Hexham Straight Widening

Air Quality Assessment

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7 October 2021

Transport for NSW

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Executive summary

Background

Transport for NSW (Transport) is proposing to widen a six kilometre section of the Pacific Highway (Maitland Road) from four lanes to six lanes, starting about 290 metres south of the intersection with the Newcastle Inner City Bypass at Sandgate, and extending through to about 760 metres north of Hexham Bridge, in Hexham, NSW (the proposal). The proposal would create two additional lanes, one in each direction and would include the replacement of the twin bridges at Ironbark Creek. The section of road is known as the 'Hexham Straight' and is located within the City of Newcastle local government area (LGA), with a small portion of the construction area on the eastern side of the Hunter River within the Port Stephens Council LGA.

Maitland Road is a critical link as part of the National Land Transport Network and is among the busiest transport corridors carrying some of the highest traffic volumes in the Hunter. The proposal is required to reduce congestion and improve safety along Maitland Road.

The proposal is subject to assessment under two planning pathways, a review of environmental factors (REF) under Part 5, Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and an environmental impact statement (EIS) under Part 4 of the EP&A Act. The majority of the proposal (the REF area) is subject to approval under Division 5.1 of the EP&A Act that would be determined through a REF by Transport. However, a small part of the proposal (3.28 hectares) is within land mapped as 'Coastal Wetlands' under State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP). As such, that part of the proposal (known as the EIS area) is subject to approval under Part 4 of the EP&A Act and will be assessed within an EIS.

Purpose

The purpose of this report is to support both the EIS and the REF and to assess the potential impacts to air quality during construction and operation of the proposal.

Existing environment

The key potential air quality issues were identified as dust during construction and changes in emissions from vehicles using the existing and modified roads affected by the proposal during operation.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators (carbon monoxide [CO], nitrogen dioxide [NO_2], and particulate matter [PM_{10} and $PM_{2.5}$]) from representative monitoring stations. The following conclusions were made in relation to the existing air quality and meteorological conditions:

- Wind patterns in the vicinity of the proposal are characteristic of the Lower Hunter Valley, with the prevailing winds being from the west-northwest
- Measured CO and NO_2 concentrations in the past five years have been consistently below NSW Environment Protection Authority (EPA) air quality impact assessment criteria
- Particle levels (as PM_{10} and $PM_{2.5}$) increased across NSW and the Hunter region from 2017 to 2019 due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (Office of Environment and Heritage (OEH), 2019). These events adversely influenced air quality with multiple days observed when PM_{10} and $PM_{2.5}$ concentrations exceeded NSW EPA criteria.

Potential air quality impacts of the proposal during construction were assessed using the semi-quantitative method developed by the UK Institute of Air Quality Management [IAQM]. Computer-based dispersion modelling was used to predict the potential change in local and regional air quality as a result of operation of the proposal.

Outcomes of the air quality assessment

The key outcomes of the air quality assessment are:

- Construction of the proposal, was determined to represent a 'high' risk of dust impacts according to the IAQM method. However the application of the recommended mitigation measures would mean that adverse residual impacts from construction would not be anticipated
- The proposal is not expected to result in concentrations of CO, NO_2, annually averaged PM_{10}, or key air toxics (benzene, formaldehyde, toluene, xylenes or benzo(a)pyrene) above the relevant EPA impact assessment criteria
- Regarding 24-hour averaged PM_{10}, applying the background concentrations measured in 2016, it was predicted that the proposal would result in one additional day of exceedance at the most-affected receiver when background concentrations were already elevated (48 $\mu g/m^3$). This outcome is within the historical variation in air quality conditions near the proposal. For 24-hour averaged $PM_{2.5}$ exceedances of the EPA's criterion were also predicted, although no additional days of exceedance were predicted for the meteorological modelling year (2016)
- Finally regarding annually averaged $PM_{2.5}$ increases of 1.7 $\mu g/m^3$ or more between corresponding 2028 and 2038 proposal and no proposal scenarios were not predicted at any of the representative receivers; a key indicator for assessing human health effects.

Overview of potential air quality impacts in the REF area

The nearest receivers to the proposal and those selected as representative receivers for the air quality assessment are located within the REF area. The key potential air quality issues to sensitive receivers located in the REF area was identified as dust during construction of the proposal based on the results of the analysis undertaken using the IAQM method. Adverse residual impacts to sensitive receivers are not anticipated provided the recommended mitigation measures are implemented. The key potential air quality issues to sensitive receivers located in the REF area during operation would be changes in emissions from vehicles using the existing and modified roads affected by the proposal.

Overview of potential air quality impacts in the EIS area

There are no sensitive receivers located within the EIS area but there are ecological receivers. As such, air quality impacts within the EIS area during construction are expected to be minor and would mainly be associated with dust. Adverse residual impacts to ecological receivers are not anticipated provided the recommended mitigation measures are implemented. Some minor changes to emissions in the EIS area may occur that may impact on ecological receptors during operation of the proposal.

Mitigation measures

Mitigation measures are required to manage impacts during construction, and these will include measures detailed in the IAQM, including appropriate work practices and scheduling, equipment selection, monitoring and preventative controls. These measures would be incorporated into a relevant Air Quality Management Plan that would form part of the Construction Environment Management Plan. Other air quality impacts associated with exhaust emissions from construction plant and equipment, and odour from the handling of potentially contaminated soils (including acid sulfate soils) would be managed via the implementation of procedures for identification, staging and handling of contaminated soils. Adverse residual impacts from construction are not anticipated following the implementation of the recommended mitigation measures.

Conclusion

The proposal would not result in adverse residual impacts during construction provided the recommended mitigation measures are implemented. Based on the results of the air quality modelling the operation of the proposal is not expected to cause unacceptable changes to local and regional air quality impacts. Further, predicted changes were within historically measured concentrations ranges.

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Limitations

The sole purpose of this report and the associated services performed by Jacobs was to provide an assessment of the impacts in air quality as a result of the proposal in accordance with the scope of services set out in the contract between Jacobs and Transport for NSW (the Client). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the public domain, the Client (if any) and from observations made during the site inspection. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the proposal and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

1.1 Proposal overview

Transport for NSW (Transport) is proposing to widen a six kilometre section of the Pacific Highway (Maitland Road) from four lanes to six lanes, starting about 290 metres south of the intersection with the Newcastle Inner City Bypass at Sandgate, and extending through to about 760 metres north of Hexham Bridge, in Hexham, NSW (the proposal). The proposal would create two additional lanes, one in each direction and would include the replacement of the twin bridges at Ironbark Creek. The section of road is known as the 'Hexham Straight' and is located within the City of Newcastle local government area (LGA) with a small portion of the construction area within the Port Stephens Council LGA (refer to **Figure 1.1**).

Maitland Road is a critical link as part of the National Land Transport Network and is among the busiest transport corridors carrying some of the highest traffic volumes in the Hunter. The proposal is required to reduce congestion and improve safety along Maitland Road during peak travel times.

The proposal is subject to assessment under two planning pathways, a review of environmental factors (REF) under Part 5, Division 5.1 of Environmental Planning and Assessment Act 1979 (EP&A Act) and an environmental impact statement (EIS) under Part 4 of the EP&A Act. The majority of the proposal (the REF area) is subject to approval under Division 5.1 of the EP&A Act that would be determined through a REF by Transport. However, a small part of the proposal (3.28 hectares) is within land mapped as 'Coastal Wetlands' under State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP). As such, that part of the proposal (known as the EIS area) is subject to approval under Part 4 of the EP&A Act and considered within the EIS.

This report has been prepared to support both the REF, the EIS and to assess the impacts of the proposal on air quality.

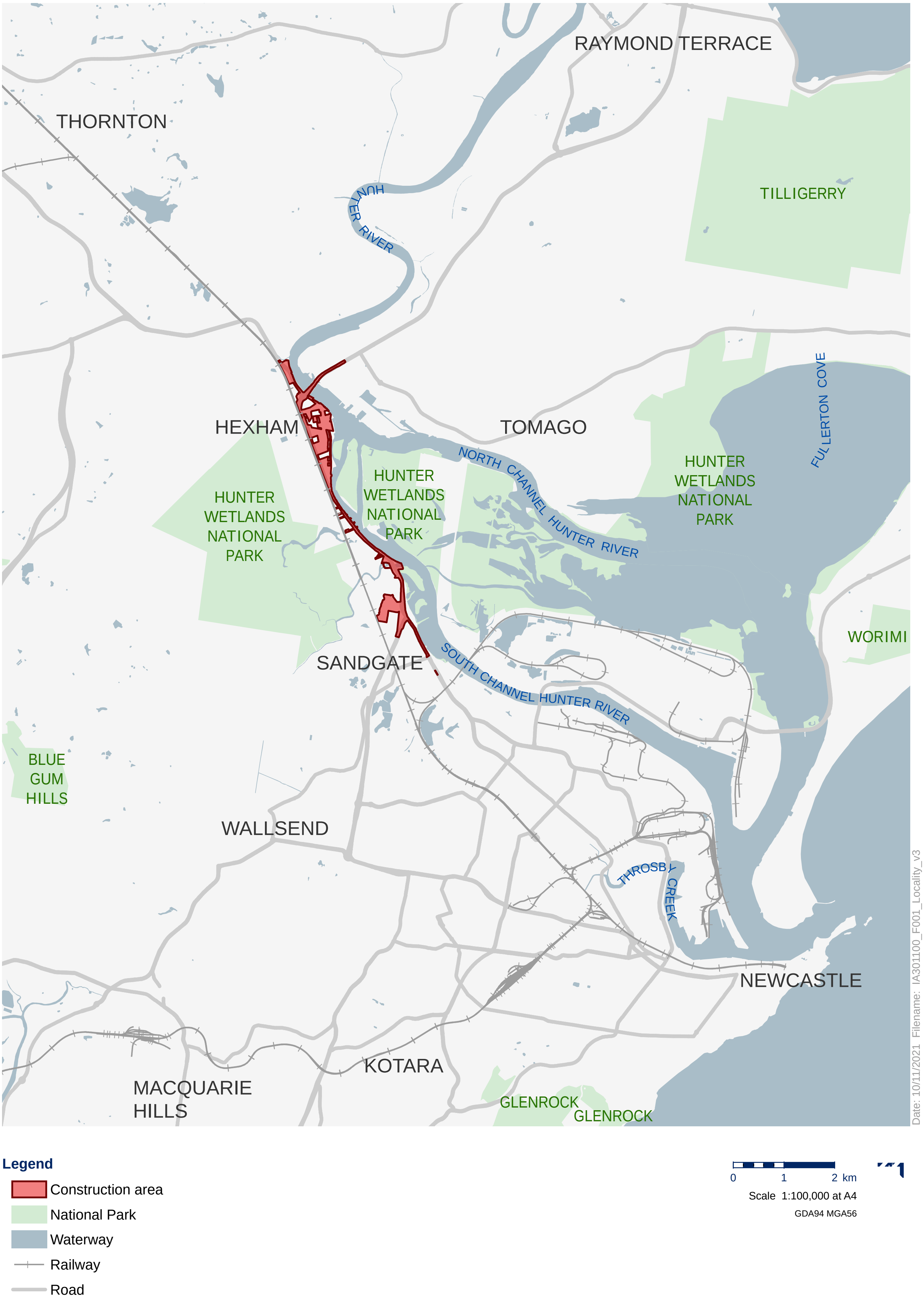
1.1.1 The proposal

The proposal consists of:

- Widening of Maitland Road for a six kilometre section starting about 290 metres to the south of the intersection with the Newcastle Inner City Bypass (A37) at Sandgate and extending to about 760 metres north of Hexham Bridge at Hexham on Maitland Road. The highway would be widened from generally two lanes in each direction to three lanes in each direction
- Replacement of the bridge which spans Ironbark Creek with new twin bridges. The existing bridge and all piers would be demolished, and the outlet of a small drainage channel would be relocated about 10 metres to the east of its existing location
- Minor improvements to nine signalised intersections
- Minor improvements to access roads, unsignalised intersections, entry and exit ramps connecting to the A1 Pacific Highway and the U-turn facility at the northern end of the proposal
- Closure of breaks in the existing median and direct access to two local side roads, one private access road and one U-turn facility
- Provision for a three metre wide shared use path northbound between the Oak Factory and the northern end of the proposal and a new section of off-road shared use path heading east along the Newcastle Inner City Bypass
- Widening of existing footpaths at intersection and bus stops
- Adjustments to property accesses and bus stops
- Provision of U-turn facilities on Sparke Street, Shamrock Street, and Old Maitland Road at Hexham

- Relocation of utilities including power, communications, water, gas and wastewater services
- Modifications and maintenance of existing drainage structures including pits, pipes, headwalls and culverts to suit the road widening and to maintain capacity
- Construction of retaining walls to minimise impacts on nearby properties
- Property acquisition, leases and adjustments
- Construction of hardstand for oversize and overmass (OSOM) vehicle parking at the southern and northern end of the proposal
- Intrusive investigation works such as geotechnical investigations
- Temporary construction facilities, including site compounds and stockpile sites at:
  - One area located in the industrial estate located on Old Maitland Road, Sandgate to the south of Calvary St Joseph's Retirement Community (Compound 1)
  - Two areas located in the industrial estate located to the east of Maitland Road and the west of Old Maitland Road, Hexham extending north from the northern boundary of the Hexham sports field to the area of road corridor underneath the entry ramps to the A1 Pacific Highway and Hexham Bridge (Compound 2)
  - Two areas located in the industrial estate located to the west of Maitland Road, Hexham near the Oak Factory (Compound 3)
  - One area located on vacant land to the east of the U-turn facility at the northern end of the proposal on Maitland Road, Hexham to the west of the main channel of the Hunter River (Compound 4).

An overview of the proposal is shown in **Figure 1.2**. Construction of the proposal would be staged and would take about 30 months to construct.



Data sources:
Jacobs 2020
Department Finance, Services and Innovation 2020

Figure 1.1 Proposal local area

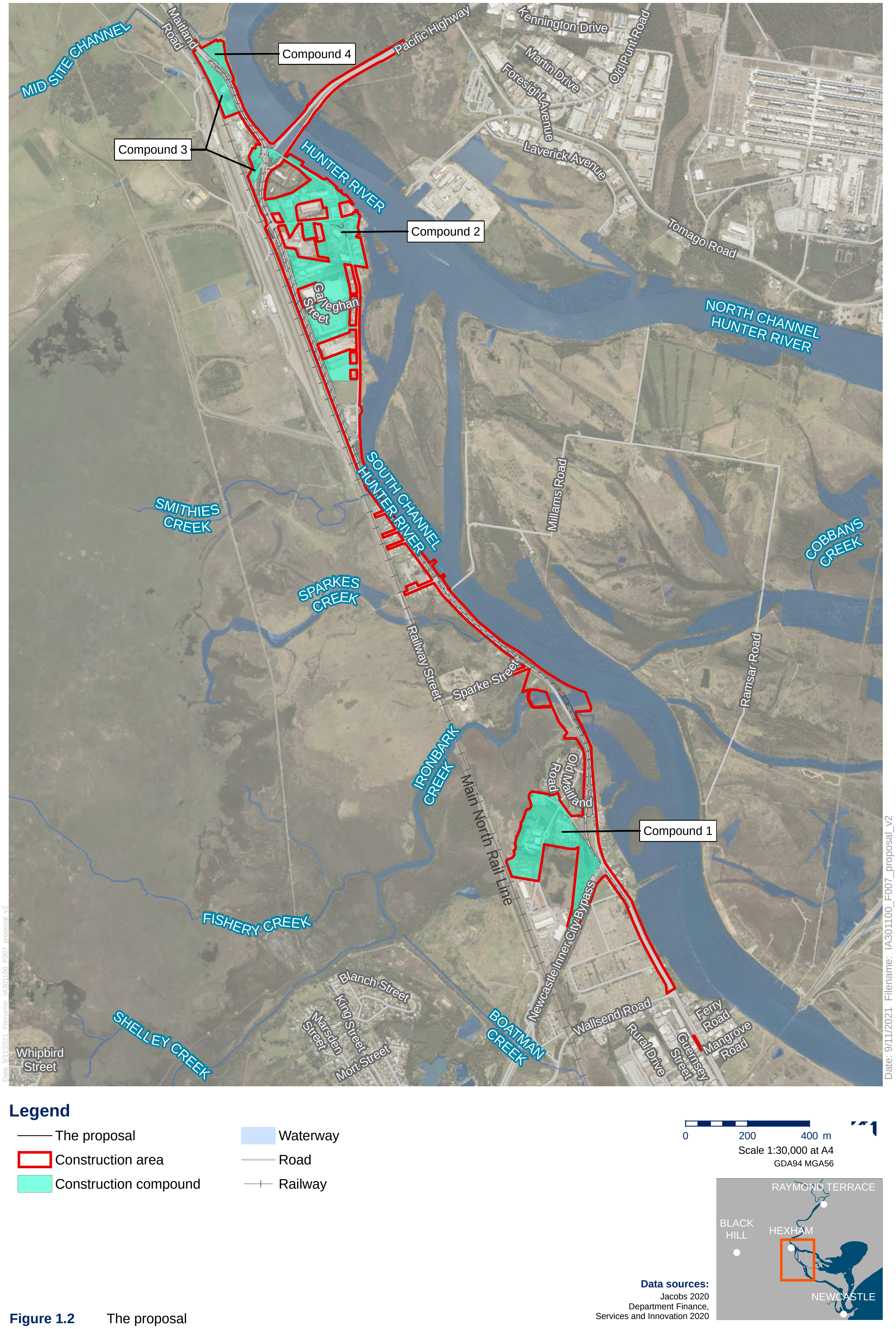


Figure 1.2 The proposal

1.1.2 The EIS area

The EIS area (refer to **Figure 1.3**) assess impacts of the proposal within land subject to the CM SEPP which are at the following three locations:

- EIS Area 1 - a small area located to the south of Ironbark Creek on the eastern side of Maitland Road and to the west of a parcel of Crown land and a section of Hunter Wetlands National Park. The land mapped as Coastal Wetlands includes areas of remnant mangrove and saltmarsh vegetation and also crosses sections of an existing track that provides access to the south bank of Ironbark Creek and to the base of Ironbark Creek Bridge. Access tracks would be required during construction and the permanent work required for the proposal in this area is comprised of road pavement, earthworks (embankment), construction of piers to support the new bridge over Ironbark Creek and the relocation of an unnamed drainage channel to the southeast of the existing bridge
- EIS Area 2 - a small area located to the north of Ironbark Creek on the eastern side of Maitland Road. The land mapped as Coastal Wetlands includes areas of remnant mangrove, saltmarsh and freshwater wetland vegetation. Access tracks would be required during construction and the permanent work required for the proposal in this area is comprised of road pavement, earthworks (embankment) and construction of piers to support the new bridge over Ironbark Creek
- EIS Area 3 - a small area located on the west bank of the south channel of Hunter River to the east of Maitland Road and to the northwest of Millams Road and the Ash Island Bridge. The land mapped as Coastal Wetlands includes areas of the road shoulder and remnant mangrove vegetation. The permanent work required for the proposal in this area is comprised of road widening work to include a third lane in the eastbound direction, as well as a new road shoulder, batter and upgrades to drainage.

There is potential for the proposal to indirectly impact other areas mapped as Coastal Wetlands under the CM SEPP. These impacts have been assessed within the EIS and relevant specialist reports. The proposal within the EIS area would be constructed and operated together with the proposal within the REF area, which has been assessed in the REF prepared by Transport.

1.1.3 The REF area

The REF area assesses all other aspects of the proposal included in **Section 1.1.1** that are outside the footprint of the EIS area described in **Section 1.1.2** and shown in **Figure 1.3**.

1.1.4 Relationship of the REF and EIS

Detailed discussion of the planning approval framework and consent requirements is provided in **Chapter 2**.

In summary, development consent under Part 4 is not usually required for development for the purposes of a road being undertaken by Transport as a public authority. Rather, this development is assessed as an ‘activity’ under Part 5 of the EP&A Act.

However, on those parts of the land which are identified as Coastal Wetland under the CM SEPP, the development is classified as designated development and requires consent from the City of Newcastle under Part 4 of the EP&A Act. The part of the proposal located within the Coastal Wetlands is therefore assessed under Part 4 of the EP&A Act. An EIS is required to assess the impacts of any works located within the Coastal Wetlands or any impacts on a Coastal Wetland.

A separate REF has been prepared in accordance with Division 5.1 of the EP&A Act to assess the areas of the proposal located within the REF areas. The REF would be determined by Transport. The proposal within the EIS area would be constructed and operated together with the proposal within the REF area. Together, the EIS and the REF assess the potential environmental impacts of the proposal and it is intended that these documents be read in conjunction with each other. The cumulative impacts of the proposal are located in **Section 5.3**.

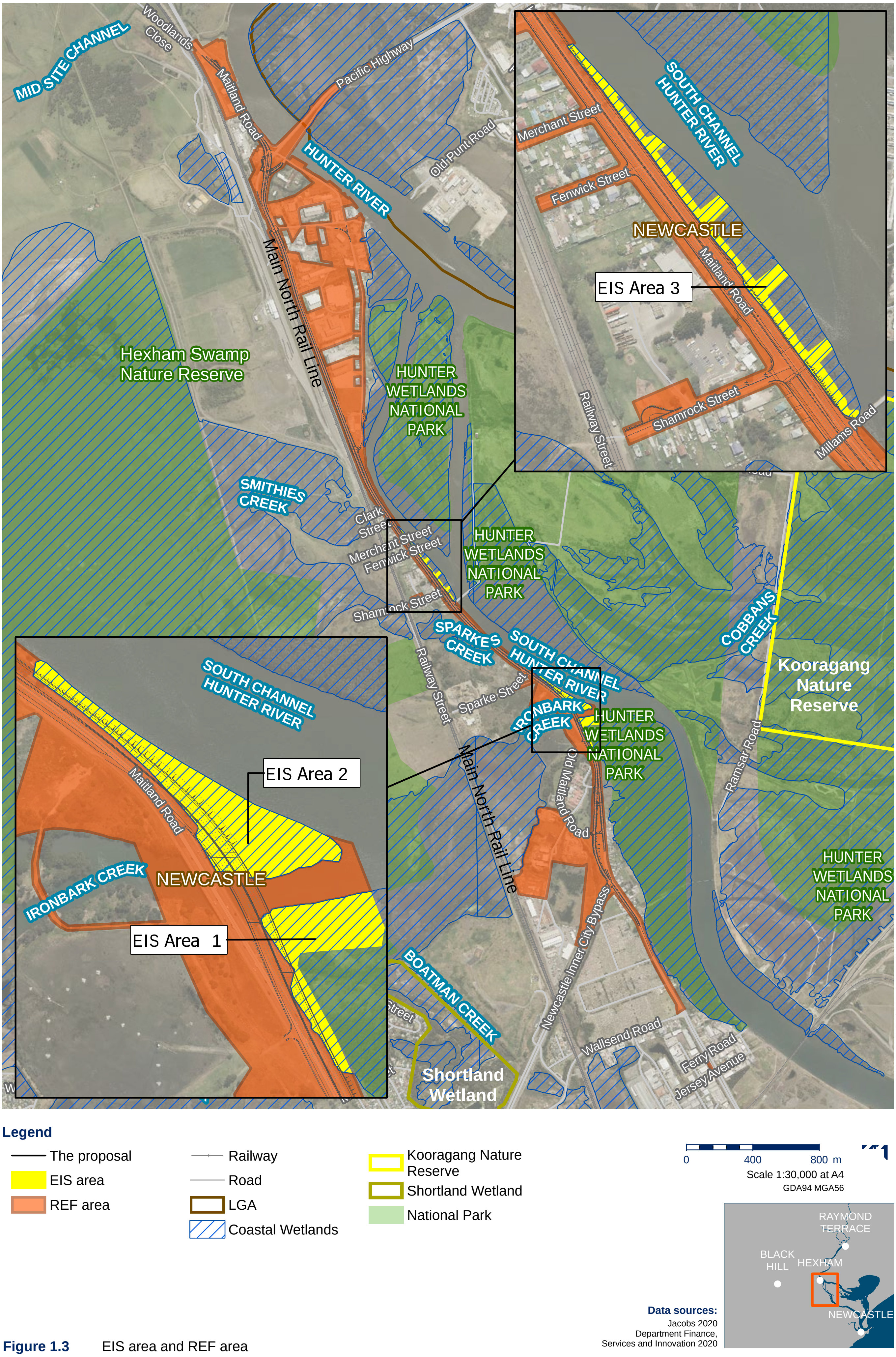


Figure 1.3 EIS area and REF area

1.1.5 Location

The proposal is located about ten kilometres north of the City of Newcastle in the suburbs of Sandgate and Hexham. To the east and in some locations next to the proposal is the Hunter River and the South Channel of the Hunter River and the proposal crosses Ironbark Creek. The major freight rail line into the Port of Newcastle uses the Main North Rail Line and this is located to the west of the proposal and in some locations immediately next to the proposal. The Hunter Wetlands National Park is located both to the east and west of the proposal and the area to the west is also known as Hexham Swamp Nature Reserve. Much of the low-lying national park estate as well as some other low-lying swamp areas including the larger back barrier Hexham Swamp areas are identified as wetlands under the CM SEPP. These low-lying areas connect to two areas of Ramsar listed wetlands identified as the Hunter Estuary Wetlands include Kooragang Nature Reserve about one kilometre to the east and Shortland Wetlands (including Hunter Wetlands Centre Australia) about 800 metres to the west of the proposal.

