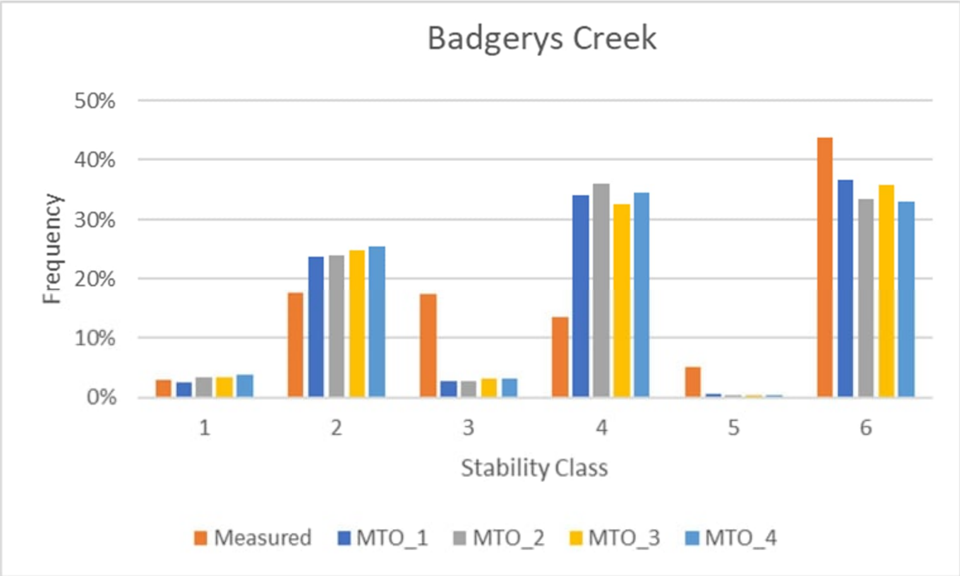


Figure F-39 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at Badgerys Creek**

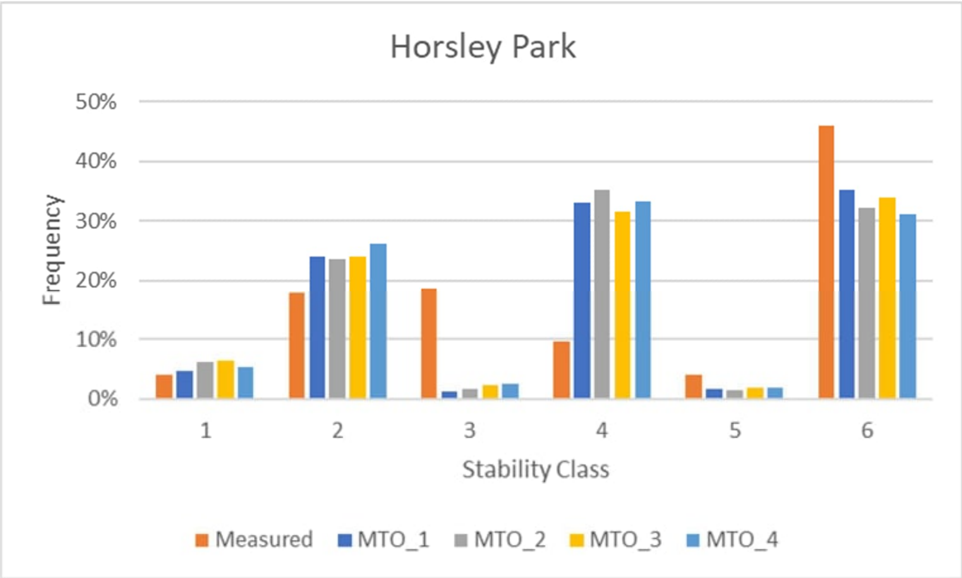


Figure F-40 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at Horsley Park**

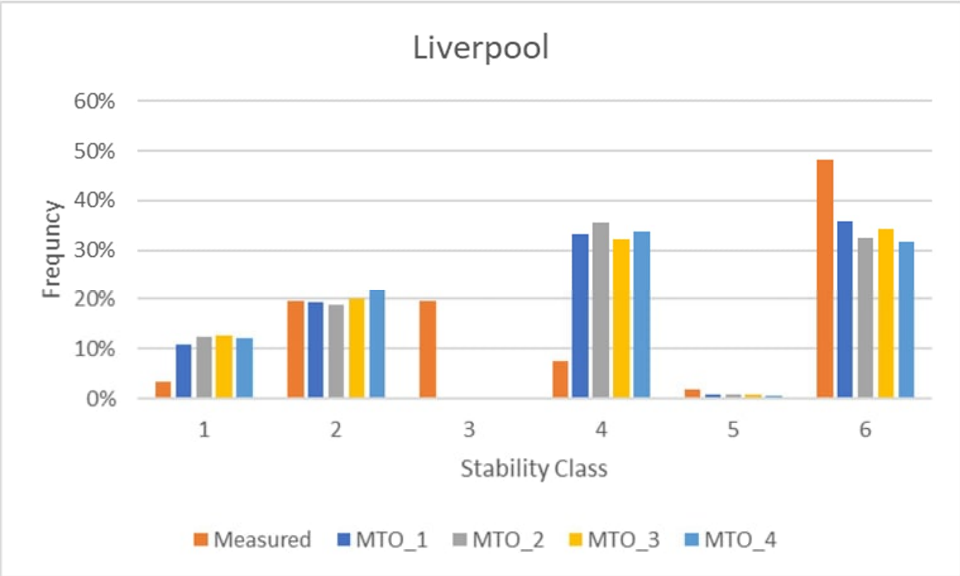


Figure F-41 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at Liverpool**

Wind direction comparison

A comparison of predicted wind direction data from the four MTO options with measured data at Badgerys Creek, Horsley Park, and Liverpool are presented in **Figure F-42**, **Figure F-43** and **Figure F-44**, respectively.

The plots show that the GRAMM MTO predictions follow the broad trend of wind direction seen in the measured data, with the dominant southwest wind direction predicted at all three locations by all four MTO options. However, the GRAMM data is noisier without the smooth transition between adjacent wind speed categories that is seen in the measured data.

Overall, there were only minor differences between the four MTO options, with the most variation between the options in winds from the north-west to north-east sector, especially at Badgerys Creek.

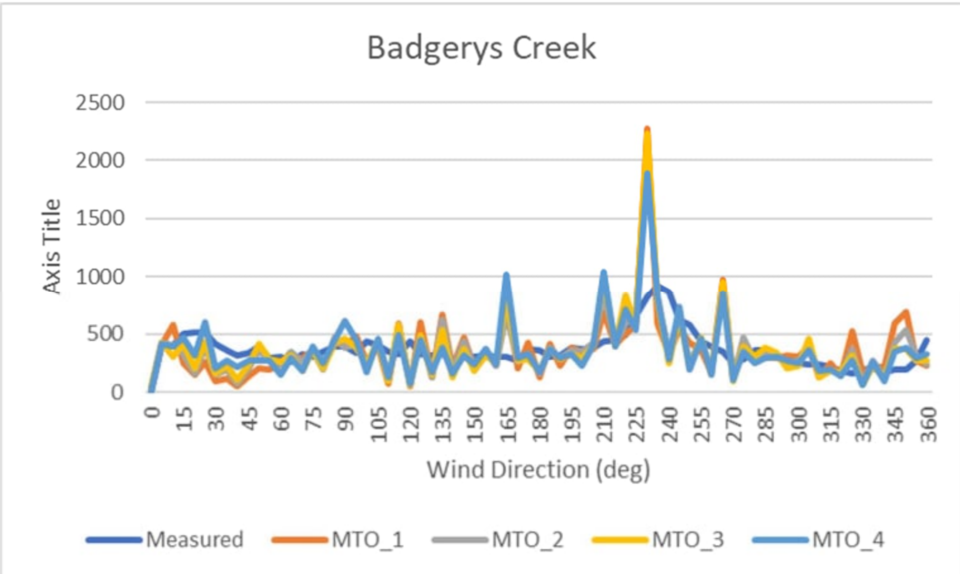


Figure F-42 **Wind directions predicted by the 4 MTO options vs measured data at Badgerys Creek**

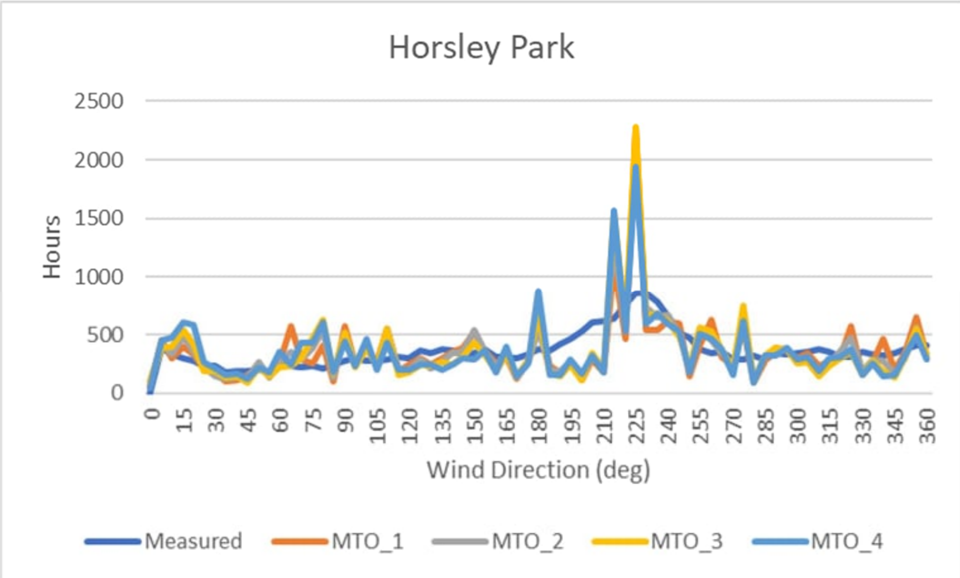


Figure F-43 Wind directions predicted by the 4 MTO options vs measured data at Horsley Park

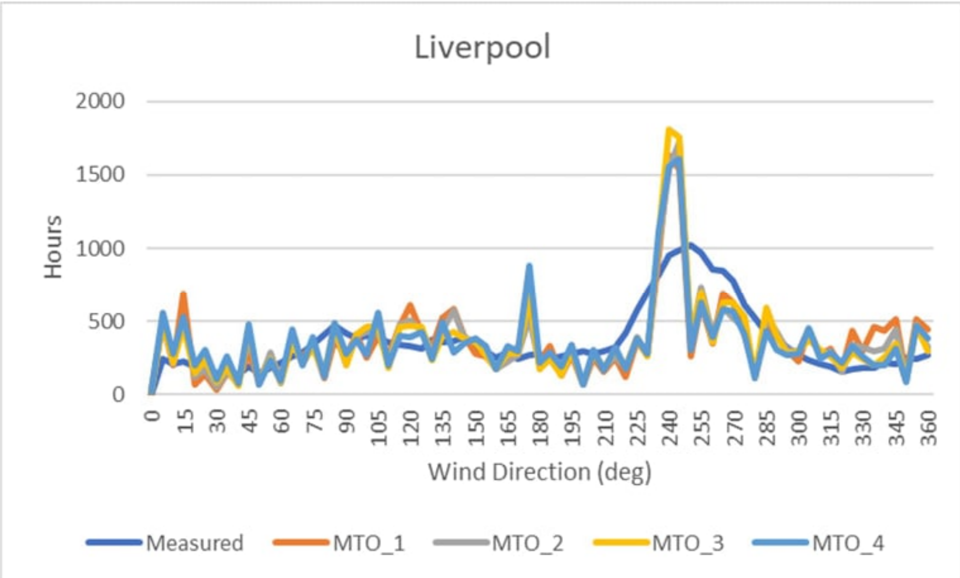


Figure F-44 Wind directions predicted by the 4 MTO options vs measured data at Liverpool

Calm percentage

The total frequency of calms conditions (winds less than 0.5 m/s) were examined for each of the MTO options at the three met statin locations, as shown in **Figure F-45**. This showed that calms were predicted by all three options at Horsley Park quite well, and the MTO process tended to overpredict calms at Badgerys Creek and Liverpool.

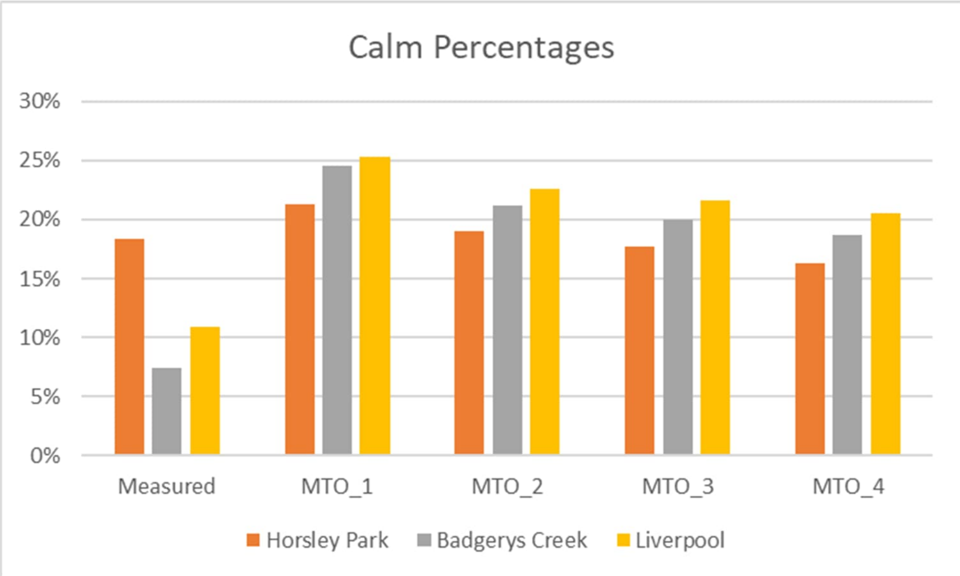


Figure F-45 **Calm frequency predicted by the 4 MTO options vs measured data**

Wind speed profile

A comparison of predicted wind speed profiles from the four MTO options with measured data at Badgerys Creek, Horsley Park, and Liverpool are presented in **Figure F-46**, **Figure F-47** and **Figure F-48**.

The MTO process matched the profile very well at Horsley Park for all options. Calms (wind up to 0.5 m/s) were overpredicted at Badgerys Creek and Liverpool. The profile above 1 m/s matched very reasonably well at all three stations for all four MTO options.

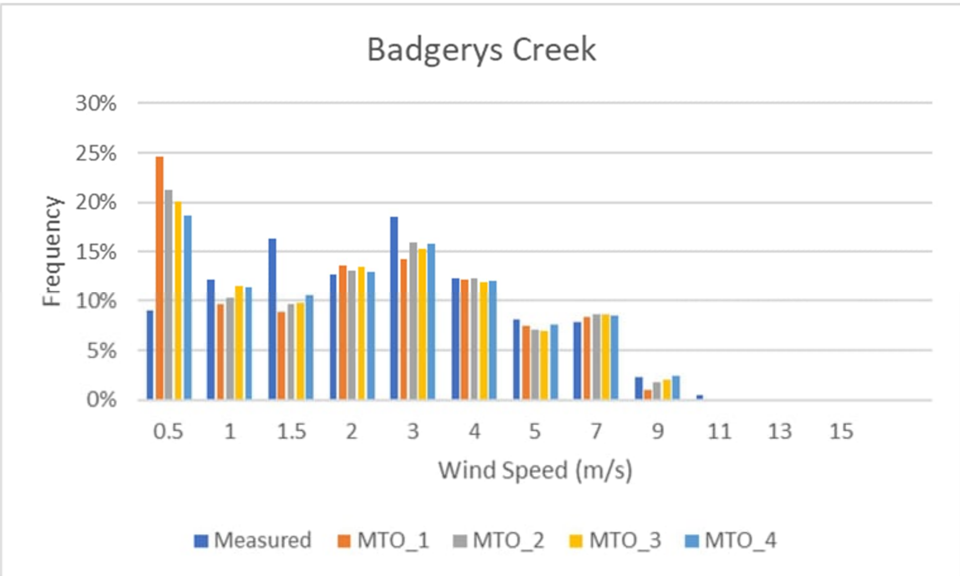


Figure F-46 **Wind speed frequency predicted by the 4 MTO options vs measured data at Badgerys Creek**

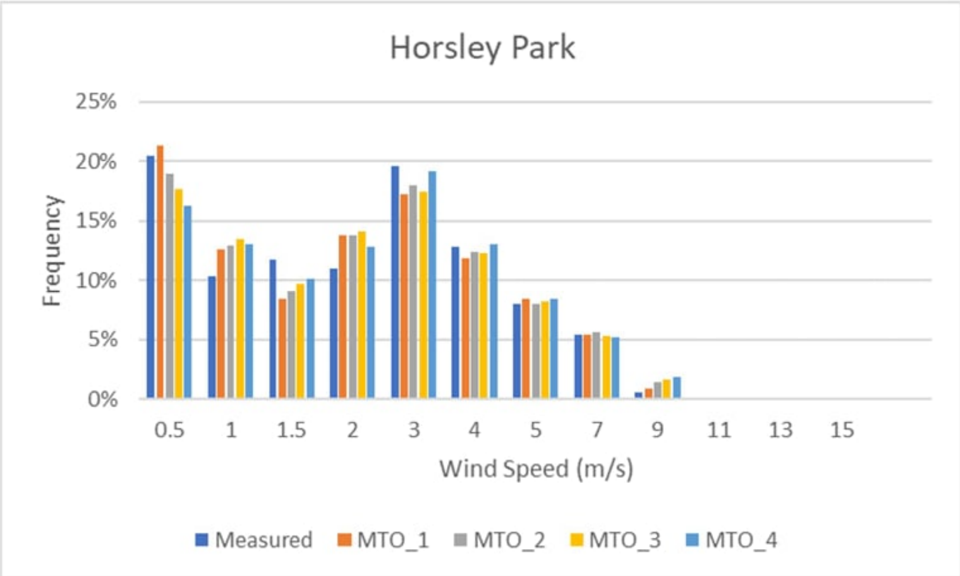


Figure F-47 **Wind speed frequency predicted by the 4 MTO options vs measured data at Horsley Park**

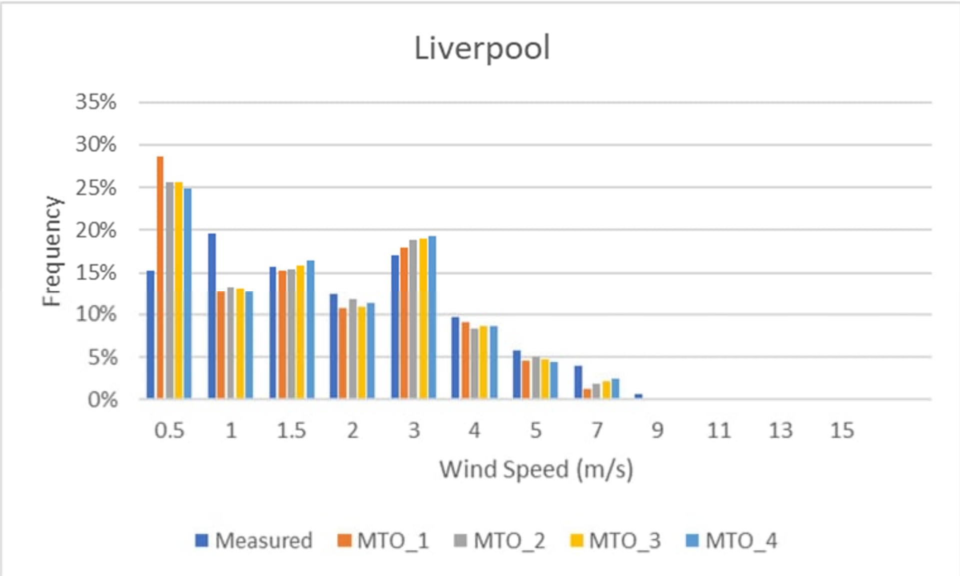


Figure F-48 **Wind speed frequency predicted by the 4 MTO options vs measured data at Badgerys Creek**

Northern Domain

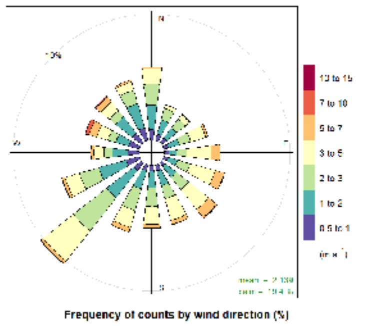
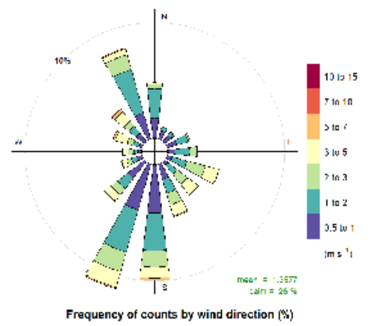
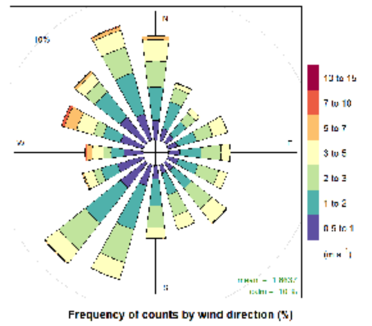
The stations used for the MTO analysis in the Southern Domain were:

- BoM Horsley Park,
- DPE Prospect, and
- DPE St Marys.

Four MTO options, each with different weighting factors, were investigated. The option with the best results (i.e. the best matching winds and stability classes at each of the three stations) was selected for use in GRAL. A summary of the settings used for each option is presented in **Table F-14**.

Option 3 was selected as the best match overall, with a particularly strong match in the wind vectors at Horsley Park, which is the closest station to the Proposed Modification alignment. Option 1 showed a slightly better match at Prospect and St Marys in the vectors, however as shown in **Figure F-49** below, the wind rose showed a strong southerly wind bias, which is not present in the measure data at Horsley Park BoM station. Based on this, Option 3 was selected for use in GRAL.

Table F-14 MTO options and settings for the Southern Domain – Option 1 selected for use in GRAL

Horsley Park		St Marys		Prospect	
					
2016-2018 Measured		2016-2018 Measured		2016-2018 Measured	
Option 1: WF = 1,1,1, DF = 1,1,1 (Order = Horsley Park, Prospect, St Marys)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
21	43	68	80	61	87
15	32	61	80	52	78
13	29	53	70	53	78
Option 2: WF = 1.5,0.5,0.5, DF = 1,0.5,0.5 (Order = Horsley Park, Prospect, St Marys)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
56	78	87	93	59	84
5	16	44	66	49	75
4	12	32	50	50	75
Option 3: WF = 2,1,0.5, DF = 1 5,1,0.5 (Order = Horsley Park, Prospect, St Marys)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
55	78	90	95	53	79
7	22	52	73	44	70
3	11	29	46	45	70
Option 4: WF =0.5,0.1,0.1, DF =0.5,0.1,0.1 (Order = Horsley Park, Prospect, St Marys)					
V 10%	V 20%	V 40%	V 60%	SC 0	SC 1
52	66	74	81	76	99
3	12	35	57	63	89
3	9	28	48	66	89
WF = Station Weighting Factor, DF = Station Direction Weighting Factor					

Wind roses

Wind roses for each of the four options are presented in **Figure F-49** to **Figure F-52**.