The land use along the proposal is characterised by a mix of transport corridors (road and rail), environmental areas including wetlands and waterways, recreational areas both public and private and light and heavy industrial areas. The main features of the proposal area and its surrounds include:

- Sandgate Cemetery
- Calvary St Joseph’s Retirement Community
- Hexham Bowling Club
- Hexham Park and Cricket Grounds
- Hexham Railway Station
- Residential properties are located on both sides of Maitland Road to the south of the Calvary St Joseph’s Retirement Community, to the west of the proposal along Shamrock Street, Fenwick Street, Merchant Street and Clark Street and along Old Maitland Road behind the industrial estate at Hexham
- Industrial and commercial properties located to the north of the Newcastle Inner City Bypass, off Sparke Road at Sandgate and at the northern end of the proposal to the east and north of the Hexham Railway Station.

1.2 Purpose and scope of the report

Jacobs was engaged by Transport to undertake an air quality assessment of the proposal. The purpose of this report is to assess the potential impacts to air quality from constructing and operating the proposal. The report:

- Describes the existing environment with respect to air quality
- Assesses the impacts of constructing and operating the proposal on air quality
- Recommends measures to mitigate and manage the potential impacts

The methodology for the assessment is described in **Section 3**.

1.3 Terms and definitions

The following terms are used in this report:

- Proposal - the widening of a six kilometre section of Maitland Road from four lanes to six lanes, starting about 290 metres south of the intersection with the Newcastle Inner City Bypass at Sandgate, and extending through to about 760 metres north of Hexham Bridge, in Hexham, NSW
- Construction area - the area to be directly impacted by the proposal. This comprises the future construction footprint of the proposed bridge over Ironbark Creek and the upgrade of the Maitland Road, including all roadside cut and fill, construction compound areas and parking areas for oversize and overmass vehicles, refer further to **Section 1.1.1**

- Study area - the construction area and additional areas that are likely to be affected by the proposal, either directly or indirectly
- EIS area - the areas of the proposal within land subject to the CM SEPP as defined in **Section 1.1.2**
- REF area - covers all other aspects of the proposal included in **Section 1.1.1** that are outside the footprint of the EIS area described in **Section 1.1.2**
- Proposal local area - the area within 10 kilometres of the proposal.

2. Legislative framework

2.1 Overview

There are several statutes, guidelines, and studies that apply to the regulation and estimation of emissions to air from developments including:

- *NSW Protection of the Environment Operations Act 1997* (POEO Act NSW)
- NSW Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO Clean Air Regulation)
- *National Environment Protection Measure for Ambient Air Quality* (AAQ NEPM) (National Environment Protection Council [NEPC], 2016)
- *National Environment Protection Measure for Air Toxics* (Air Toxics NEPM) (NEPC, 2011)
- *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) (NSW EPA, 2016)
- *Approved Methods for Sampling and Analysis of Air Pollutants in NSW* (NSW Department of Environment and Conservation [DEC], 2005)
- *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA, 2019a)
- *Guidance on the Assessment of Dust from Demolition and Construction Version 1.1* (UK Institute of Air Quality Management [IAQM], 2014)
- *Assessment and Management of Odour from Stationary Sources in NSW* (DEC, 2006).

Requirements relevant to the proposal from each of these documents are outlined below. It is noted that there are other standards which regulate emissions from new and in-service vehicles and fuel quality, although these are not relevant to how air quality impacts have been assessed from the proposal.

2.2 NSW legislation

2.2.1 Protection of the Environment Operations Act 1997

The NSW POEO Act is the primary piece of legislation for the regulation of potential pollution impacts associated with scheduled operations or activities in NSW. Scheduled activities are those defined in Schedule 1 of the POEO Act. These include road construction where the activity results in the existence of four or more traffic lanes (other than bicycle lanes or lanes used for entry or exit) for at least:

- Roads classified under the NSW *Roads Act 1993* as a ‘freeway’ or’ tollway’
  - One kilometre of their length in the metropolitan area, or five kilometres of their length in any other area
- Roads classified as a main road:
  - Three kilometres of their length in the metropolitan area, or five kilometres of their length in any other area.

The proposal comprises about six kilometres of new roadway and its construction would constitute as a scheduled activity under the POEO Act. As such, proposal construction activities would need to comply with the requirements of Chapter 5, Part 5.4 – Air Pollution of the POEO Act. In general, these requirements seek to ensure that emissions from a project do not result in unacceptable air quality beyond the project, including at surrounding sensitive receivers.

2.2.2 Protection of the Environment Operations (Clean Air) Regulation 2010

The NSW POEO Clean Air Regulation contains provisions for the regulation of emissions to air from wood heaters, open burning, motor vehicles and fuels and industry. In the context of the proposal the applicability of the POEO Clean Air Regulation is limited. This is because the proposal does not involve any of the four areas of regulation (wood heaters, open burning, motor vehicles and fuels and industry), noting that 'motor vehicles and fuels' refers to emission standard from new and in-service vehicles, and the quality of fuels used in NSW. In addition, the proposal does not include sources that may be regulated under the POEO Clean Air Regulation, such as road tunnel stacks.

2.3 Commonwealth legislation

2.3.1 National Environment Protection (Ambient Air Quality) Measure 2018

The AAQ NEPM sets national ambient air standards that allow for the adequate protection of human health and well-being. The NEPM entered into force in 1998 and established national ambient air standards for six key pollutants:

- Carbon monoxide (CO)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Lead (Pb)
- Photochemical oxidants as ozone (O_3)
- Particulate matter (PM) with an aerodynamic diameter less than 10 microns (PM_{10}).

The AAQ NEPM was expanded in 2003 to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). On 25 February 2016, NEPM entered into force and introduced the following changes:

- $PM_{2.5}$ advisory reporting standards were changed to formal standards consistent with the other six pollutants
- The annually averaged PM_{10} standard was revised from 30 micrograms per cubic metre (µg/m^3) to 25 µg/m^3
- The introduction of an aim to reduce the 24-hour and annually averaged $PM_{2.5}$ standards from 8 µg/m^3 and 25 µg/m^3 to 7 µg/m^3 and 20 µg/m^3 by 2025
- Initiating a nationally consistent approach to reporting population exposure to $PM_{2.5}$
- Replacing the five-day exceedance form of the 24-hour $PM_{2.5}$ and PM_{10} standards with an exceptional event rule.

Further, on 7 December 2018, the National Government notified of their intent to vary the NEPM again to strengthen standards applicable to O_3, SO_2 and NO_2. This update would reflect current scientific understanding to provide a higher level of health protection from air pollution impacts associated with these pollutants for the Australian population.

The ambient air standards presented in the NEPM apply to urban ambient air quality monitoring stations, which broadly represent levels of exposure to urban populations. The standards are not intended to be used as criteria for assessing air quality impacts associated with projects and developments. These criteria are set by individual states and territories.

2.3.2 National Environment Protection Measure for Air Toxics 2011

Recognising the health effects associated with exposure to air toxics, the Air Toxics NEPM was developed to improve the information base regarding ambient air toxics within the Australian environment to facilitate the development of ambient air quality standards for these substances.

Five priority pollutants are covered in the Air Toxics NEPM; these are benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene as a marker for Polycyclic Aromatic Hydrocarbons (PAHs). The Air Toxics NEPM includes monitoring investigation levels for these pollutants which are for use in assessing the significance of monitored concentrations with respect to provisions for the protection of human health. These monitoring investigation levels are not intended for assessing compliance from projects and developments but aim to improve the information base regarding ambient air toxics with the Australian environment in order to facilitate the development of standards.

Vehicles on the existing and proposed road network would be the main source of air toxics.

2.4 Relevant guidelines

2.4.1 Approved Methods for the Modelling and Assessment of Air Pollutants in NSW

The Approved Methods (EPA, 2016) was published by the NSW EPA and outlines the approach to be applied for the modelling and assessment of air pollutants from stationary sources in NSW. Although the document does not relate specifically to road projects, the impact assessment criteria have been considered to provide an indication of the significance of the proposals effect on air quality. Criteria relevant to the key pollutants related to the proposal are listed in **Table 2.1**.

Table 2.1 NSW EPA air quality impact assessment criteria

Pollutant	Averaging time	Criterion	Source
Criterion pollutants			
CO	1-hour	30,000 $\mu g/m^3$	NSW EPA, 2016
	8-hours	10,000 $\mu g/m^3$	NSW EPA, 2016
NO_2	1-hour	246 $\mu g/m^3$	NSW EPA, 2016
	Annual	62 $\mu g/m^3$	NSW EPA, 2016
PM_{10}	24-hour	50 $\mu g/m^3$	NSW EPA, 2016
	Annual	25 $\mu g/m^3$	NSW EPA, 2016
$PM_{2.5}$	24-hour	25 $\mu g/m^3$	NSW EPA, 2016
	Annual	8 $\mu g/m^3$	NSW EPA, 2016
Particulate matter as Total Suspended Particulates (TSP)	Annual	90 $\mu g/m^3$	NSW EPA, 2016
Air toxics			
Benzene	1-hour	29 $\mu g/m^3$	NSW EPA, 2016
Formaldehyde	1-hour	20 $\mu g/m^3$	NSW EPA, 2016
Toluene	1-hour	360 $\mu g/m^3$	NSW EPA, 2016
Xylenes	1-hour	190 $\mu g/m^3$	NSW EPA, 2016

The intent of each of these criteria has been summarised below:

- CO – The criteria for CO adopted from the *WHO Air Quality Guidelines for Europe*, 2nd Edition, (World Health Organisation, 2000) are intended to preserve a COHb (Carbon monoxide haemoglobin oxygen carrying capacity of the blood) safe level of 2.5 per cent for a 'normal subject' engaging in light or moderate exercise. Exposures to concentrations above these levels for the periods specified were stated to result in adverse health effects
- NO_2 – The same objective is stated for NO_2 in the *Ambient Air – National Environment Protection Measure for Ambient Air Quality*, (National Environment Protection Council, 1998); namely to provide 'adequate protection of human health and well-being'. Guidance regarding NO_2 exposure is detailed in the World Health Organisation (2000) guideline which indicates that a one-hour averaged criteria of 200 µg/m^3 includes a 50 per cent 'safety margin' and that it was only when short-term exposure was greater than 400 µg/m^3 that there was 'evidence to suggest possible small effects in function of asthmatics'
- PM_{10} and $PM_{2.5}$ – Part 2, Clause 5 of the NEPM states that the desired outcome of the measure is 'ambient air quality that allows for the adequate protection of human health and well-being'
- TSP – The now rescinded 'Ambient Air Quality Goals Recommended by the National Health and Medical Research Council', (National Health and Medical Research Council, 1996) states that 'at these levels (criterion in **Table 2.1** above) there still may be some people who would experience respiratory symptoms' but that the intent of this criteria is the protection of human health for the broader majority of the population
- Volatile organic compounds (VOCs) – This criterion is adopted from guidance presented in *State Environment Protection Policy (Air Quality Management)* No. S 240, (Government of Victoria, 2001). Part II Schedule A of the guideline describes how this criterion includes a factor of safety of 40, given the high toxicity and potential health effects arising from exposure to such substances.

The criteria for CO, NO_2, PM_{10}, $PM_{2.5}$, and TSP relate to the total concentration in the ambient air. For an air quality impact assessment this comprises of the maximum incremental concentration from the proposal or activity plus background levels due to influences of all other surrounding natural and anthropogenic sources. Further details of the background levels applied in the assessment are discussed below in **Section 4**. These criteria apply to the nearest existing or likely future sensitive receiver areas in relation to the project.

As noted in **Section 2.3.2**, the NEPM identifies 'investigation levels' for five priority air toxics: benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene as a marker for PAHs. The 'investigation levels' levels are not compliance standards but are used for assessing the significance of monitored levels of air toxics with respect to the protection of human health. Although these criteria do not specifically apply to road projects, they have been used to provide an indication of the significance of the proposal's effect on air quality during operations.

2.4.2 Approved Methods for Sampling and Analysis of Air Pollutants in NSW

The *Approved Methods for Sampling and Analysis of Air Pollutants in NSW* (DEC, 2005) provides guidance for the monitoring and analysis of air pollutants in NSW. Ambient air quality data collected from stations being operated by the NSW Department of Planning, Industry and Environment (DPIE) in accordance with this guideline were adopted for this assessment (see **Section 4.3**).

2.4.3 Air Emissions Inventory for the Greater Metropolitan Region in New South Wales

The *Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA, 2019a) provides the outcomes of a study into the anthropogenic (i.e. human-made), and natural sources of emissions to air in the Greater Metropolitan Region comprising of Sydney, Newcastle and Wollongong. The investigation quantifies emissions from all sources of air pollution, including on-road transportation. The study and subsequent updates established vehicle emission databases for the base year of assessment (2008), and projections for 2011, 2016, 2021, 2026, 2031 and 2036. These emission factors are incorporated into Transport's Tool for Roadside Air

Quality (TRAQ), a tool commonly used in NSW to quantify the potential operational air quality impacts of vehicles using an existing or new road.

2.4.4 Guidance on the assessment of dust from demolition and construction

In the absence of a NSW guideline for the assessment of dust from construction activities, a suitable alternative was used. The UK IAQM developed the guideline, *Guidance on the assessment of dust from demolition and construction Version 1.1* (UK IAQM, 2014). The document provides an approach for assessing the potential for dust-related impacts during construction, taking into consideration the sensitivity of the local environment and the expected magnitude of different construction activities. Further details of the IAQM assessment methodology are provided in **Section 3.2**, and its application to the proposal in **Section 5.1**.

2.4.5 Assessment and Management of Odour from Stationary Sources in NSW (DEC, 2006)

The document, *Assessment and Management of Odour from Stationary Sources in NSW*, (DEC, 2006) provides guidance for the assessment and management of odours arising from stationary sources in NSW. Recommendations for the management of potential odours during the proposal were included in line with the guidance provided in this document.

3. Methodology for the assessment

3.1 Air quality issues

Air quality issues can arise when emissions from an industry or activity lead to a deterioration in the ambient air quality. Construction of the proposal could lead to emissions to air from a variety of activities including land clearing, earthworks, material handling, and material transport. Emissions may also arise from wind erosion of exposed areas. These construction-related emissions would mainly comprise of particulate matter in the form of:

- TSP, typically where particles are less than 30 microns in equivalent aerodynamic diameter
- PM_{10}, representing particulate matter with equivalent aerodynamic diameter of 10 microns or less
- $PM_{2.5}$, representing particulate matter with equivalent aerodynamic diameter of 2.5 microns or less.

There are relatively minor emissions (i.e. smaller quantities) from construction machinery exhausts such as CO, oxides of nitrogen (NO_x), PM_{10}, $PM_{2.5}$, some hydrocarbons, and to a lesser extent SO_2. Odour and other volatile organic compounds also have the potential to be generated from the handling of potentially contaminated soils associated with historical land uses (Jacobs,2020).

Operation of the proposal would lead to emissions to air from vehicles using both the existing and modified road network. There are a variety of air pollutants associated with road vehicles with the most significant pollutants, in terms of potential impacts to health, being:

- CO
- NO_x, representing the total of nitric oxide (NO) and NO_2
- Particulate matter as PM_{10} and $PM_{2.5}$
- Hydrocarbons (HC).

These pollutants are generated from the combustion of fuel and emitted via the exhaust system. Particulate matter emissions are also generated from brake and tyre wear, as well as re-suspended road dust.

In summary, the key potential air quality issues for the proposal include:

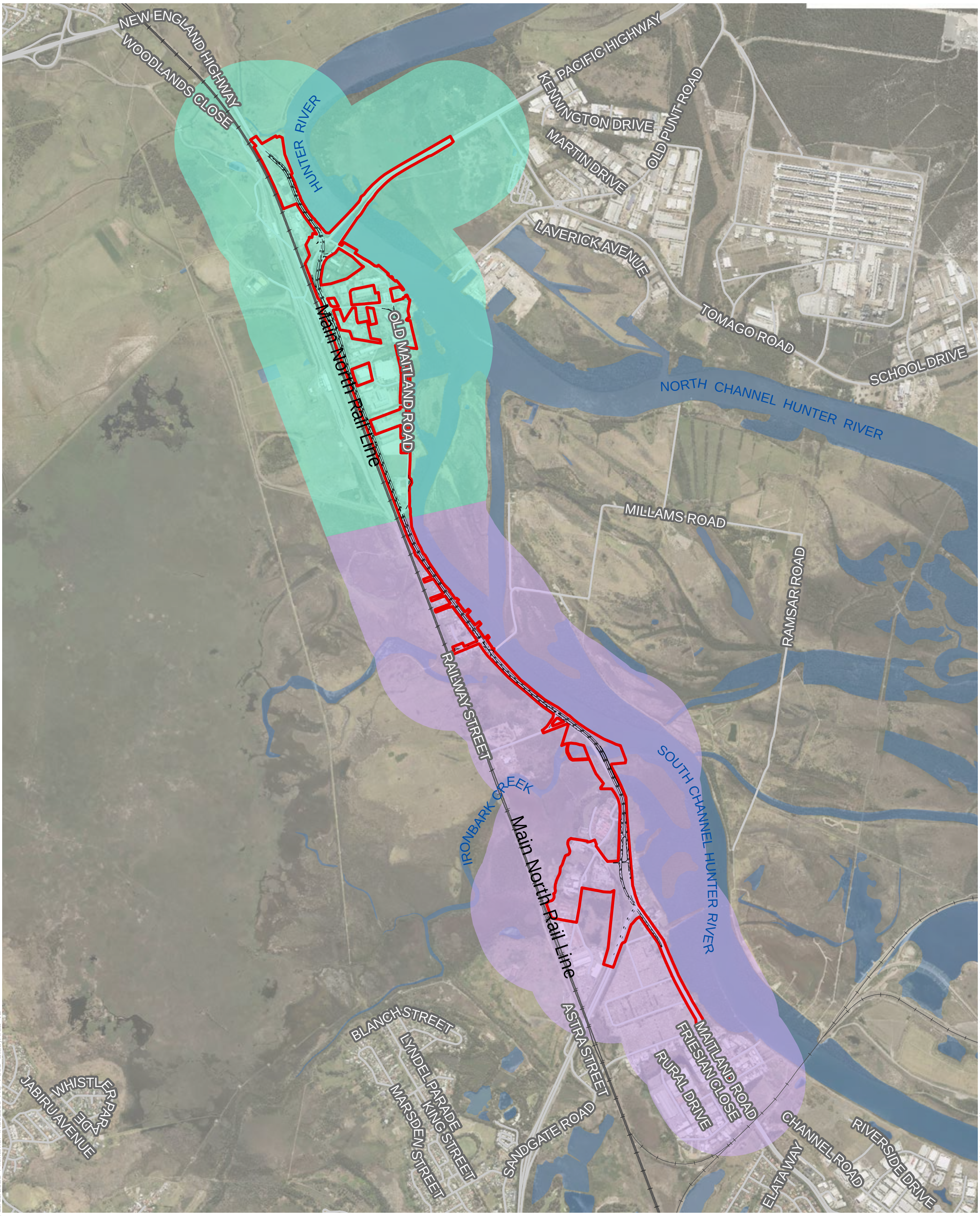
- Dust from construction activities
- Odour from the handling of potentially contaminated materials during the construction phase
- Emissions from vehicles using the existing and modified road network during operation.

The issues outlined above are the focus of this assessment and are the basis of the methodology that have been implemented for the construction and operation phases of the proposal.

3.2 Air quality study area

For the purposes of this air quality assessment, the proposal area has been split into two study areas that are shown in **Figure 3.1** and described as follows:

- Southern study area – located to the south of Hexham Bowling Club in Hexham and extending to the southern end of the proposal in Sandgate. Land uses in this area are mainly characterised by a higher density or more sensitive land uses (e.g. residential receivers and retirement living) near the proposal. The study area is defined by a 500 metre buffer on the construction area.



Legend

Construction area

ImpactArea

Construction impact area north

Construction impact area south

Waterway

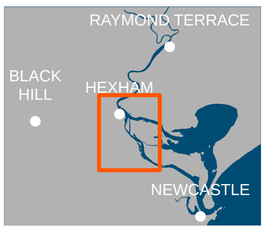
Road

Railway

0 200 400 m

Scale 1:35,834 at A4

GDA94 MGA56



Data sources:
Jacobs 2020
NSW Spatial Services 2020

Figure 3.1 Study area

- Northern study area – located to the north of Hexham Bowling Club and extending to the northern end of the proposal in Hexham. Land uses in this area are mainly characterised by industrial land uses although some residential properties are also located to the east of the industrial estate on Old Maitland Road and to the west of the Southern Arm of the Hunter River. The study area is defined by a 500 metre buffer on the construction area.

3.3 Construction assessment methodology

Potential impacts to human health, annoyance and ecology (e.g. impacts to plant health) from dust generation represents the primary air quality-related risk during construction. The assessment has followed guidance presented in *Guidance on the assessment of dust from demolition and construction Version 1.1* (UK IAQM, 2014) to identify the potential for dust impacts during the proposal. The IAQM aims to identify the overall unmitigated risks of the whole proposal and recommends appropriate management measures. Four primary activities are defined by the IAQM, as follows:

- 'Demolition'
- 'Earthworks'
- 'Construction'
- 'Trackout', or the transport-related handling of construction materials.

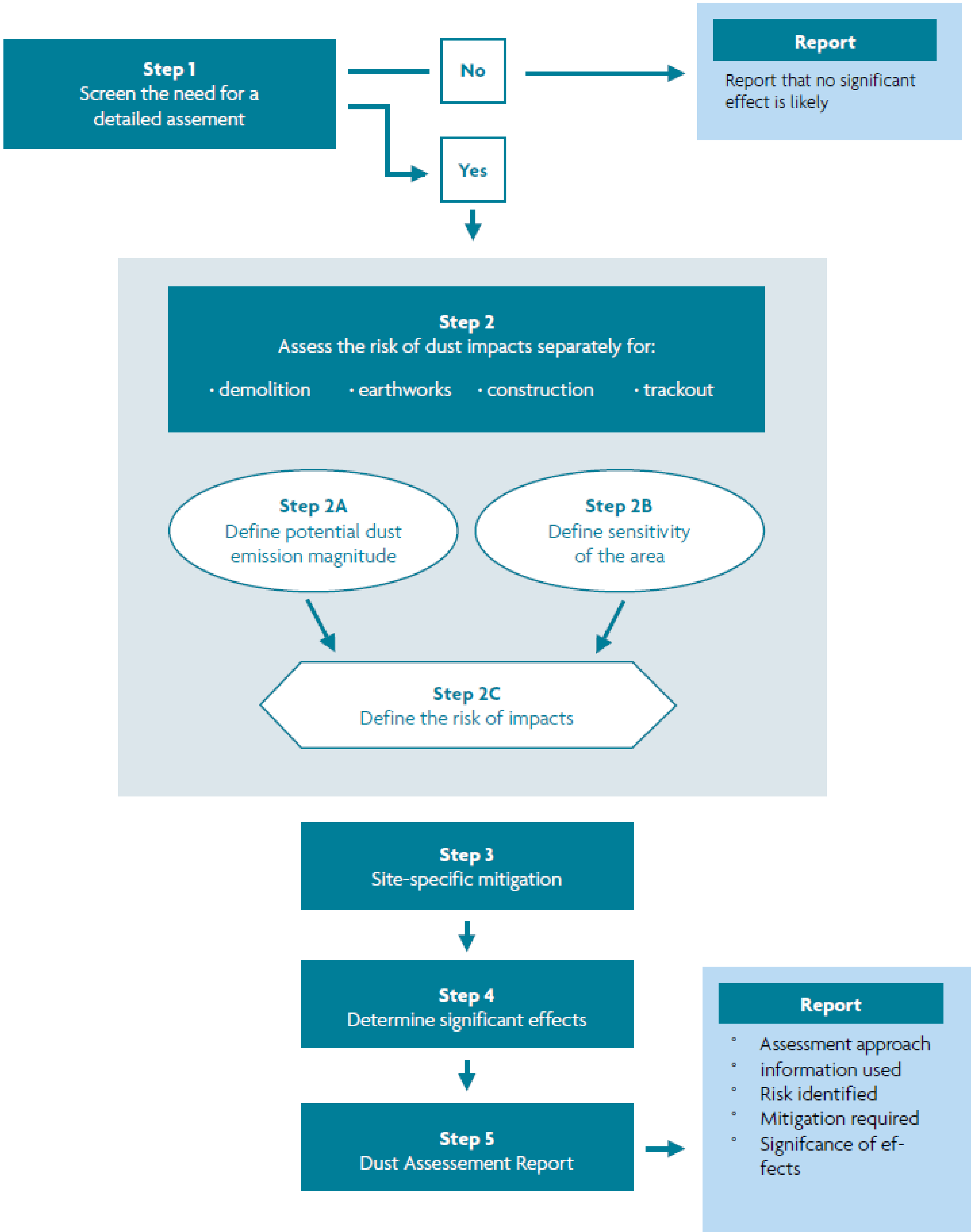
Application of this semi-quantitative, risk-based assessment approach is consistent with the approach used to assess construction related impacts on other recent large-scale Australian road transport projects. The approach is preferred as it can be difficult to reliably predict potential impacts using modelling approaches which have high levels of uncertainty about when, where and how intensively specific activities would be completed, and the corresponding weather conditions. The IAQM provides robust mitigation and management measures which are aligned to the assessed levels of unmitigated risk.

The assessment procedure involves four steps of assessment, with the intended outcome of developing suitable mitigation measures to avoid any potential nuisance, human health and ecological impacts (such as impacts to vegetation health) from dust generated during the four primary activities. These steps are presented in **Figure 3.2** and involve:

- Step 1, a screening review to establish a study area for and identify nearby human and ecological receivers which have the potential to be impacted by the proposal
- Step 2, an evaluation of the potential magnitude (Step 2A) and sensitivity of the surrounding receiving environment to dust impacts (Step 2B). Step 2A and 2B were combined in Step 2C to estimate the risk of dust impacts if no mitigation measures were applied. Step 2 was completed for different work areas across the proposal so that changes in risk profiles could be identified and assessed across the proposal
- Step 3, the development of mitigation for each work location, commensurate to the level of risk determined in Step 2
- Step 4, an evaluation of any residual dust-related risks following the application of the control measures developed during Step 3 to verify that a suitable level of mitigation has been developed to reduce the impacts to the extent practicable.

The construction assessment methodology is intrinsically linked to the process and full details of how the assessment was completed and its outcomes are presented in **Section 5.1**. In step 1 of the assessment, a study area of within 500 metres of the proposal construction boundary is established which is presented and discussed further in **Section 5.1.2**.

As noted in **Section 3.1**, there are other air quality risks that have the potential to result in impacts to sensitive receivers during construction. These included exhaust emissions from construction plant and equipment, odour, airborne hazardous materials and cumulative effects. These matters have been assessed qualitatively and are discussed in **Section 5.1.6**, with mitigation and management measures provided in **Section 6**.



Source: UK IAQM, 2014

Figure 3.2 Construction air quality assessment procedure

3.4 Operation assessment methodology

3.4.1 Overview

Changes to local air quality as a result of the proposal during operation were quantified and assessed. The following sections outline the operational scenarios that were assessed, how emissions were calculated, and how an air dispersion model was used to predict changes in air quality as a result of the proposal.

The Approved Methods specifies how assessments based on the use of air dispersion models should be carried out. Although the Approved Methods is intended for stationary sources, not projects such as roadways, it includes relevant information related to the preparation of meteorological data, reporting requirements and air quality assessment criteria that are used to assess the significance of dispersion model predictions.

Emissions from vehicles on the local road network have been estimated using information on traffic volumes, traffic mix, and link locations, combined with emission factors from the NSW EPA. The computer-based dispersion model known as GRAL ('Graz Lagrangian') has then been used to predict key air pollutant concentrations due to these emissions under a range of operational scenarios, taking into account the local meteorological conditions. Details are outlined below.

As noted in **Section 3.1** the main objective of the operational assessment was to identify the potential change in air quality as a result of the proposal. These changes would be primarily influenced by changes in traffic volumes, mix, speed, and locations.

3.4.2 Emissions

Emissions have been calculated for each road link along the proposal alignment, as well as along adjoining side roads displayed below in **Figure 3.3**. Emissions were calculated using the hourly traffic volumes, mix and speed data in combination with emission factors from the NSW EPA Motor Vehicle Emissions Inventory (MVEI). The MVEI is fully described by the NSW EPA (2019a) and has been specifically designed for use in the NSW Greater Metropolitan Region (GMR).

The MVEI has been selected for the emission calculations for the following reasons:

- The model takes into account the operation of vehicles on surface roads and characteristics of vehicle fleets in the GMR
- The emission factors have been derived using an extensive database of Australian measurements
- The emission factors allow for the deterioration in emissions performance with mileage, the effects of tampering or failures in emission-control systems, and the use of ethanol in petrol
- The emission factors are defined for five specific road types and nine vehicle classes
- The emission factors are available for future years, taking into account the technological changes in the vehicle fleet
- Cold start and speed corrections are incorporated.

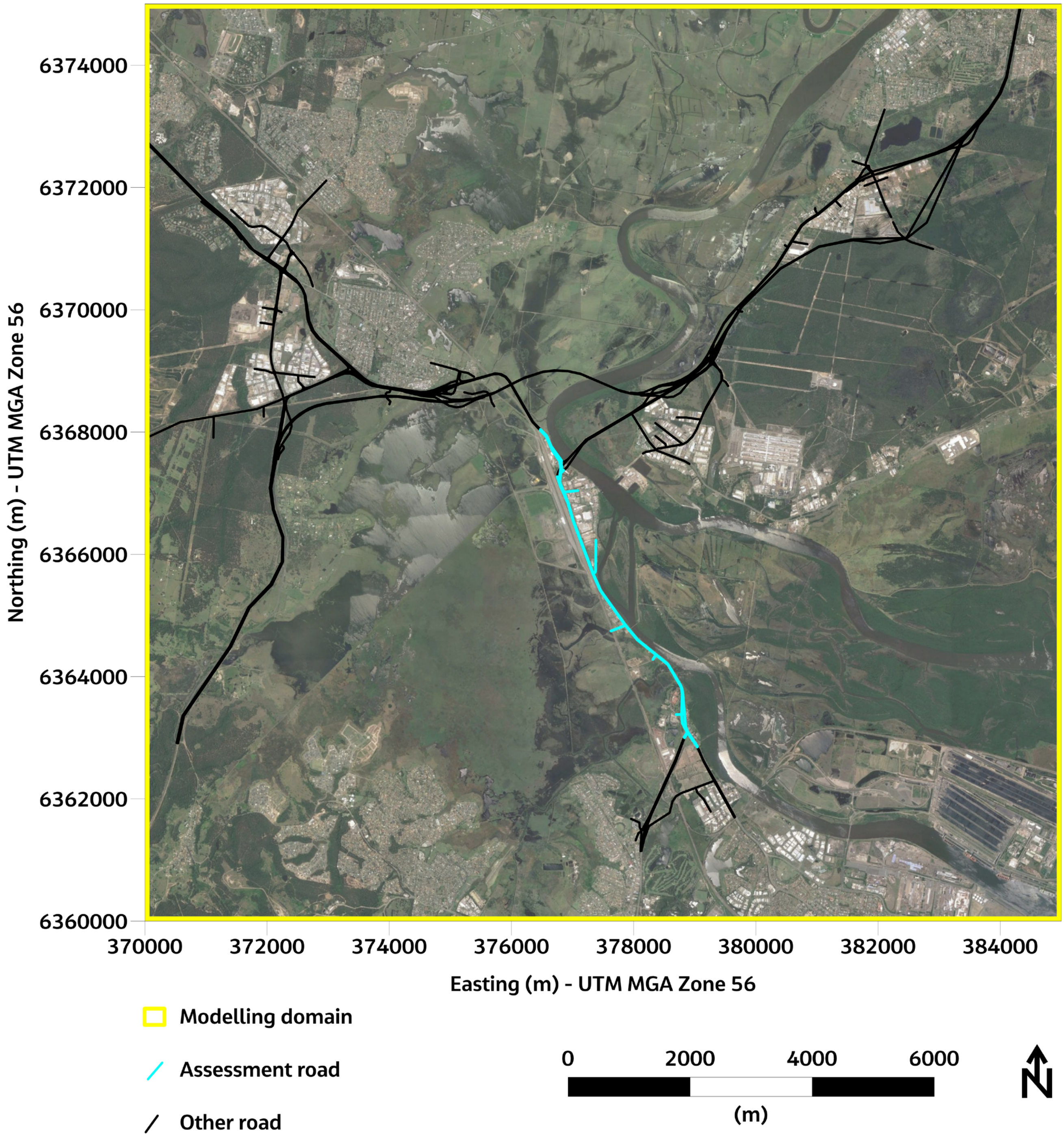


Figure 3.3 Road links for operational air quality assessment

Five operational scenarios were developed in order to quantify and assess the potential change in air quality. These scenarios are listed in **Table 3.1**.

Table 3.1 Operational air quality assessment scenarios

Scenario ID	Description
2028 DN	2028 'Do Nothing'. Traffic conditions in the planned opening year**, without the proposal.**
2028 WP	2028 'With Proposal'. Traffic conditions in the planned opening year, **with the proposal**.
2038 DN	2038 'Do Nothing'. Traffic conditions 10 years after the planned opening year, **without the proposal**.
2038 WP	2038 'With Proposal'. Traffic conditions 10 years after the planned opening year, **with the proposal**.

As outlined above, emissions of CO, NO_x, PM_{10}, and HC were calculated for every blue link displayed in **Figure 3.3**, for each assessment scenario. The emission calculations involved:

- Extracting volumes, mix, and speed forecasts from the proposal links and adjoining side roads, as hourly breakdowns, for each assessment scenario
- Matching the traffic model road types to the NSW EPA road types
- Categorising the traffic into nine vehicle types (CP, CD, LCV-P, LCV-D, HDV-P, RT, AT, BusD and MC) for each hour of the day. The traffic mix data by road type and year were derived from the Western Harbour Tunnel air quality assessment (ERM, 2020)
- Calculating emissions of CO, NO_x, PM_{10} and HC in kilograms per hour (kg/h) for each hour of the day, for each vehicle type, for every road link by multiplying the vehicle numbers for each type by the respective NSW EPA emission factors
- Applying cold start effects (i.e. up-scaling of emissions to account for combustion inefficiencies during cold conditions)
- Correcting NO_x emission factors. The NSW EPA NO_x emissions are reported as NO_2. NO_x emission correction factors have therefore been derived from fleet weighted NO_2 to NO_x percentages, by vehicle type, from the NSW EPA
- Applying NSW EPA speed correction factors for each vehicle type, based on the road type
- Adding non-exhaust emissions, in the case of PM_{10}, for each vehicle type
- Preparing the emission estimates into a format for use in the dispersion models.

Table 3.2 provides a summary of the calculated total daily emissions and traffic movements from all modelled roads. As shown, total daily traffic movements were predicted to increase by around three percent in 2028 with the proposal (i.e. 2028 WP) compared with the 2028 no proposal scenario (2028 DN). As such calculated emissions of CO, NO_x, PM_{10}, HC and equivalent CO2 (CO_2-e) emissions with the proposal increased by up to around 12 per cent. In 2038, daily traffic movements with the project (i.e. 2038 WP) were around 21 per cent higher than the 2038 no project scenario (2038 DN). As a result of this change, and the associated traffic mix, the calculated emissions also increase by up to 34 per cent.

Table 3.2 Calculated daily emissions for assessed roads

Scenario ID	Vehicle movements per day	Total emissions (kg/day)				
		CO	NO_x	PM_{10}	HC	CO_2-e
2028 DN	741,674	329	136	25	20	112,000
2028 WP	765,533	369	138	25	20	116,000
2038 DN	762,109	224	130	25	16	115,000
2038 WP	920,154	301	140	30	19	137,000

Attachment A provides details of the emission calculations including the key inputs and assumptions.

3.4.3 Meteorological modelling

The air dispersion model used for this assessment, GRAL, requires information on the meteorological conditions in the modelled region. This information can be generated by the prognostic, meso-scale wind field model GRAMM ('Graz Mesoscale Model'), using surface observation data from local weather stations. The result of a GRAMM simulation is a compilation of classified meteorological conditions that can be used as input to GRAL.

Key model settings for GRAMM are shown below in **Table 3.3**.

Table 3.3 Model input settings for GRAMM

Parameter	Value
Model version	20.01
Model domain (MGA Zone 56)	Easting 370000-385000, Northing 6360000-6375000 (15 km x 15 km)
Horizontal grid resolution (m)	300
Vertical thickness of first layer (m)	10
Number of vertical layers	15
Vertical stretching factor	1.4
Relative layer height (m)	3874
Maximum time step (s)	10
Modelling time (s)	3600
Terrain option	Flat terrain
Land use	CORINE land-use categories, digitized from aerial imagery (**Figure 3.4**)
Wind speed classes	7
Wind direction sectors	36 sectors x 10 degree sector size

Terrain across the 15 kilometre by 15 kilometre domain varies from sea level to approximately 40 metres above sea level. There would be very little topographical influence on meteorological conditions in this area so model terrain was therefore assumed to be flat. Spatially varying land use data were extracted from aerial imagery and prescribed to the GRAMM using the CORINE (Coordination of Information on the Environment) categories. **Figure 3.4** shows the model domain, model grid, and land use information, as used by GRAMM.

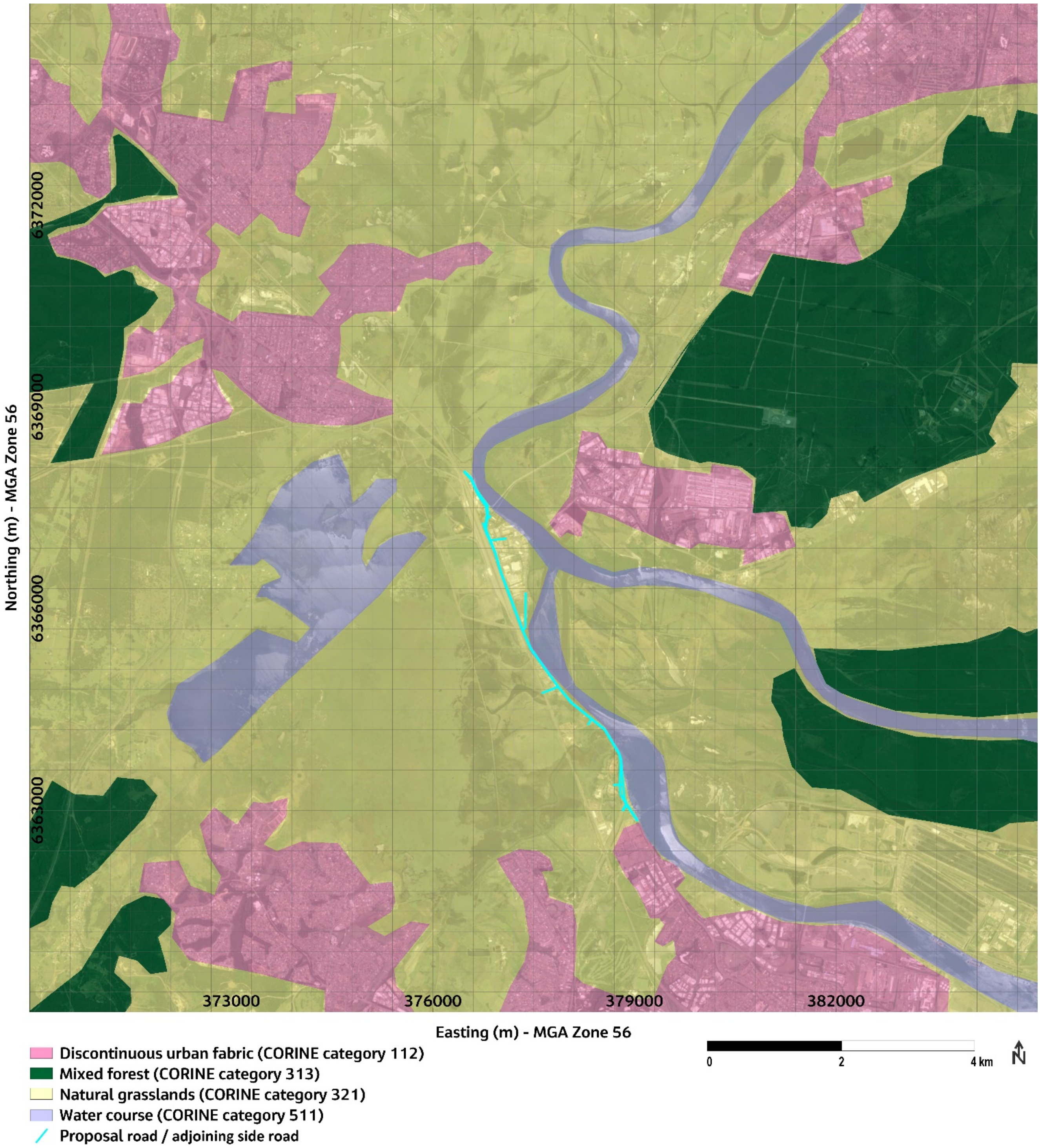


Figure 3.4 GRAMM model domain, grid resolution and land use setup and operational study area

GRAMM has been used to develop a range of wind fields for the model domain based on the setup described above and informed by data from a representative meteorological station. The resultant wind fields, often referred to as 'meteorological situations', have then been used as input to the dispersion model, GRAL.

The DPIE operates a meteorological and air quality monitoring station in the grounds of Francis Greenway High School, Beresfield. This station is located approximately four kilometres to the northwest of the proposal and well positioned to collect data that are representative of conditions around Hexham and Sandgate, across the proposal.

GRAMM requires hourly records of wind speed, wind direction, and atmospheric stability. Wind speed and wind direction are measured directly while atmospheric stability is a derived parameter. In this case, atmospheric stability was derived using sigma-theta and the method described by the United Stated Environmental Protection Agency (US EPA, 2000). Meteorological data collected at the Beresfield meteorological and air quality monitoring station in 2016 were used for GRAMM.

The GRAMM Match-to-Observation function was used to refine the order of the simulated wind fields to provide a better match to the observations at Beresfield. Weighting factors of 1 were used for both the overall weighting and wind direction weighting.

Further details regarding the meteorological conditions near the proposal are provided in **Section 4.2**.

3.4.4 Dispersion modelling

The changes in the air pollutant concentrations for each assessment scenario have been predicted over a 15 kilometre by 15 kilometre region using GRAL (Version 20.01). GRAL is a Lagrangian particle model that was developed at the Graz University of Technology, Austria. It is most commonly used for predicting air quality across road networks. Pollutant concentrations are predicted by simulating the movement of individual particles in a three-dimensional wind field. The trajectory of each of the particles is determined by mean and random velocity components.

GRAL simulates dispersion for all prescribed meteorological situations. Typically between 500 and 600 different meteorological situations are sufficient to characterise the dispersion conditions in an area during all 8760 hours of a year. The model is fully described in the user manual (Öttl and Kutner, 2020).

The modelling was performed using the emission estimates from **Section 3.4.2** and using the meteorological information provided by the GRAMM model, described in **Section 3.4.3**. The model has been used in this study to predict air pollutant concentrations across a region of 15 kilometres by 15 kilometres. Model predictions were made at regular spaced (20 metres) grid points across the entire model domain.

Key model settings for GRAL are shown below in **Table 3.4**.

Table 3.4 Model input settings for GRAL

Parameter	Value
Model version	20.01
Model domain (MGA Zone 56)	Easting 370000-385000, Northing 6360000-6375000
Dispersion time (s)	3600
Particles per second	400
Surface roughness (m)	0.4 (overridden by two-dimensional land use data provided to GRAMM)
Latitude (degrees)	32.80 S
Horizontal grid resolution (m)	20
Number of horizontal slices	1

Model predictions were then compared with the air quality design criteria, previously discussed in **Section 2.4** Results have been tabulated for key sensitive receiver locations and contour plots have also been created to show the spatial distribution of model predictions. A low pass Gaussian filter has been applied to contour plots for averaging times of 24 hours or less to smooth some of the artefacts that arise from particle models that use random components.

Dispersion modelling has inherent uncertainties. The key sources of uncertainty in this assessment relate to the input traffic data, emission factors and the ability of the model to reproduce atmospheric conditions. In practice, this uncertainty cannot be reliably calculated for air quality modelling due to the nature of the key sources. However, the uncertainty has been managed by adopting conservative approaches where possible. These approaches have included the selection of maximum or near maximum background levels, season maximum emission factors and, in the case of hydrocarbons, maximum assumed speciation percentages. In addition, four assessment scenarios have been considered in order to identify the variability of model predictions.

The existing environment has first been characterised (**Section 4**) and then an assessment of the proposal has been made (**Section 5**).

4. Existing environment

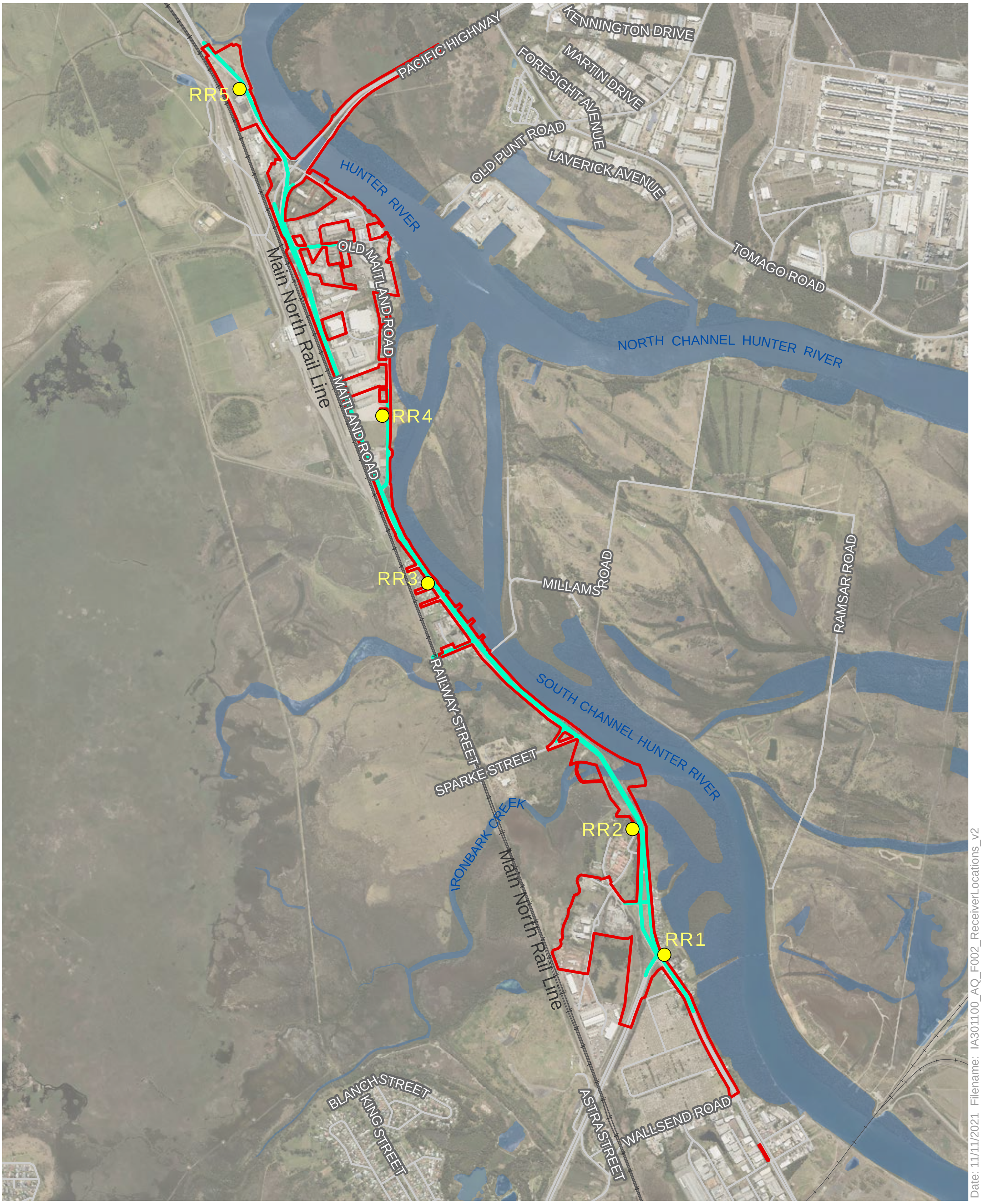
4.1 Local setting

Land around the proposal is used for several purposes. These include residential, aged care, commercial and industrial (including heavy and passenger rail) and existing roads. There are also environmentally significant areas located nearby including Hunter Wetlands National Park, Hexham Swamp Nature Reserve, two areas of Ramsar listed wetlands including Kooragang Nature Reserve and Shortland Wetlands (including Hunter Wetlands Centre Australia), areas of Coastal Wetlands listed under the CM SEPP, Ironbark Creek and the Hunter River.