Predicted wind direction was quite different between the options, with Option 1, 2 and 4 showing a very strong southerly component at Horsley Park, which is not present in the measured data. Option 3 on the other hand, appears to match the measured data much better with a high frequency of southwest winds. Option 3 also shows the best match at Prospect. Option 1 shows the best match at St Marys.

Wind speeds and calms are discussed separately below.

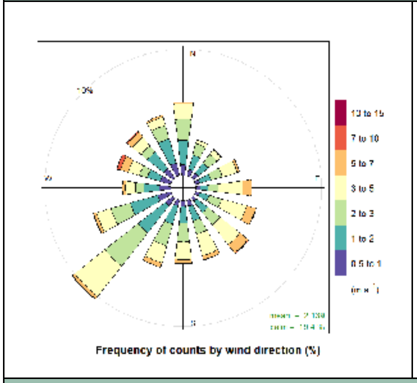
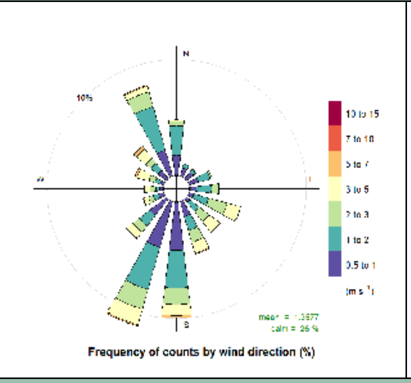
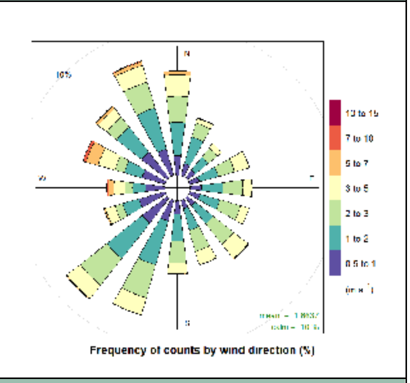
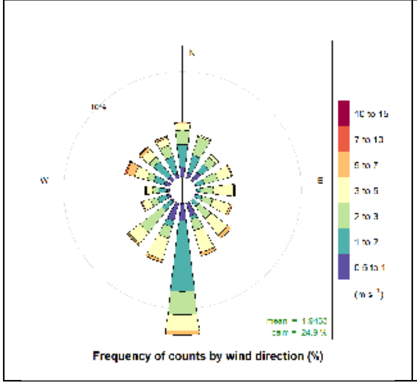
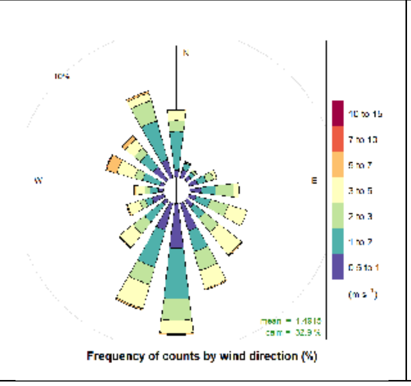
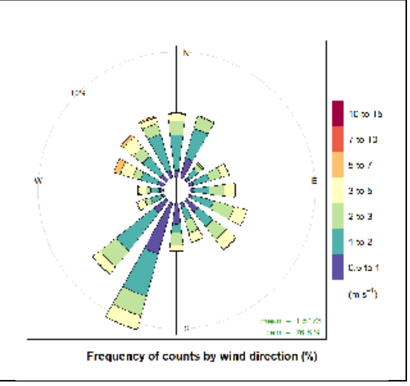
Horsley Park	St Marys	Prospect
2016-2018 Measured		
		
2016-2018 MTO Data		
		

Figure F-49 Option 1: WF = 1,1,1, DF = 1,1,1 (Order = Badgerys Creek, Horsley Park, Liverpool)

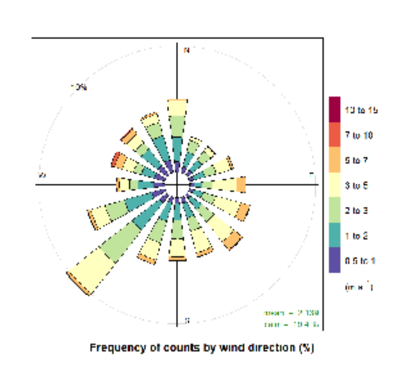
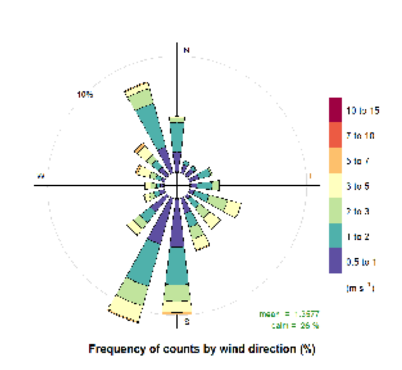
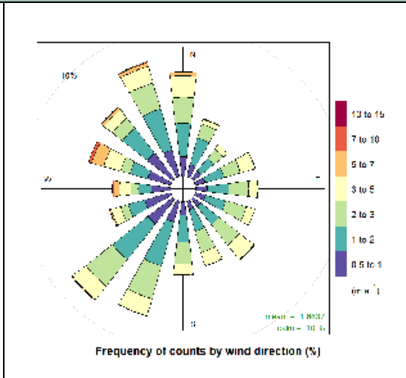
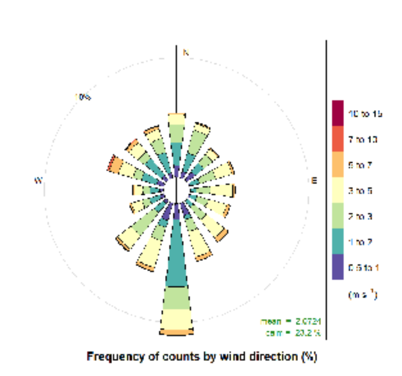
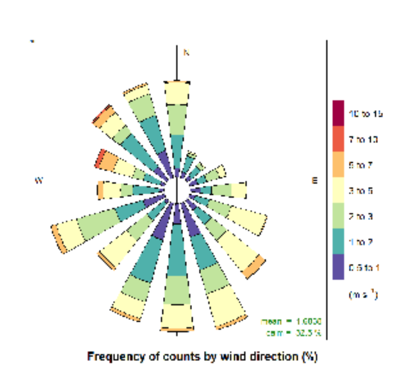
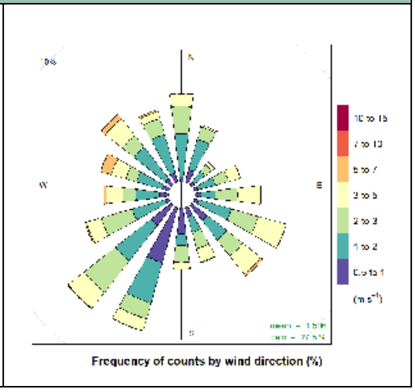
Horsley Park	St Marys	Prospect
2016-2018 Measured		
		
2016-2018 MTO Data		
		

Figure F-50 Option 2: WF = 1.5,0.5,0.5, DF = 1,0.5,0.5 (Order = Horsley Park, Prospect, St Marys)

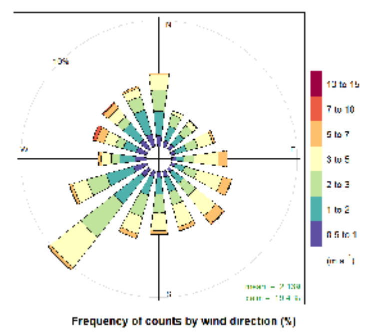
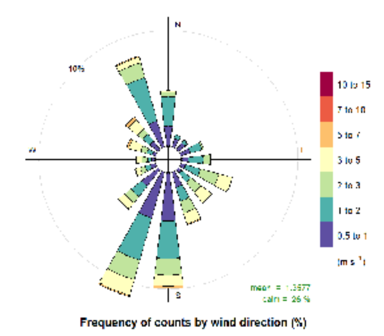
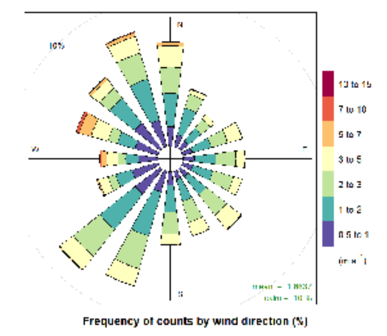
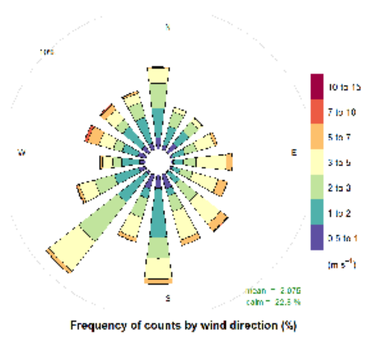
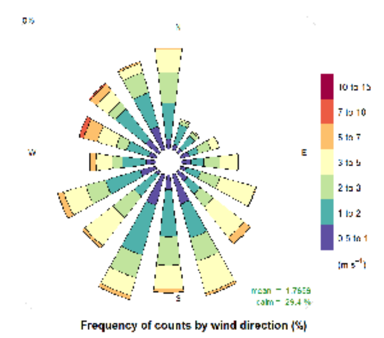
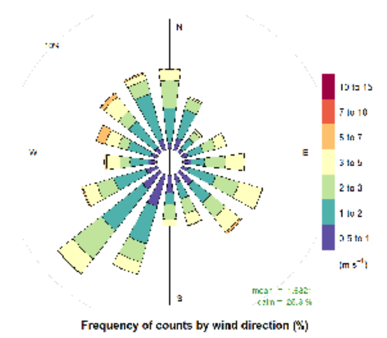
<table>
<tr><th>Horsley Park</th><th>St Marys</th><th>Prospect</th></tr>
<tr><td colspan="3">2016-2018 Measured</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">2016-2018 MTO Data</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Figure F-51 Option 3: WF = 2,1,0.5, DF = 1.5,1,0.5 (Order = Horsley Park, Prospect, St Marys)

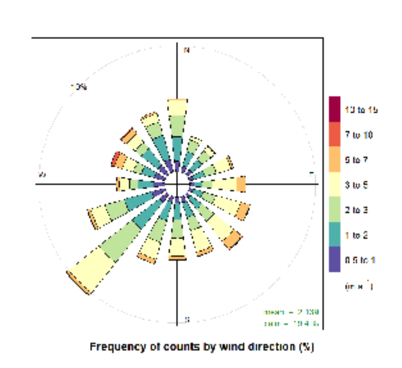
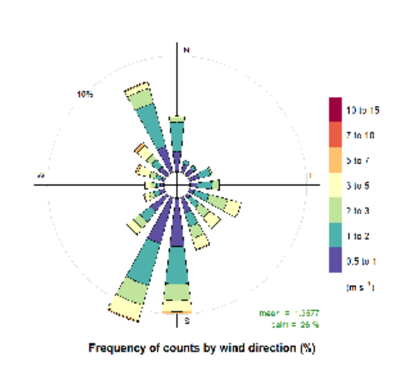
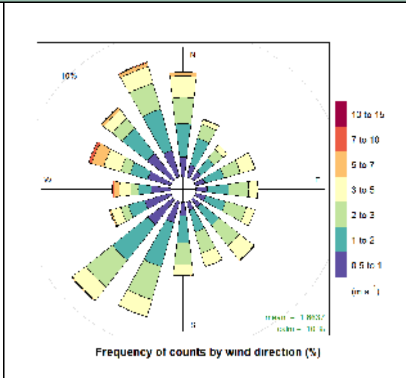
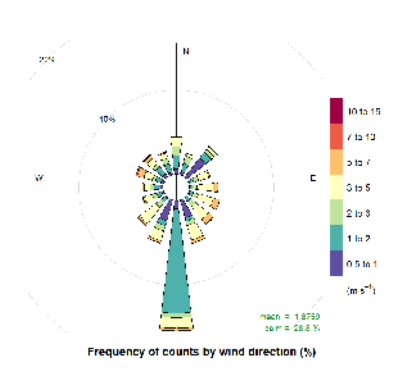
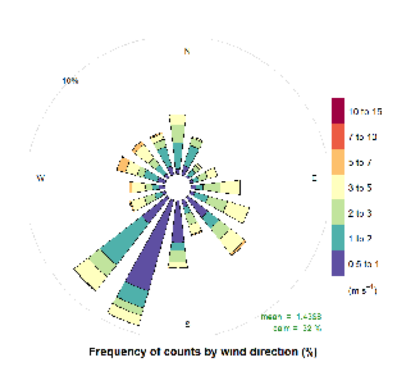
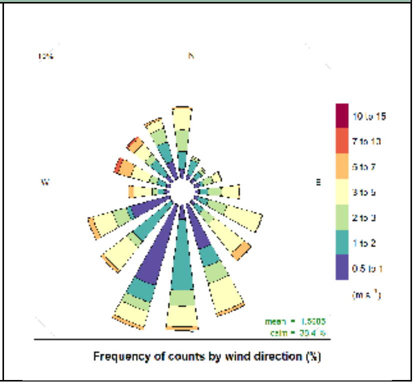
Horsley Park	St Marys	Prospect
2016-2018 Measured		
		
2016-2018 MTO Data		
		

Figure F-52 Option 4: WF = 0.5,0.1,0.1, DF = 0.5,0.1,0.1 (Order = Horsley Park, Prospect, St Marys)

Stability class analysis

An analysis of the MTO GRAMM-predicted stability classes compared with stability classes predicted by CALMET are presented for each station location in **Figure F-39**, **Figure F-40** and **Figure F-41**. There were some large differences in the frequency of stability class produced by each of the MTO options. Option 4 produced a much higher number of Class 6 hours at all three locations. There were more Class 4 hours predicted by Options 2 and 3 compared with Options 1 and 4.

Similarly to the Southern Domain, GRAMM tended to favour Class 4 stability over Class 3 stability, with a higher frequency of Class 4 predicted at each location compared with CALMET. Important to note however, is that Class 3 and 4 both indicate relatively neutral stability, and the combined Class 3 and Class 4 frequency is similar between both CALMET and all the MTO options.

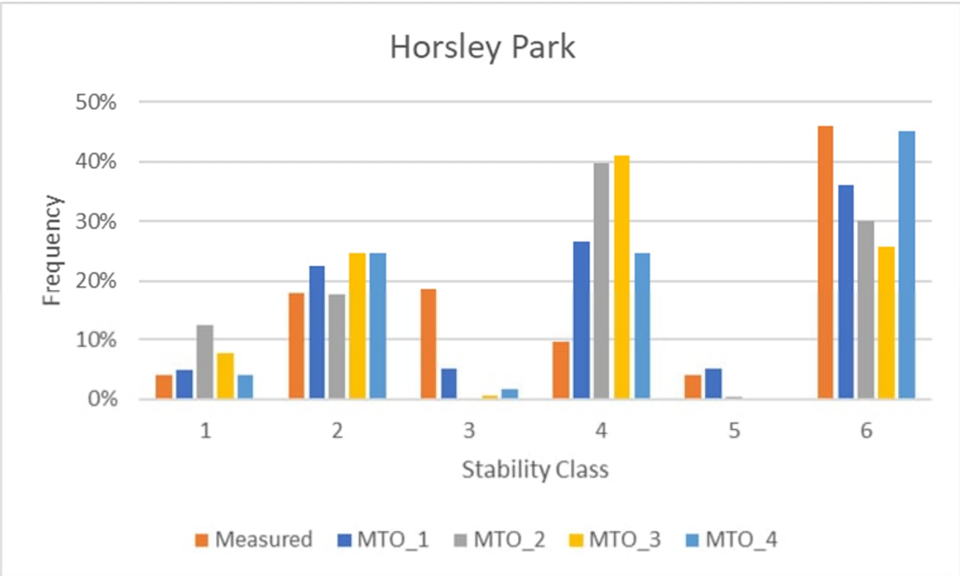


Figure F-53 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at Horsley Park**

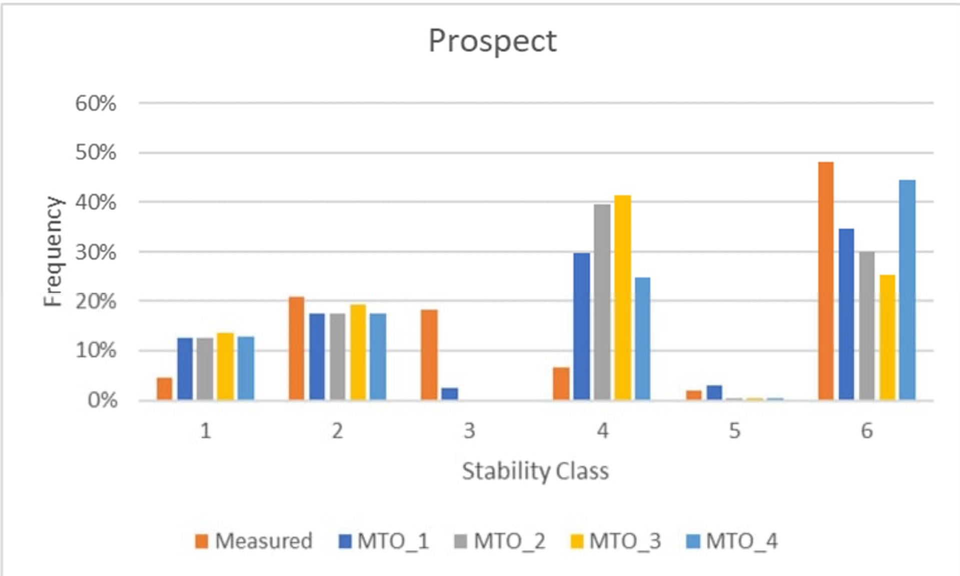


Figure F-54 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at Prospect**

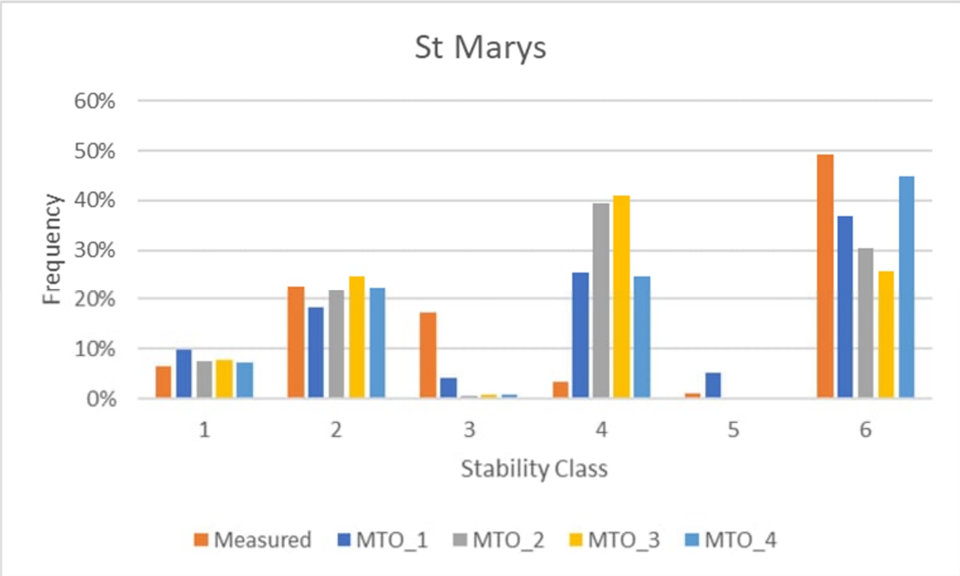


Figure F-55 **Stability class predicted by the 4 MTO options vs CALMET ('measured') at St Marys**

Wind direction comparison

A comparison of predicted wind direction data from the four MTO options with measured data at Horsley Park, Prospect and St Marys are presented in **Figure F-56**, **Figure F-57** and **Figure F-58**. This shows that the GRAMM MTO predictions follow the broad trend of wind direction seen in the measured data, although at Horsley Park the high frequency of winds in the 210-240 degrees sector were predicted to be more in the 180-200 sector by GRAMM. There was considerable variation between the MTO options, especially at Horsley Park and Prospect.