The receiver locations listed in **Table 4.1** and displayed in **Figure 4.1** represent a range of sensitive receivers around the proposal. The proximity of these receivers to the proposal also means that these locations would be expected to experience the highest potential air quality impacts. These locations have been used as the basis for summarising worst-case potential impacts during the operational phase of the proposal.

Table 4.1 Representative receivers

ID	Locality	Type	Location UTM MGA Zone 56	
			Easting (m)	Northing (m)
RR1	Receivers along Pacific Highway near the intersection with Newcastle inner City Bypass, Sandgate	Residential	378916	6363092
RR2	Aged care receivers along Old Maitland Road, Sandgate	Aged care	378739	6363791
RR3	Residential receivers along the Pacific Highway between Shamrock street and north of Clark Street, Hexham	Residential	377601	6365158
RR4	Residential receivers along Old Maitland Road, Hexham	Residential	377348	6366090
RR5	Residential receivers along the New England Highway north of the Pacific Highway intersection	Residential	376554	6367907



Legend

- Construction area
- Representative receiver
- Project road / adjoining side road
- Waterway
- Road
- Railway

0 200 400 m
Scale 1:30,000 at A4
GDA94 MGA56

RAYMOND TERRACE
BLACK HILL
HEXHAM
NEWCASTLE

Data sources:
Jacobs 2020
NSW Spatial Services 2020

Figure 4.1 Representative receiver locations

4.2 Meteorological conditions

Meteorological conditions are important for determining the direction and rate at which emissions from a source would disperse. The key meteorological requirements of air dispersion models are, typically, hourly records of wind speed, wind direction, temperature and atmospheric stability. For air quality assessments, a minimum of one year of hourly data is usually required, which means that almost all possible meteorological conditions, including seasonal variations, are considered in the model simulations.

The NSW EPA has prescribed the minimum requirements for meteorological data that are to be used in dispersion modelling. These requirements are outlined in the Approved Methods and state that at least one year of ‘site-specific’ data should be used. If ‘site-specific’ data are not available then ‘site-representative’ data, correlated against at least five years of data, are acceptable. The meteorological data must also be at least 90 per cent complete. Although the Approved Methods do not specifically apply to road projects, this guidance was appropriate to use for this assessment to establish representative meteorological data suitable for air dispersion modelling.

Meteorological data collected over five recent years (2015 to 2019 inclusive) from DPIE’s Beresfield monitoring station located about four kilometres to the northwest of the proposal have been analysed in order to identify a representative year for the assessment. Hourly records of wind speed and wind direction were examined. The process for identifying a representative meteorological year involved comparing statistics and wind patterns for each calendar year.

Table 4.2 shows a range of statistics from the data collected at the DPIE Beresfield meteorological and air quality monitoring station from 2015 to 2019. These data show that the wind speed statistics do not vary significantly from year to year.

Table 4.2 Annual statistics from meteorological data collected at DPIE’s Beresfield meteorological and air quality monitoring station between 2015 and 2019

Statistic	2015	2016	2017	2018	2019
Per cent complete (%)	99	98	85	100	99
Mean wind speed (m/s)	2.5	2.8	2.3	2.4	2.4
99th percentile wind speed (m/s)	9.6	11.2	8.9	9.8	10.2
Percentage of calms (%)	4.0	4.2	4.0	4.9	4.7
Percentage of winds >6 m/s (%)	5.9	9.9	3.8	5.1	6.5

Figure 4.2 shows the annual wind patterns for each year from 2015 to 2019, based on data collected at Beresfield. It can be seen from these wind roses that the most common winds in the area are from the west-northwest. This pattern of winds is common for the Lower Hunter Valley and reflects the influence of the northwest to southeast alignment of the Hunter Valley. It is also clear from **Figure 4.2** that wind patterns were similar in all five years of data presented. This suggests that wind patterns do not vary significantly from year to year, and potentially the data from any of the years presented could be used as a representative year for modelling purposes.

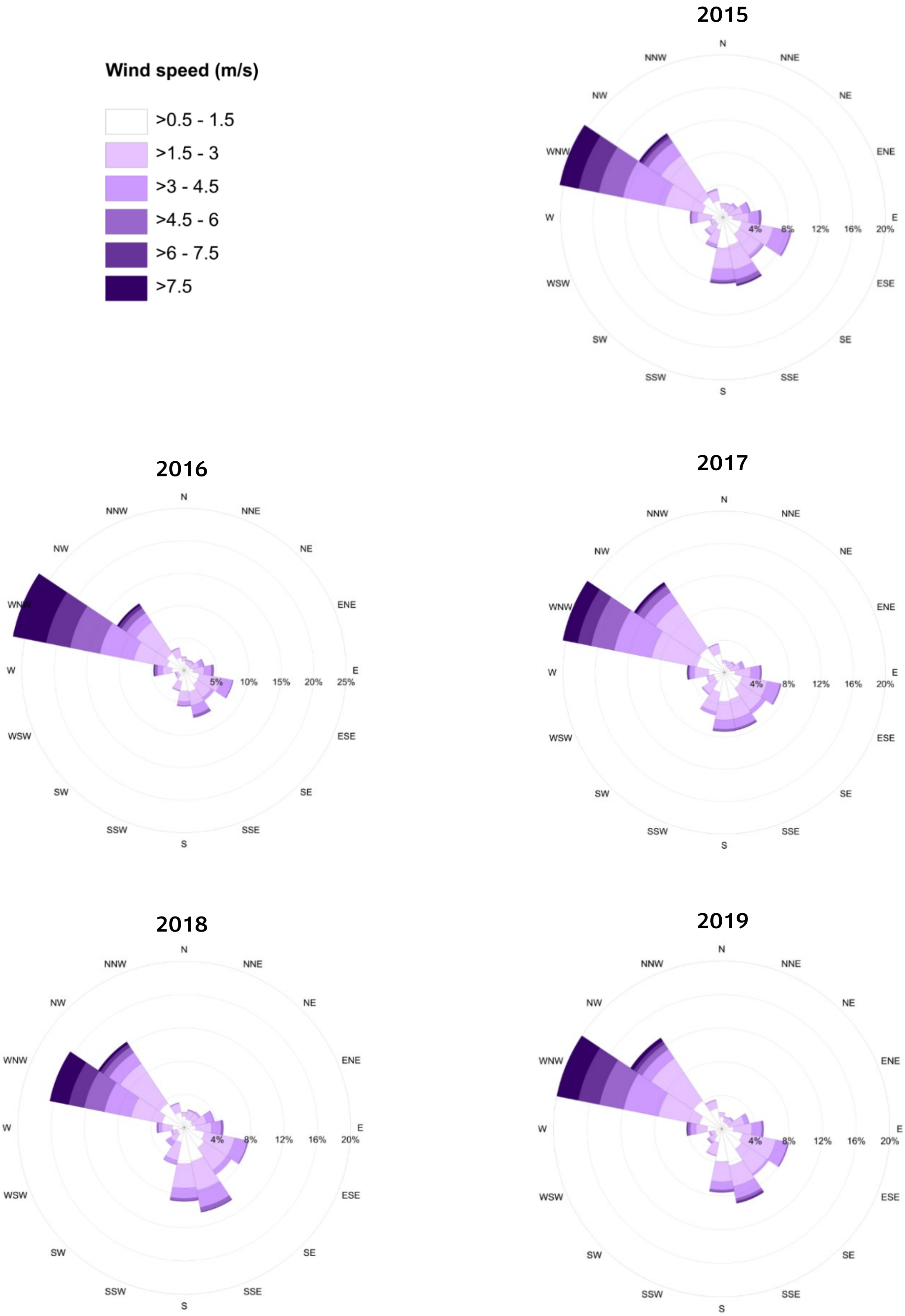


Figure 4.2 Annual wind-roses for data collected at DPIE’s Beresfield meteorological and air quality monitoring station

4.3 Air quality conditions

4.3.1 Overview

The DPIE has established a network of monitoring stations across NSW to understand current air quality conditions and impacts, and to help identify programs to improve air quality. The closest air quality monitoring station to the area of interest is located at Beresfield. Data from this station have been examined and compared to relevant impact assessment criteria in order to understand the existing air quality conditions for the key pollutants that are relevant to the proposal.

Table 4.3 identifies the parameters that are measured at the Beresfield meteorological and air quality monitoring station. Carbon monoxide is not measured at the Beresfield meteorological and air quality monitoring station, so these records were obtained from the next nearest station, Newcastle, located approximately 14 kilometres to the southeast of the proposal.

Table 4.3 Measured parameters at nearby DPIE monitoring stations

Station	Distance from proposal	Measured parameters
DPIE Beresfield	4 kilometres	Meteorology, NO_2, PM_{10}, $PM_{2.5}$
DPIE Newcastle	9 kilometres	Meteorology, CO, NO_2, PM_{10}, $PM_{2.5}$

As for meteorological data, data completeness is important for ambient air quality records with 90 per cent completeness preferred. **Table 4.4** shows the data capture rates based on hourly records for the pollutants listed in **Table 4.3**. Data capture was more than 90 per cent in all cases except for CO in 2015.

Table 4.4 Summary of air quality monitoring data completeness

Parameter	2015	2016	2017	2018	2019
CO (Newcastle)	89	94	93	92	91
NO_2 (Beresfield)	94	94	94	93	90
PM_{10} (Beresfield)	98	99	99	99	99
$PM_{2.5}$ (Beresfield)	93	94	94	91	91

Measurement data by pollutant are discussed further in the following sections.

4.3.2 Carbon monoxide (CO)

As noted above, the nearest monitoring station that measures CO is located at Newcastle. **Table 4.5** below provides a summary of CO concentrations measured at Newcastle from 2015 to 2019.

Table 4.5 Summary of measured CO concentrations at DPIE's Newcastle meteorological and air quality monitoring station

Statistic	Criterion	2015	2016	2017	2018	2019
Maximum 1-hour average in µg/m^3	30,000	2,000	2,400	1,600	1,400	2,200
Maximum 8-hour average in µg/m^3	10,000	1,700	1,600	1,300	1,200	1,700

These data listed in **Table 4.5** show that CO concentrations have been consistently below the relevant NSW EPA impact assessment criteria for each year.

4.3.3 Nitrogen dioxide (NO_2)

Table 4.6 below provides a summary of the measured NO_2 concentrations from the Beresfield monitoring station for the past five years.

Table 4.6 Summary of measured NO_2 concentrations at DPIE's Beresfield meteorological and air quality monitoring station

Statistic	Criterion	2015	2016	2017	2018	2019
Maximum 1-hour average in µg/m^3	246	92	77	75	75	105
Annual average in µg/m^3	62	17	15	16	17	15

These data show that NO_2 concentrations have been consistently below the relevant NSW EPA impact assessment criteria for each year.

The assessment has been based on the modelling of NO_x emissions however NO_2 is the pollutant of interest for comparison with the air quality criteria. It is therefore important to distinguish between total NO_x and NO_2 and it is useful to assess the likely fraction of NO_x that is converted to NO_2 at locations where maximum impacts may be expected to occur. The monitoring data provide some insight into this conversion.

Oxides of nitrogen are produced in most combustion processes. During high-temperature processes there will be a variety of NO_x formed including NO and NO_2. In general, at the point of emission, NO will comprise the greatest proportion of the total emission. Typically, this is approximately 90% by volume of the NO_x. The remaining 10 per cent will comprise mostly NO_2. It is the NO_2 which has been linked to adverse health effects. Over time, in the presence of ozone and sunlight, most of the NO_x converts to NO_2, but in general by the time this has occurred the NO_2 has been well dispersed to lower, less harmful concentrations.

At the point of maximum NO_x impacts from motor vehicle exhausts the time interval may be such that only a small fraction of the NO_x would be oxidised to NO_2. In many ambient NO_x monitoring programs the percentage of NO_2 in the NO_x is (as a rule) inversely proportional to the total NO_x concentration, and when NO_x concentrations as detected at monitoring stations are at their highest, the percentage of NO_2 in the NO_x is typically of the order of 20 per cent.

Data from the DPIE monitoring station at Beresfield show that the NO_2 to NO_x ratio decreases with increasing NO_x concentration. **Figure 4.3** plots the ratio of NO_2 to NO_x against total NO_x concentrations measured at Beresfield between 2015 and 2019, including the exponential fit. The average NO_2 to NO_x percentage from all data is 68 per cent. This percentage decreases with increasing NO_x concentrations and for the very highest NO_x concentrations (i.e. above 300 µg/m^3) the NO_2 concentration is less than 20 per cent. Since the operations modelling aims to predict maximum NO_x concentrations it has therefore been assumed that 20 per cent of the NO_x is NO_2 when assessing the maximum 1-hour average predictions. This method of determining NO_2 from NO_x predictions is referred to as the ambient air quality method.

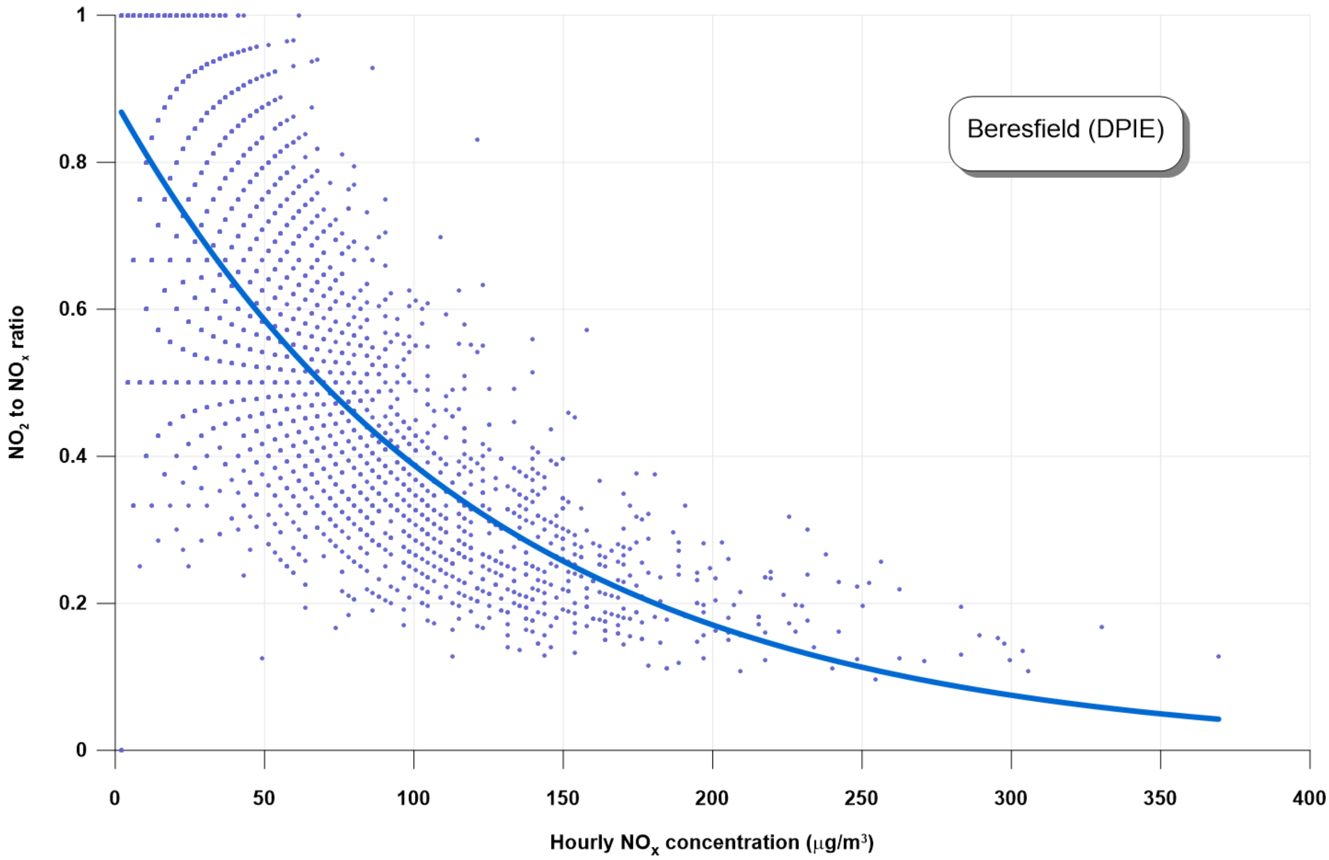


Figure 4.3 Measured NO_2 to NO_x ratios from hourly data collected at DPIE Beresfield meteorological and air quality monitoring station (2015 to 2019)

4.3.4 Particulate matter (PM_{10})

A time-series of 24-hour average PM_{10} concentrations data collected from the Beresfield meteorological and air quality monitoring station between 2015 and 2019 is displayed below in **Figure 4.4**. For reference, the NSW EPA's daily impact assessment criterion of 50 µg/m^3 is also displayed (red-dashed line).

The measurement data represent the contributions from all sources that have at some stage been upwind of the monitor. For example, the measured concentrations may contain emissions from many sources such as from mining activities, construction works, bushfires and 'burning off', industry, vehicles, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, domestic wood fires and so on.

From 2015 to 2019 there were multiple instances when the 24-hour average PM_{10} concentrations exceeded 50 µg/m^3. In their 'Annual Air Quality Statement 2018' the Office of Environment and Heritage (now DPIE) concluded that particle levels increased across NSW due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (OEH, 2019). Air quality conditions in the Lower Hunter region were clearly influenced by the drought conditions in 2017 and 2018 and lower than average rainfall. In addition, late 2019 coincided with a period of unprecedented bushfires in Australia, predominantly across southeast Australia. The bushfires adversely affected air quality across many parts of NSW including the Lower Hunter and these events are reflected in the data presented in **Figure 4.4** and in the summary statistics (**Table 4.7**).

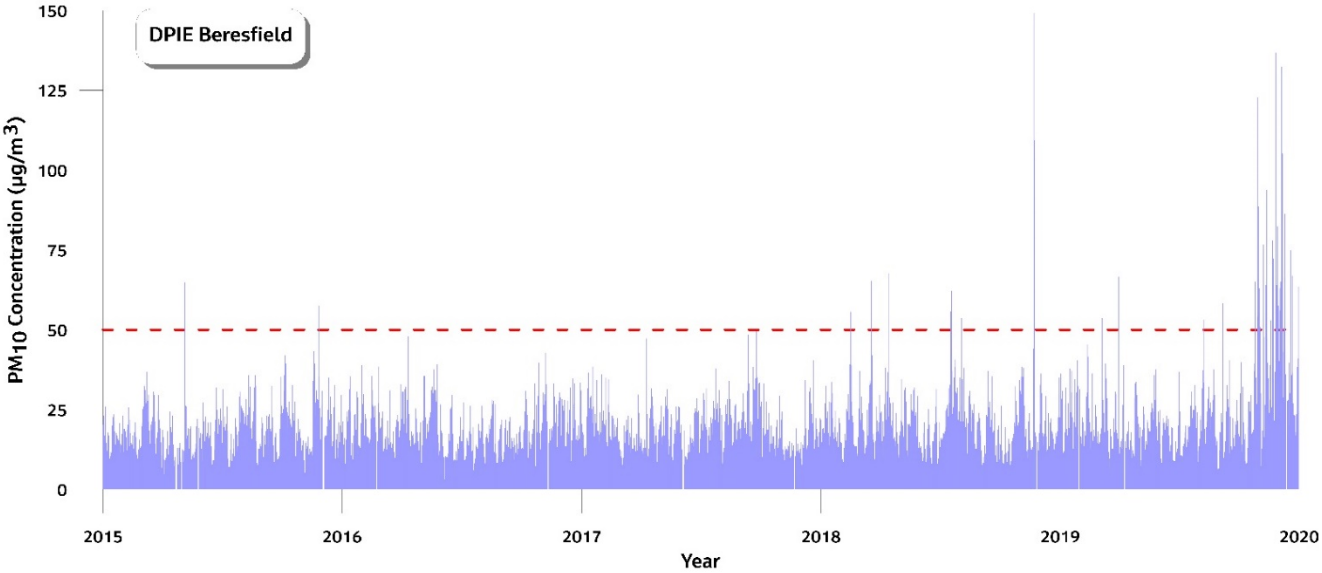


Figure 4.4 Measured 24-hour average PM_{10} concentrations at DPIE's Beresfield meteorological and air quality monitoring station

Table 4.7 Summary of measured PM_{10} concentrations at DPIE Beresfield

Statistic	Criterion	2015	2016	2017	2018	2019
Maximum 24-hour average in µg/m^3	50	65	48	49	149	137
Number of days above 50 µg/m^3	N/A	2	0	0	8	30
Annual average in µg/m^3	25*	19	19	20	22	26

NA = Not applicable (no criterion)

* Introduced by the NSW EPA from January 2017 onwards

4.3.5 Particulate matter ($PM_{2.5}$)

A time-series of 24-hour average $PM_{2.5}$ concentrations data collected from the Beresfield monitoring station between 2015 and 2019 is displayed below in **Figure 4.5**. The NSW EPA's 24-hour average $PM_{2.5}$ assessment criterion of 25 µg/m^3 is also displayed (red-dashed line).

There were multiple days from 2015 to 2019 when $PM_{2.5}$ concentrations exceeded the NSW EPA's impact assessment criterion (in this case 25 µg/m^3) with a higher frequency of exceedances also occurring in 2019 as a result of the bushfires. These outcomes are exhibited in the summary statistics (**Table 4.8**).

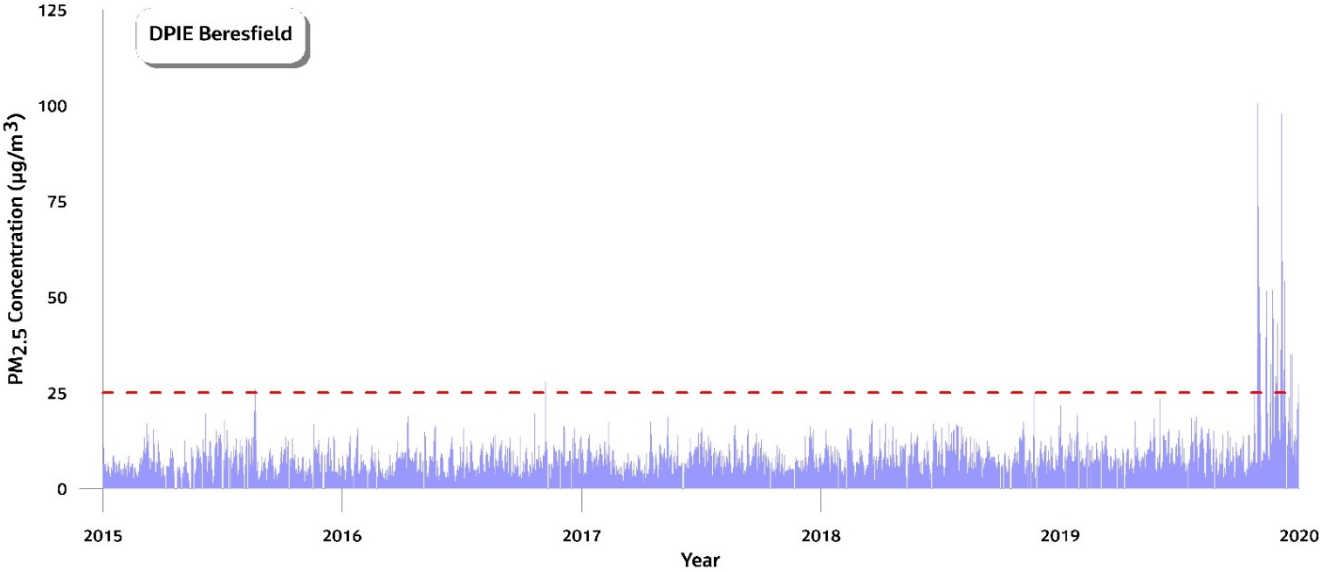


Figure 4.5 Measured 24-hour average $PM_{2.5}$ concentrations at DPIE's Beresfield meteorological and air quality monitoring station

Table 4.8 Summary of measured $PM_{2.5}$ concentrations at DPIE Beresfield

Statistic	Criterion	2015	2016	2017	2018	2019
Maximum 24-hour average in µg/m^3	25*	26	28	19	25	101
Number of days above 25 µg/m^3	NA	1	1	0	0	23
Annual average in µg/m^3	8*	7.4	7.4	7.6	8.7	12.2

NA = Not applicable (no criterion)

* Introduced by the NSW EPA from January 2017 onwards

4.3.6 Summary of existing environment

The following conclusions have been made from the review of local meteorological and ambient air quality monitoring data:

- Wind patterns in the vicinity of the proposal are characteristic of the Lower Hunter Valley, with the prevailing winds being from the west-northwest
- Measured CO and NO_2 concentrations have been consistently below NSW EPA air quality impact assessment criteria
- NO_2 concentrations are typically 68 per cent of the total NO_x concentrations, on average. However, the NO_2 percentage decreases with increasing NO_x concentrations and for the very highest NO_x concentrations the NO_2 concentration is less than 20 per cent
- Particle levels (as PM_{10} and $PM_{2.5}$) will be influenced by many sources including mining activities, construction works, bushfires and 'burning off', industry, vehicles, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, and domestic wood fires. Concentrations increased across NSW from 2017 to 2019 due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (OEH 2019). These events adversely influenced air quality with multiple days observed when PM_{10} and $PM_{2.5}$ concentrations exceeded NSW EPA criteria.

Meteorological data from the 2016 calendar year were used for the modelling, based on data completeness, and being a representative year that was not adversely impacted by bushfires and dust storms.

Background air quality measurement data for relevant key pollutants were also reviewed. All years met the 90 per cent target for data completeness, except CO in 2015. The review highlighted that drought and bushfires had adversely influenced air quality between 2017 and 2019 but particularly in late 2019. The 2019 calendar year was an extraordinary year with regards to background air quality and cannot be considered as representative.

One of the objectives for reviewing the air quality monitoring data was to determine appropriate background levels to be added to model predictions for the assessment of potential cumulative impacts, that is, due to all existing and potentially modified sources of air pollutants. For this objective, it was necessary to estimate background levels that apply at sensitive receivers.

Table 4.9 shows the assumed background levels that apply in the vicinity of the proposal. The justification for these background levels is also provided, with conservative approaches adopted in most instances.

Table 4.9 Assumed background levels in the vicinity of the proposal

Pollutant	Averaging time	Assumed background level	Notes	NSW EPA Impact assessment criteria
CO	1-hour	2,400 µg/m³	Maximum 1-hour concentration from Newcastle (2015 to 2019)	30,000 µg/m³
	8-hour	1,700 µg/m³	Maximum 8-hour concentration from Newcastle (2015 to 2019)	10,000 µg/m³
NO_2	1-hour	105 µg/m³	Maximum 1-hour concentration from Beresfield (2015 to 2019)	246 µg/m³
	Annual	17 µg/m³	Highest annual concentration from Beresfield (2015 to 2019)	62 µg/m³
PM_{10}	24-hour	48 µg/m³	Maximum 24-hour average in 2016 (2017 to 2019 were excluded due to drought, dust storms and bushfires)	50 µg/m³
	Annual	22 µg/m³	Highest annual concentration from Beresfield (2015 to 2018)	25 µg/m³
$PM_{2.5}$	24-hour	28 µg/m³	Maximum 24-hour average in 2016 (2017 to 2019 were excluded due to drought, dust storms and bushfires)	25 µg/m³
	Annual	8.7 µg/m³	Highest annual concentration from Beresfield (2015 to 2018)	8 µg/m³

5. Impact assessment

5.1 Construction impacts

5.1.1 Overview

The key air quality issue during construction of the proposal would be dust. Dust emissions from construction works have the potential to cause nuisance impacts if not properly managed. Air quality impacts during construction would largely result from vegetation clearing, topsoil stripping, lime stabilisation of soils and lime neutralisation of acid sulphate soils, demolition of redundant assets, stockpiling of soil, and general material handling.

The total amount of dust generated would depend on the quantities of material handled, silt and moisture content of the soil, the types of operations being carried out, exposed areas, frequency of water spraying and speed of vehicles and machinery operating on unpaved roads and areas. The detailed approach to construction would depend on decisions made by the successful contractor(s), and changes to the construction methods and sequences that are expected to take place during the construction phase.

During construction, various materials would need to be handled including topsoil, mulch, cut and fill, pavement, and concrete. The handling of these materials has the potential to generate dust. Equipment is anticipated to include excavators and backhoes, concrete trucks, tipper trucks, cranes, compressors for pneumatic equipment, generators, staff vehicles, fuel for equipment, machinery and vehicles, asphalt paver and profilers, and water carts. The number and type of equipment would vary depending on the development activity being carried out.

In practice, it is not possible to realistically quantify impacts using dispersion modelling. To do so would require knowledge of weather conditions for the period in which work would be taking place in each location on the site. However, it would be important that exposed areas be stabilised as quickly as possible and that appropriate dust measures are implemented to keep dust impacts to a minimum.

The semi-quantitative method developed by the IAQM was used to assess the potential for dust impacts during the construction phase of the proposal. This method aims to identify a dust risk for the entire proposal in accordance with the four steps identified in **Section 3.3** and shown in **Figure 3.2**.

The findings of the four steps of the construction assessment are presented in the following sections.

5.1.2 Step 1 (Screening review)

Step 1 of the IAQM assessment method involves a screening review to confirm the presence of human and ecological receptors within the vicinity of a proposal. The IAQM considers human receivers as any location where people spend some period of time and where property may be impacted by dust, and ecological receivers as any ecological areas that might be sensitive to dust impacts. This definition is considered to include threatened ecological communities, as well as ecologically sensitive commercial developments. The intent of this step is to identify whether there are human and ecological receivers nearby which have the potential to be impacted by the proposed work. The IAQM advises a study area of 350 metres from the boundary of the site or within 500 metres of site egress points for human receivers, and 50 metres from the boundary of the site or within 500 metres of site egress points for ecological receivers.

As described in **Section 4.1**, there are many human and ecological receivers located within the setback distances above from the construction footprint of the proposal. As such, it was determined that the next stages of the assessment would be required.

5.1.3 Step 2 (Risk assessment)

The second step in the IAQM methodology involves evaluating the risk of dust impacts during construction. This step is further divided into three steps which are described in the following sections.

Step 2A (potential for dust emissions)

Step 2A involves the estimation of the magnitude of potential dust emissions associated with the proposal construction activities. The method for evaluating the magnitude of potential emissions considers the scale and nature of the anticipated activities. The objectives used to classify the magnitude of dust emissions arising from demolition, earthworks, construction and trackout activities from the IAQM method have been reproduced in **Table 5.1**. Colour-coding was added in **Table 5.1** as well as subsequent tables for ease of interpretation of the results. 'Orange' shading was added for large or high classifications or ratings, with 'yellow' and 'green' shading applied for medium and low or small classifications and ratings respectively.

Table 5.1 IAQM Step 2A (objectives for classifying the magnitude of potential dust emissions)

Activity	Potential dust emission magnitude classification		
	'Large'	'Medium'	'Small'
Demolition	Large – Total building volume greater than 50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities greater than 20 metres above ground level	Medium – Total building volume 20,000 to 50,000 m^3, potentially dusty construction material, demolition activities 10 to 20 metres above ground.	Small – Total building volume less than 20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities less than 10 metres above ground, demolition during wetter months.
Earthworks	Large – Total site area greater than 10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), more than 10 heavy earth moving materials active at any one time, formation of bunds greater than eight metres in height, total materials moved exceeding 100,000 tonnes.	Medium – Total site area between 2500 and 10,000 m^2, moderately dusty soil type (e.g. silt), five to 10 heavy earth moving vehicles active at any one time, formation of bunds four to eight metres in height, total material moved between 20,000 and 100,000 tonnes.	Small – Total site area less than 2500 m^2, soil type with large grain size (e.g. sand), less than five heavy earth moving vehicles active at any one time, formation of bunds less than four metres in height, total materials moved less than 20,000 tonnes, earthworks during wetter months.
Construction	Large – Total building volume greater than 100,000 m^3, on-site concrete batching, sandblasting	Medium – Total building volume between 25,000 and 100,000 m^3, potentially dusty construction material (e.g. concrete), on-site concrete batching plant.	Small – Total building volume less than 25,000 m^3, construction material with a low potential for dust release (e.g. metal cladding or timber).
Trackout	Large – More than 50 heavy vehicle movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road lengths greater than 100 metres.	Medium – 10 to 50 heavy vehicle movements in any one day, moderately dusty surface (e.g. high clay content), unpaved road length between 50 and 100 metres.	Small – Less than 10 heavy vehicle movements in any one day, surface material with low potential for dust release, unpaved road length less than 50 metres.

Source: UK IAQM, 2014

Using the descriptions of proposed construction activities for the proposal outlined in Chapter 5 of the EIS, potential dust emission magnitude classifications were developed for the proposal. These are listed in **Table 5.2**.

Table 5.2 Dust emission magnitude classifications determined for the proposal

Construction impact area	Activity	Potential dust emission magnitude classification
Northern study area	Demolition	Medium
	Earthworks	Medium
	Construction	Medium
	Trackout	Large
Southern study area	Demolition	Medium
	Earthworks	Medium
	Construction	Medium
	Trackout	Large

Step 2B (sensitivity of surrounding local environment)

Step 2B involves the evaluation of the sensitivity of the receiving environment around the construction footprint. Classification of the sensitivity of these receiver areas considered:

- The specific sensitivities of receptors in the area
- The proximity and number of nearby receivers
- Local background air quality conditions characterised based on PM_{10} concentrations
- Site-specific factors such as whether there are natural shelters, to reduce the risk of wind-blown dust (UK IAQM, 2014).

The IAQM method considers how sensitive surrounding receiver areas may be to the effects of dust soiling, human health, and ecosystem impacts. Guidance on how the sensitivity of the receiving environment to these different dust effects were classified is listed in **Table 5.3**.

Table 5.3 IAQM receiver sensitivity classifications

Receiver sensitivity	Classification		
	'Large'	'Medium'	'Low'
Sensitivity to dust soiling	High – Surrounding land where: ▪ Users can reasonably expect enjoyment of a high level of amenity ▪ The appearance, aesthetics or value of a property would be diminished by soiling ▪ The people or property would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land.	Medium – Surrounding land where: ▪ Users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home ▪ The appearance, aesthetics or value of a property could be diminished by soiling ▪ The people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the	Low – Surrounding land where: ▪ The enjoyment of amenity would not reasonably be expected ▪ Property would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling ▪ There is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land.

Receiver sensitivity	Classification		
	'Large'	'Medium'	'Low'
	Indicative examples include dwellings, museums and other culturally important collections, medium and long-term car parks and car show rooms.	normal pattern of use of the land. Indicative examples include parks and places of worship.	Indicative examples include playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short-term car parks and roads.
Sensitivity to human health impacts	High: Locations where members of the public are exposed over a time period relevant to the air quality criteria for PM_{10}. Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purpose of this assessment.	Medium: Locations where the people exposed are workers, and exposure is over a time period relevant to the air quality criteria for PM_{10}. Indicative examples include office and shop workers but will generally not include workers occupationally exposed to PM_{10}, as protection is covered by relevant Health and Safety legislation.	Low: Locations where human exposure is transient. Indicative examples include public footpaths, playing fields, parks and shopping streets.
Sensitivity to ecological effects	High: Locations with an international or national designation and the designated features may be affected by dust soiling. Locations where there is a community of particularly dust sensitive species	Medium: Locations where there is particularly important plant species, where dust sensitivity is uncertain or unknown. Locations with a national or state designation where the features may be affected by dust deposition.	Low: Locations with a local designation where the features may be affected by dust deposition.

Source: UK IAQM, 2014

The techniques used to determine the respective sensitivities of nearby receivers to these effects have been reproduced in **Table 5.4**, **Table 5.5** and **Table 5.6**. In **Table 5.5** it is noted that the annual PM_{10} background concentration adopted for the assessment was 22 μg/m^3, as was determined from monitoring data for the local environment around the proposal (**Section 4.3**).

Table 5.4 IAQM Step 2B (method for determining sensitivity of receiving area to dust soiling effects)

Receiver sensitivity	Approximate number of receivers	Distance of receivers from the source (m)			
		Less than 20 m	20 to 50 m	50 to 100 m	100 to 350 m
High	More than 100	High	High	Medium	Low
	10 to 100	High	Medium	Low	Low
	1 to 10	Medium	Low	Low	Low

Receiver sensitivity	Approximate number of receivers	Distance of receivers from the source (m)			
		Less than 20 m	20 to 50 m	50 to 100 m	100 to 350 m
Medium	More than 1	Medium	Low	Low	Low
Low	More than 1	Low	Low	Low	Low

Source: UK IAQM, 2014

Table 5.5 IAQM Step 2B (method for determining sensitivity of receiving area to human health impacts)

Receiver sensitivity	Average PM_{10} concentration [a]	Approximate number of receivers	Distance of receivers from the source (m)				
			< 20 m	20 to 50	50 to 100	100 to 200	200 to 350
High	> 20 µg/m^3	More than 100	High	High	High	Medium	Low
		10 to 100	High	High	Medium	Low	Low
		1 to 10	High	Medium	Low	Low	Low
Medium	> 20 µg/m^3	More than 10	High	Medium	Low	Low	Low
		1 to 10	Medium	Low	Low	Low	Low
Low	-	More than 1	Low	Low	Low	Low	Low

Source: UK IAQM, 2014.

[a] scaled for proposal according to the ratio of NSW and UK annual average PM_{10} standards (25 µg/m^3 and 40 µg/m^3 respectively)

Table 5.6 IAQM Step 2B (method for determining sensitivity of receiving area to ecological impacts)

Receiver sensitivity	Distance of receivers from the source (m)	
	< 20 m	20 to 50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Source: UK IAQM, 2014.

The following dust soiling, human health, and ecological area sensitivity classifications were developed from application of the method outlined above and land use mapping around the proposal.

Sensitivity to dust soiling impacts

Potentially sensitive receivers and land uses would include residential, commercial, educational, medical, place of worship, sporting venues. The 'receiver sensitivity' to dust soiling near all construction areas was therefore determined to be high based on the definitions in **Table 5.3**. The number of high sensitivity human receiver locations were counted by mapping and, using the guidance in **Table 5.4**, the following dust soiling sensitivity ratings were determined (**Table 5.7**). In this context a human receiver is a location that may be affected by dust emissions.

Table 5.7 Results for sensitivity of areas to dust soiling effects

Construction impact area	Receiver sensitivity	Number of receivers by distance from the source (m)				Sensitivity to dust soiling impacts of area
		< 20 m	20 to 50 m	50 to 100 m	100 to 350 m	
Northern study area	High	10 to 100	1 to 10	1 to 10	1 to 10	High
Southern study area	High	10 to 100	10 to 100	10 to 100	10 to 100	High

Source: UK IAQM, 2014.

Given the density of receivers within 20 and 50 metres of the proposal, receiver sensitivity to dust soiling from construction activities was determined to be 'high'.

Sensitivity to human health impacts

For human health impacts, 'receiver sensitivity' was estimated based on the proximity and density of different types of receivers as outlined in **Table 5.3.** Using mapping, the number of high sensitivity human receiver locations were counted and using the guidance from **Table 5.5**, the human health sensitivity ratings in **Table 5.8** were determined.

Table 5.8 Results for sensitivity of areas to human health effects

Construction Impact Area	Receiver sensitivity	Number of receivers by distance from the source (m)				Sensitivity to dust soiling impacts of area
		< 20 m	20 to 50 m	50 to 100 m	100 to 350 m	
North	High	10 to 100	1 to 10	1 to 10	1 to 10	High
South	High	10 to 100	10 to 100	10 to 100	10 to 100	High

Source: UK IAQM, 2014.

As listed, the sensitivity of the surrounding environment to human health effects was also determined to be high given the density of receivers in closer proximity to the construction footprint.

Sensitivity to ecological impacts

Sensitivity of the receiving environment to ecological impacts was classified by reviewing the presence of any ecologically sensitive areas within 50 metres of construction areas, consistent with **Table 5.6**. A number of ecologically sensitive habitat areas are located within 20 metres of the proposal. On this basis, as displayed in **Table 5.9**, the ecological sensitivity around each construction area was determined to be 'high'.

Table 5.9 Results for sensitivity of areas to ecological impacts

Construction impact area	Receptor sensitivity	Distance from the source (m)	Ecological sensitivity of area
Northern study area	High	<20 m	High
Southern study area	High	<20 m	High

Summary

Table 5.10 summarises the receiver sensitivity ratings determined for dust soiling, human health effects and ecological impacts. It should be noted that the IAQM aims to identify the overall unmitigated risks of the whole proposal. That is, the outcomes presented below represent the worst case, unmitigated outcome.

Table 5.10 Surrounding receiver sensitivity classifications determined for the proposal

Construction impact area	Receptor sensitivity	Sensitivity rating
Northern study area	Dust soiling	High
	Human health impacts	High
	Ecological effects	High
Southern study area	Dust soiling	High
	Human health impacts	High
	Ecological effects	High

Step 2C – Evaluation of the risk of dust impacts

Potential dust emission magnitude ratings determined in Step 2A (**Table 5.2**) and the surrounding area sensitivity classifications determined in Step 2B (**Table 5.10**) were combined in Step 2C using the guidance below in **Table 5.11** to 'determine the risk of impacts with no mitigation applied' (UK IAQM, 2014).The highest unmitigated risk values determined for each dust-related risk (i.e. dust soiling, human health and ecological impacts) for each of the four types of construction activities are summarised in **Table 5.12**.

Table 5.11 IAQM Step 2C (method for determining unmitigated dust impact risks)

Sensitivity of area (from Step 2B)	Dust emission potential (from Step 2A)		
	Large	Medium	Small
Demolition			
High	High risk	Medium risk	Medium risk
Medium	High risk	Medium risk	Low risk
Low	Medium risk	Low risk	Negligible
Earthworks			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Low risk
Low	Low risk	Low risk	Negligible
Construction			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Low risk
Low	Low risk	Low risk	Negligible
Trackout			
High	High risk	Medium risk	Low risk
Medium	Medium risk	Medium risk	Negligible
Low	Low risk	Low risk	Negligible

Source: UK IAQM, 2014.

Table 5.12 Unmitigated construction dust risk values for the proposal

Construction impact area	Activity	Potential impact		
		Dust soiling	Human health impacts	Ecological effects
Northern study area	Demolition	Medium risk	Medium risk	Medium risk
	Earthworks	Medium risk	Medium risk	Medium risk
	Construction	Medium risk	Medium risk	Medium risk
	Trackout	High risk	High risk	High risk
Southern study area	Demolition	Medium risk	Medium risk	Medium risk
	Earthworks	Medium risk	Medium risk	Medium risk
	Construction	Medium risk	Medium risk	Medium risk
	Trackout	High risk	High risk	High risk

As presented in **Table 5.12**, the highest unmitigated risk rating determined for the proposal was 'high risk'. This was determined for dust soiling, human health and ecological effects during trackout activities. This outcome represents the worst case, unmitigated outcome across the whole proposal.

5.1.4 Step 3 (Mitigation and management)

As shown in **Table 5.12** a 'high' potential risk was the highest unmitigated level determined from the review of potential dust deposition, human health and ecological impacts from demolition, earthworks, construction and trackout activities during the proposal. Based on this result, the proposal was determined to present a 'high' risk of dust impacts during construction and measures commensurate to this level of risk have been recommended from guidance in the IAQM method. These are presented in **Section 6**.

5.1.5 Step 4 (residual risks)

It is anticipated that, with the application of the measures detailed in **Section 6**, residual risks from key activities during construction would be reduced to the extent where impacts could be effectively managed. Adverse residual impacts are therefore not anticipated during construction of the proposal.

5.1.6 Other air quality risks during construction

In addition to construction dust, there are a range of other potential air quality issues identified that have the potential to impact on sensitive receivers during construction. These include exhaust emission from the combustion of fossil fuels generated by equipment and construction plant, odours arising from uncovered contaminated and/or hazardous materials, and other airborne hazardous materials, which may be generated during demolition and excavation activities. Potential impacts from construction plant and equipment exhaust emissions are not anticipated, owing to the expected intensity of construction operations, setback distances from surrounding sensitive receivers, and the linear nature of the proposal. Regarding odours and airborne hazardous materials, there is potential for these effects to arise during demolition activities. These risks may also be present during excavation works, noting the presence of potentially contaminated soils and areas of illegal dumping within the construction study area.

Measures to effectively manage these risks as they are encountered are included in **Section 6**. Provided there is effective implementation of these measures, significant air quality impacts associated with exhaust emissions, odours, and airborne hazardous materials are not anticipated.

5.1.7 Summary of construction impacts to the REF area

The nearest receivers to the proposal and those selected as representative receivers for the air quality assessment are located within the REF area. The key potential air quality issues to sensitive receivers located in the REF area was identified as dust during construction of the proposal based on the results of the analysis undertaken using the IAQM method. Adverse residual impacts to sensitive receivers are not anticipated provided the recommended mitigation measures included in **Section 6** are implemented.

5.1.8 Summary of construction impact to the EIS area

There are no sensitive receivers located within the EIS area but there are ecological receivers. As such, air quality impacts within the EIS area during construction are expected to be minor and would mainly be associated with dust. Adverse residual impacts to ecological receivers are not anticipated provided the recommended mitigation measures included in **Section 6** are implemented.

5.2 Operation impacts

5.2.1 Overview

The potential operational impacts of the proposal have been quantified using dispersion modelling. Results from the modelling have been assessed by examining the spatial differences between with and without proposal scenarios, and also in terms of the potential for the proposal to cause exceedances of NSW EPA air quality impact assessment criteria at sensitive receivers. In this context, changes in air quality represent the difference between future scenarios with and without the proposal.

Air quality has been assessed at both a local scale (i.e. within a few hundred metres of the proposed route) and at a regional scale (i.e. across an area of 15 kilometres by 15 kilometres). Specific assessment of each key air quality indicator is provided below.

5.2.2 Carbon monoxide (CO)

Model predictions of 1-hour and 8-hour averaged CO concentrations for each scenario are presented in **Figure 5.1** and **Figure 5.2**, with the relative change between 2028 and 2038 proposal and no proposal scenarios shown in **Figure 5.3** and **Figure 5.4**. These results represent the contribution of emissions from the proposal and along adjoining side roads displayed in **Figure 3.2**. Background levels are not included in the contour plots but are discussed below with reference to **Table 5.13**.