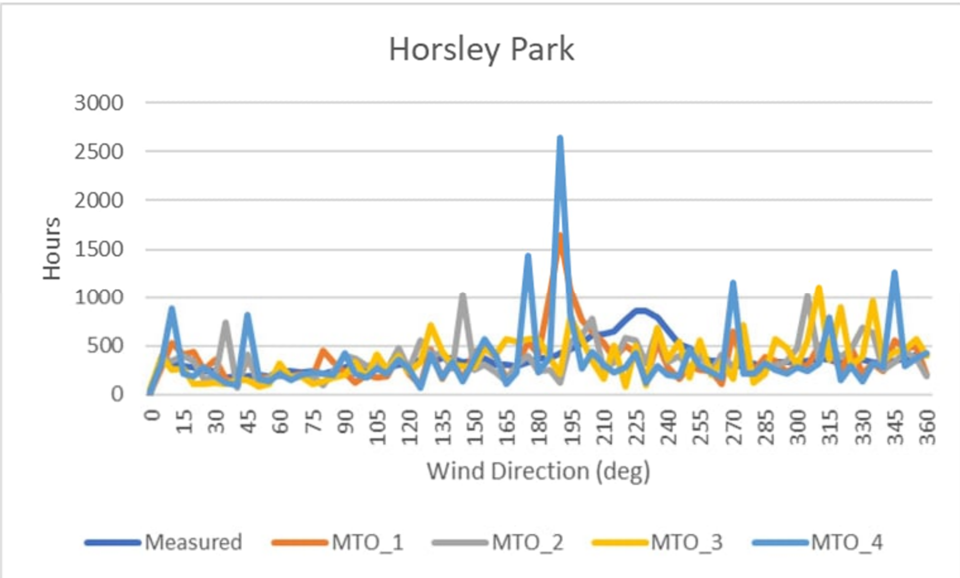


Figure F-56 **Wind directions predicted by the 4 MTO options vs measured data at Horsley Park**

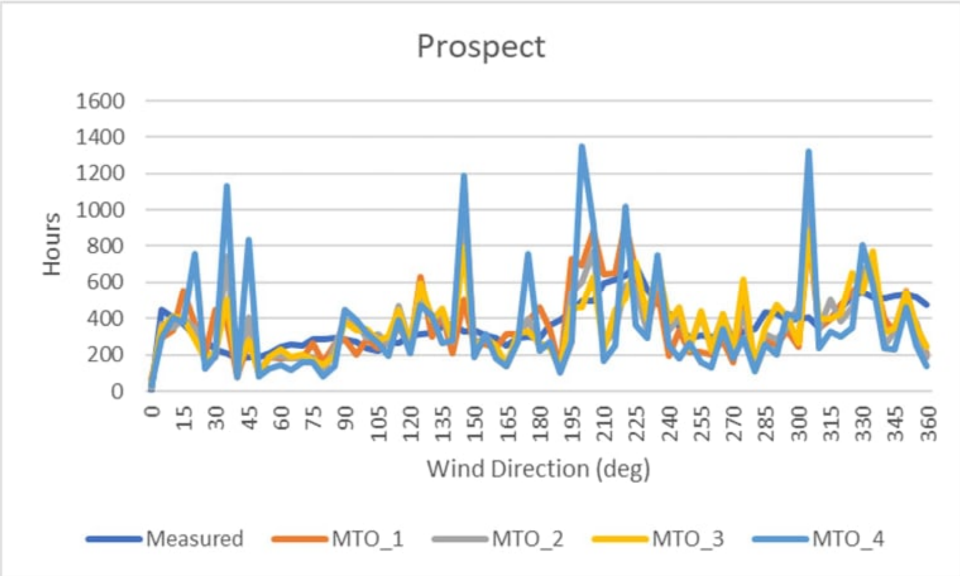


Figure F-57 **Wind directions predicted by the 4 MTO options vs measured data at Prospect**

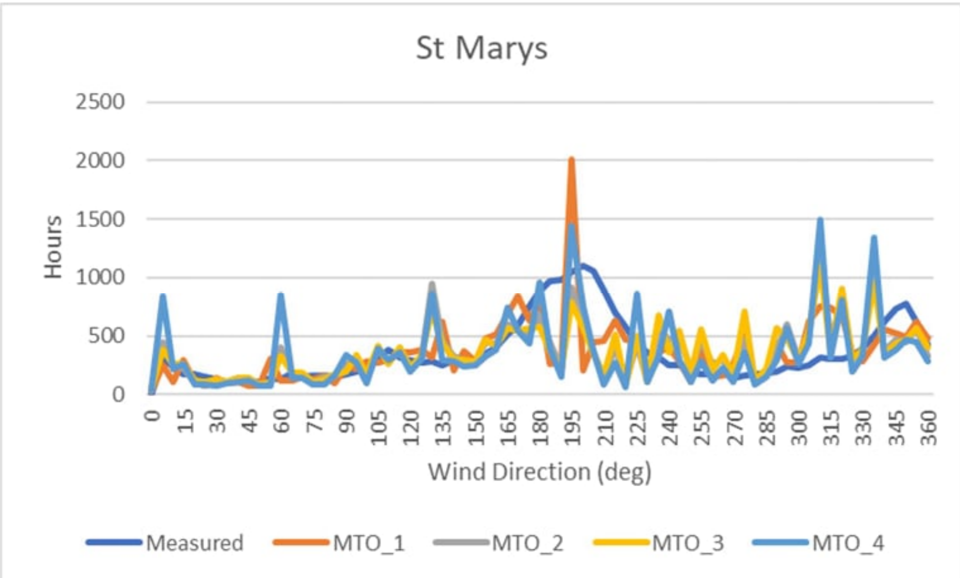


Figure F-58 **Wind directions predicted by the 4 MTO options vs measured data at St Marys**

Calm percentage

The total frequency of calms conditions (winds less than 0.5 m/s) were examined for each of the MTO options at the three met station locations, as shown in **Figure F-59**. This showed that calms were predicted by all four options at St Marys quite well, but tended to overpredict calms at Horsley Park and Prospect.

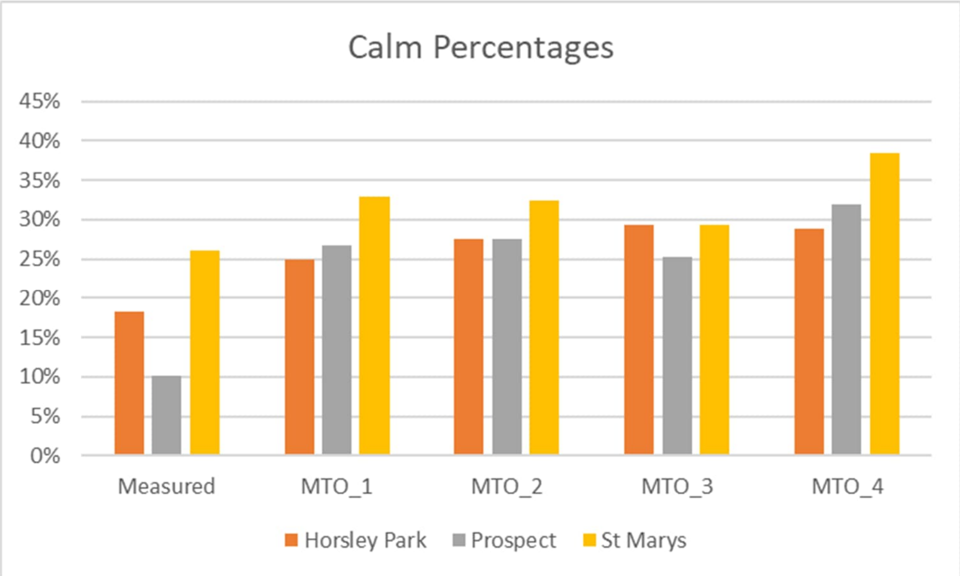


Figure F-59 **Calm frequency predicted by the 4 MTO options vs measured data**

Wind speed profile

Comparisons of predicted wind speed profiles from the four MTO options with measured data at the three stations are presented in **Figure F-60**, **Figure F-61** and **Figure F-62**.

Overall, the profile makes it obvious that GRAMM is overpredicting calms for all MTO options at Horsley Park and Prospect. The correlation is quite good however, at St Marys. The profile for winds above 0.5 m/s match reasonably well for all options, especially at Horsley Park.

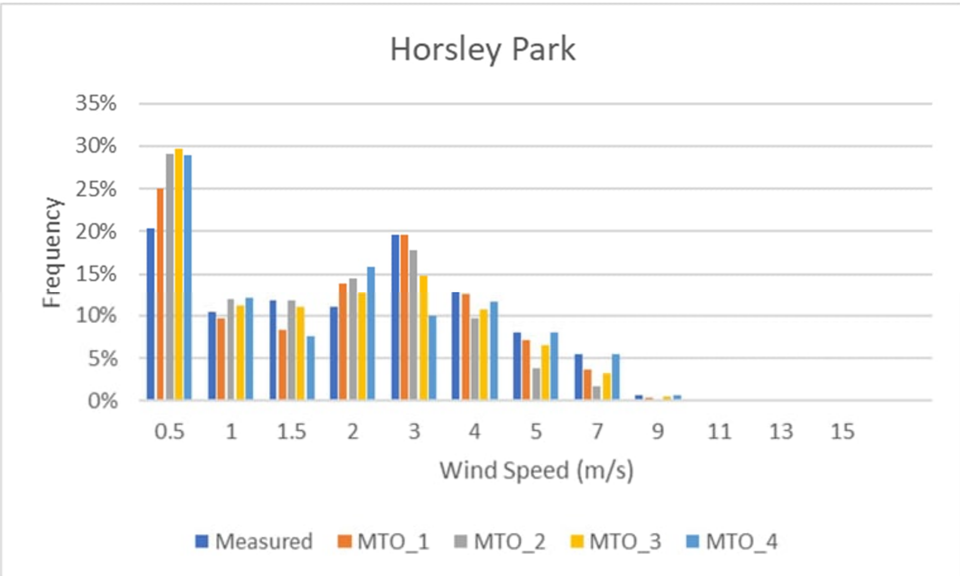


Figure F-60 **Wind speed frequency predicted by the 4 MTO options vs measured data at Horsley Park**

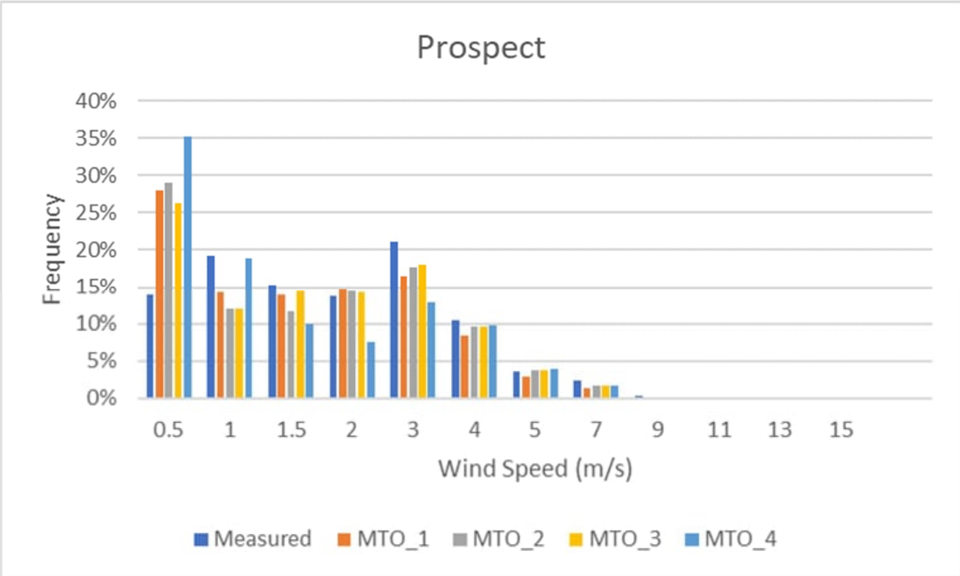


Figure F-61 Wind speed frequency predicted by the 4 MTO options vs measured data at St Marys

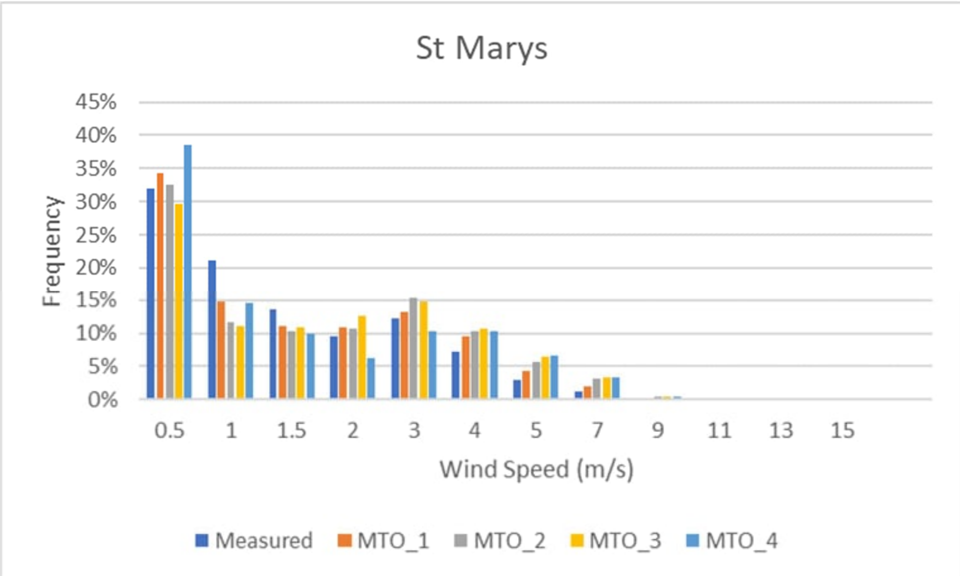


Figure F-62 Wind speed frequency predicted by the 4 MTO options vs measured data at St Marys

Horsley Park comparison (Northern vs Southern Domain)

The Horsley Park BoM location is located within both the northern and southern domain, and as such predictions from the MTO process are available for both domains. An analysis of the two separately predicted data sets at the Horsley Park location was undertaken to determine ensure there was some level of consistency between the two domains.

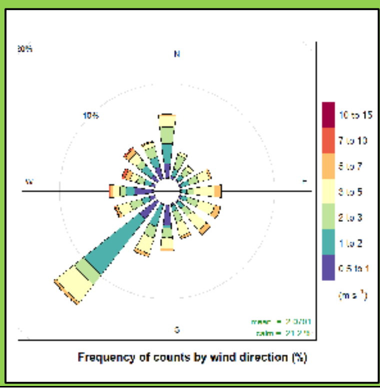
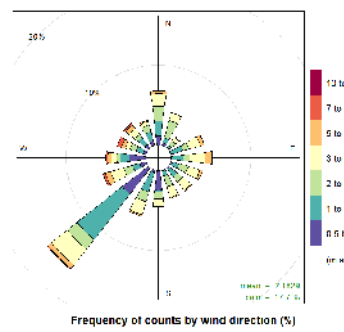
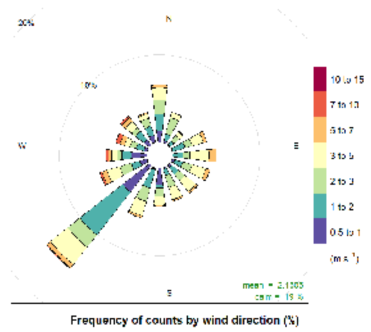
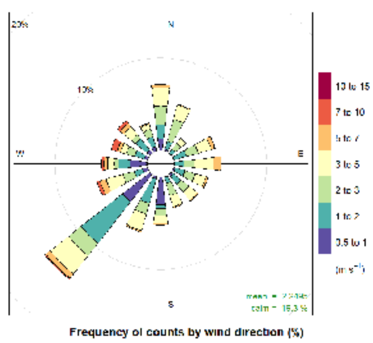
A comparison of wind roses for each MTO option for the Southern and Northern domains at Horsley Park is presented in this **Table F-15**. Option 1 in the Southern Domain, and Option 3 in the Northern Domain were the two options selected for use in GRAL and are shaded green.

For the Southern Domain, all four options were similar, with all four sharing the dominant southwest winds that are seen in the measured data.

Option 3 is easily the best match of the four Northern Domain options, as it is the only option to predict the frequent southwest winds. The other three Northern Domain options all have a strong bias towards light southerly winds, which are not seen in the measured data at Horsley Park. This is part of the reason they were not selected for use in GRAL.

A further comparison of the selected Southern Domain Option 1, Northern Domain Option 3, and measured data at Horsley Park is presented in **Table F-15.** The selected options are circled red where applicable. Comprehensive commentary on the similarities and differences between the data sets selected for the Southern and Northern Domains is not provided here. However, AECOM considers that the match between the two data sets is adequate and shows sufficient consistency between the selected meteorological data sets for the Southern and Northern Domain.

Table F-15 Comparison of wind roses at Horsley Park -Southern and Northern Domain

MTO Options			
Southern Domain MTO Option 1		Southern Domain MTO Option 3	
Southern Domain MTO Option 2		Southern Domain MTO Option 4	

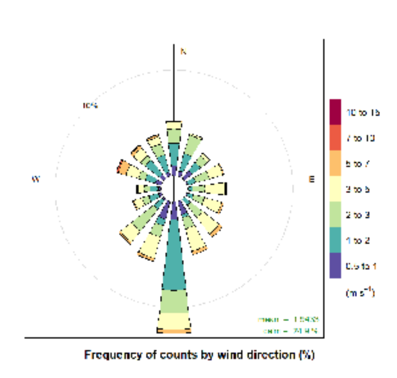
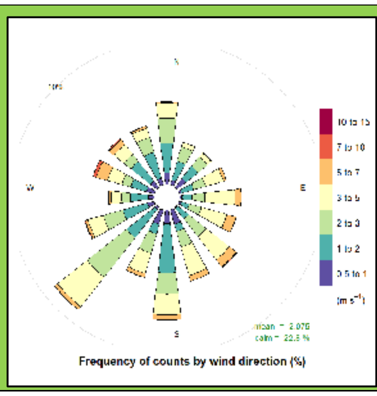
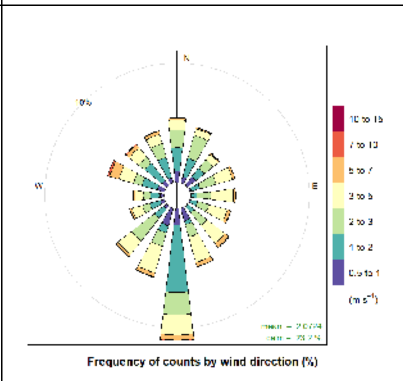
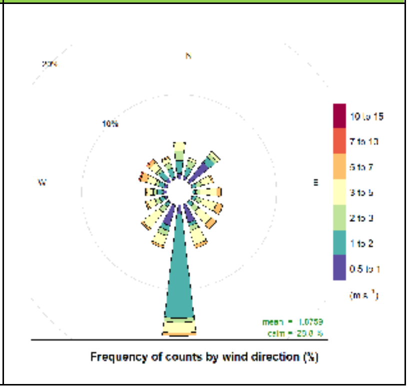
<table>
<tr><td>Northern Domain MTO Option 1</td><td></td><td>Northern Domain MTO Option 3</td><td></td></tr>
<tr><td>Northern Domain MTO Option 2</td><td></td><td>Northern Domain MTO Option 4</td><td></td></tr>
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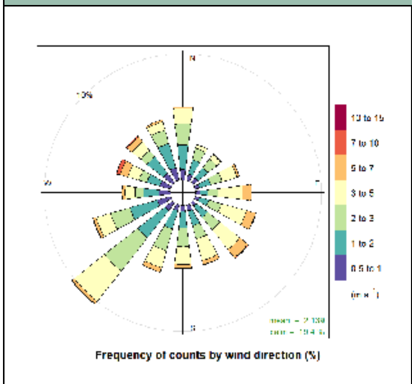
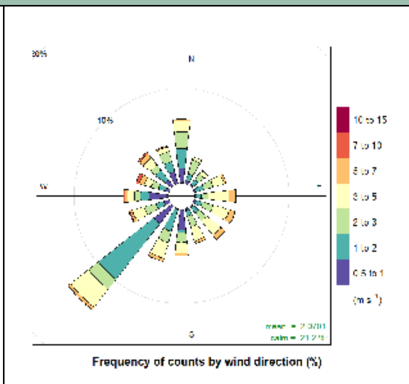
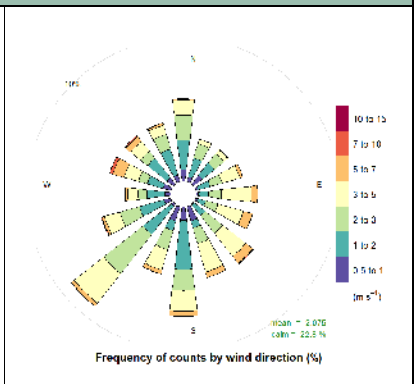
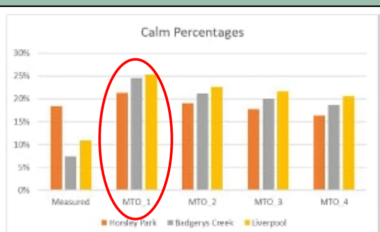
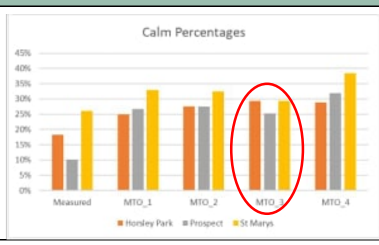
Table F-16 Comparison of Southern Domain Option 1 and Northern Domain Option 3 at Horsley Park

<table>
<tr><th colspan="3">Best MTO Options, Horsley Park</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Measured</td><td>Southern Domain</td><td>Northern Domain</td></tr>
<tr><td>MTO Option</td><td>1</td><td>3</td></tr>
<tr><td>Calms = 19.4%</td><td>Calms = 21.2%</td><td>Calms = 22.8%</td></tr>
<tr><th>Parameter</th><th>Southern Domain</th><th>Northern Domain</th></tr>
<tr><td>Calm Percentages →</td><td></td><td></td></tr>
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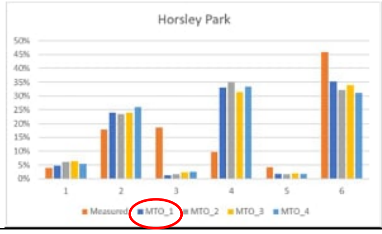
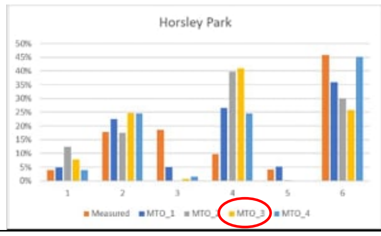
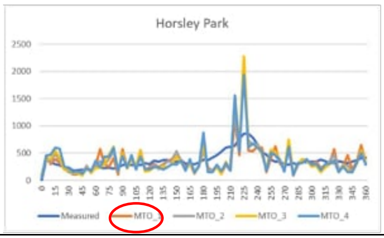
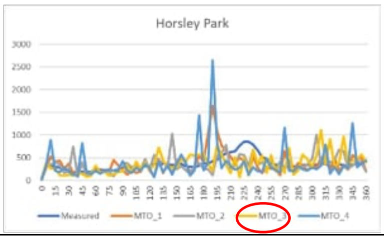
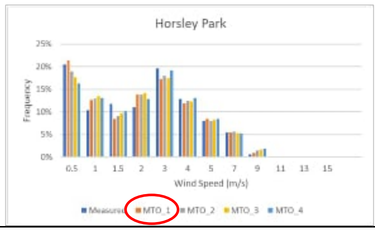
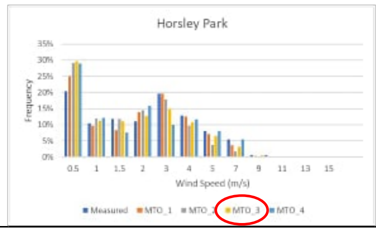
Stability Class Occurrence →		
Wind Direction Comparison →		
Wind Speed Profile →		

Appendix G

Emissions Inventory

Appendix G Emissions inventory

Additional information on inputs into the emissions inventory are provided in this appendix and supplement the details discussed in **Section 4.2.5**.

Base hot running emission factors used in the assessment for each vehicle type and road type are presented in **Table G-17**. These factors were sourced from NSW EPA Air Emissions Inventory for the Greater Metropolitan Region in NSW - On Road Mobile Emissions model for the 2013 calendar year.

Road grade factors used in the assessment are presented in **Table G-18**. The grade factors are derived from PIARC's *Road Tunnels: Vehicle Emissions and Air Demand for Ventilation* report, as have other recent road projects in NSW. PIARC (2019).