Figure 5.1 Predicted maximum 1-hour average CO due to modelled sources

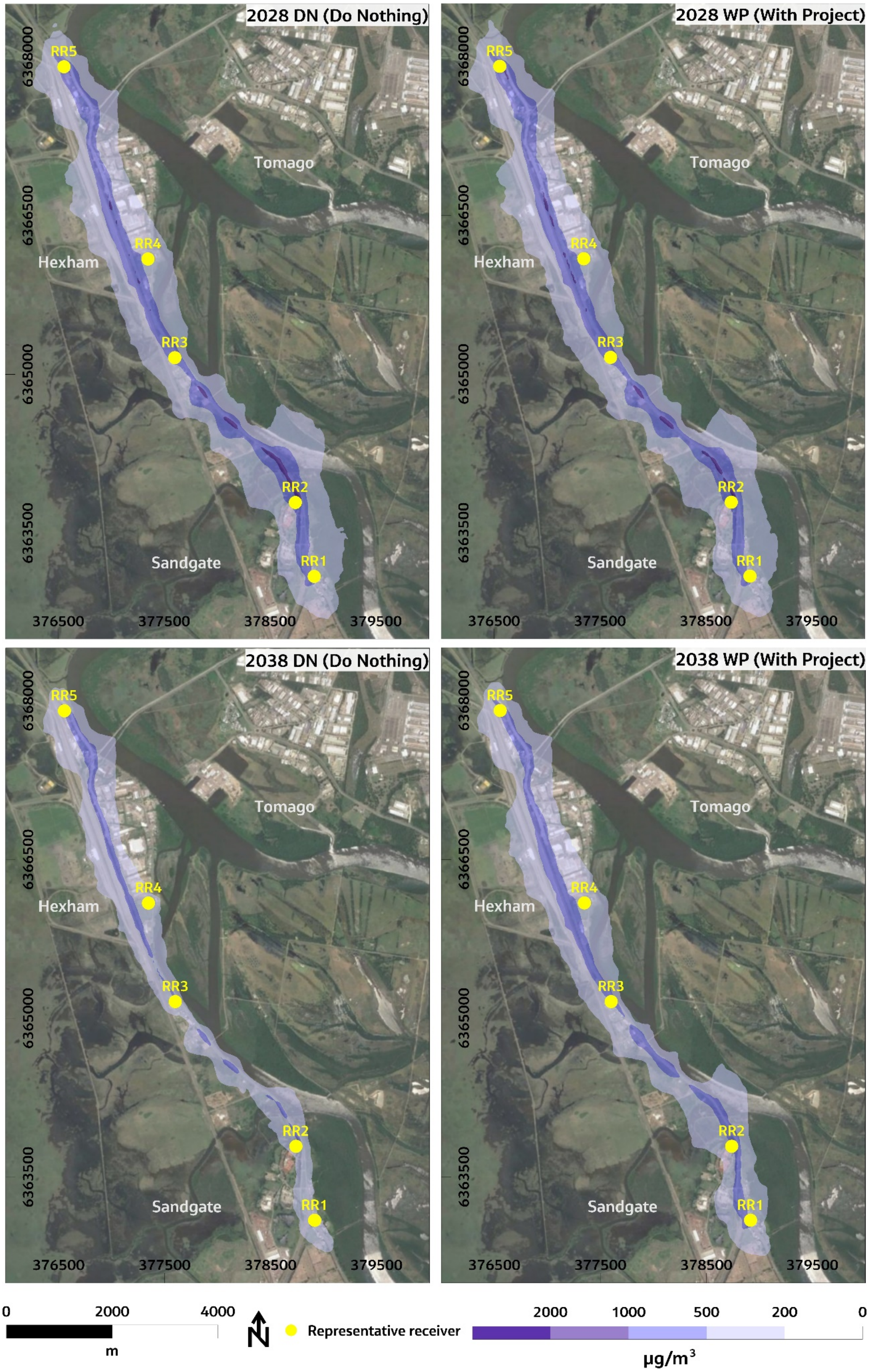


Figure 5.2 Predicted maximum 8-hour average CO due to modelled sources

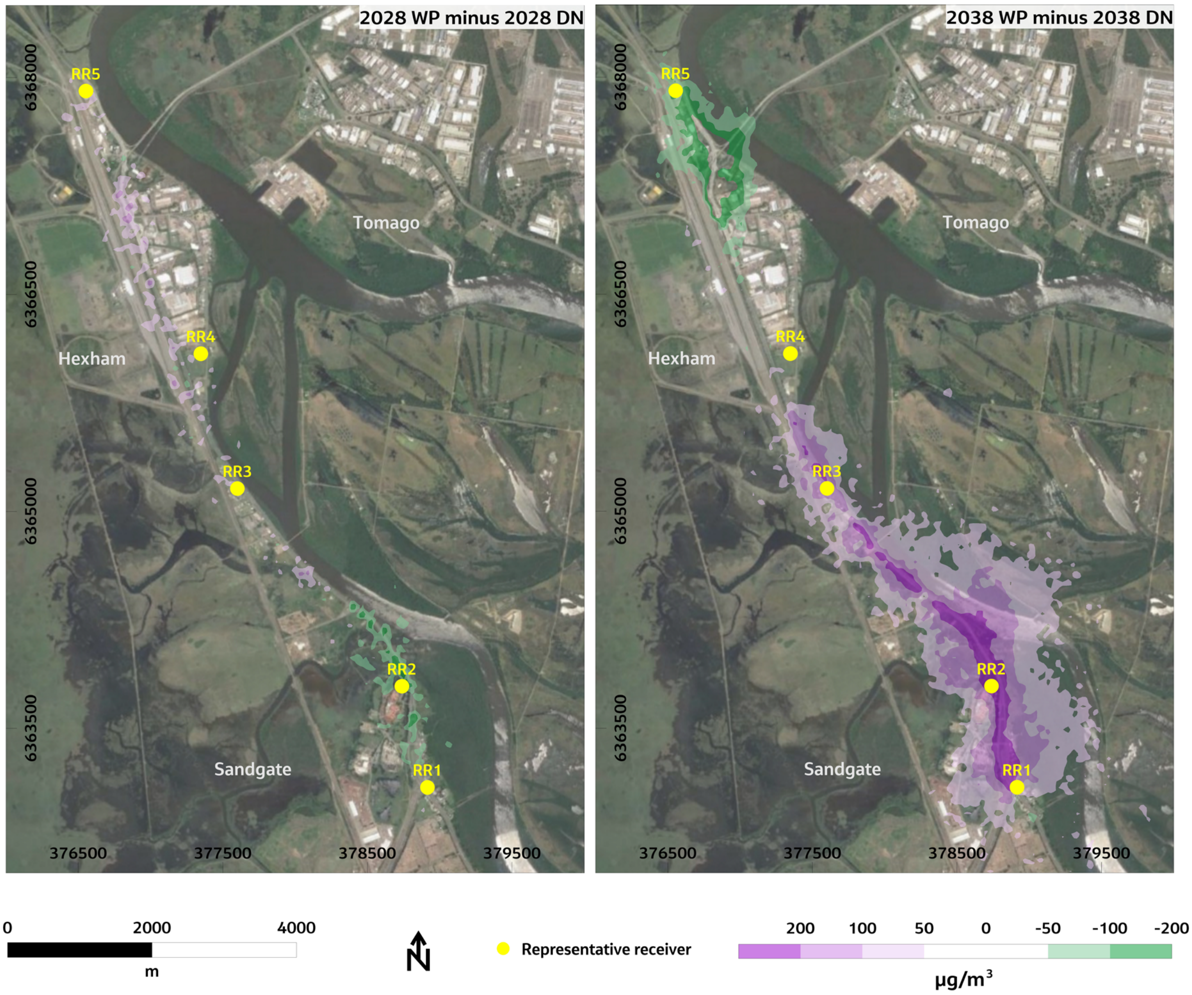


Figure 5.3 Predicted change in maximum 1-hour average CO

The model results in **Figure 5.1** and **Figure 5.2** indicate the following outcomes in terms of the spatial variations in CO:

- The highest 1-hour and 8-hour average CO concentrations are expected to occur close (i.e. within 20 metres) of the proposal

As a result of emission reductions from technological changes in the vehicle fleet, maximum 1-hour and 8-hour CO concentrations with and without the proposal generally improved in 2038 compared with 2028.

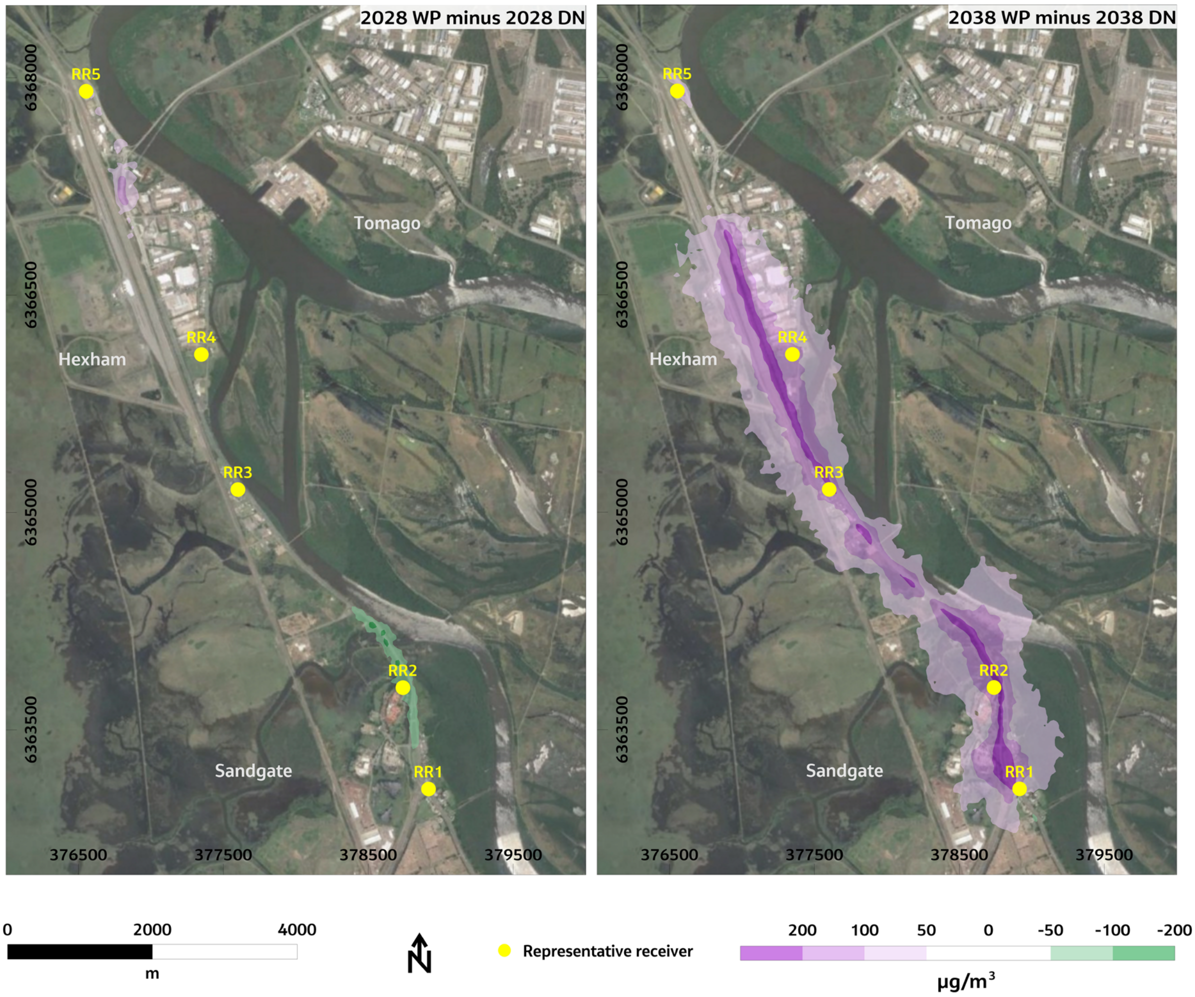


Figure 5.4 Predicted change in maximum 8-hour average CO

Table 5.13 provides a summary of the model results for key sensitive receivers, where maximum impacts may be expected. These data show the contribution of modelled sources, the background levels, the predicted change in road contributions, as well as cumulative (i.e. concentration of background level plus the increment of the project relative to the scenario without the proposal) over the two assessment timescales (i.e. 2028 year of opening and 2038, 10 years after opening).

Table 5.13 Predicted CO concentrations at selected sensitive receivers

Representative receiver	Cumulative criterion	Concentration due to modelled road sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2038 WP		2028	2038	2028	2038
Maximum 1-hour average CO (µg/m³)										
RR1	30,000	611	598	531	687	2,400	-13	156	2,387	2,556
RR2		894	869	458	802		-25	344	2,375	2,744
RR3		853	933	611	775		80	164	2,480	2,564
RR4		511	509	466	463		-2	-3	2,398	2,397
RR5		935	962	833	744		27	-89	2,427	2,311

Representative receiver	Cumulative criterion	Concentration due to modelled road sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2038 WP		2028	2038	2028	2038
Maximum 8-hour average CO (µg/m^3)										
RR1	10,000	507	501	405	494	1,700	-6	89	1,694	1,789
RR2		755	700	342	534		-55	192	1,645	1,892
RR3		757	799	416	603		42	187	1,742	1,887
RR4		415	430	273	385		15	112	1,715	1,812
RR5		808	847	582	634		39	52	1,739	1,752

As **Table 5.13** shows, the predicted change in maximum 1-hour and 8-hour CO concentrations due to the project (both increases and decreases) represent less than two per cent of the respective NSW EPA air quality assessment criteria (30,000 µg/m^3 and 10,000 µg/m^3). The highest increase in maximum 1-hour and 8-hour averaged CO concentrations from the proposal at the identified representative receivers were 344 µg/m^3 and 192 µg/m^3 respectively. The predicted maximum changes in CO concentrations due to the project (both increases and decreases in 1-hour and 8-hour averages) are within the range of historically measured fluctuations in maximum CO concentrations for the region (see **Section 4.3.2**). Also as displayed, the highest cumulative 1-hour and 8-hour averaged CO concentrations at the identified representative receivers were 2,744 µg/m^3 and 1,892 µg/m^3 respectively; well below the EPA's 30,000 µg/m^3 and 10,000 µg/m^3 impact assessment criteria.

Considering the limited changes in road emissions between corresponding with and without proposal assessment scenarios and that the resulting cumulative levels remained below the EPA's impact assessment criteria, it was concluded that changes in CO emissions as a result of the proposal are unlikely to result in unacceptable impacts.

5.2.3 Nitrogen dioxide (NO_2)

Model predictions of NO_2 concentrations for each scenario are presented in **Figure 5.5** and **Figure 5.6**, with the relative change between 2028 and 2038 proposal and no proposal scenarios shown in **Figure 5.7**and **Figure 5.8**. These results represent the contribution of emissions from the proposal and along adjoining side roads displayed in **Figure 3.2**. Background levels are not included in the contour plots but are discussed below with reference to **Table 5.14**. As discussed in **Section 4.3.3**, the maximum 1-hour average NO_2 concentrations have been derived from the NO_x predictions by assuming that 20 per cent of the NO_x is NO_2 at the point of maximum concentrations. Annual average NO_2 concentrations have been derived by assuming the 100 per cent of the NO_x has converted to NO_2. This is a conservative approach since air quality monitoring data showed that 68 per cent of the NO_x is NO_2, on average (**Section 4.3.3**).

The model results in **Figure 5.5** and **Figure 5.6** indicate the following outcomes in terms of the spatial variations in NO_2:

- The highest 1-hour and annually averaged NO_2 concentrations are also expected to occur close (i.e. within 20 metres) of the proposal
- Higher relative contributions from the proposal in 2038 compared with 2028.