Table G-17 Base hot running emission factor by vehicle and road type

Year	2016 (Existing)					2026 (Design Opening Year)					2036 (Ten Years after Design Opening)				
Veh Class	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW
1 - HC (g/km)															
PPV	0.075	0.081	0.081	0.069	0.051	0.020	0.023	0.024	0.018	0.015	0.015	0.017	0.017	0.011	0.010
DPV	0.056	0.055	0.054	0.049	0.036	0.009	0.009	0.009	0.008	0.005	0.003	0.003	0.002	0.002	0.002
PLCV	0.414	0.446	0.451	0.374	0.270	0.171	0.191	0.196	0.139	0.107	0.069	0.080	0.083	0.055	0.044
DLCV	0.077	0.076	0.075	0.071	0.060	0.010	0.010	0.010	0.010	0.008	0.003	0.003	0.003	0.003	0.002
RIG	0.300	0.291	0.284	0.244	0.196	0.065	0.063	0.062	0.053	0.042	0.030	0.030	0.029	0.025	0.020
ART	0.511	0.489	0.476	0.436	0.337	0.138	0.133	0.129	0.117	0.089	0.092	0.088	0.086	0.077	0.058
BUSD	0.317	0.310	0.303	0.270	0.211	0.071	0.070	0.069	0.062	0.049	0.040	0.040	0.039	0.036	0.029
2 - CO (g/km)															
PPV	0.929	1.150	1.220	1.090	0.913	0.366	0.531	0.592	0.532	0.483	0.365	0.459	0.494	0.438	0.392
DPV	0.281	0.277	0.271	0.274	0.188	0.103	0.101	0.099	0.103	0.064	0.053	0.053	0.052	0.056	0.038
PLCV	4.852	5.634	5.833	5.439	4.898	1.897	2.513	2.698	2.919	2.750	0.859	1.157	1.253	1.322	1.204
DLCV	0.369	0.364	0.358	0.361	0.276	0.083	0.082	0.080	0.083	0.064	0.022	0.021	0.021	0.022	0.017
RIG	1.525	1.488	1.458	1.231	0.993	1.088	1.074	1.059	0.952	0.830	0.499	0.493	0.487	0.437	0.379
ART	6.601	5.660	5.250	4.123	2.307	6.503	5.487	5.065	4.082	2.213	2.481	2.089	1.927	1.552	0.827
BUSD	1.747	1.787	1.775	1.527	1.087	1.482	1.491	1.471	1.240	0.824	1.105	1.112	1.097	0.926	0.614
3 - NO_x (g/km)															
PPV	0.194	0.229	0.240	0.231	0.248	0.048	0.060	0.065	0.059	0.052	0.034	0.041	0.043	0.036	0.027
DPV	0.863	0.893	0.896	0.908	0.964	0.716	0.745	0.749	0.834	1.029	0.390	0.405	0.408	0.473	0.618
PLCV	0.792	0.893	0.925	0.874	0.932	0.321	0.377	0.395	0.367	0.375	0.141	0.168	0.177	0.161	0.158
DLCV	1.241	1.292	1.301	1.266	1.199	1.159	1.163	1.161	1.128	1.090	0.628	0.628	0.625	0.609	0.591
RIG	4.488	4.433	4.370	3.835	3.197	3.786	3.705	3.615	2.836	1.849	1.698	1.660	1.617	1.245	0.770

Year	2016 (Existing)					2026 (Design Opening Year)					2036 (Ten Years after Design Opening)				
Veh Class	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW	Centroid Conn.	Local/ Coll.	Sub-Arterial	Arterial	MW/ FW
ART	12.379	12.545	12.499	11.640	9.828	9.409	9.769	9.812	8.274	5.143	3.380	3.502	3.509	2.945	1.766
BUSD	10.506	10.526	10.389	9.156	6.783	7.478	7.455	7.304	6.056	3.680	5.301	5.279	5.167	4.244	2.487
4 - Exhaust PM_{10} (g/km)															
PPV	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
DPV	0.031	0.031	0.031	0.029	0.025	0.010	0.010	0.010	0.010	0.008	0.004	0.004	0.004	0.003	0.003
PLCV	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.002
DLCV	0.180	0.179	0.178	0.172	0.169	0.009	0.009	0.008	0.008	0.006	0.003	0.003	0.003	0.003	0.002
RIG	0.183	0.182	0.180	0.172	0.174	0.051	0.051	0.050	0.047	0.044	0.018	0.017	0.017	0.016	0.014
ART	0.295	0.284	0.276	0.247	0.204	0.141	0.136	0.132	0.119	0.095	0.048	0.046	0.045	0.041	0.032
BUSD	0.147	0.151	0.151	0.147	0.140	0.069	0.073	0.073	0.068	0.059	0.045	0.047	0.047	0.044	0.038
5 - Non-Exhaust PM_{10} (g/km)															
PPV	0.034	0.034	0.034	0.026	0.022	0.034	0.034	0.034	0.026	0.022	0.034	0.034	0.034	0.026	0.022
DPV	0.034	0.034	0.034	0.026	0.022	0.034	0.034	0.034	0.026	0.022	0.034	0.034	0.034	0.026	0.022
PLCV	0.046	0.046	0.046	0.035	0.030	0.046	0.046	0.046	0.035	0.030	0.046	0.046	0.046	0.035	0.030
DLCV	0.046	0.046	0.046	0.035	0.030	0.046	0.046	0.046	0.035	0.030	0.046	0.046	0.046	0.035	0.030
RIG	0.141	0.141	0.141	0.106	0.087	0.141	0.141	0.141	0.106	0.087	0.141	0.141	0.141	0.106	0.087
ART	0.182	0.182	0.182	0.143	0.120	0.182	0.182	0.182	0.143	0.120	0.182	0.182	0.182	0.143	0.120
BUSD	0.139	0.139	0.139	0.104	0.085	0.139	0.139	0.139	0.104	0.085	0.139	0.139	0.139	0.104	0.085

Table G-18 PIARC 2019 derived grade factors

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
		PPV	PC	P	CO	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PPV	PC	P	CO	10	0.70	0.80	0.88	1.00	1.09	1.28	1.51
		PPV	PC	P	CO	20	0.54	0.66	0.81	1.00	1.47	2.29	3.24
		PPV	PC	P	CO	30	0.56	0.68	0.81	1.00	1.26	1.67	2.27
		PPV	PC	P	CO	40	0.50	0.63	0.79	1.00	1.36	2.02	2.98
		PPV	PC	P	CO	50	0.49	0.65	0.77	1.00	1.30	1.81	2.56
		PPV	PC	P	CO	60	0.47	0.63	0.73	1.00	1.39	2.08	3.26
		PPV	PC	P	CO	70	0.39	0.52	0.70	1.00	1.42	2.36	4.26
		PPV	PC	P	CO	80	0.40	0.52	0.68	1.00	1.61	2.88	5.37
		PPV	PC	P	CO	90	0.33	0.44	0.64	1.00	1.89	4.10	7.42
		PPV	PC	P	CO	100	0.31	0.42	0.63	1.00	1.71	4.16	8.25
		PPV	PC	P	CO	110	0.34	0.43	0.61	1.00	1.90	4.18	10.13
		PPV	PC	P	CO	120	0.36	0.42	0.57	1.00	1.99	4.62	11.52
		PPV	PC	P	CO	130	0.36	0.45	0.60	1.00	2.13	5.57	10.86
		PPV	PC	P	NOx	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PPV	PC	P	NOx	10	0.65	0.73	0.86	1.00	1.12	1.23	1.39
		PPV	PC	P	NOx	20	0.56	0.65	0.82	1.00	1.20	1.41	1.74
		PPV	PC	P	NOx	30	0.48	0.61	0.78	1.00	1.26	1.59	1.99
		PPV	PC	P	NOx	40	0.45	0.57	0.76	1.00	1.33	1.62	1.99
		PPV	PC	P	NOx	50	0.40	0.52	0.72	1.00	1.34	1.71	2.18
		PPV	PC	P	NOx	60	0.36	0.50	0.70	1.00	1.42	1.92	2.38
		PPV	PC	P	NOx	70	0.33	0.48	0.68	1.00	1.48	2.09	2.55
		PPV	PC	P	NOx	80	0.27	0.40	0.62	1.00	1.43	1.90	2.38
		PPV	PC	P	NOx	90	0.24	0.37	0.57	1.00	1.54	1.83	2.27
		PPV	PC	P	NOx	100	0.25	0.39	0.57	1.00	1.57	1.99	2.32
		PPV	PC	P	NOx	110	0.28	0.41	0.65	1.00	1.51	1.99	2.44
		PPV	PC	P	NOx	120	0.28	0.41	0.67	1.00	1.34	1.78	2.17
		PPV	PC	P	NOx	130	0.25	0.40	0.73	1.00	1.11	1.38	1.66
		PPV	PC	P	PM	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PPV	PC	P	PM	10	0.96	0.97	0.98	1.00	1.01	1.03	1.07
		PPV	PC	P	PM	20	0.97	0.98	0.99	1.00	1.02	1.05	1.10
		PPV	PC	P	PM	30	0.98	0.98	0.99	1.00	1.02	1.06	1.11
		PPV	PC	P	PM	40	0.99	0.99	0.99	1.00	1.02	1.06	1.11
		PPV	PC	P	PM	50	0.99	0.99	0.99	1.00	1.02	1.06	1.10
		PPV	PC	P	PM	60	0.98	0.98	0.98	1.00	1.03	1.08	1.16

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
		PPV	PC	P	PM	70	0.98	0.98	0.98	1.00	1.04	1.11	1.23
		PPV	PC	P	PM	80	0.96	0.97	0.97	1.00	1.06	1.14	1.34
		PPV	PC	P	PM	90	0.96	0.96	0.96	1.00	1.09	1.23	1.50
		PPV	PC	P	PM	100	0.97	0.95	0.96	1.00	1.10	1.30	1.58
		PPV	PC	P	PM	110	0.95	0.94	0.95	1.00	1.11	1.31	1.61
		PPV	PC	P	PM	120	0.89	0.89	0.93	1.00	1.13	1.31	1.60
		PPV	PC	P	PM	130	0.80	0.83	0.89	1.00	1.18	1.35	1.55
		DPV	PC	D	CO	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		DPV	PC	D	CO	10	0.61	0.70	0.83	1.00	1.18	1.40	1.54
		DPV	PC	D	CO	20	0.32	0.38	0.46	1.00	1.19	1.30	1.50
		DPV	PC	D	CO	30	0.39	0.49	0.60	1.00	1.26	1.47	1.63
		DPV	PC	D	CO	40	0.47	0.58	0.69	1.00	1.34	1.59	1.81
		DPV	PC	D	CO	50	0.55	0.62	0.74	1.00	1.40	1.71	1.97
		DPV	PC	D	CO	60	0.63	0.68	0.75	1.00	1.47	1.86	2.17
		DPV	PC	D	CO	70	0.60	0.67	0.75	1.00	1.29	1.73	2.11
		DPV	PC	D	CO	80	0.57	0.66	0.74	1.00	1.28	1.46	1.97
		DPV	PC	D	CO	90	0.62	0.71	0.81	1.00	1.29	1.45	1.99
		DPV	PC	D	CO	100	0.75	0.83	0.91	1.00	1.19	1.42	2.02
		DPV	PC	D	CO	110	0.88	0.89	0.91	1.00	1.11	1.28	1.87
		DPV	PC	D	CO	120	0.93	0.96	0.87	1.00	1.28	1.42	2.01
		DPV	PC	D	CO	130	1.00	1.02	0.88	1.00	1.48	1.76	2.09
		DPV	PC	D	NOx	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		DPV	PC	D	NOx	10	0.64	0.74	0.85	1.00	1.19	1.39	1.63
		DPV	PC	D	NOx	20	0.53	0.65	0.79	1.00	1.25	1.57	1.93
		DPV	PC	D	NOx	30	0.46	0.58	0.74	1.00	1.29	1.70	2.13
		DPV	PC	D	NOx	40	0.42	0.54	0.71	1.00	1.36	1.83	2.42
		DPV	PC	D	NOx	50	0.39	0.50	0.69	1.00	1.41	1.95	2.65
		DPV	PC	D	NOx	60	0.35	0.47	0.68	1.00	1.47	2.13	2.99
		DPV	PC	D	NOx	70	0.30	0.43	0.65	1.00	1.51	2.18	3.04
		DPV	PC	D	NOx	80	0.22	0.35	0.59	1.00	1.67	2.61	3.72
		DPV	PC	D	NOx	90	0.19	0.30	0.56	1.00	1.59	2.47	3.91
		DPV	PC	D	NOx	100	0.19	0.30	0.53	1.00	1.70	2.58	4.01
		DPV	PC	D	NOx	110	0.19	0.32	0.55	1.00	1.67	2.61	3.61
		DPV	PC	D	NOx	120	0.22	0.38	0.62	1.00	1.66	2.78	3.67
		DPV	PC	D	NOx	130	0.21	0.40	0.64	1.00	1.58	2.41	3.09
		DPV	PC	D	PM	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
		DPV	PC	D	PM	10	0.82	0.88	0.93	1.00	1.08	1.16	1.26
		DPV	PC	D	PM	20	0.79	0.85	0.92	1.00	1.09	1.19	1.30
		DPV	PC	D	PM	30	0.79	0.84	0.92	1.00	1.08	1.18	1.29
		DPV	PC	D	PM	40	0.77	0.82	0.90	1.00	1.10	1.22	1.33
		DPV	PC	D	PM	50	0.76	0.81	0.90	1.00	1.12	1.25	1.36
		DPV	PC	D	PM	60	0.77	0.82	0.90	1.00	1.14	1.30	1.46
		DPV	PC	D	PM	70	0.75	0.81	0.90	1.00	1.13	1.27	1.49
		DPV	PC	D	PM	80	0.72	0.79	0.88	1.00	1.17	1.30	1.53
		DPV	PC	D	PM	90	0.71	0.78	0.87	1.00	1.19	1.35	1.49
		DPV	PC	D	PM	100	0.70	0.75	0.85	1.00	1.16	1.31	1.41
		DPV	PC	D	PM	110	0.72	0.78	0.86	1.00	1.17	1.28	1.37
		DPV	PC	D	PM	120	0.72	0.79	0.89	1.00	1.11	1.21	1.29
		DPV	PC	D	PM	130	0.70	0.80	0.91	1.00	1.07	1.15	1.23
		PLCV	LCV	P	CO	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PLCV	LCV	P	CO	10	0.78	0.84	0.92	1.00	1.10	1.23	1.36
		PLCV	LCV	P	CO	20	0.69	0.78	0.91	1.00	1.13	1.31	1.61
		PLCV	LCV	P	CO	30	0.63	0.73	0.90	1.00	1.15	1.38	1.81
		PLCV	LCV	P	CO	40	0.56	0.64	0.85	1.00	1.27	1.72	1.82
		PLCV	LCV	P	CO	50	0.56	0.63	0.82	1.00	1.29	1.77	2.02
		PLCV	LCV	P	CO	60	0.59	0.68	0.88	1.00	1.35	1.90	2.95
		PLCV	LCV	P	CO	70	0.48	0.57	0.79	1.00	1.39	2.13	4.20
		PLCV	LCV	P	CO	80	0.53	0.63	0.83	1.00	1.67	2.77	6.57
		PLCV	LCV	P	CO	90	0.44	0.57	0.84	1.00	2.00	4.91	11.65
		PLCV	LCV	P	CO	100	0.46	0.64	0.93	1.00	2.23	6.44	14.83
		PLCV	LCV	P	CO	110	0.46	0.63	0.85	1.00	2.56	7.18	14.61
		PLCV	LCV	P	CO	120	0.37	0.51	0.69	1.00	2.49	5.79	9.25
		PLCV	LCV	P	CO	130	0.23	0.31	0.48	1.00	2.24	3.69	4.32
		PLCV	LCV	P	NOx	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		PLCV	LCV	P	NOx	10	0.48	0.62	0.79	1.00	1.25	1.56	1.86
		PLCV	LCV	P	NOx	20	0.39	0.47	0.65	1.00	1.34	1.90	2.23
		PLCV	LCV	P	NOx	30	0.34	0.36	0.54	1.00	1.39	1.86	2.27
		PLCV	LCV	P	NOx	40	0.30	0.33	0.55	1.00	1.53	2.13	2.69
		PLCV	LCV	P	NOx	50	0.22	0.27	0.59	1.00	1.65	2.35	3.10
		PLCV	LCV	P	NOx	60	0.12	0.22	0.52	1.00	1.64	1.96	2.83
		PLCV	LCV	P	NOx	70	0.09	0.21	0.52	1.00	1.62	2.00	2.69
		PLCV	LCV	P	NOx	80	0.06	0.16	0.46	1.00	1.56	1.76	2.08

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
		PLCV	LCV	P	NOx	90	0.07	0.18	0.51	1.00	1.55	1.62	1.76
		PLCV	LCV	P	NOx	100	0.11	0.21	0.53	1.00	1.45	1.45	1.46
		PLCV	LCV	P	NOx	110	0.13	0.25	0.57	1.00	1.23	1.15	1.08
		PLCV	LCV	P	NOx	120	0.13	0.29	0.64	1.00	1.07	0.95	0.88
		PLCV	LCV	P	NOx	130	0.16	0.37	0.73	1.00	1.01	0.90	0.85
		PLCV	LCV	P	PM	0	0.65	0.75	0.87	1.00	1.34	1.86	2.77
		PLCV	LCV	P	PM	10	0.96	0.97	0.98	1.00	1.04	1.10	1.21
		PLCV	LCV	P	PM	20	0.96	0.97	0.98	1.00	1.05	1.14	1.29
		PLCV	LCV	P	PM	30	0.96	0.96	0.98	1.00	1.05	1.15	1.32
		PLCV	LCV	P	PM	40	0.94	0.95	0.96	1.00	1.07	1.24	1.32
		PLCV	LCV	P	PM	50	0.96	0.96	0.98	1.00	1.05	1.16	1.35
		PLCV	LCV	P	PM	60	0.96	0.97	0.98	1.00	1.07	1.22	1.51
		PLCV	LCV	P	PM	70	0.91	0.92	0.95	1.00	1.11	1.35	1.85
		PLCV	LCV	P	PM	80	0.93	0.94	0.96	1.00	1.18	1.55	2.40
		PLCV	LCV	P	PM	90	0.94	0.95	0.97	1.00	1.27	1.82	2.74
		PLCV	LCV	P	PM	100	0.90	0.91	0.92	1.00	1.37	1.87	2.95
		PLCV	LCV	P	PM	110	0.78	0.81	0.84	1.00	1.30	1.95	2.98
		PLCV	LCV	P	PM	120	0.73	0.78	0.83	1.00	1.31	2.28	3.09
		PLCV	LCV	P	PM	130	0.72	0.76	0.83	1.00	1.49	2.58	3.25
		DLCV	LCV	D	CO	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		DLCV	LCV	D	CO	10	0.63	0.72	0.86	1.00	1.11	1.26	1.42
		DLCV	LCV	D	CO	20	0.57	0.67	0.84	1.00	1.09	1.18	1.29
		DLCV	LCV	D	CO	30	0.53	0.66	0.83	1.00	1.12	1.22	1.31
		DLCV	LCV	D	CO	40	0.52	0.66	0.82	1.00	1.15	1.25	1.43
		DLCV	LCV	D	CO	50	0.51	0.68	0.81	1.00	1.19	1.35	1.47
		DLCV	LCV	D	CO	60	0.49	0.67	0.78	1.00	1.26	1.42	1.59
		DLCV	LCV	D	CO	70	0.46	0.69	0.77	1.00	1.30	1.44	1.65
		DLCV	LCV	D	CO	80	0.55	0.71	0.79	1.00	1.33	1.46	1.70
		DLCV	LCV	D	CO	90	0.68	0.77	0.79	1.00	1.37	1.50	1.96
		DLCV	LCV	D	CO	100	0.74	0.83	0.80	1.00	1.42	1.67	2.06
		DLCV	LCV	D	CO	110	0.80	0.86	0.84	1.00	1.45	1.77	2.05
		DLCV	LCV	D	CO	120	0.67	0.72	0.82	1.00	1.28	1.42	1.57
		DLCV	LCV	D	CO	130	0.56	0.70	0.82	1.00	1.18	1.25	1.33
		DLCV	LCV	D	NOx	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		DLCV	LCV	D	NOx	10	0.58	0.67	0.81	1.00	1.26	1.53	1.78
		DLCV	LCV	D	NOx	20	0.45	0.57	0.74	1.00	1.36	2.37	2.99

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
		DLCV	LCV	D	NOx	30	0.37	0.50	0.70	1.00	1.41	2.36	3.10
		DLCV	LCV	D	NOx	40	0.31	0.44	0.65	1.00	1.51	2.55	3.45
		DLCV	LCV	D	NOx	50	0.26	0.38	0.61	1.00	1.59	2.42	3.43
		DLCV	LCV	D	NOx	60	0.22	0.42	0.58	1.00	2.05	3.11	4.41
		DLCV	LCV	D	NOx	70	0.15	0.30	0.56	1.00	1.64	2.49	3.53
		DLCV	LCV	D	NOx	80	0.11	0.22	0.46	1.00	1.75	2.51	3.38
		DLCV	LCV	D	NOx	90	0.15	0.27	0.52	1.00	1.77	2.50	3.14
		DLCV	LCV	D	NOx	100	0.16	0.31	0.57	1.00	1.60	2.22	2.76
		DLCV	LCV	D	NOx	110	0.18	0.36	0.62	1.00	1.41	1.81	2.13
		DLCV	LCV	D	NOx	120	0.22	0.42	0.69	1.00	1.31	1.55	1.72
		DLCV	LCV	D	NOx	130	0.30	0.50	0.75	1.00	1.22	1.34	1.41
		DLCV	LCV	D	PM	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		DLCV	LCV	D	PM	10	0.78	0.82	0.90	1.00	1.12	1.24	1.32
		DLCV	LCV	D	PM	20	0.72	0.79	0.89	1.00	1.11	1.28	1.48
		DLCV	LCV	D	PM	30	0.73	0.78	0.88	1.00	1.21	1.44	1.63
		DLCV	LCV	D	PM	40	0.69	0.79	0.87	1.00	1.18	1.44	1.65
		DLCV	LCV	D	PM	50	0.66	0.74	0.87	1.00	1.16	1.50	1.58
		DLCV	LCV	D	PM	60	0.63	0.71	0.83	1.00	1.14	1.47	1.61
		DLCV	LCV	D	PM	70	0.62	0.68	0.80	1.00	1.24	1.45	1.64
		DLCV	LCV	D	PM	80	0.64	0.69	0.81	1.00	1.22	1.40	1.57
		DLCV	LCV	D	PM	90	0.67	0.74	0.83	1.00	1.19	1.36	1.53
		DLCV	LCV	D	PM	100	0.72	0.79	0.88	1.00	1.16	1.33	1.47
		DLCV	LCV	D	PM	110	0.71	0.79	0.88	1.00	1.13	1.27	1.40
		DLCV	LCV	D	PM	120	0.72	0.81	0.90	1.00	1.14	1.26	1.35
		DLCV	LCV	D	PM	130	0.71	0.80	0.89	1.00	1.12	1.21	1.24
RIG	ART	BUSD	HGV	D	CO	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RIG	ART	BUSD	HGV	D	CO	10	0.55	0.67	0.82	1.00	1.15	1.33	1.49
RIG	ART	BUSD	HGV	D	CO	20	0.45	0.51	0.80	1.00	1.18	1.37	1.58
RIG	ART	BUSD	HGV	D	CO	30	0.37	0.42	0.77	1.00	1.28	1.58	1.77
RIG	ART	BUSD	HGV	D	CO	40	0.22	0.32	0.70	1.00	1.39	1.79	2.05
RIG	ART	BUSD	HGV	D	CO	50	0.14	0.21	0.66	1.00	1.47	1.93	2.20
RIG	ART	BUSD	HGV	D	CO	60	0.10	0.18	0.57	1.00	1.53	1.79	1.94
RIG	ART	BUSD	HGV	D	CO	70	0.09	0.15	0.50	1.00	1.57	1.68	1.75
RIG	ART	BUSD	HGV	D	CO	80	0.08	0.13	0.45	1.00	1.60	1.68	1.67
RIG	ART	BUSD	HGV	D	CO	90	0.08	0.13	0.47	1.00	1.61	1.77	1.75
RIG	ART	BUSD	HGV	D	CO	100	0.07	0.12	0.45	1.00	1.58	1.79	1.78

NSW EPA ID			PIARC ID	Fuel	Pollutant	Speed	-6%	-4%	-2%	0%	2%	4%	6%
RIG	ART	BUSD	HGV	D	NOx	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RIG	ART	BUSD	HGV	D	NOx	10	0.63	0.76	0.89	1.00	1.07	1.14	1.20
RIG	ART	BUSD	HGV	D	NOx	20	0.46	0.62	0.86	1.00	1.11	1.17	1.26
RIG	ART	BUSD	HGV	D	NOx	30	0.35	0.52	0.81	1.00	1.11	1.20	1.38
RIG	ART	BUSD	HGV	D	NOx	40	0.23	0.40	0.66	1.00	1.13	1.34	1.66
RIG	ART	BUSD	HGV	D	NOx	50	0.18	0.30	0.57	1.00	1.16	1.50	1.89
RIG	ART	BUSD	HGV	D	NOx	60	0.13	0.20	0.51	1.00	1.48	2.01	2.46
RIG	ART	BUSD	HGV	D	NOx	70	0.09	0.12	0.43	1.00	1.75	2.45	2.93
RIG	ART	BUSD	HGV	D	NOx	80	0.08	0.11	0.40	1.00	1.97	2.81	3.32
RIG	ART	BUSD	HGV	D	NOx	90	0.08	0.11	0.39	1.00	2.01	2.86	3.31
RIG	ART	BUSD	HGV	D	NOx	100	0.08	0.11	0.38	1.00	2.01	2.83	3.22
RIG	ART	BUSD	HGV	D	PM	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RIG	ART	BUSD	HGV	D	PM	10	0.82	0.86	0.93	1.00	1.07	1.14	1.21
RIG	ART	BUSD	HGV	D	PM	20	0.82	0.86	0.95	1.00	1.06	1.13	1.21
RIG	ART	BUSD	HGV	D	PM	30	0.84	0.87	0.94	1.00	1.08	1.16	1.22
RIG	ART	BUSD	HGV	D	PM	40	0.82	0.84	0.91	1.00	1.10	1.19	1.27
RIG	ART	BUSD	HGV	D	PM	50	0.82	0.84	0.91	1.00	1.11	1.21	1.29
RIG	ART	BUSD	HGV	D	PM	60	0.83	0.84	0.91	1.00	1.14	1.28	1.37
RIG	ART	BUSD	HGV	D	PM	70	0.83	0.85	0.91	1.00	1.16	1.33	1.43
RIG	ART	BUSD	HGV	D	PM	80	0.81	0.82	0.88	1.00	1.15	1.33	1.43
RIG	ART	BUSD	HGV	D	PM	90	0.80	0.80	0.86	1.00	1.13	1.26	1.34
RIG	ART	BUSD	HGV	D	PM	100	0.81	0.81	0.86	1.00	1.14	1.24	1.31

Appendix H

Road Links Modelled by the Proposed Modification

Appendix H Road links modelled for the Proposed Modification

The Westlink M7 covers approximately 27km of road from north to south and therefore the road was modelled across two smaller domains to aid with processing time (modelling and receptor timeseries extraction). Northbound and Southbound road links as defined in the model are presented below.

Table H-19 Road links

Direction	Model	Road Type	From	To	Link ID	Grade
NB	Southern	MW/FW	M5/Hume (Start of Project)	Bernera Rd	NB1	-0.4%
NB	Southern	MW/FW			NB2	-0.3%
NB	Southern	MW/FW	Bernera Rd Off Ramp	Bernera Rd On Ramp	NB3	0.0%
NB	Southern	MW/FW			NB4	0.0%
NB	Southern	MW/FW			NB5	0.0%
NB	Southern	MW/FW	Bernera Rd	Cowpasture Rd	NB6	0.7%
NB	Southern	MW/FW			NB7	0.1%
NB	Southern	MW/FW	Cowpasture Rd Off Ramp	Cowpasture Rd On Ramp	NB8	1.8%
NB	Southern	MW/FW			NB9	0.0%
NB	Southern	MW/FW	Cowpasture Rd	Elizabeth Dr	NB10	1.3%
NB	Southern	MW/FW			NB11	0.8%
NB	Southern	MW/FW			NB12	0.4%
NB	Southern	MW/FW			NB13	0.6%
NB	Southern	MW/FW			NB14	0.7%
NB	Southern	MW/FW			NB15	1.5%
NB	Southern	MW/FW			NB16	2.0%
NB	Southern	MW/FW			NB17	2.3%
NB	Southern	MW/FW			NB18	3.3%
NB	Southern	MW/FW			NB19	3.6%

Direction	Model	Road Type	From	To	Link ID	Grade
NB	Southern	MW/FW	Elizabeth Dve/M12 Off Ramp	Elizabeth Dve/M12 On Ramp	NB20	1.6%
NB	Southern	MW/FW			NB21	-1.7%
NB	Southern	MW/FW	Elizabeth Dve/M12	Horsley Dve	NB22	-1.8%
NB	Southern	MW/FW			NB23	1.4%
NB	Southern	MW/FW			NB24	0.2%
NB	Southern	MW/FW			NB25	-1.8%
NB	Southern	MW/FW			NB26	-1.7%
NB	Southern	MW/FW	Horsley Dve Off Ramp	Horsley Dve On Ramp	NB27	-3.3%
NB	Southern	MW/FW			NB28	-0.8%
NB	Southern	MW/FW	Horsley Dve	Old Wallgrove Rd	NB29	-1.1%
NB	Northern	MW/FW	Horsley Dve Off Ramp	Horsley Dve On Ramp	NB1	0.0%
NB	Northern	MW/FW	Horsley Dve	Old Wallgrove Rd	NB2	-1.1%
NB	Northern	MW/FW			NB3	-0.8%
NB	Northern	MW/FW			NB4	-0.7%
NB	Northern	MW/FW			NB5	-1.3%
NB	Northern	MW/FW			NB6	0.2%
NB	Northern	MW/FW			NB7	-2.3%
NB	Northern	MW/FW	Old Wallgrove Rd Off Ramp	Old Wallgrove Rd On Ramp	NB8	-0.5%
NB	Northern	MW/FW			NB9	0.0%
NB	Northern	MW/FW	Old Wallgrove Rd	M4	NB10	0.0%
NB	Northern	MW/FW	M4 Off Ramp	M4 On Ramp	NB11	1.4%
NB	Northern	MW/FW			NB12	-1.6%
NB	Northern	MW/FW			NB13	-1.9%
NB	Northern	MW/FW	M4	Great Western Hwy	NB14	-0.3%

Direction	Model	Road Type	From	To	Link ID	Grade
NB	Northern	MW/FW			NB15	-0.8%
NB	Northern	MW/FW	Great Western Hwy	Woodstock Ave	NB16	-0.8%
NB	Northern	MW/FW			NB17	1.1%
NB	Northern	MW/FW			NB18	-1.1%
NB	Northern	MW/FW			NB19	0.3%
NB	Northern	MW/FW	Woodstock Ave	Power St	NB20	1.2%
NB	Northern	MW/FW			NB21	-0.8%
NB	Northern	MW/FW			NB22	-0.2%
NB	Northern	MW/FW			NB23	0.5%
NB	Northern	MW/FW	Power St	Richmond Rd	NB24	1.4%
NB	Northern	MW/FW			NB25	-0.2%
NB	Northern	MW/FW			NB26	1.3%
NB	Northern	MW/FW	Richmond Rd Off Ramp	Richmond Road (End of Project)	NB27	0.0%
NB	Southern	MW/FW	Bernera Rd	Off	NBOFF1	0.0%
NB	Southern	MW/FW	Bernera Rd	On	NBON1	0.7%
NB	Southern	MW/FW	Cowpasture Rd	Off	NBOFF2	0.4%
NB	Southern	MW/FW	Cowpasture Rd	On	NBON2	0.9%
NB	Southern	MW/FW	Elizabeth Dr	Off	NBOFF3	1.3%
NB	Southern	MW/FW	Elizabeth Dr	On	NBON3	0.3%
NB	Southern	MW/FW	M12	Off	NBOFF4	2.1%
NB	Southern	MW/FW	M12	On	NBON4	1.4%
NB	Southern	MW/FW	Horsley Dve	Off	NBOFF5	-2.3%
NB	Southern/ Northern	MW/FW	Horsley Dve	On	NBON5	-0.6%
NB	Northern	MW/FW	Old Walgrove Rd	Off	NBOFF6	-0.4%

Direction	Model	Road Type	From	To	Link ID	Grade
NB	Northern	MW/FW	Old Walgrove Rd	On	NBON6	-0.2%
NB	Northern	MW/FW	M4	Off	NBOFF7	1.0%
NB	Northern	MW/FW	M4	On	NBON7	-0.6%
NB	Northern	MW/FW	Great Western Hwy	On	NBON8	0.2%
NB	Northern	MW/FW	Woodstock Ave	Off	NBOFF8	-0.5%
NB	Northern	MW/FW	Power St	On	NBON9	-0.4%
NB	Northern	MW/FW	Richmond Rd	Off	NBOFF9	-1.8%
SB	Southern	MW/FW	M5/Hume	Bernera Rd	SB29	0.2%
SB	Southern	MW/FW			SB28	0.2%
SB	Southern	MW/FW			SB27	0.3%
SB	Southern	MW/FW	Bernera Rd Off Ramp	Benera Rd On Ramp	SB26	-0.3%
SB	Southern	MW/FW			SB25	0.3%
SB	Southern	MW/FW	Bernera Rd	Cowpasture Rd	SB24	-1.0%
SB	Southern	MW/FW			SB23	-0.2%
SB	Southern	MW/FW	Cowpasture Rd Off Ramp	Cowpasture Rd On Ramp	SB22	-2.5%
SB	Southern	MW/FW			SB21	0.0%
SB	Southern	MW/FW			SB20	-0.5%
SB	Southern	MW/FW	Cowpasture Rd	Elizabeth Dve	SB19	-0.8%
SB	Southern	MW/FW			SB18	-0.4%
SB	Southern	MW/FW			SB17	-0.6%
SB	Southern	MW/FW			SB16	-0.7%
SB	Southern	MW/FW			SB15	-1.3%
SB	Southern	MW/FW			SB14	-2.3%
SB	Southern	MW/FW			SB13	-2.4%

Direction	Model	Road Type	From	To	Link ID	Grade
SB	Southern	MW/FW			SB12	-3.4%
SB	Southern	MW/FW	Elizabeth Dve/M12 Off Ramp	Elizabeth Dve/M12 On Ramp	SB11	-2.7%
SB	Southern	MW/FW			SB10	-0.8%
SB	Southern	MW/FW			SB9	1.6%
SB	Southern	MW/FW	Elizabeth Dve	Horsley Dve	SB8	1.4%
SB	Southern	MW/FW			SB7	-2.1%
SB	Southern	MW/FW			SB6	-0.4%
SB	Southern	MW/FW			SB5	1.6%
SB	Southern	MW/FW			SB4	1.9%
SB	Southern	MW/FW			SB3	2.8%
SB	Southern	MW/FW	Horsley Dve Off Ramp	Horsley Dve On Ramp	SB2	0.8%
SB	Southern	MW/FW	Horsley Dve	Old Wallgrove Rd	SB1	0.6%
SB	Northern	MW/FW	Horsley Dve Off Ramp	Horsley Dve On Ramp	SB27	-0.4%
SB	Northern	MW/FW	Horsley Dve	Old Wallgrove Rd	SB26	0.9%
SB	Northern	MW/FW			SB25	0.6%
SB	Northern	MW/FW			SB24	0.9%
SB	Northern	MW/FW			SB23	1.6%
SB	Northern	MW/FW			SB22	-0.4%
SB	Northern	MW/FW			SB21	2.8%
SB	Northern	MW/FW	Old Wallgrove Rd Off Ramp	Old Wallgrove Rd On Ramp	SB20	0.3%
SB	Northern	MW/FW			SB19	0.6%
SB	Northern	MW/FW	Old Wallgrove Rd	M4	SB18	-0.2%
SB	Northern	MW/FW	M4 Off Ramp	M4 On Ramp	SB17	-1.2%
SB	Northern	MW/FW			SB16	1.2%

Direction	Model	Road Type	From	To	Link ID	Grade
SB	Northern	MW/FW			SB15	1.1%
SB	Northern	MW/FW	M4	Great Western Hwy	SB14	1.0%
SB	Northern	MW/FW	Great Western Hwy	Woodstock Ave	SB13	0.8%
SB	Northern	MW/FW			SB12	0.4%
SB	Northern	MW/FW			SB11	-1.0%
SB	Northern	MW/FW			SB10	0.9%
SB	Northern	MW/FW			SB9	-0.4%
SB	Northern	MW/FW			SB8	-0.4%
SB	Northern	MW/FW	Woodstock Ave	Power St	SB7	0.1%
SB	Northern	MW/FW			SB6	0.2%
SB	Northern	MW/FW			SB5	-0.6%
SB	Northern	MW/FW	Power St	Richmond Rd	SB4	-1.5%
SB	Northern	MW/FW			SB3	0.2%
SB	Northern	MW/FW			SB2	-0.9%
SB	Northern	MW/FW	Richmond Rd (start of Project)	Richmond Rd On Ramp	SB1	0.0%
SB	Southern	MW/FW	Bernera Rd	On	SBON9	0.3%
SB	Southern	MW/FW	Bernera Rd	Off	SBOFF9	-0.6%
SB	Southern	MW/FW	Cowpasture Rd	On	SBON8	-0.2%
SB	Southern	MW/FW	Cowpasture Rd	Off	SBOFF8	-1.0%
SB	Southern	MW/FW	Elizabeth Dr	On	SBON7_ED	-0.2%
SB	Southern	MW/FW	Elizabeth Dr	Off	SBOFF7_ED	-0.4%
SB	Southern	MW/FW	M12	On	SBON6_M12	-2.3%
SB	Southern	MW/FW	M12	Off	SBOFF6_M12	0.6%
SB	Southern	MW/FW	Horsley Dve	On	SBON5	1.5%

Direction	Model	Road Type	From	To	Link ID	Grade
SB	Southern/ Northern	MW/FW	Horsley Dve	Off	SBOFF5	0.8%
SB	Northern	MW/FW	Old Walgrove Rd	On	SBON4	-0.5%
SB	Northern	MW/FW	Old Walgrove Rd	Off	SBOFF4	1.4%
SB	Northern	MW/FW	M4	On	SBON3	0.2%
SB	Northern	MW/FW	M4	Off	SBOFF3	-8.1%
SB	Northern	MW/FW	Great Western Hwy	Off	SBOFF2	-0.2%
SB	Northern	MW/FW	Woodstock Ave	On	SBON2	0.6%
SB	Northern	MW/FW	Power St	Off	SBOFF1	1.0%
SB	Northern	MW/FW	Richmond Rd	On	SBON1	1.9%

Appendix I

Detailed Results Analysis

Appendix I Detailed results analysis

This Appendix provides a detailed assessment of predicted incremental and cumulative air quality impacts from the Proposed Modification. Predicted ground level concentrations for this section have been within both the Southern and Northern Domains in the context of:

- Road contributions (or incremental contributions) from road traffic in isolation for all pollutants for the worst affected receptors in each modelling domain. Road contributions for all sensitive receptors have also been presented graphically for each modelled scenario.
- Cumulative concentrations for the worst affected receptor where the road contribution is added to the background concertation and assessed against relevant EPA criteria for pollutants NO_2, CO, PM_{10} and $PM_{2.5}$.
  - Background data used to estimate predicted cumulative impacts for NO_2 and particulates have utilised the background data interpolation methodology as described in **Section 4.2.7** and **Appendix D**.
  - Background data used to estimate predicted cumulative impacts for 1-hour and 8-hour maximum CO have been based on the maximum recorded values at Prospect Monitoring station between 2015 and 2018 ad discussed in **Section 4.2.7** and **Section 5.2.2**.

Nitrogen dioxide

The following section provides a discussion on predicted incremental (road contributions) and cumulative maximum 1-hour and annual average NO_2 ground level concentrations at sensitive receptors. Predicted NO_2 ground level concentrations are discussed for each modelled scenario.

NO_2 concentrations were based on the concentration of NO_X and the conversion ratio outlined in **Section 4.2.8**. Background data used to estimate predicted cumulative impacts for NO_2 and utilise the background data interpolation methodology as described in **Section 4.2.7** and **Appendix D**.

Road contributions

Predicted incremental maximum 1-hour NO_2 concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-20** In addition to **Table I-20**; predicted incremental maximum 1-hour NO_2 at all sensitive receptors are provided in **Figure I-63** for the Southern domain and **Figure I-64** for the northern domain. **Figure I-65** also provides additional resolution on predicted elevated maximum 1-hour NO_2 receptor concentrations north of Power Street in the Northern Domain for all modelled scenarios.

Most receptors had maximum concentrations below the EPA criterion for 1-hour NO_2 of 246 µg/m^3. However, several receptors in the northern domain had concentrations well above the criterion, especially for the existing baseline. The highest incremental 1-hour maximum NO_2 concentrations were highest in the northern domain. The worst affected receptor was predicted to be N26, 23 m to the east of the M7 roadside, north of Power Street.

Concentrations were predicted to be overall lower than the existing baseline in the 2026 and 2036 scenarios, with or without the Proposed Modification. The majority of locations in 2036 were predicted to have incremental concentrations below the 1-hour criterion.

Concentrations were predicted to be higher with the Proposed Modification in both 2016 and 2036, compared with the Do-nothing scenario. This is most likely due to the higher traffic numbers for the Proposed Modification on the M7 mainline itself.

Table I-20 Predicted incremental maximum 1-hour NO_2 concentrations for all modelled scenarios

Modelling Domain	Predicted Incremental Maximum 1-hour NO_2 Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	259	214	217	191	205
North Domain	720	490	616	268	342
Criteria (µg/m^3)	246				

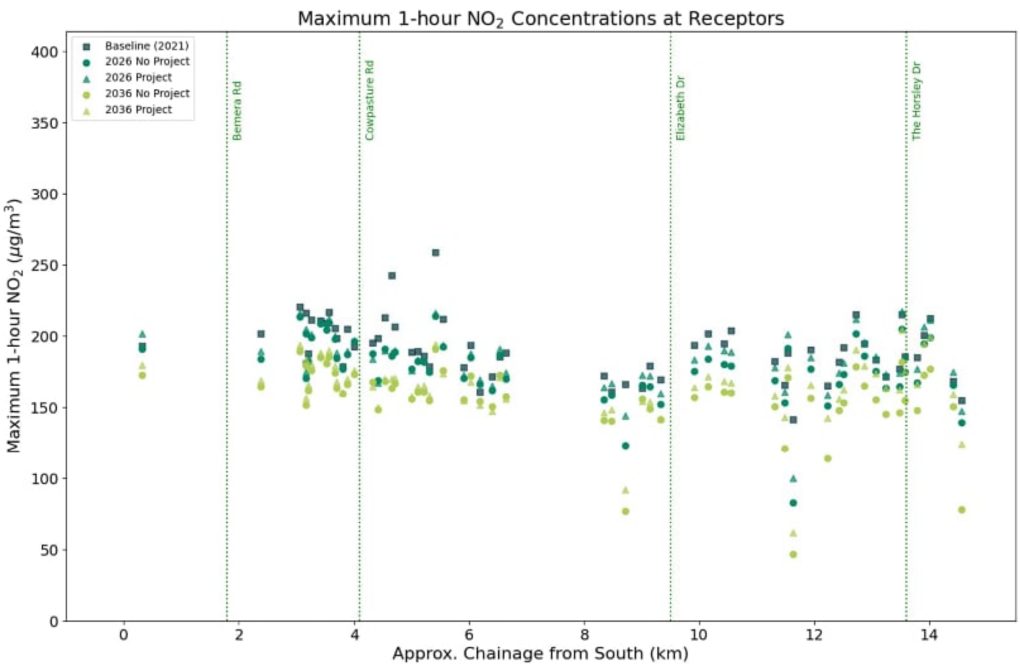


Figure I-63 South Domain: predicted maximum 1-hour NO_2 incremental concentration at sensitive receptors

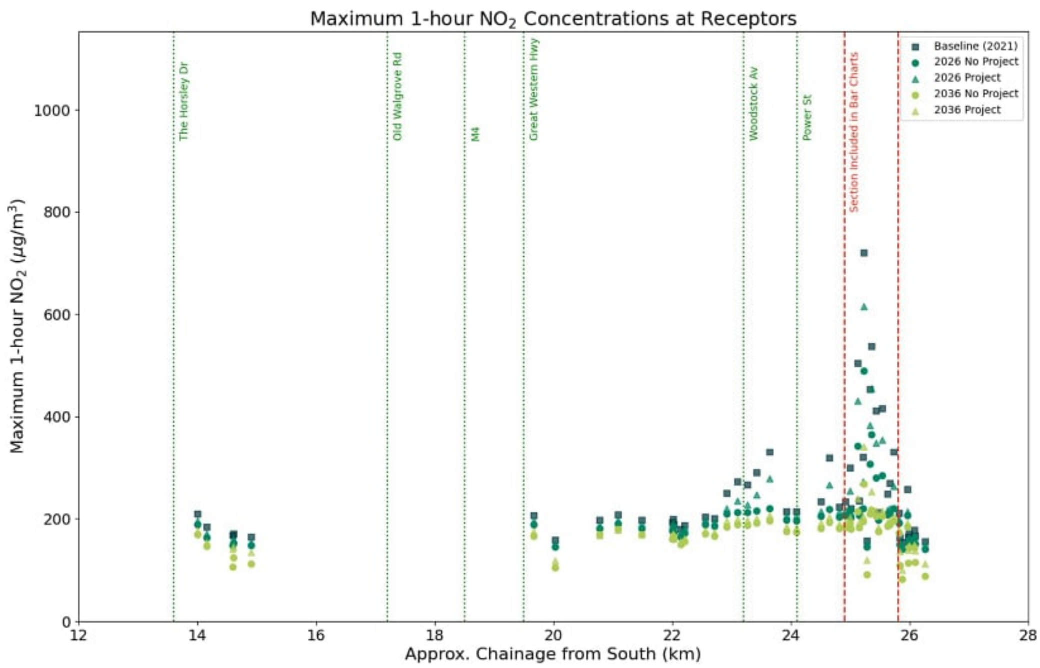


Figure I-64 North Domain: predicted maximum 1-hour NO_2 incremental concentration at sensitive receptors

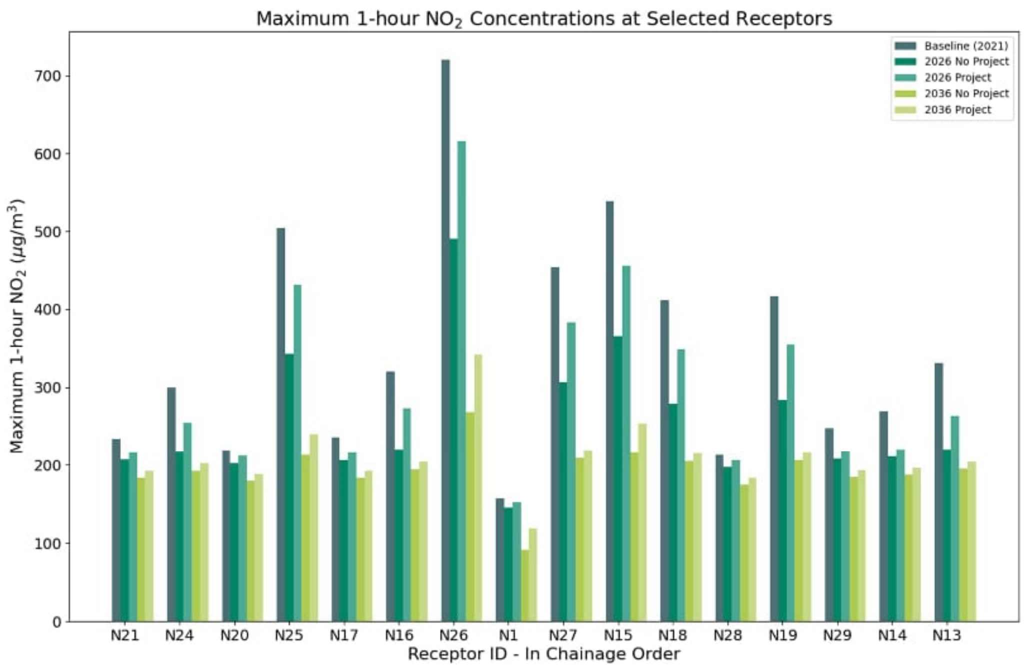


Figure I-65 Predicted 1-Hour maximum NO_2 incremental concentration at sensitive receptors north of Power Street

Predicted incremental annual average NO_2 concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-21** In addition to **Table I-21**; predicted incremental annual average NO_2 at all sensitive receptors are provided in **Figure I-66** for the Southern domain and **Figure I-67** for the northern domain.