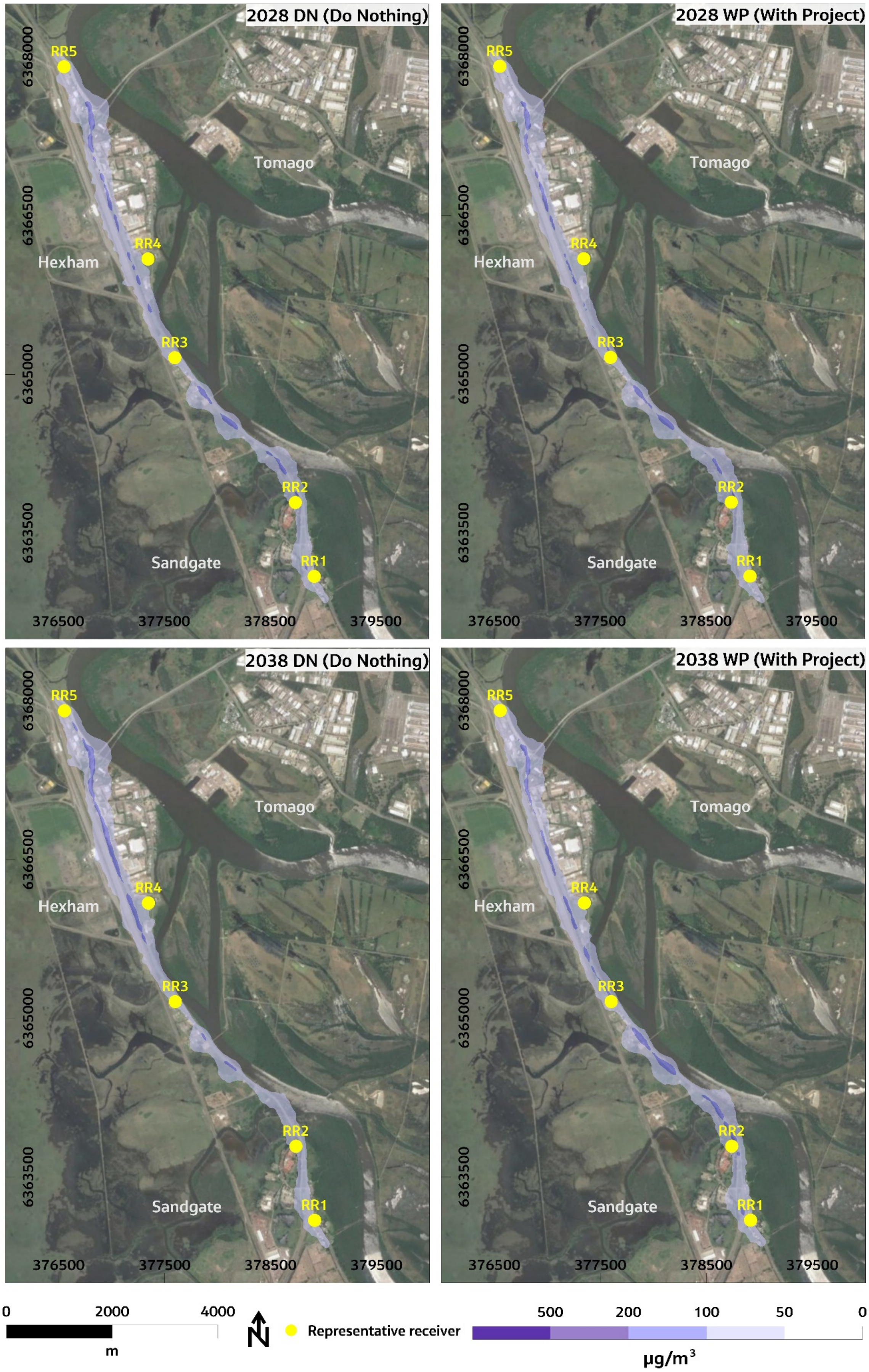


Figure 5.5 Predicted maximum 1-hour average NO_2 due to modelled sources

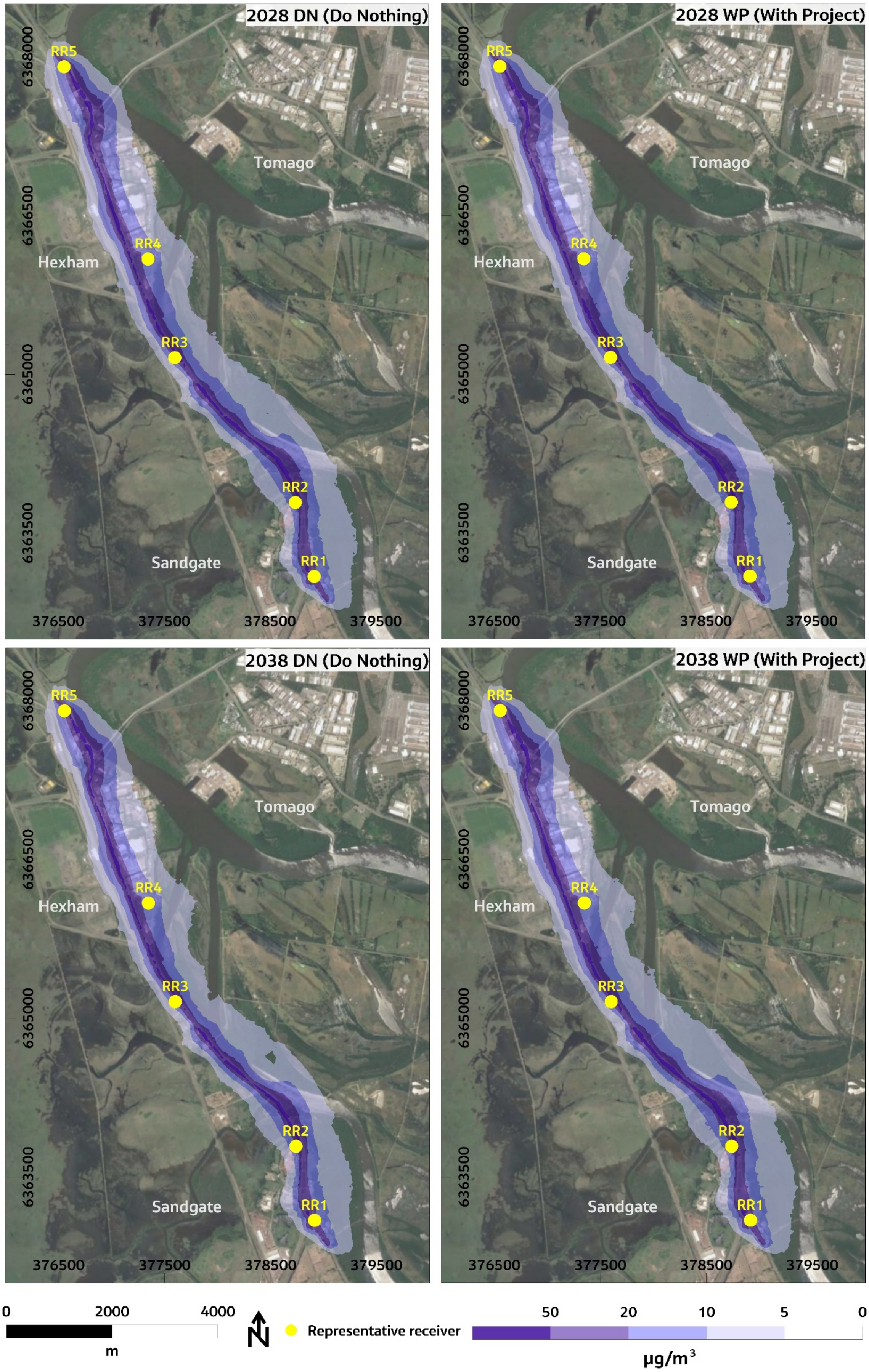


Figure 5.6 Predicted annual average NO_2 due to modelled sources

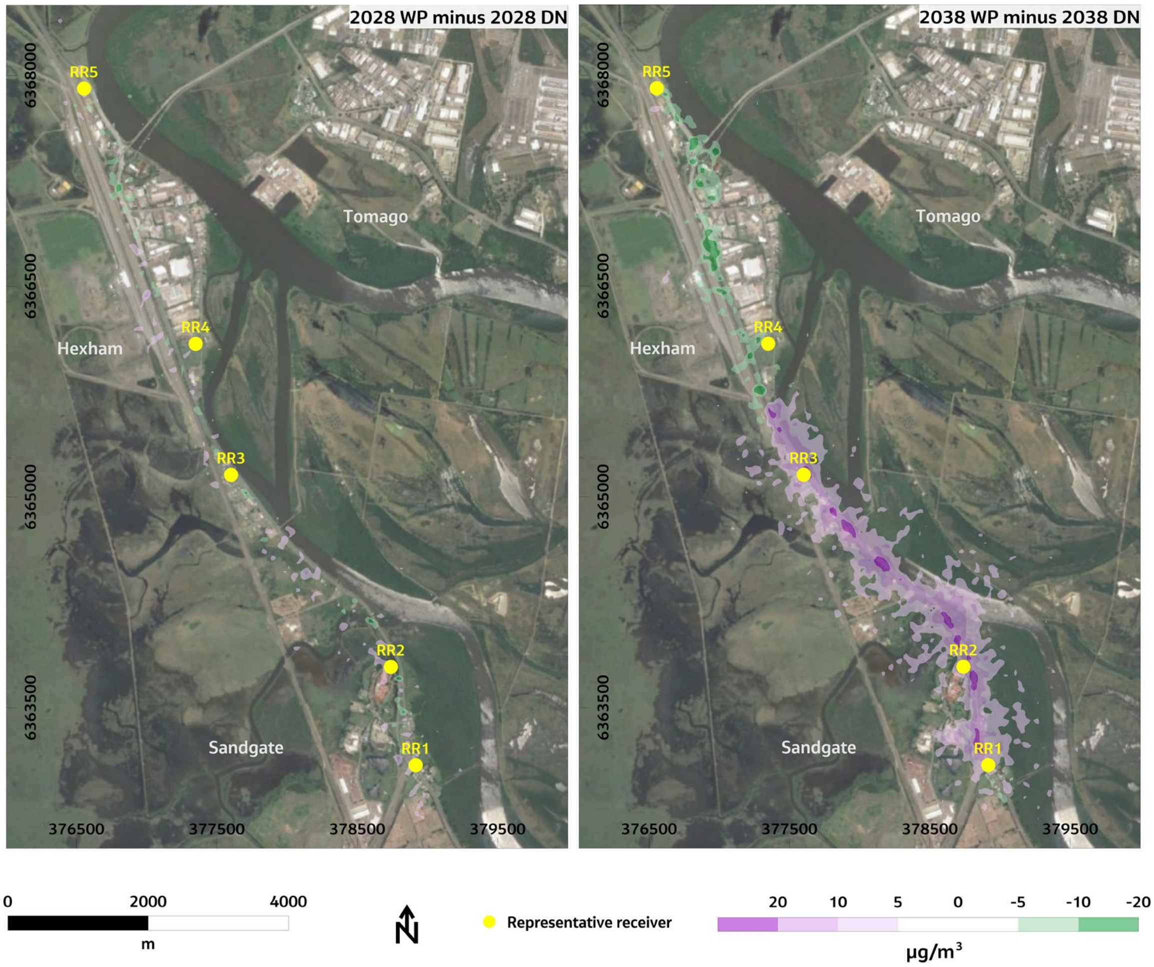


Figure 5.7 Predicted change in maximum 1-hour average NO_2

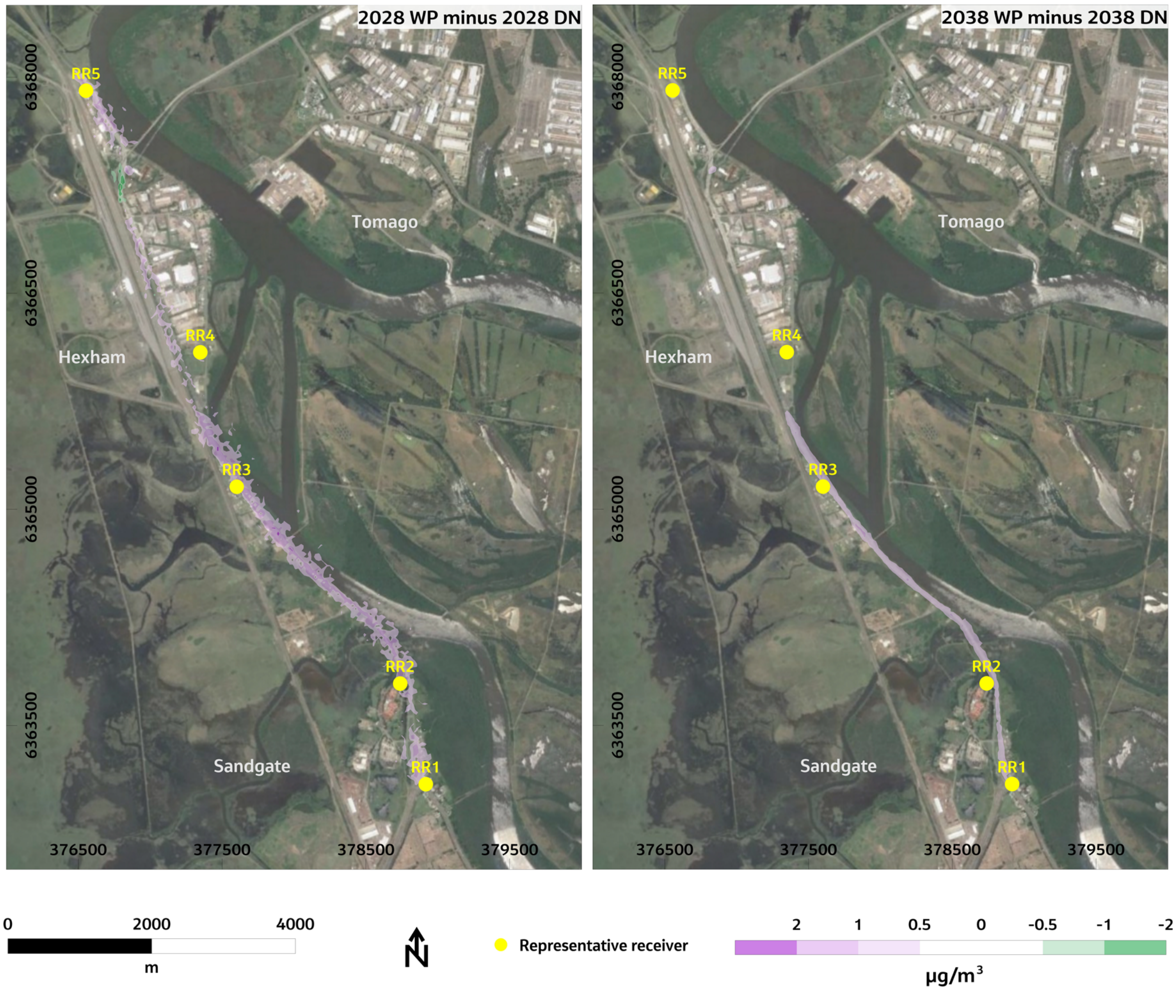


Figure 5.8 Predicted change in annually averaged NO_2

Table 5.14 provides a summary of the model results for key sensitive receivers, where maximum impacts may be expected. These data show the contribution of modelled sources, the background levels, and the predicted change in road contributions and cumulative concentrations.

Table 5.14 Predicted NO_2 concentrations at selected sensitive receivers

Representative receiver	Criterion	Concentration due to modelled sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2028		2028	2038	2028	2038
Maximum 1-hour average NO_2 ($\mu g/m^3$)										
RR1	246	70	74	65	80	105	4	15	109	120
RR2		70	70	63	70		0	7	105	112
RR3		82	82	69	85		0	16	105	121
RR4		50	45	50	52		-5	2	100	107
RR5		81	78	77	76		-3	-1	102	104
Annual average NO_2 ($\mu g/m^3$)										
RR1	62	37.8	38.2	36.8	39.7	17	0.4	2.9	17.4	19.9

Representative receiver	Criterion	Concentration due to modelled sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2028		2028	2038	2028	2038
RR2		21.4	21.8	20.1	22.5		0.4	2.4	17.4	19.4
RR3		25.3	26.0	22.5	25.9		0.7	3.4	17.7	20.4
RR4		15.4	15.5	15.6	16.0		0.1	0.4	17.1	17.4
RR5		29.2	30.3	28.7	29.2		1.1	0.5	18.1	17.5

As displayed in **Table 5.14**, the predicted change in maximum 1-hour and annually averaged NO_2 concentrations due to the project (both increases and decreases) represent less than seven and five per cent of the respective NSW EPA air quality assessment criteria (246 µg/m^3 and 62 µg/m^3). The highest increase in maximum 1-hour and annually averaged NO_2 concentrations from the proposal at the identified representative receivers were 16 µg/m^3 and 3.4 µg/m^3 respectively. These changes due to the proposal (are within the range of historically measured fluctuations in maximum CO concentrations for the region (see **Section 4.3.3**). As displayed, the highest cumulative 1-hour and annually averaged NO_2 concentrations at the identified representative receivers were 121 µg/m^3 and 20.4 µg/m^3 respectively; well below the EPA's impact assessment criteria.

Considering the limited changes in road contributions between corresponding with and without proposal assessment scenarios and that the resulting cumulative levels remained below the EPA's impact assessment criteria, it was concluded that changes in NO_2 emissions as a result of the proposal are unlikely to result in unacceptable impacts.

5.2.4 Particulate matter (PM_{10})

Model predictions of PM_{10} concentrations for each scenario are presented in **Figure 5.9** and **Figure 5.10**, with the relative change between 2028 and 2038 proposal and no proposal scenarios shown in **Figure 5.11** and **Figure 5.12**. These results represent the contribution of emissions from those roads that are expected to undergo the most change as a result of the proposal. The scattered contour patterns in **Figure 5.11** and **Figure 5.12** reflect some of the artefacts that arise from particle models that use random components. Background levels are not included in the contour plots but are discussed below.

The model results in **Figure 5.9** and **Figure 5.10** indicate the following outcomes in terms of the spatial variations in PM_{10}:

- The highest 24-hour and annually averaged PM_{10} concentrations are expected to occur close (i.e. within 20 metres) of the proposal
- Increases in predicted 24-hour and annually averaged PM_{10} concentrations from the proposal over time (i.e. from 2028 to 2038).

Table 5.15 provides a summary of the model results for key sensitive receivers, where maximum impacts may be expected. These data show the contribution of modelled sources, the background levels, the predicted change in road contributions, and change in cumulative concentrations with and without the proposal over the two assessment timescales (i.e. 2028 year of opening and 2038, 10 years after opening).

Table 5.15 Predicted PM_{10} concentrations at selected sensitive receivers

Representative receiver	Criterion	Concentration due to modelled sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2028		2028	2038	2028	2038
Maximum 24-hour average PM_{10} (µg/m^3)										
RR1	50	17	17	17	21	48	0	4	48	52
RR2		12	12	12	14		0	2	48	50
RR3		16	16	15	20		0	5	48	53
RR4		8	8	8	10		0	2	48	50
RR5		19	19	20	22		0	2	48	50
Annual average PM_{10} (µg/m^3)										
RR1	25	6.7	6.8	6.9	7.8	22	0.1	0.9	22.1	22.9
RR2		3.8	3.8	3.9	4.6		0	0.7	22.0	22.7
RR3		4.6	4.6	4.6	5.5		0	0.9	22.0	22.9
RR4		2.8	2.9	2.8	3.5		0.1	0.7	22.1	22.7
RR5		5.2	5.4	5.5	6.3		0.2	0.8	22.2	22.8

As displayed in **Table 5.15**, the predicted change in maximum 24-hour and annually averaged PM_{10} concentrations due to the proposal (both increases and decreases) represent less than ten and four per cent of the respective NSW EPA air quality assessment criteria (246 µg/m^3 and 62 µg/m^3). The predicted maximum changes in PM_{10} concentrations due to the project (both increases and decreases in 24-hour averages) are within the range of historically measured fluctuations in maximum PM_{10} concentrations for the region (see **Section 4.3.4**). The highest increase in maximum 24-hour and annually averaged PM_{10} concentrations from the proposal at the identified representative receivers were 5 µg/m^3 and 0.9 µg/m^3 respectively. As displayed, the highest cumulative 24-hour and annually averaged PM_{10} concentrations at the identified representative receivers were 53 µg/m^3 and 22.9 µg/m^3 respectively. These results indicate that when background PM_{10} conditions are elevated (i.e. 46 µg/m^3 or higher) the proposal may result in additional exceedances of the EPA's 50 µg/m^3 impact assessment criterion. Applying the background concentrations measured in 2016, it was predicted that the proposal would result in one additional instances of exceedance at the most-affected receiver. Regarding annually averaged PM_{10}, it was predicted that cumulative concentrations would remain below the 25 µg/m^3 EPA criterion.

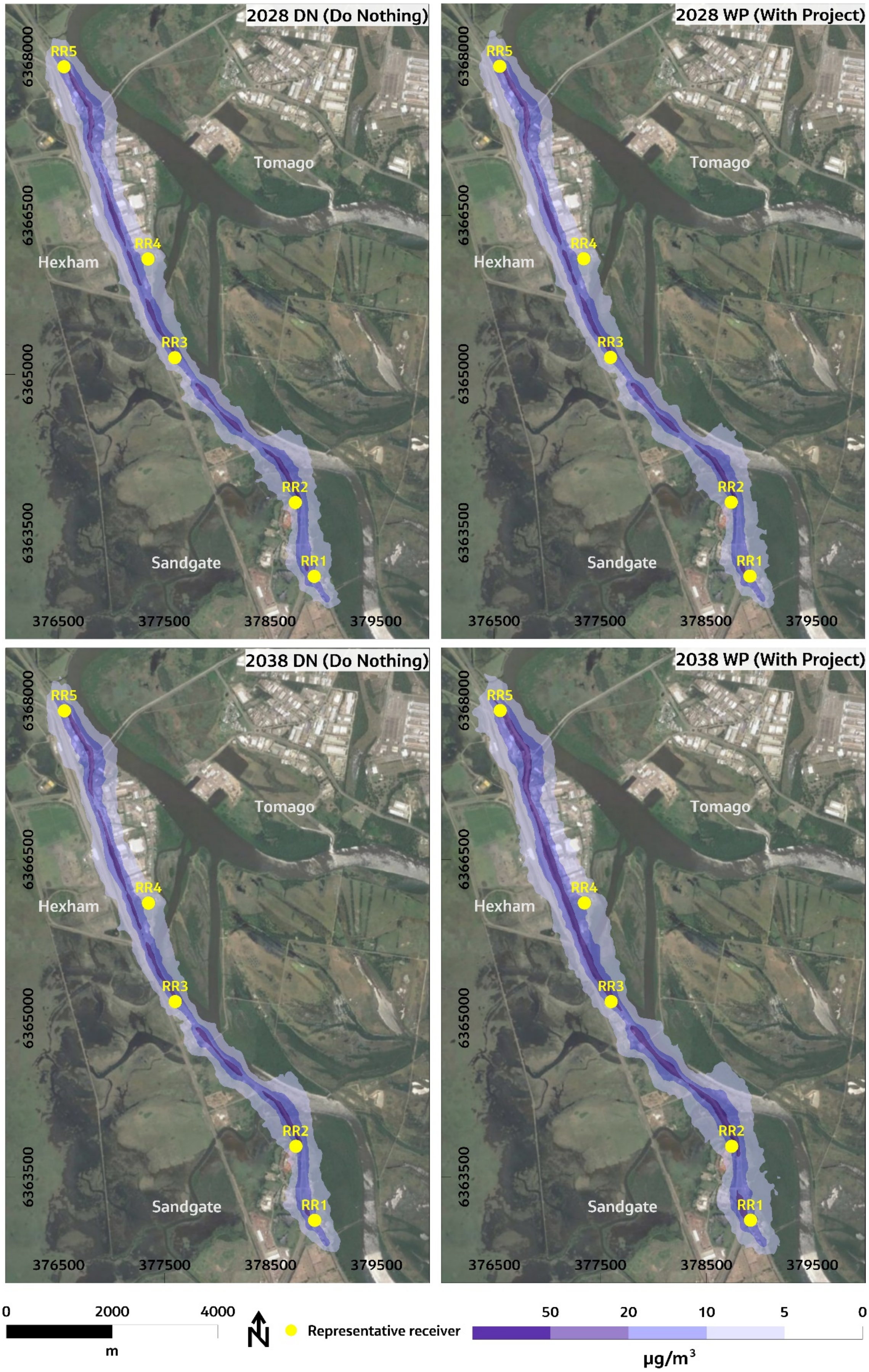


Figure 5.9 Predicted 24-hour averaged PM_{10} due to modelled sources

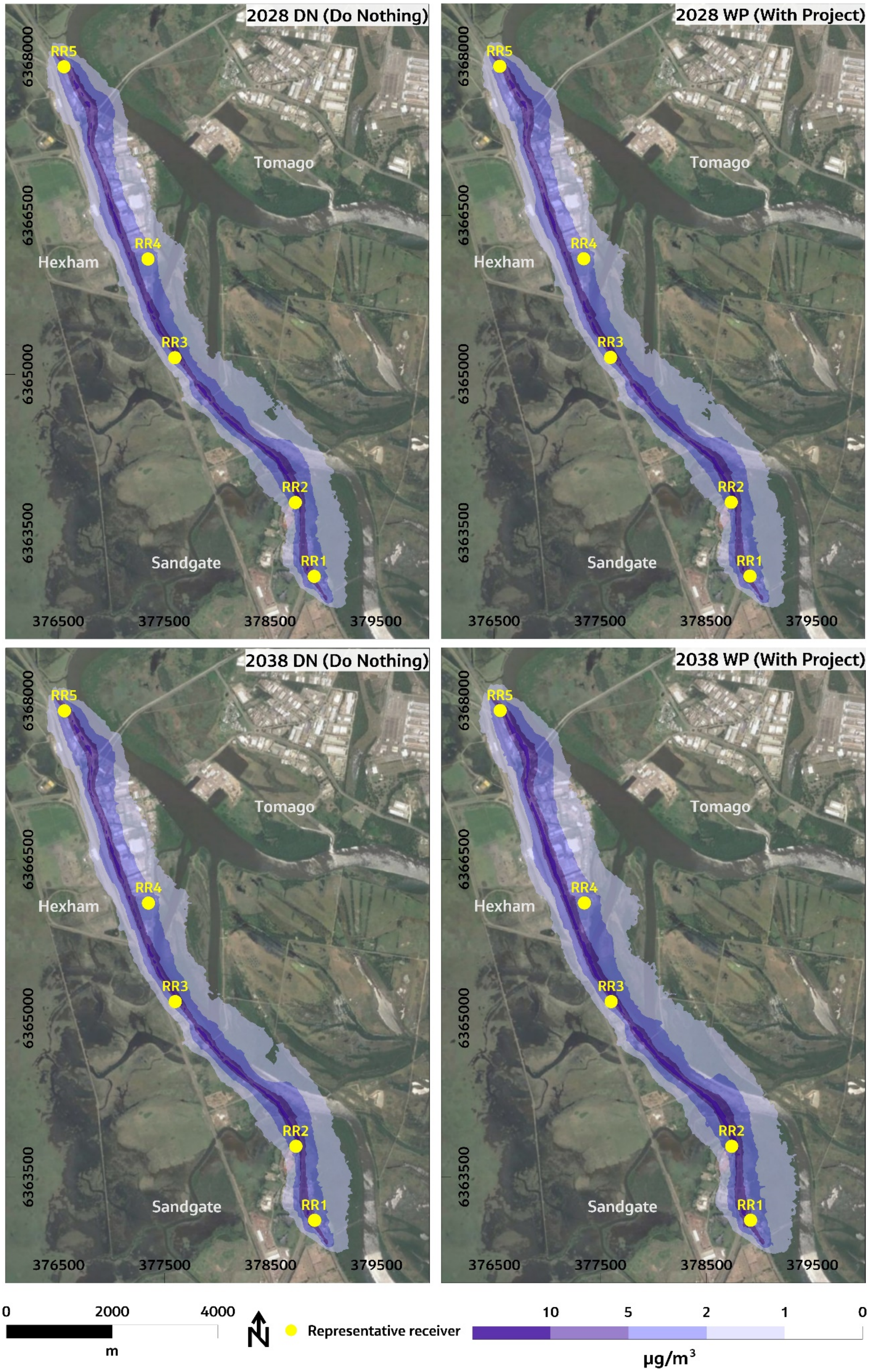


Figure 5.10 Predicted annual average PM_{10} due to modelled sources

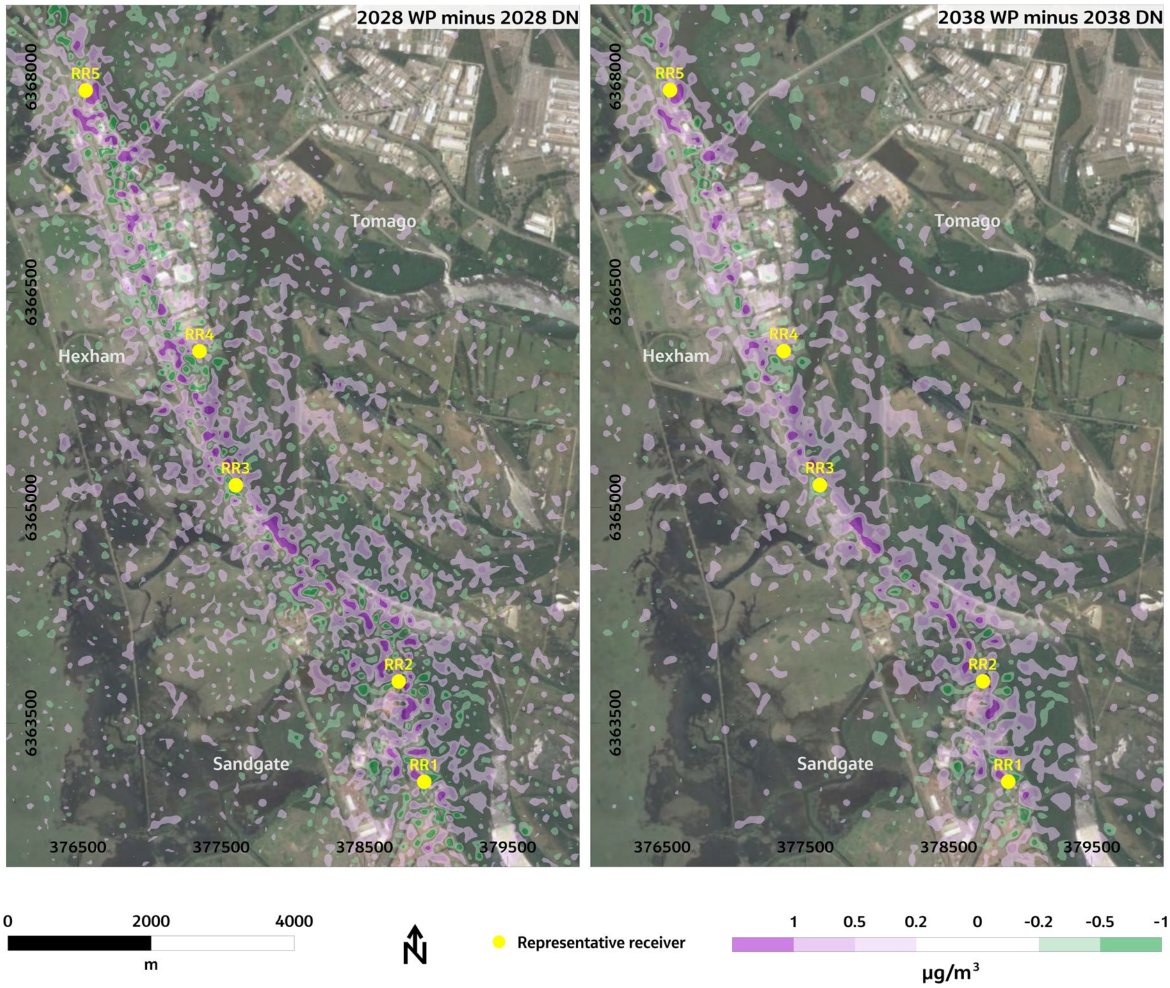


Figure 5.11 Predicted change in maximum 24-hour average PM_{10}

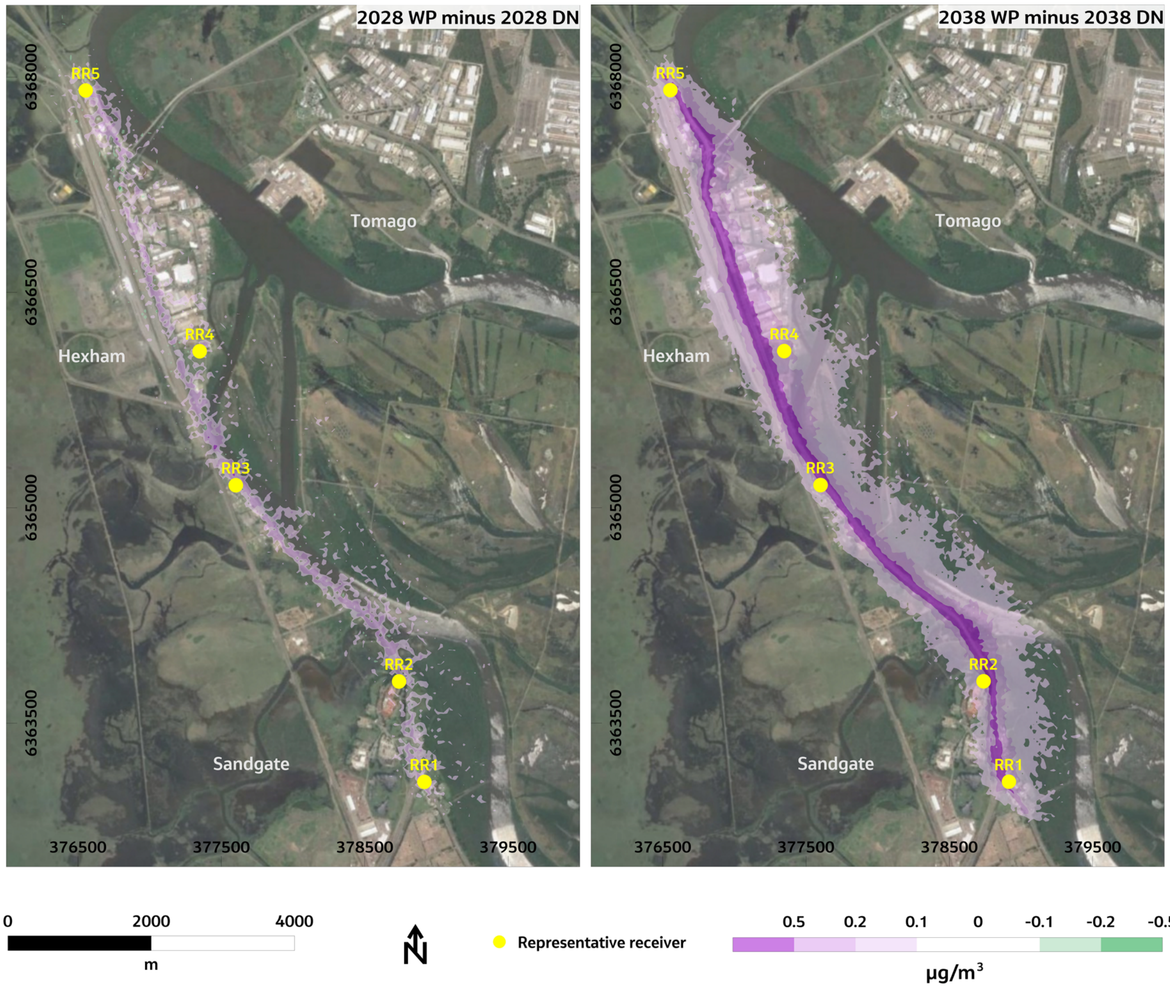


Figure 5.12 Predicted change in annually averaged PM_{10}

5.2.5 Particulate matter ($PM_{2.5}$)

Emissions of $PM_{2.5}$ have not been explicitly modelled however the potential for $PM_{2.5}$ impacts has been assessed by assuming that 100 per cent of the PM_{10} is $PM_{2.5}$. This is a conservative assumption as not all the PM_{10} would be $PM_{2.5}$. Emissions of PM_{10} would be higher than $PM_{2.5}$ as a greater fraction of the PM_{10} is related to non-exhaust components than for $PM_{2.5}$, for example, due to brake and tyre wear. The NSW EPA estimated that $PM_{2.5}$ emissions were 69 per cent of the PM_{10} emissions for on-road mobile sources in the Newcastle region (NSW EPA, 2019b).