Most receptors had maximum concentrations below the EPA criterion for annual average NO_2 of 62 µg/m^3. However, several receptors in the northern domain had concentrations well above the criterion, especially for the existing baseline. The highest incremental annual NO_2 concentrations were at receptors in the northern domain. The worst affected receptor was predicted to be N27 (for all scenarios), 18 m to the east of the M7 roadside, north of Power Street. Concentrations were predicted to be overall lower than the existing baseline in the 2026 and 2036 scenarios, with or without the Proposed Modification.

Table I-21 Predicted incremental maximum annual average NO_2 concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average NO_2 Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	53	40	44	27	30
North Domain	72	61	67	42	47
Criteria (µg/m^3)	62				

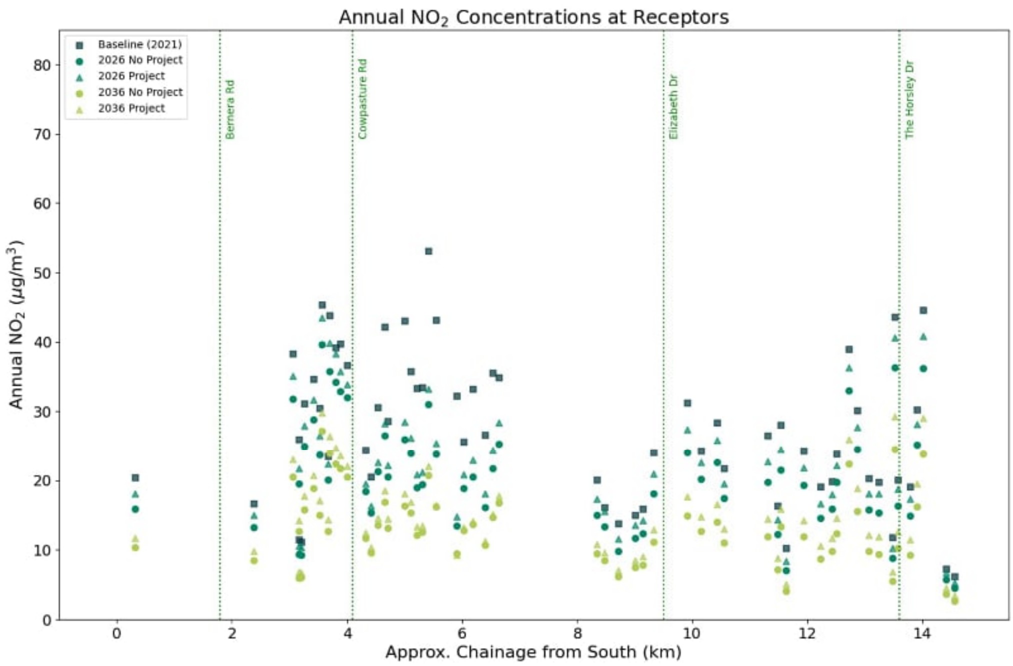


Figure I-66 South Domain: predicted annual average NO_2 incremental concentration at sensitive receptors

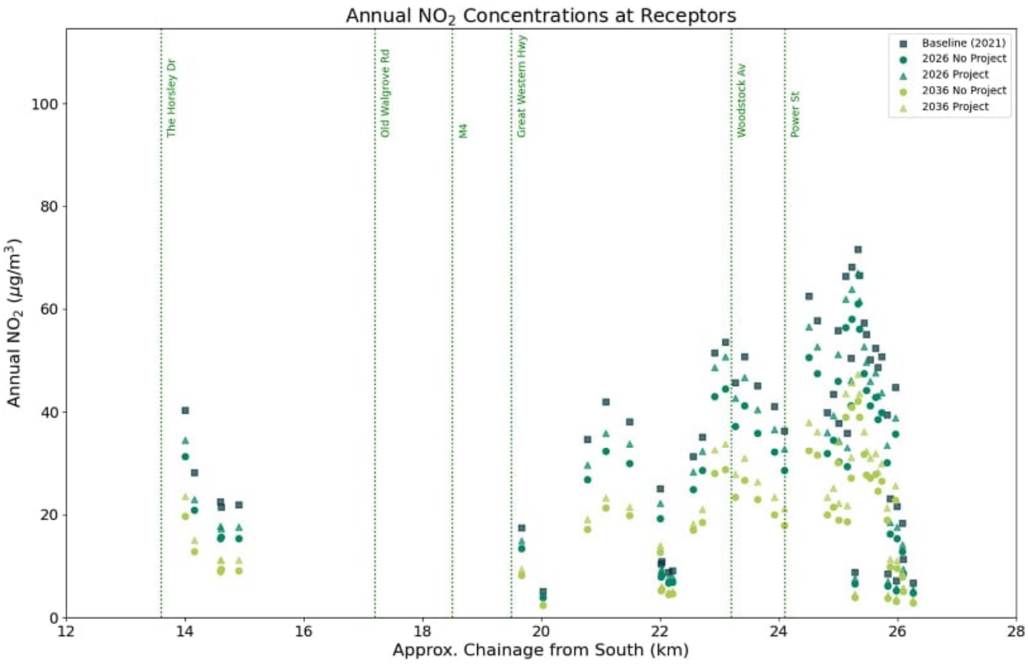


Figure I-67 North Domain: predicted annual average NO_2 incremental concentration at sensitive receptors

Cumulative concentrations

Cumulative concentrations of maximum 1-hour NO_2 are presented in **Table I-22**. Concentrations at the worst affected receptor were above the EPA criterion of 246 µg/m^3 for all scenarios in the Northern Domain. The worst affected receptor was Receptor N26 in the Northern Domain, 23 m east of the M7 roadside, north of Power Street. Cumulative concentrations were expected to reduce in the future compared with the baseline. Future concentrations with the Proposed Modification were predicted to be slightly higher than for the Do-nothing scenario.

Table I-22 Predicted cumulative maximum 1-hour NO_2 concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 1-hour NO_2 Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	298	267	269	243	251
North Domain	755	524	650	302	376
Criteria (µg/m^3)	246				

Cumulative concentrations of maximum annual average NO_2 are presented in **Table I-23**. Concentrations at the worst affected receptor were above the EPA criterion of 246 µg/m^3 for all scenarios in the Northern Domain. The worst affected receptor was Receptor N26 in the Northern Domain, 23 m east of the M7 roadside, north of Power Street. Cumulative concentrations were expected to reduce in the future compared with the baseline. Future concentrations with the Proposed Modification were predicted to be slightly higher than for the Do-nothing scenario.

Table I-23 Predicted cumulative maximum annual average NO_2 concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average NO_2 Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	71	59	63	46	49
North Domain	85	75	81	56	61
Criteria (µg/m^3)	62				

Carbon monoxide

The following section provides a discussion on predicted incremental (road contributions) and cumulative maximum 1-hour and 8-hour CO ground level concentrations at sensitive receptors. Predicted CO ground level concentrations are discussed for each modelled scenario.

Background data used to estimate predicted cumulative impacts for 1-hour and 8-hour maximum CO have been based on the maximum recorded values at Prospect Monitoring station between 2015 and 2018 ad discussed in **Section 4.2.7** and **Section 5.2.2**.

Road contributions

Predicted incremental 1-hour maximum CO concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-24** In addition to **Table I-24**; predicted incremental 1-hour maximum CO concentrations at all sensitive receptors are provided in **Figure I-68** for the Southern domain and **Figure I-69** for the northern domain.

Concentrations of CO were highest in the Northern Domain at Receptor N26. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline. Concentrations were well below the EPA criterion for all scenarios.

Table I-24 Predicted incremental maximum 1-hour CO concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 1-hour CO Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	1684	747	994	478	706
North Domain	4154	2187	2926	1405	2096
Criteria (µg/m^3)	30,000				

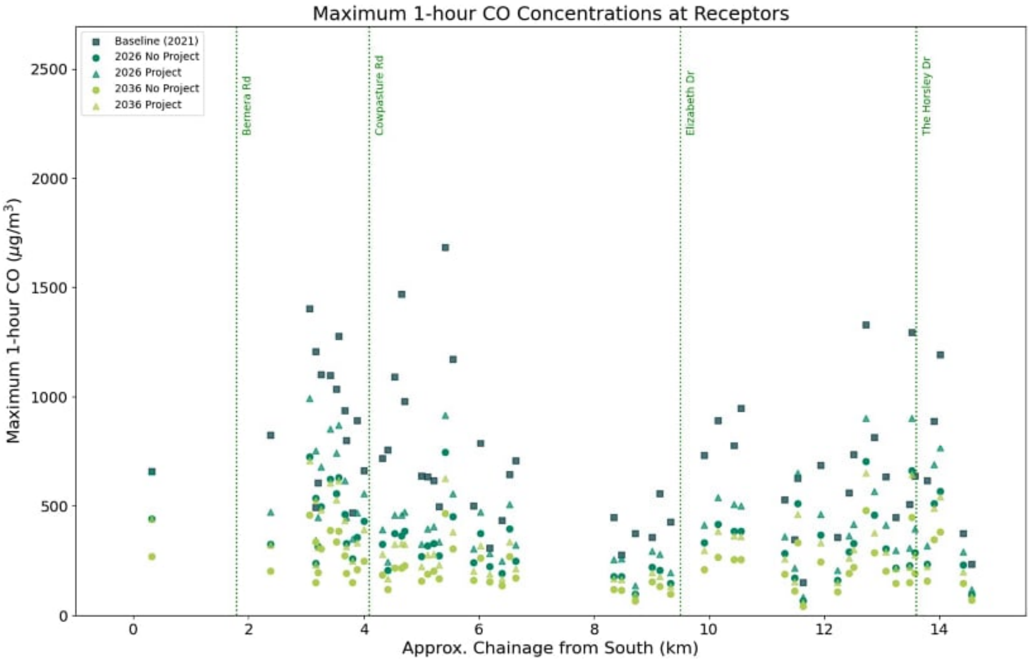


Figure I-68 **South Domain: predicted maximum 1-hour CO incremental concentration at sensitive receptors**

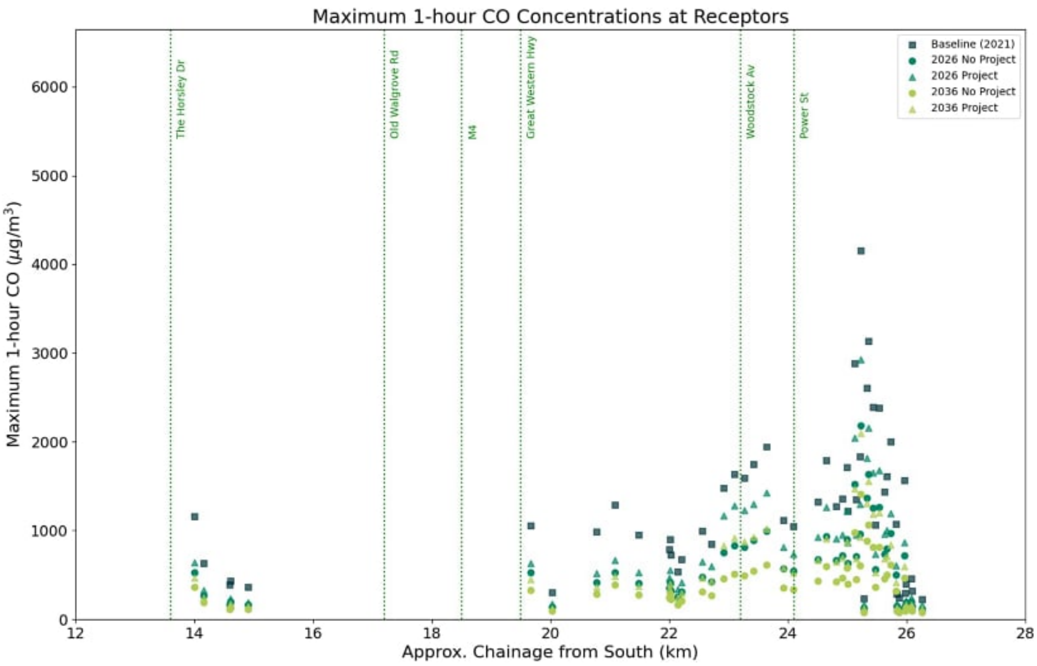


Figure I-69 **North Domain: predicted maximum 1-hour CO incremental concentration at sensitive receptors**

Predicted incremental 8-hour maximum CO concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-25**. Predicted incremental 8-hour maximum CO concentrations at all sensitive receptors are provided in **Figure I-70** for the Southern domain and **Figure I-71** for the northern domain.

Concentrations of CO were highest in the Northern Domain at Receptor N26. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline. Concentrations were well below the EPA criterion for all scenarios.

Table I-25 Predicted incremental maximum 8-hour CO concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 8-hour CO Concertation (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	611	337	403	242	306
North Domain	1393	709	979	489	695
Criteria (µg/m³)	10,000				

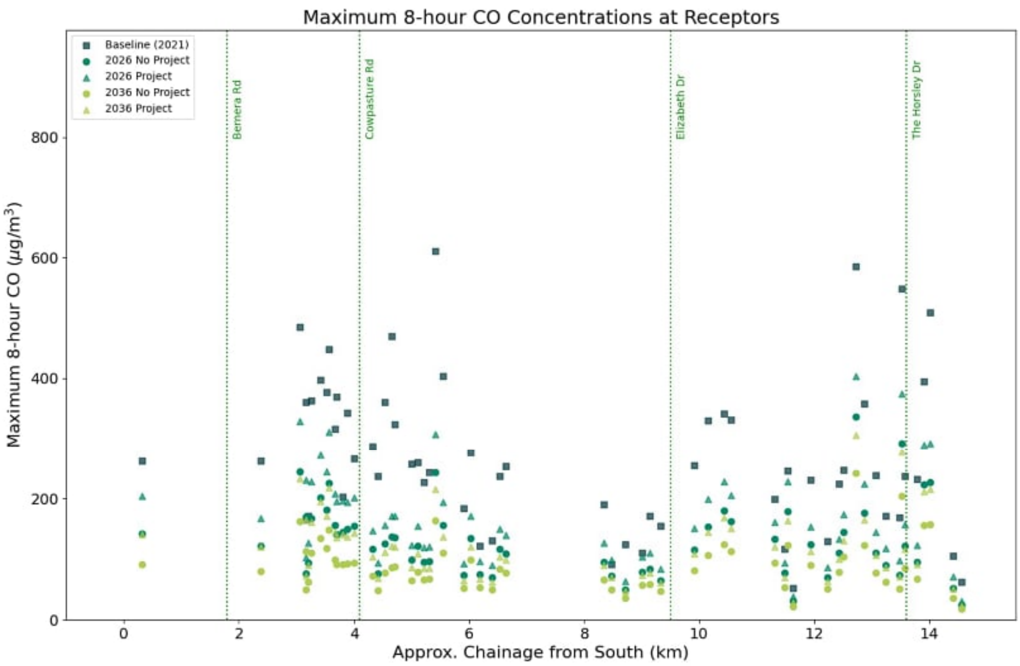


Figure I-70 South Domain: predicted maximum 8-hour CO incremental concentration at sensitive receptors

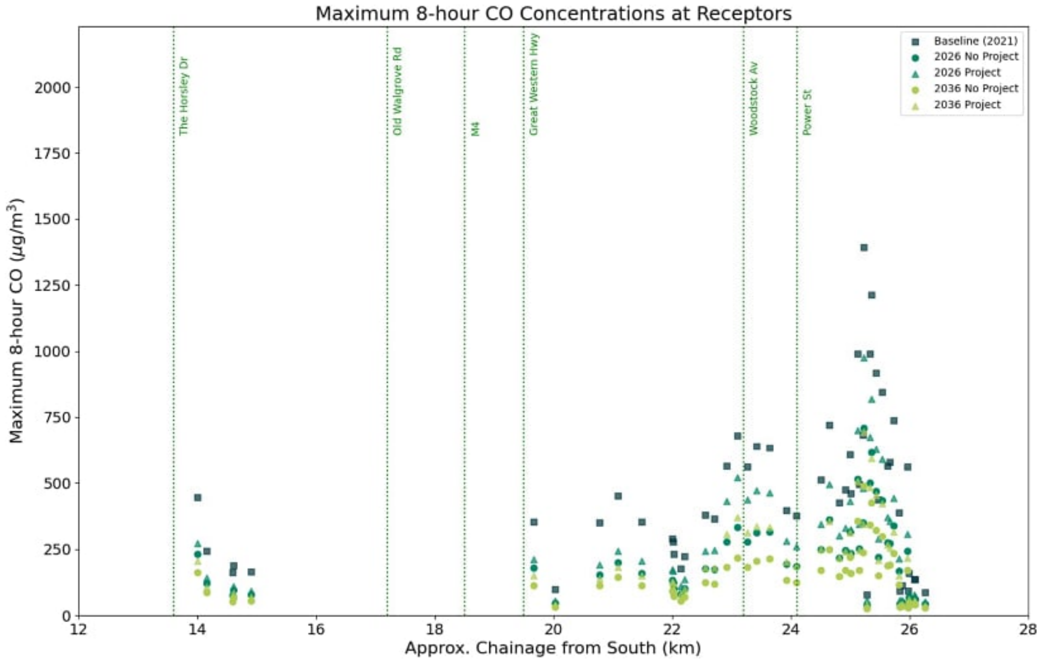


Figure I-71 North Domain: predicted maximum 8-hour CO incremental concentration at sensitive receptors

Cumulative concentrations

Cumulative 1-hour CO concentrations are presented in **Table I-26**. Existing background values of 3,000 µg/m^3 and 2,375 µg/m^3 were adopted for Southern and Norther Domains respectively. Cumulative concentrations were well below the EPA criterion at all receptors for all scenarios.

Table I-26 Predicted Cumulative Maximum 1-hour CO_2 Concentrations for all Modelled Scenarios.

Modelling Domain	Predicted Incremental Maximum 1-hour CO Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	4684	3747	3994	3478	3706
North Domain	6529	4562	5301	3780	4471
Criteria (µg/m^3)	30,000				

Cumulative 8-hour CO concentrations are presented in **Table I-27**. Existing background values of 2,016 µg/m^3 and 1,578 µg/m^3 were adopted for Southern and Norther Domains respectively. Cumulative concentrations were well below the EPA criterion at all receptors for all scenarios.

Table I-27 Predicted cumulative Maximum 8-hour CO_2 concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 8-hour CO Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	2627	2353	2419	2258	2322
North Domain	2971	2287	2557	2067	2273
Criteria (µg/m^3)	10,000				

Particulate matter (PM_{10})

The following section provides a discussion on predicted incremental (road contributions) and cumulative maximum 24-hour and annual average PM_{10} ground level concentrations at sensitive receptors. Predicted PM_{10} ground level concentrations are discussed for each modelled scenario.

Background data used to estimate predicted cumulative impacts for PM_{10} and utilise the background data interpolation methodology as described in **Section 4.2.7** and **Appendix D**.

Road contributions

Predicted incremental 24-hour maximum PM_{10} concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in Table **I**-28. Predicted incremental 24-hour maximum PM_{10} concentrations at all sensitive receptors are provided in **Figure I-72** for the Southern domain and **Figure I-73** for the northern domain.

Concentrations were highest in the Northern Domain for the existing baseline scenario. The worst affected receptor was Receptor N26, 23 m to the east of the M7 roadside, north of Power Street.

Concentrations were predicted to be higher with the Proposed Modification in both 2016 and 2036, compared with the Do-nothing scenario. This is most likely due to the higher traffic numbers for the Proposed Modification on the M7 mainline itself.

Table I-28 Predicted incremental maximum 24-hour PM_{10} concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 24-hour PM_{10} Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	27.5	14.3	17.1	13.5	17.0
North Domain	43.2	23.8	27.6	23.0	27.5
Criteria (µg/m^3)	50				

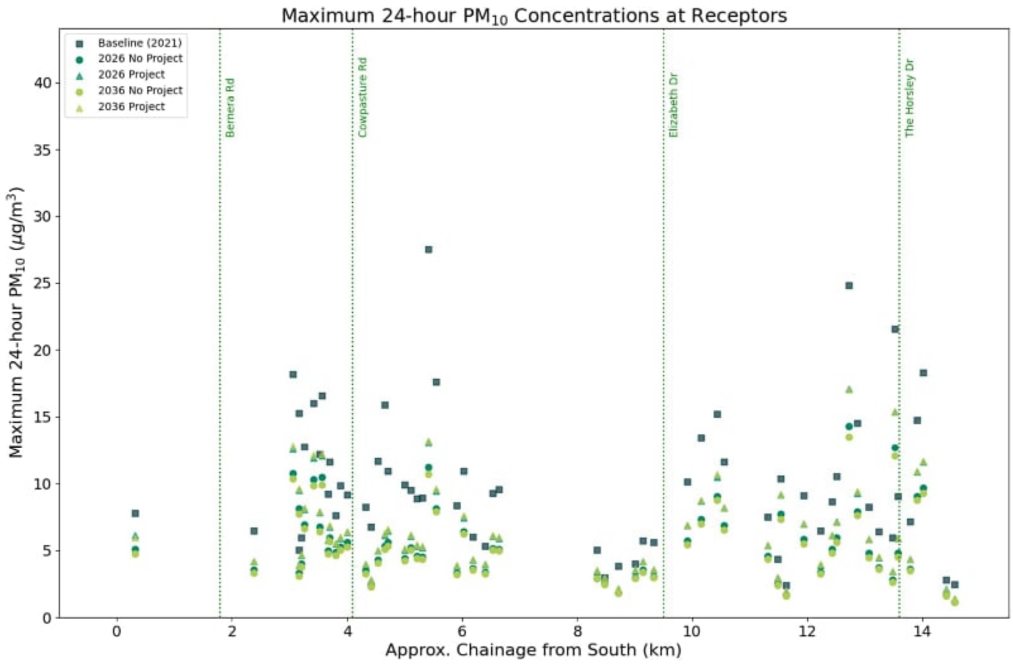


Figure I-72 **South Domain: predicted maximum 24-hour PM_{10} incremental concentration at sensitive receptors**

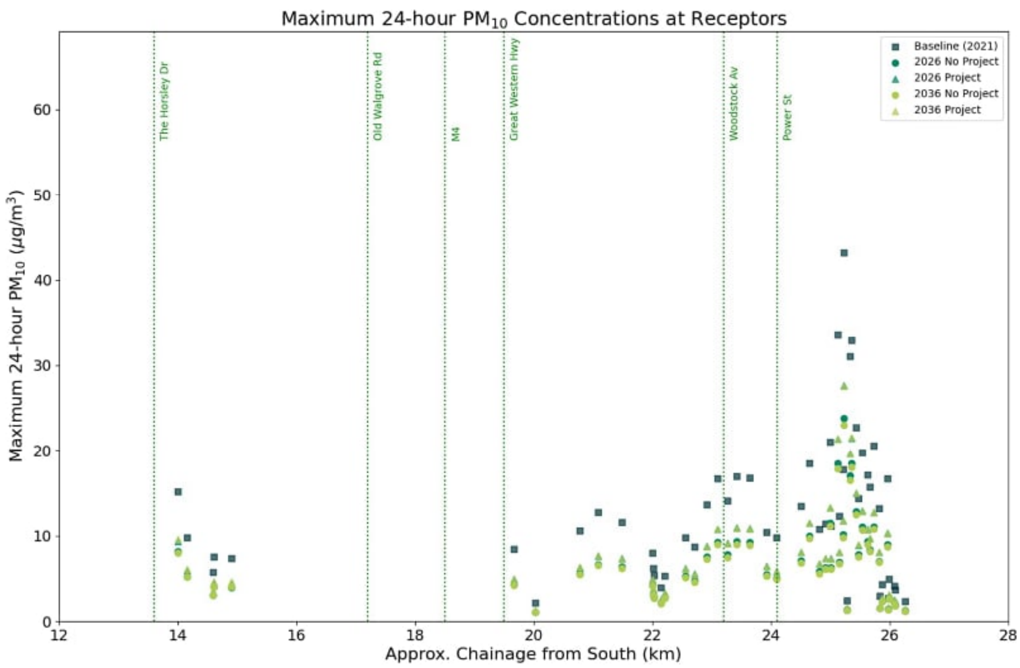


Figure I-73 **North Domain: predicted maximum 24-hour PM_{10} incremental concentration at sensitive receptors**

Predicted incremental annual average PM_{10} concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-29.**

Predicted incremental annual average PM_{10} concentrations at all sensitive receptors are provided in **Figure I-74** for the Southern domain and **Figure I-75** for the northern domain.

Annual concentrations were highest for the existing baseline scenario at Receptor N26 in the Northern Domain, 23 m to the east of the M7 roadside, north of Power Street. This was the worst affected receptor for all scenarios. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline, both with and without the Proposed Modification.

Table I-29 Predicted incremental maximum annual average PM_{10} concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average PM_{10} Concertation ($\mu g/m^3$)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	6.0	3.5	4.0	3.5	4.2
North Domain	7.5	4.4	4.9	4.3	5.0
Criteria ($\mu g/m^3$)	25				

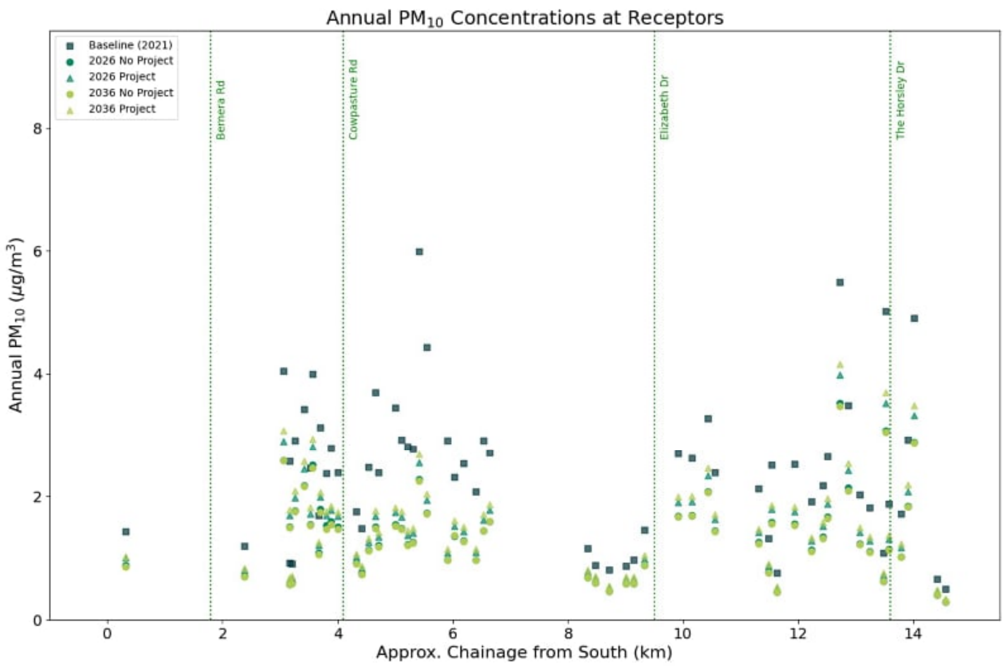


Figure I-74 **South Domain: predicted annual average PM_{10} incremental concentration at sensitive receptors**

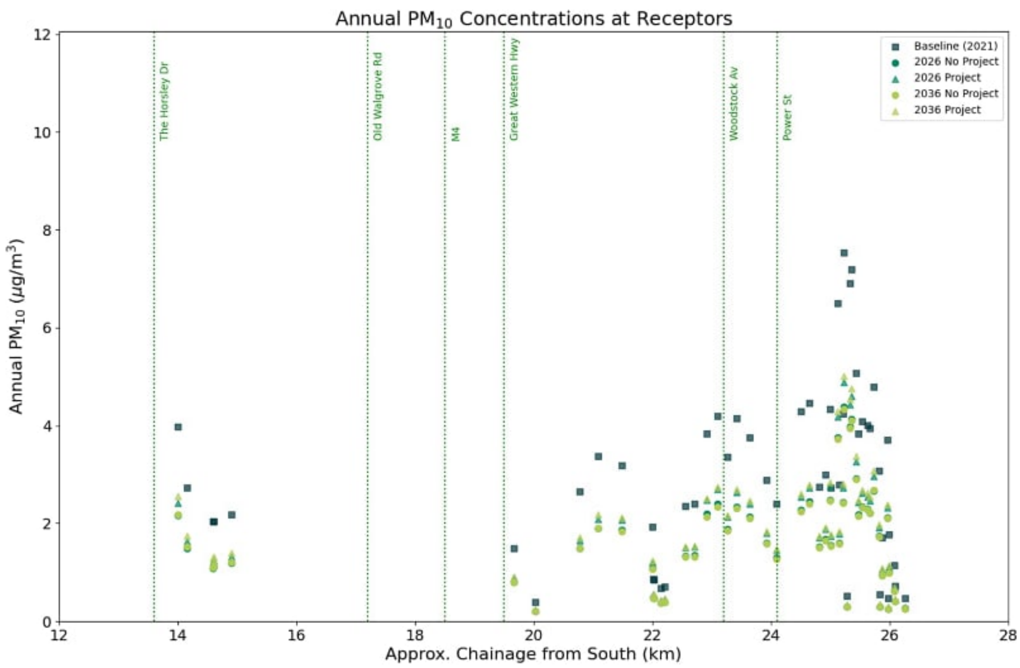


Figure I-75 North Domain: predicted annual average PM_{10} incremental concentration at sensitive receptors

Cumulative concentrations

Cumulative 24-hour PM_{10} concentrations are presented in **Table I-30**. Interpolated background 1-hour PM_{10} concentrations (described in **Appendix D**) were combined with model predicted 1-hour PM_{10} concentrations at each receptor and then averaged to 24-hour values.

In this case, the highest concentrations were predicted in the Southern Domain, due to slightly higher maximum background observations in this part of the study area. The highest cumulative concentrations were above the EPA criterion for all scenarios, both with and without the Proposed Modification. This is not unexpected, however, due to concentrations above the criterion observed in the background data, especially at Bringelly and Liverpool (see **Section 5.2.3.1**).

Overall, there was little difference in the predicted maximum cumulative concentrations between scenarios, suggesting that they are likely mostly due to existing background concentrations.

Table I-30 Predicted cumulative maximum 24-hour PM_{10} concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 24-hour PM_{10} Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	82.6	76.9	77.6	76.8	77.9
North Domain	64.2	56.4	57.5	56.2	57.5
Criteria (µg/m^3)	50				

Predicted annual average PM_{10} concentrations for the worst affect receptor are presented in Table I-31.

The highest predicted concentrations for the existing baseline were in the Southern Domain for the existing baseline scenario. Overall, there was little difference in the predicted maximum cumulative concentrations between the future 2026 and 2036 scenarios, with or without the Proposed Modification. The predicted future concentrations were below the criterion at all receptors.

Table I-31 Predicted cumulative maximum annual average PM_{10} concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average PM_{10} Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	25.8	22.5	23.0	22.5	23.1
North Domain	24.9	21.7	22.2	21.7	22.3
Criteria (µg/m^3)	25				

Particulate matter ($PM_{2.5}$)

The following section provides a discussion on predicted incremental (road contributions) and cumulative maximum 24-hour and annual average $PM_{2.5}$ ground level concentrations at sensitive receptors. Predicted $PM_{2.5}$ ground level concentrations are discussed for each modelled scenario.

Background data used to estimate predicted cumulative impacts for $PM_{2.5}$ and utilise the background data interpolation methodology as described in **Section 4.2.7** and **Appendix D**.

Road contributions

Predicted incremental 24-hour maximum $PM_{2.5}$ concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-32**. Predicted incremental 24-hour maximum $PM_{2.5}$ concentrations at all sensitive receptors are provided in **Figure I-76** for the Southern domain and **Figure I-77** for the northern domain.

The highest concentrations were in the existing baseline in the Northern Domain, with incremental concentrations predicted to be above the criterion of 25 µg/m^3. The worst affected receptor was Receptor N26 in the Northern Domain for all scenarios. This receptor about 23 m to the east of the M7 roadside, north of Power Street.

Concentrations were predicted to be slightly higher with the Proposed Modification in both 2016 and 2036, compared with the Do-nothing scenario. This is most likely due to the higher traffic numbers for the Proposed Modification on the M7 mainline itself.

Table I-32 Predicted incremental maximum 24-hour $PM_{2.5}$ concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 24-hour $PM_{2.5}$ Concertation (µg/m^3)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	21.5	8.9	10.7	7.8	9.8
North Domain	34.1	15.0	17.4	13.4	16.0
Criteria (µg/m^3)	25				

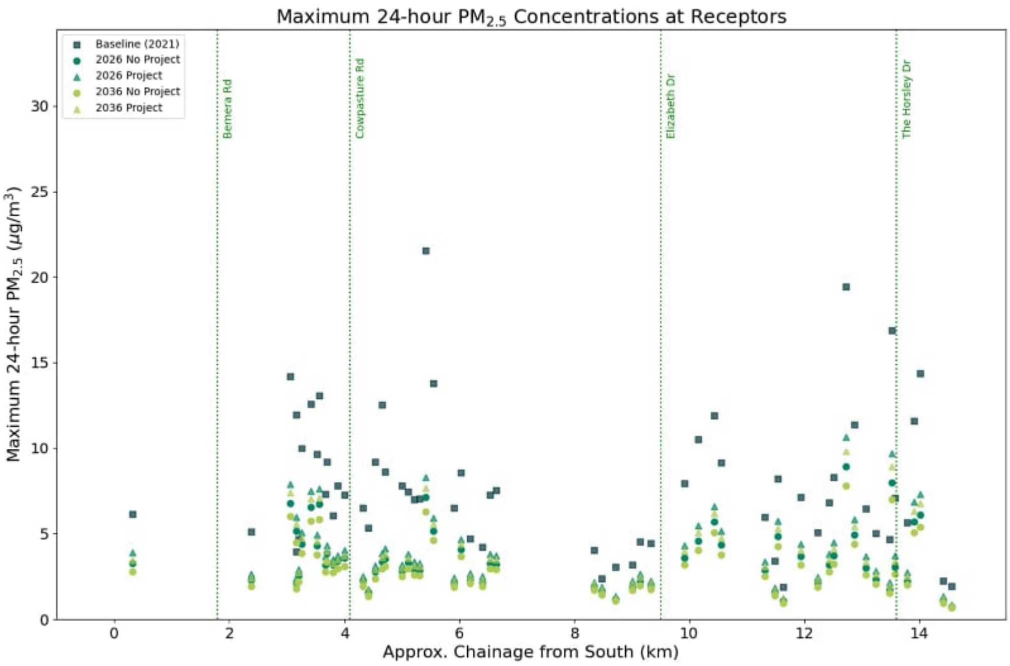


Figure I-76 **South Domain: predicted maximum 24-hour $PM_{2.5}$ incremental concentration at sensitive receptors**

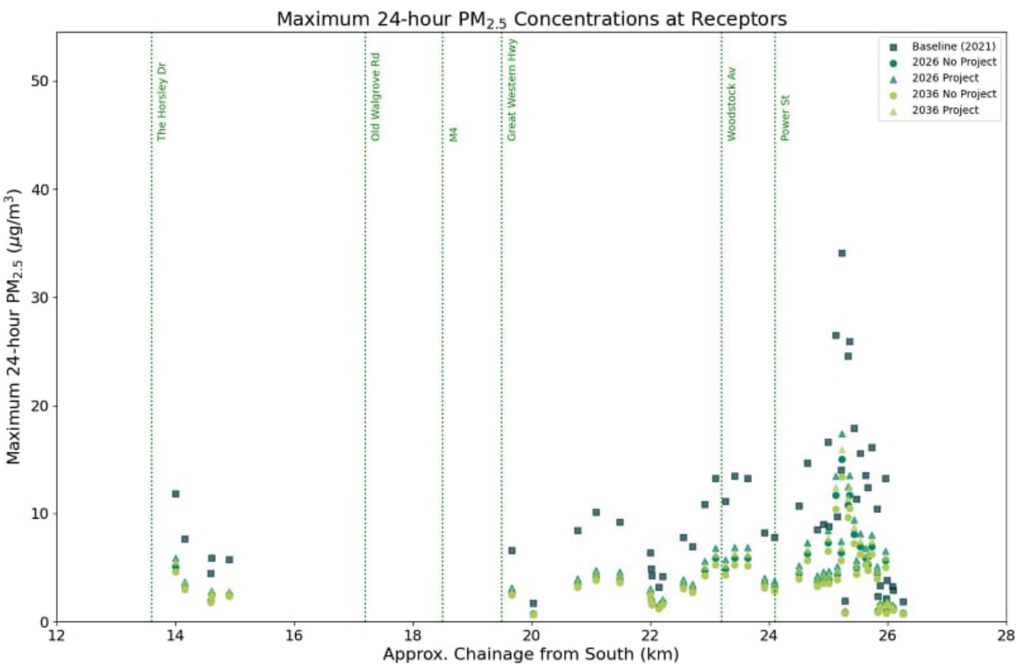


Figure I-77 **North Domain: predicted maximum 24-hour $PM_{2.5}$ incremental concentration at sensitive receptors**

Predicted incremental annual average $PM_{2.5}$ concentrations at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-33** In addition to **Table I-33**; predicted incremental annual average $PM_{2.5}$ concentrations at all sensitive receptors are provided in **Figure I-78** for the Southern domain and **Figure I-79** for the northern domain. **Figure I-80** also provides additional resolution on predicted elevated annual average $PM_{2.5}$ receptor concentrations north of Power Street in the Northern Domain for all modelled scenarios.

Incremental annual average $PM_{2.5}$ concentrations were predicted to be much higher for the baseline scenario, primarily due to higher emission factors. Future 2026 and 2036 emission factors for $PM_{2.5}$ are much lower due to improved exhaust emission technologies that are expected to become more widespread in the fleet as new vehicles replace older vehicles.

The worst affected receptors were in the Northern Domain, north of Power Street on the east side of the M7 were the housing estate comes within 15-20m of the M7 roadside.

Concentrations were predicted to be slightly higher for the Proposed Modification in the 2026 and 2036 scenarios, mostly due to higher vehicle numbers predicted to use utilize the proposed extra lanes.

Table I-33 Predicted incremental maximum annual average $PM_{2.5}$ concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average $PM_{2.5}$ Concertation (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	4.7	2.2	2.5	2.0	2.4
North Domain	6.0	2.8	3.1	2.5	2.9
Criteria (µg/m³)	8				

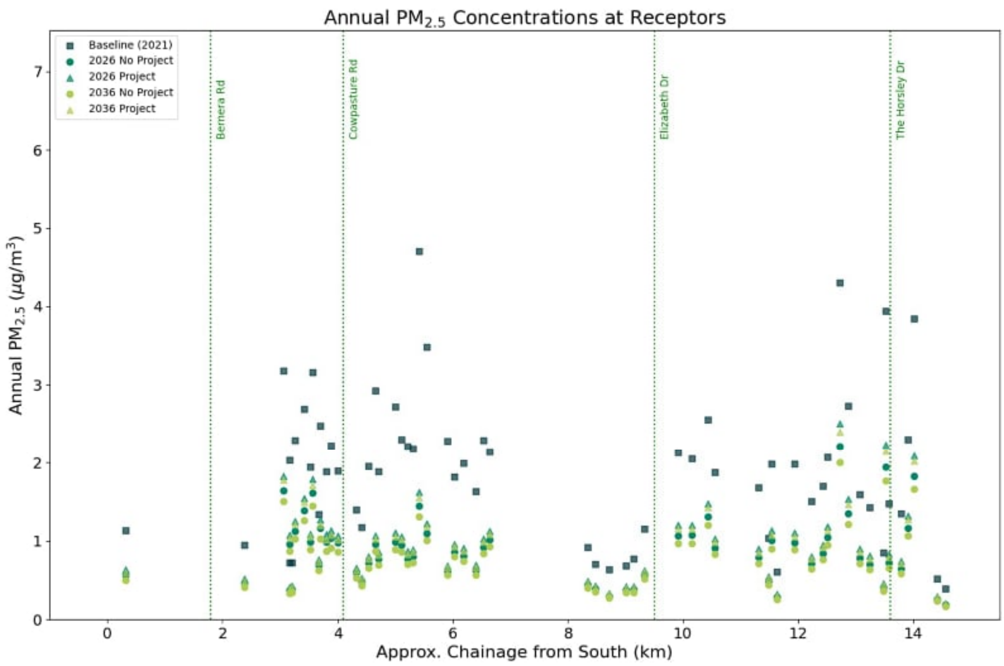


Figure I-78 South Domain: predicted annual average $PM_{2.5}$ incremental concentration at sensitive receptors

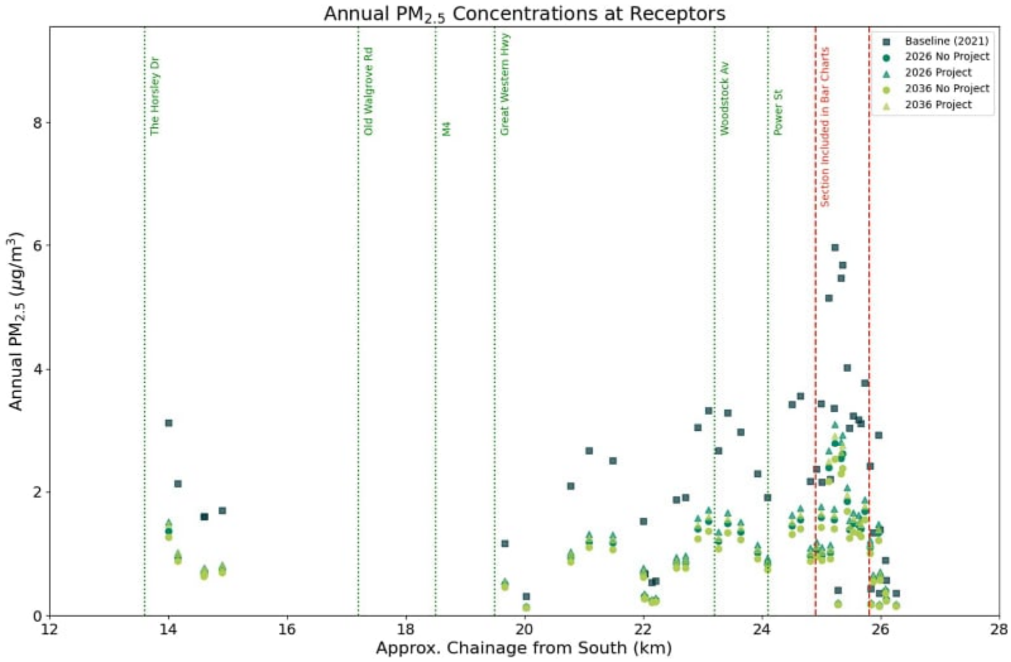


Figure I-79 North Domain: predicted annual average $PM_{2.5}$ incremental concentration at sensitive receptors

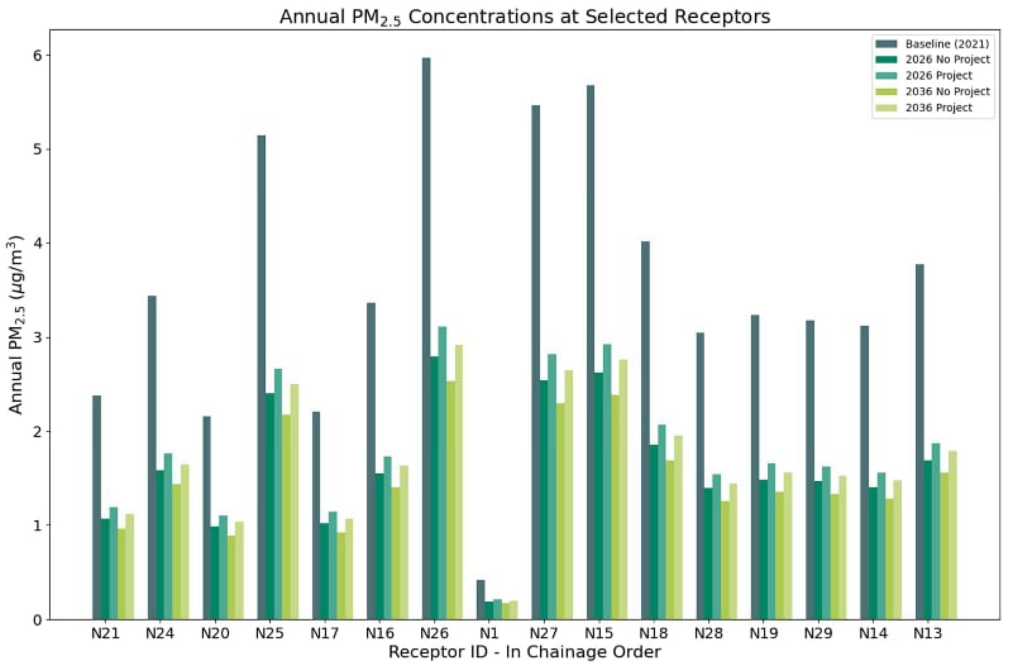


Figure I-80 Predicted 24-Hour maximum $PM_{2.5}$ incremental concentration at sensitive receptors north of Power Street

Cumulative Concentrations

Cumulative concentrations of 24-hour $PM_{2.5}$ are presented in **Table I-34**. Existing background concentrations (see **Section 5.2.4.1**) had maximum concentrations above the criterion so all cumulative concentrations were also predicted to be above the criterion. The existing baseline scenario was predicted to be the highest, with little difference between the future scenarios, with or without the Proposed Modification. The worst affected receptors were in the Southern Domain, where slightly higher background concentrations were observed.

Table I-34 Predicted cumulative maximum 24-hour $PM_{2.5}$ concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum 24-hour $PM_{2.5}$ Concertation ($\mu g/m^3$)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	61.2	56.4	56.8	56.1	56.7
North Domain	48.9	41.0	41.7	40.6	41.3
Criteria ($\mu g/m^3$)	25				

The highest cumulative annual average $PM_{2.5}$ concentrations predicted at the modelled receptors are presented in **Table I-35**. Predicted concentrations were above the criterion for all scenarios, primarily driven by background concentrations which were already approaching or above the criterion (see **Section 5.2.4.2**). Concentrations were highest for the existing baseline and in the Northern Domain. There was little difference between the future scenarios, with or without the Proposed Modification.

Due to already elevated background concentrations, the difference in annual average $PM_{2.5}$ between the Proposed Modification and the "Do-nothing" scenario was used to assess annual average $PM_{2.5}$ impacts. The assessment is summarised in **Section 7.1.4.3**.

Table I-35 Predicted cumulative maximum annual average $PM_{2.5}$ concentrations for all modelled scenarios.

Modelling Domain	Predicted Incremental Maximum Annual Average $PM_{2.5}$ Concertation ($\mu g/m^3$)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	12.8	10.0	10.3	9.8	10.2
North Domain	13.3	10.1	10.4	9.9	10.2
Criteria ($\mu g/m^3$)	8				

Volatile organic compounds (VOCs)

The following section provides a discussion on predicted incremental (road contributions) 1-hour 99.9th percentile ground level concentrations at sensitive receptors for VOCs. Predicted benzene and formaldehyde ground level concentrations are discussed for each modelled scenario.

Road contributions from benzene

Predicted incremental 1-hour 99.9th percentile concentrations for benzene at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-36**.Predicted incremental 1-hour 99.9th percentile concentrations for benzene at all sensitive receptors are provided in **Figure I-81** for the Southern domain and **Figure I-82** for the northern domain.

Concentrations of benzene were highest in the Northern Domain at Receptor N26. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline. Concentrations were well below the EPA criterion for all scenarios.

Table I-36 Predicted incremental 1-hour 99.th percentile concentrations for benzene for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for Benzene (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	3.5	0.7	0.8	0.4	0.5
North Domain	8.1	1.7	2.2	1.0	1.3
Criteria (µg/m³)	**29**				

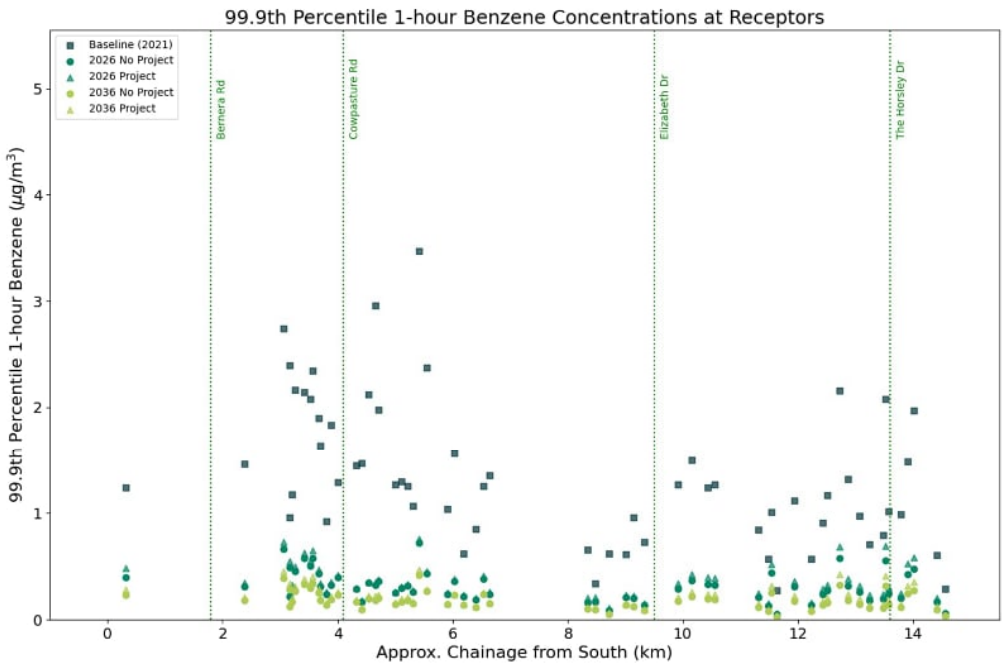


Figure I-81 South Domain: Predicted 1-hour 99.9th %ile benzene incremental concentration at sensitive receptors

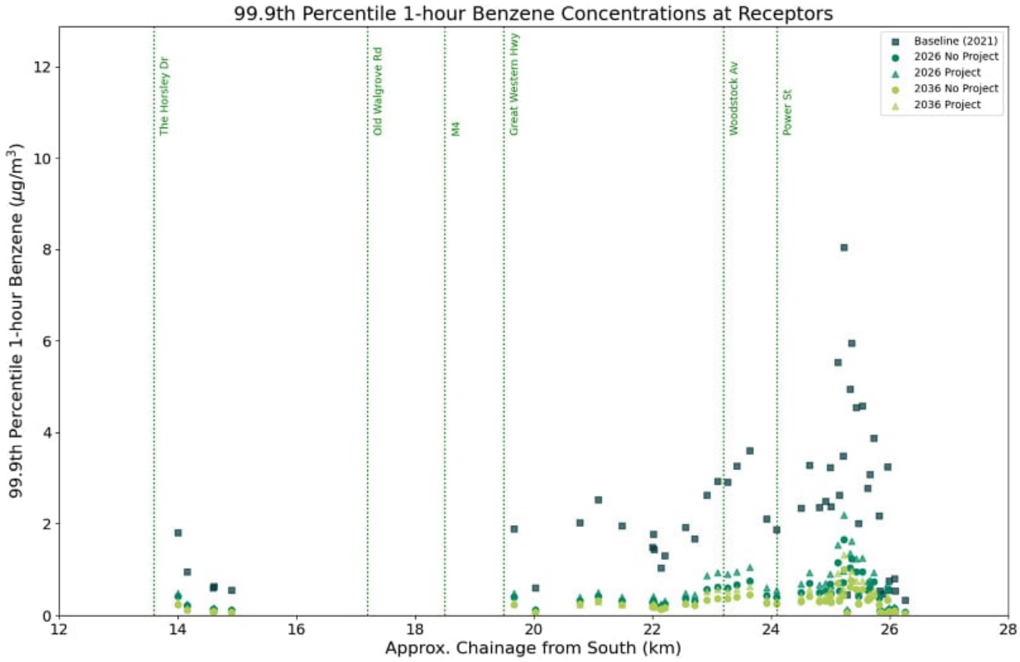


Figure I-82 North Domain: Predicted 1-hour 99.9th %ile benzene incremental concentration at sensitive receptors

Road contributions from formaldehyde

Predicted incremental 1-hour 99.9th percentile concentrations for formaldehyde at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-37**. Predicted incremental 1-hour 99.9th percentile concentrations for formaldehyde at all sensitive receptors are provided in **Figure I-83** for the Southern domain and **Figure I-84** for the northern domain.

Concentrations of benzene were highest in the Northern Domain at Receptor N26. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline. Concentrations were well below the EPA criterion for all scenarios.

Table I-37 **Predicted incremental 1-hour 99.th percentile concentrations for formaldehyde for all modelled scenarios.**

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for Formaldehyde (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	2.1	0.4	0.4	0.2	0.3
North Domain	4.8	1.0	1.3	0.6	0.8
Criteria (µg/m³)	**20**				

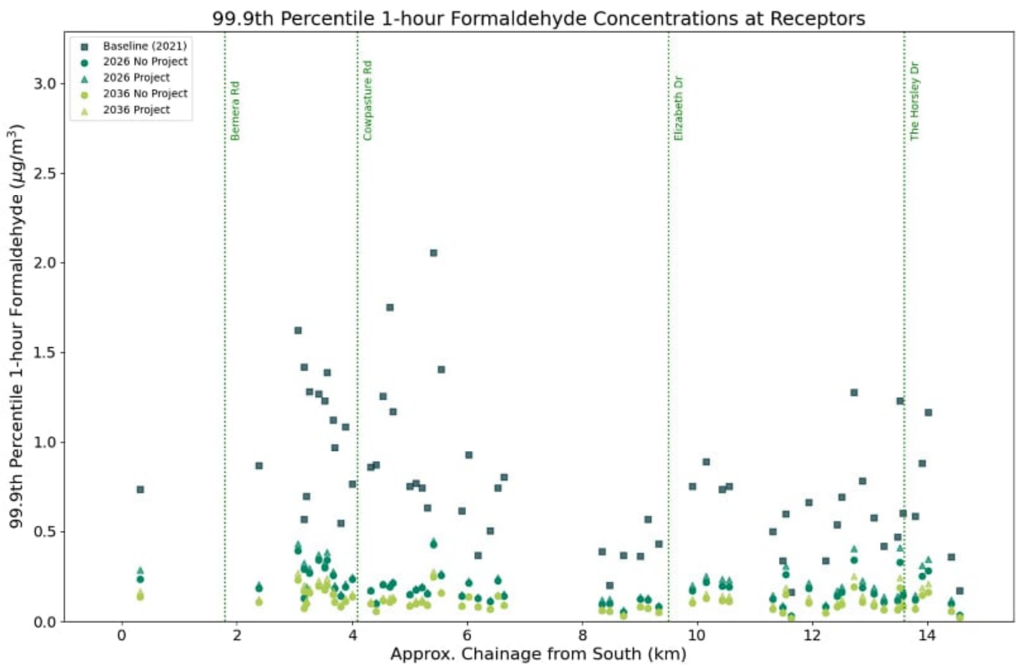


Figure I-83 South Domain: Predicted 1-hour 99.9th %ile formaldehyde incremental concentration at sensitive receptors

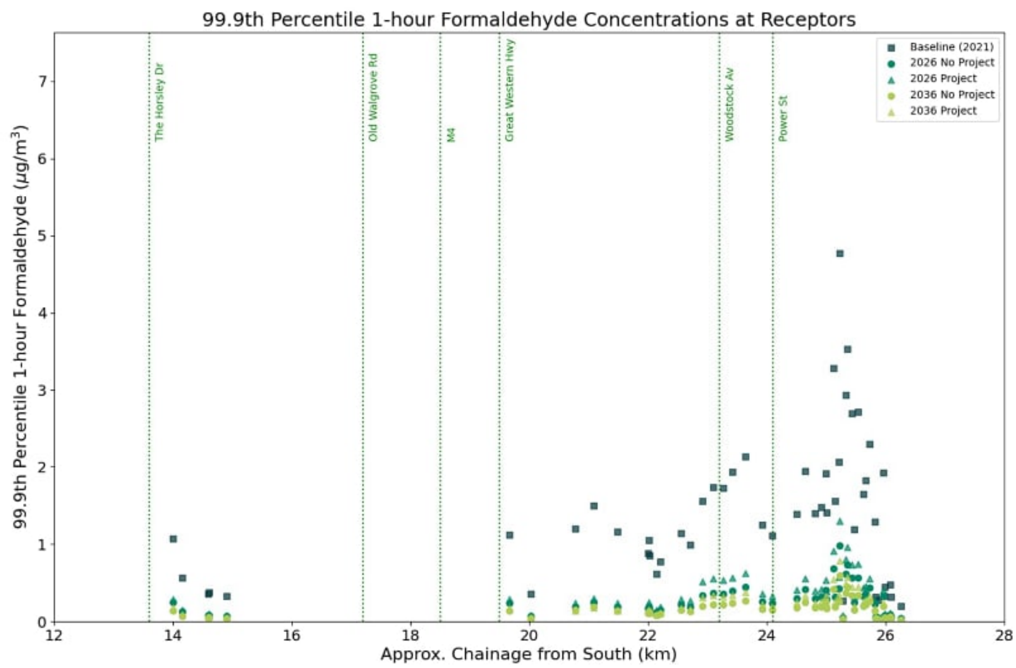


Figure I-84 North Domain: Predicted 1-hour 99.9th %ile formaldehyde incremental concentration at sensitive receptors

Predicted concentrations for other VOCs 1,3 butadiene, acetaldehyde, toluene and xylene are presented in **Table I-38** to **Table I-41**. These tables represent the maximum 99.9th percentile concentrations at the worst affected receptors for each domain. The predicted concentrations are well below the respective criterion for each pollutant.

Table I-38 Predicted incremental 1-hour 99.th percentile concentrations for 1,3 butadiene for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for 1,3 Butadiene (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	0.8	0.2	0.2	0.1	0.1
North Domain	1.9	0.4	0.5	0.2	0.3
Criteria (µg/m³)	40				

Table I-39 Predicted incremental 1-hour 99.th percentile concentrations for acetaldehyde for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for Acetaldehyde (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	0.8	0.2	0.2	0.1	0.1
North Domain	1.9	0.4	0.5	0.2	0.3
Criteria (µg/m³)	42				

Table I-40 Predicted incremental 1-hour 99.th percentile concentrations for toluene for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for Toluene (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	7.2	1.5	1.6	0.9	1.0
North Domain	16.8	3.5	4.6	2.1	2.7
Criteria (µg/m³)	360				

Table I-41 Predicted incremental 1-hour 99.th percentile concentrations for xylene for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for Xylene (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	5.4	1.1	1.2	0.7	0.7
North Domain	12.5	2.6	3.4	1.6	2.0
Criteria (µg/m³)	190				

Polycyclic aromatic hydrocarbons (PAHs)

The following section provides a discussion on predicted incremental (road contributions) 1-hour 99.9th percentile ground level concentrations at sensitive receptors for total PAHs expressed as BaP equivalent. Predicted benzene and formaldehyde ground level concentrations are discussed for each modelled scenario.

Road contributions

Predicted incremental 1-hour 99.9th percentile concentrations for total PAHs (as BaP) at the worst affected sensitive receptors for all modelled scenarios reported against the EPA criterion are shown in **Table I-42**. Predicted incremental 1-hour 99.9th percentile concentrations for total PAHs at all sensitive receptors are provided in **Figure I-85** for the Southern domain and **Figure I-86** for the northern domain.

Concentrations of PAS (as BaP) were predicted to be highest in the Northern Domain at Receptor N26. Concentrations were predicted to become lower in the future scenarios (2026 and 2036) compared with the existing baseline. Concentrations were well below the EPA criterion for all scenarios.

Table I-42 Predicted incremental 1-hour 99.th percentile concentrations for total PAHs (BaP) for all modelled scenarios.

Modelling Domain	Predicted Highest 1-hour 99.9%ile Concentrations for PAH (µg/m³)				
	Existing 2016	Opening Year 2026		10 Years After Opening 2036	
		Do Nothing	Proposed Modification	Do Nothing	Proposed Modification
South Domain	0.0034	0.0007	0.0007	0.0004	0.0005
North Domain	0.0078	0.0016	0.0021	0.0010	0.0013
Criteria (µg/m³)	**0.04**				

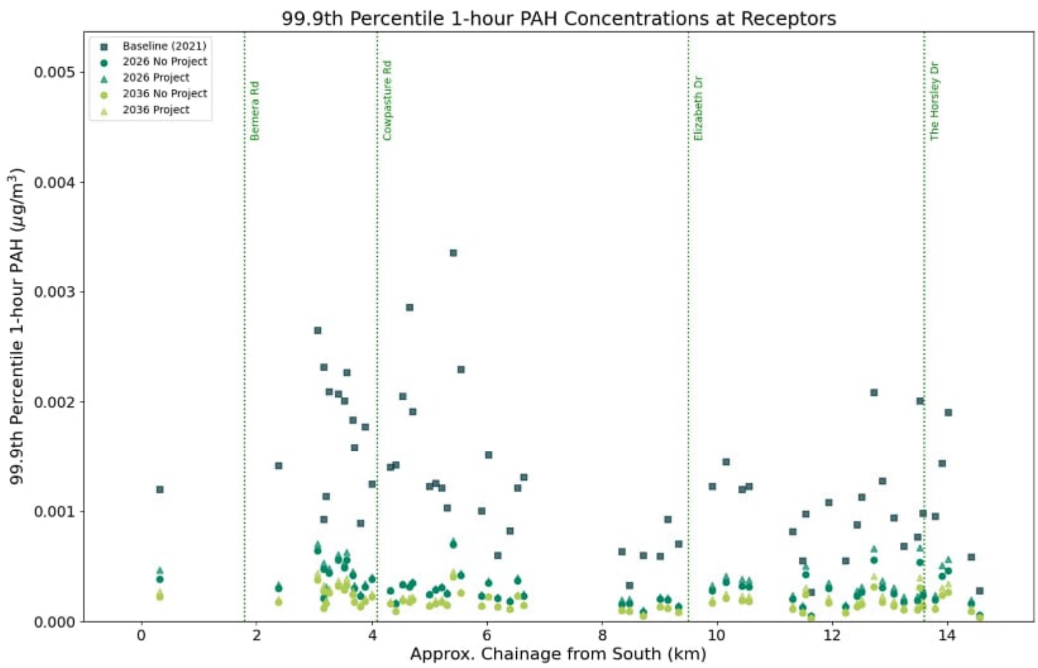


Figure I-85 **South Domain: predicted 1-hour 99.9th %ile PAHs (as BaP) incremental concentration at sensitive receptors**

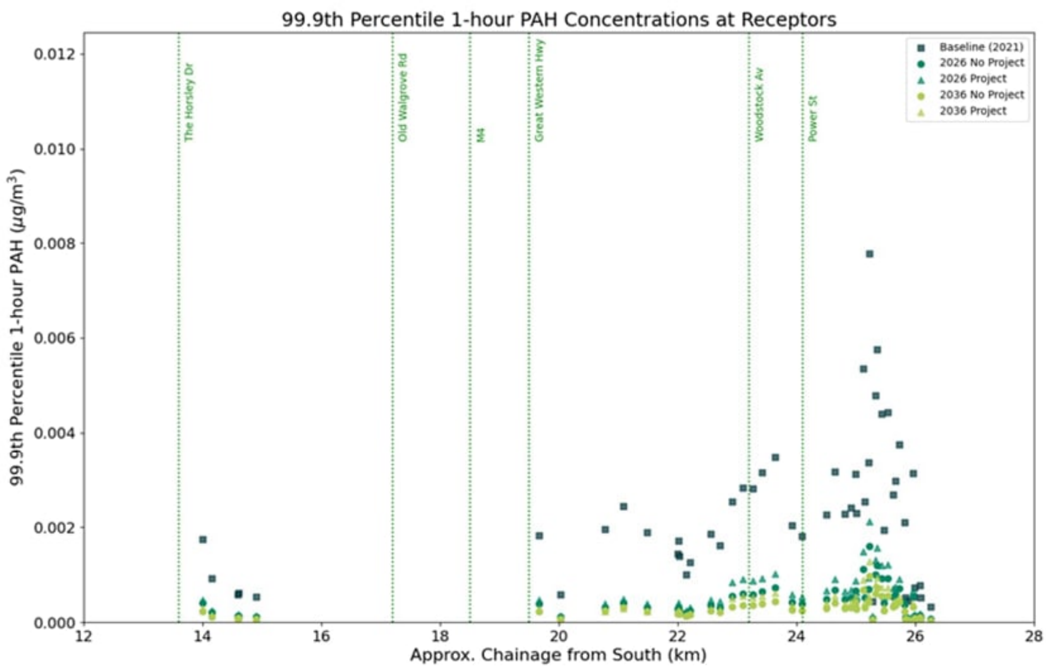


Figure I-86 **North Domain: predicted 1-hour 99.9th %ile PAHs (as BaP) incremental concentration at sensitive receptors**