Model predictions of PM_{10} concentrations were presented for each scenario in **Figure 5.9** to **Figure 5.10**. On the assumption that all PM_{10} is $PM_{2.5}$ the model results indicate the following outcomes in terms of the spatial variations in $PM_{2.5}$:

- The highest 24-hour and annually averaged $PM_{2.5}$ concentrations are expected to occur close (i.e. within 20 metres) of the proposal
- As for PM_{10}, increases in predicted 24-hour and annually averaged $PM_{2.5}$ concentrations from the proposal over time (i.e. from 2028 to 2028).

Table 5.16 provides a summary of the model results for key sensitive receivers, where maximum $PM_{2.5}$ impacts may be expected. These data show the contribution of modelled sources, the background levels, and the predicted change in road contributions as well as cumulative concentrations with and without the proposal over the two assessment timescales (i.e. 2028 year of opening and 2038, 10 years after opening).

Table 5.16 Predicted $PM_{2.5}$ concentrations at selected sensitive receivers

Representative receiver	Criterion	Concentration due to modelled sources				Background level	Change due to proposal		Cumulative due to change with the proposal	
		2028 DN	2028 WP	2038 DN	2028 WP		2028	2038	2028	2028
Maximum 24-hour average $PM_{2.5}$ (µg/m³)										
RR1	25	17	17	17	21	28	0	4	28	32
RR2		12	12	12	14		0	2	28	30
RR3		16	16	15	20		0	5	28	33
RR4		8	8	8	10		0	2	28	30
RR5		19	19	20	22		0	2	28	30
Annual average $PM_{2.5}$ (µg/m³)										
RR1	8	6.7	6.8	6.9	7.8	8.7	0.1	0.9	8.8	15.6
RR2		3.8	3.8	3.9	4.6		0	0.7	12.5	12.6
RR3		4.6	4.6	4.6	5.5		0	0.9	13.3	13.3
RR4		2.8	2.9	2.8	3.5		0.1	0.7	11.6	11.5
RR5		5.2	5.4	5.5	6.3		0.2	0.8	14.1	14.2

The data in **Table 5.16** show how changes in maximum 24-hour and annually averaged $PM_{2.5}$ concentrations concentrations due to the proposal (both increases and decreases) represent up to 20 and 11 per cent of the respective NSW EPA air quality assessment criteria (25 µg/m³ and 8 µg/m³).

For both 24-hour and annually averaged 2028 and 2038 proposal and no proposal scenarios, concentrations were predicted to exceed the EPA's 25 µg/m³ impact assessment criterion, given that 100th percentile background concentration of 28 µg/m³ was measured (refer to **Section 4.3.5**). Applying the background concentrations measured in 2016, it was predicted that the proposal would not result in any additional days of exceedance at the most-affected receiver.

The change in annual average $PM_{2.5}$ concentration is a key metric for assessing the risk to human health. An increment change in annual average $PM_{2.5}$ of 1.7 µg/m³ has recently been determined as the criterion to manage the risk of all-cause mortality below one in 10,000 (ERM, 2020). As listed above in **Table 5.16** increases of 1.7 µg/m³ or more between corresponding 2028 and 2038 proposal and no proposal scenarios were not predicted at any of the representative receivers.

5.2.6 Air toxics

An assessment of the five priority air toxics identified by the NEPM has been made. These air toxics include benzene, formaldehyde, toluene, xylenes and PAHs as benzo(a)pyrene. Model predictions of these air toxics have been derived from the hydrocarbon results using the speciation factors shown in **Table 5.17**.

Table 5.17 Speciation of selected air toxics from hydrocarbon predictions

Air toxic	Assumed percentage of total hydrocarbons (%) *
Benzene	5
Formaldehyde	1.4
Toluene	4.7

Air toxic	Assumed percentage of total hydrocarbons (%) *
Xylenes	3.5
PAHs as benzo(a)pyrene	0.4

* From data published by the NSW EPA (2019a)

Table 5.18 provides the predicted air toxics concentrations for key sensitive receivers, where maximum impacts may be expected. These results show that, at the selected sensitive receivers and local communities located near main roads along the proposed route, the concentrations would not exceed NSW EPA air quality impact assessment criteria. Lower concentrations would be expected at locations further from main roads. It is therefore concluded that the proposal would not lead to adverse air quality impacts with regards to air toxics.

Table 5.18 Predicted air toxics concentrations at selected sensitive receivers

Representative receiver	Criterion	Concentration due to modelled sources				Change due to proposal	
		2028 DN	2028 WP	2038 DN	2038 WP	2028	2038
Maximum 1-hour average benzene (µg/m^3)							
RR1	29	4.1	4.5	3.4	4.1	0.3	0.7
RR2		3.7	3.9	2.8	3.5	0.2	0.7
RR3		4.1	4.5	3.3	4.0	0.4	0.7
RR4		2.7	2.5	2.2	2.7	-0.2	0.5
RR5		4.2	4.5	3.6	4.0	0.3	0.4
Maximum 1-hour average formaldehyde (µg/m^3)							
RR1	20	1.2	1.2	0.9	1.1	0.1	0.2
RR2		1.0	1.1	0.8	1.0	0.1	0.2
RR3		1.2	1.3	0.9	1.1	0.1	0.2
RR4		0.8	0.7	0.6	0.8	-0.1	0.1
RR5		1.2	1.2	1.0	1.1	0.1	0.1
Maximum 1-hour average toluene (µg/m^3)							
RR1	360	3.9	4.2	3.2	3.8	0.3	0.7
RR2		3.5	3.6	2.6	3.3	0.2	0.6
RR3		3.9	4.2	3.1	3.8	0.4	0.7
RR4		2.6	2.4	2.1	2.5	-0.2	0.4
RR5		3.9	4.2	3.4	3.7	0.3	0.4
Maximum 1-hour average xylene (µg/m^3)							
RR1	190	2.9	3.1	2.4	2.9	0.2	0.5
RR2		2.6	2.7	1.9	2.4	0.1	0.5
RR3		2.9	3.1	2.3	2.8	0.3	0.5
RR4		1.9	1.8	1.5	1.9	-0.2	0.3
RR5		2.9	3.1	2.5	2.8	0.2	0.3
Maximum 1-hour average benzo(a)pyrene (µg/m^3)							
RR1	0.4	0.3	0.4	0.3	0.3	0.1	0
RR2		0.3	0.3	0.2	0.3	0	0.1
RR3		0.3	0.4	0.3	0.3	0.1	0

Representative receiver	Criterion	Concentration due to modelled sources				Change due to proposal	
		2028 DN	2028 WP	2038 DN	2038 WP	2028	2038
RR4		0.2	0.2	0.2	0.2	0	0
RR5		0.3	0.4	0.3	0.3	0.1	0

5.2.7 Summary of operation impacts to the REF area

The nearest receivers to the proposal and those selected as representative receivers for the air quality assessment are located within the REF area. The key potential air quality issues to sensitive receivers located in the REF area during operation would be changes in emissions from vehicles using the existing and modified roads affected by the proposal.

5.2.8 Summary of operation impact to the EIS area

There are no sensitive receivers located within the EIS area but there are ecological receivers. Air quality impacts within the EIS area during operation would be associated with changes in emissions from vehicles using the modified roads, however these impacts are expected to be minor. Some minor changes to emissions in the EIS area may occur that may impact on ecological receptors during operation of the proposal.

5.3 Cumulative impact assessment

Cumulative air quality impacts may arise from the interaction of construction and operation activities of the proposal, and other approved or proposed projects in the area. When considered in isolation, specific project impacts may be considered minor. These minor impacts may, however, be more substantial, when the impact of multiple projects on the same receivers is considered.

The projects detailed in **Table 5.19** are in varying stages of delivery and planning and only includes projects that are relevant to air quality. This section provides an assessment of cumulative air quality impacts based on the most current and publicly available information for these projects. In many instances this is a high-level qualitative assessment.

In summary, the contributions of these projects to local air quality in areas where the proposal has the potential to influence air quality are either already being considered (operational traffic changes associated with the M1 Pacific Motorway Extension to Raymond Terrace projects), or are unlikely to be significant enough to influence the outcomes of this assessment.

Table 5.19 Assessment of potential cumulative impacts from identified projects

Project status	Relevance in consideration of cumulative impacts	Potential cumulative impacts
M1 Pacific Motorway Extension to Raymond Terrace (M12RT) (In planning)	Located about one kilometre north of the proposal and directly alongside the proposal to the east of the Hunter River. Potential to be consecutive (back to back) construction and concurrent (simultaneous) operation.	This road project is currently in planning. Transport plan to construct a new segment of the M1 Pacific Motorway between Tarro and Raymond Terrace. The M1 Pacific Motorway extension to Raymond Terrace has been captured in the traffic modelling as part of the ‘do minimum’ upgrades (reflected in the 2028 DM and 2038 DM operational air quality assessment scenarios) The construction of the M1 Pacific Motorway extension will result in additional construction vehicles on Maitland Road. These construction vehicle volumes are not expected to exceed capacity (including heavy vehicle capacity) of these state roads.

Project status	Relevance in consideration of cumulative impacts	Potential cumulative impacts
		When both projects are operational, the M1 Pacific Motorway between Tarro and Raymond Terrace will reduce traffic at the A1 Pacific Highway and Maitland Road intersection improving traffic performance for Maitland Road. These traffic changes have also been captured in the traffic data applied in the assessment.
Lower Hunter Freight Corridor (In planning)	The investigation area includes Hexham at the south east of the proposal and M1 Pacific Motorway and Lenaghans Drive at the south west of the proposal	The Transport Lower Hunter Freight Corridor (LHFC) forms a part of the NSW Freight and Ports Strategy and in 2018 preliminary investigations were being carried out to assess options for a dedicated freight rail line between Fassifern and Hexham. No options were available on the website to review. An investigation areas figure between Fassifern and Hexham was available. The construction of a rail freight corridor would reduce the demand for road freight in the study area. As the scale and alignment of the Lower Hunter Freight Corridor are undetermined, the cumulative operational impact of this project is unknown. However, the proposed Hexham Straight widening design would allow for the LHFC.
Richmond Vale Rail Trail to Shortland, including Shortland to Tarro Bike Trail (In planning)	Runs parallel to the proposal about one kilometre to the west	This project is not expected to result in cumulative negative impact with the proposal. The Richmond Vale Rail Trail to Shortland would encourage additional active transport use within the study area. The Shortland to Tarro Bike Trail does not intersect with the proposal however it provides an additional alternative active transport route within the study area. Overall, it would have minimal impact on the operational traffic within the study area.
Newcastle Power Station (AGL) (In planning)	Located at Tomago near Old Punt Road on the southern side of the Hunter River about one kilometre east of the most eastern extent of the proposal. Potential to be concurrent (simultaneous) operation.	AGL propose to construct a 250 megawatt (MW) gas fired power station at Tomago, with gas pipelines and electricity transmission lines. Construction of the power station is due to commence in 2021 with the power station expected to be operational in 2022. The power station would be located upstream of the proposal. Operation of the power station would result in increases in local background concentrations of NO_2, CO, SO_2 and particulate matter. These changes would be the same for both with and without project operational scenarios and so would not affect the relative changes as assessed above in **Section 5.2**. The Power Station would also result in emissions of VOCs to the local environment, including the study area. The EPA regulates these pollutants by source (i.e. not cumulatively).
Hunter Gas Pipeline (Approved)	The Hunter Gas Pipeline is designed to be about 833kms in length, running from Wallumbilla in Queensland to Newcastle in NSW. The Hunter Gas Pipeline is located to the	This project is located to the east of the proposal in Tomago. Construction is planned between 2024 and 2028, with different construction times for each proposal consequently no cumulative impacts to air quality are anticipated during construction.

Project status	Relevance in consideration of cumulative impacts	Potential cumulative impacts
	east of the proposal in Tomago and would connect to the Tomago Aluminium Smelter in Tomago.	During operation, since the proposal is likely to consist of a buried pipeline, no cumulative surface air quality impacts are anticipated.

6. Mitigation measures

6.1 Construction

The air quality assessment has indicated that construction of the proposal represented a 'high' risk of dust impacts according to the IAQM method (**Section 5.1.3**). This outcome represented the worst case, unmitigated outcome across the whole project, although these risks are not present where major earthworks activities, such as bridge construction, are not occurring. The following management measures (refer to **Table 6.1**) have been developed to specifically manage potential impacts during construction and have been informed by the outcomes of the IAQM methodology. These measures would be incorporated into a relevant Air Quality Management Plan (AQMP).

Table 6.1 Construction air quality mitigation measures

Impact	Mitigation measure	Timing
Risks to air quality during construction	Preparation and implementation of an Air Quality Management Plan (AQMP) to minimise risks to air quality. The AQMP will identify: ▪ Potential sources of air pollution (including odours unexpected finds and dust) during construction ▪ Air quality management objectives consistent with relevant published guidelines ▪ Identification of all dust and odour sensitive receivers ▪ Measures to manage air quality impacts ▪ Community notification and complaint handling, monitoring and incident response procedures.	Prior to and during construction

6.2 Operations

Given that there were no unacceptable changes in operational air quality as a result of the proposal (refer to **Section 5.2**), no specific operational air quality measures were identified as being required. Hence no operational air quality management measures were recommended.

7. Conclusion

This report has presented an assessment of the potential air quality impacts of the proposal to widen a six kilometre section of the Maitland Road from four lanes to six lanes, from the intersection with the Newcastle Inner City Bypass at Sandgate, through to Hexham Bridge, in Hexham, NSW. The key potential air quality issues were identified as dust during construction and changes in emissions from vehicles using the existing and modified roads affected by the proposal during operation.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators (CO, NO_2, PM_{10} and $PM_{2.5}$) from representative monitoring stations. The following conclusions were made in relation to the existing air quality and meteorological conditions:

- Wind patterns in the vicinity of the proposal are characteristic of the Lower Hunter Valley, with the prevailing winds being from the west-northwest
- Measured CO and NO_2 concentrations in the past five years have been consistently below NSW EPA air quality impact assessment criteria
- Particle levels (as PM_{10} and $PM_{2.5}$) increased across NSW and the Hunter region from 2017 to 2019 due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (OEH 2019). These events adversely influenced air quality with multiple days observed when PM_{10} and $PM_{2.5}$ concentrations exceeded NSW EPA criteria.

Potential air quality impacts of the proposal during construction were assessed using the semi-quantitative method developed by the IAQM.

Five representative receivers comprised of residential receivers and aged care receivers within the REF area were selected as the basis for summarising worst-case potential impacts during the operational phase of the proposal. Computer-based dispersion modelling was used to predict the potential change in local and regional air quality as a result of the proposal operation.

The key outcomes of the air quality assessment are:

- Construction of the proposal, was determined to represent a 'high' risk of dust impacts according to the IAQM method. However, the application of the recommended mitigation measures would mean that adverse residual impacts from construction would not be anticipated
- The proposal is not expected to result in concentrations of CO, NO_2, annually averaged PM_{10}, or key air toxics (benzene, formaldehyde, toluene, xylenes or benzo(a)pyrene) above the relevant EPA impact assessment criteria
- Regarding 24-hour averaged PM_{10}, applying the background concentrations measured in 2016, it was predicted that the proposal would result in one additional day of exceedance at the most-affected receiver when background concentrations were already elevated (48 µg/m^3). This outcome is within the historical variation in air quality conditions near the proposal. For 24-hour averaged $PM_{2.5}$ exceedances of the EPA's criterion were also predicted, although no additional days of exceedance were predicted for the meteorological modelling year (2016)
- Finally regarding annually averaged $PM_{2.5}$ increases of 1.7 µg/m^3 or more between corresponding 2028 and 2038 proposal and no proposal scenarios were not predicted at any of the representative receivers; a key indicator for assessing human health effects.

7.1 Overview of potential impacts in the REF area

The nearest receivers to the proposal and those selected as representative receivers for the air quality assessment are located within the REF area. The key potential air quality issues to sensitive receivers located in the REF area was identified as dust during construction of the proposal based on the results of the analysis undertaken using the IAQM method. Adverse residual impacts to sensitive receivers are not anticipated provided the recommended mitigation measures included in **Section 6** are implemented. The key potential air quality issues to sensitive receivers located in the REF area during operation would be changes in emissions from vehicles using the existing and modified roads affected by the proposal.

7.2 Overview of potential impacts in the EIS area

There are no sensitive receivers located within the EIS area but there are ecological receivers. As such, air quality impacts within the EIS area during construction are expected to be minor and would mainly be associated with dust. Adverse residual impacts to ecological receivers are not anticipated provided the recommended mitigation measures included in **Section 6** are implemented. Some minor changes to emissions in the EIS area may occur that may impact on ecological receptors during operation of the proposal.

7.3 Proposal summary

Based on this assessment, during construction, adverse residual impacts are not anticipated with the application of the recommended mitigation measures. Operation of the proposal is not expected to cause adverse air quality impacts, based on dispersion modelling which showed that the proposal would not result in changes to air quality at local or regional scales that would cause any additional exceedances of air quality criteria at sensitive receivers. Further, predicted changes were within historically measured concentrations ranges.

8. References

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9. Terms and acronyms

Term or Acronym	Definition
AQMP	Air Quality Management Plan
BaP	Benzo(a)pyrene
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CO	Carbon monoxide
CEMP	Construction environment management plan
CO	Carbon monoxide
DEC	Department of Environment and Conservation
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
EIS	Environmental impact statement
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
GMR	Greater Metropolitan Region
GRAL	Graz Lagrangian Model
GRAMM	Graz Mesoscale Model
IAQM	Institute of Air Quality Management
Jacobs	Jacobs Group (Australia) Pty Limited
LEP	Local Environment Plan
LGA	Local government area
M12RT	M1 Extension to Raymond Terrace
MVEI	Motor Vehicle Emissions Inventory
NEPM	National Environment Protection Measure
NEPC	National Environmental Protection Council of Australia
NSW	New South Wales
NSW EPA	New South Wales Environment Protection Authority
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
OEH	Office of Environment and Heritage, now part of the Department of Planning, Industry and Environment
PAHs	Polycyclic aromatic hydrocarbons
PEI	Preliminary environmental investigation
$PM_{2.5}$	Particulate matter with equivalent aerodynamic diameters less than 2.5 microns
PM_{10}	Particulate matter with equivalent aerodynamic diameters less than 10 microns
POEO Act	*Protection of the Environment and Operations Act 1997*
REF	Review of environmental factors
SEPP	State Environmental Planning Policy
SO_2	Sulfur dioxide

Term or Acronym	Definition
THC	Total hydrocarbons
TRAQ	Tool for Roadside Air Quality, an air pollution screening tool developed by Roads and Maritime
TSP	Total suspended particulates
VOCs	Volatile organic compounds
$\mu g/m^3$	Micrograms per cubic metre

Attachment A. Emission factors

Emission factors for 2026 were used for 2026 scenarios. Emission factors for 2036 were used for 2036 scenarios.

Table A.1 Descriptions of NSW EPA vehicle types

Code	Description	Initial category
CP	Cars (petrol)	Light
CD	Cars (diesel)	Light
LDC-P	Light duty commercial (petrol)	Light
LDC-D	Light duty commercial (diesel)	Light
HDC-P	Heavy duty commercial (petrol)	Heavy
RT	Rigid trucks	Heavy
AT	Articulated trucks	Heavy
BusD	Buses (diesel)	Heavy
MC	Motorcycles	Light

Table A.2 Approach to matching road types to NSW EPA road types

Road type	Assumed NSW EPA road type
Motorway, ramp	Highway / freeway
Arterial, sub-arterial	Arterial
Collector, minor road	Residential
Regional, arterial (speed less than or equal to 70 km/h)	Commercial arterial
Regional, arterial (speed greater than 70 km/h)	Commercial highway

Table A.3 Traffic mix by road type and year

Road type	Year	Proportion of traffic (%)								
		CP	CD	LCV-P	LCV-D	HDV-P	RT	AT	BusD	MC
Residential	2026	59.2	20.0	2.5	13.0	0.0	3.2	1.0	0.6	0.5
Arterial	2026	56.8	19.2	2.8	14.7	0.0	4.3	1.3	0.5	0.5
Commercial arterial	2026	54.8	18.5	3.0	15.6	0.0	5.4	1.9	0.4	0.5
Commercial highway	2026	54.8	18.5	3.0	15.6	0.0	5.4	1.9	0.4	0.5
Highway / freeway	2026	47.8	16.2	2.7	14.1	0.0	11.9	6.8	0.3	0.4
Residential	2036	48.0	30.8	0.7	14.9	0.0	3.5	1.0	0.6	0.5
Arterial	2036	46.0	29.4	0.8	16.8	0.0	4.6	1.4	0.5	0.5
Commercial arterial	2036	44.2	28.3	0.8	18.0	0.0	5.8	2.0	0.4	0.5
Commercial highway	2036	44.2	28.3	0.8	18.0	0.0	5.8	2.0	0.4	0.5
Highway / freeway	2036	37.9	24.3	0.8	16.0	0.0	13.0	7.3	0.2	0.4

Table A.4 Average speed relating to emission factors

Road type	Average speed (km/hr)	
	2026	2036
Residential	23.7	23.6
Arterial	36	35.5
Commercial arterial	33.9	33.6
Commercial highway	54.6	54.1
Highway / freeway	65.1	64.8

Table A.5 Base composite emission factors for 2026 (hot running)

Road type	CP	CD	LDCP	LDCD	HDCP	RT	AT	BusD	MC
CO (season maximum) (g/km)									
Residential	0.486	0.077	1.57	0.228	20.9	0.201	0.74	0.582	8.855
Arterial	0.325	0.046	1.105	0.176	12.58	0.147	0.439	0.427	7.557
Commercial arterial	0.611	0.056	1.806	0.217	13.81	0.16	0.295	0.504	7.685
Commercial highway	0.538	0.074	1.444	0.166	8.789	0.111	0.229	0.314	7.654
Highway / freeway	0.711	0.069	1.653	0.136	8.225	0.103	0.213	0.22	8.152
NO_x (season maximum) (g/km)									
Residential	0.068	0.432	0.257	0.599	2.188	2.09	6.527	7.385	0.126
Arterial	0.074	0.385	0.231	0.444	2.362	1.779	5.621	5.659	0.127
Commercial arterial	0.102	0.434	0.28	0.498	2.325	1.864	6.207	6.268	0.125
Commercial highway	0.064	0.367	0.215	0.45	2.601	1.579	4.709	4.693	0.161
Highway / freeway	0.047	0.357	0.203	0.447	2.715	1.544	4.309	3.783	0.189
PM_{10} (season maximum) (g/km)									
Residential	0.001	0.009	0.004	0.02	0.005	0.046	0.106	0.102	0.014
Arterial	0.001	0.008	0.004	0.015	0.005	0.039	0.071	0.074	0.014
Commercial arterial	0.001	0.008	0.003	0.017	0.005	0.047	0.072	0.085	0.014
Commercial highway	0.001	0.008	0.004	0.011	0.006	0.032	0.051	0.061	0.014
Highway / freeway	0.002	0.008	0.004	0.009	0.006	0.028	0.047	0.054	0.014
HC (season maximum) (g/km)									
Residential	0.036	0.031	0.161	0.06	1.604	0.04	0.083	0.12	1.551
Arterial	0.041	0.022	0.137	0.039	0.887	0.027	0.053	0.085	1.066
Commercial arterial	0.057	0.023	0.19	0.04	0.995	0.029	0.054	0.093	1.134
Commercial highway	0.029	0.017	0.086	0.027	0.522	0.019	0.039	0.066	0.795

Road type	CP	CD	LDCP	LDCD	HDCP	RT	AT	BusD	MC
Highway / freeway	0.024	0.016	0.071	0.023	0.443	0.017	0.036	0.052	0.732

Table A.6 Base composite emission factors for 2036 (hot running)

Road type	CP	CD	LDCP	LDCD	HDCP	RT	AT	BusD	MC
CO (season maximum) (g/km)									
Residential	0.486	0.077	1.57	0.228	20.9	0.201	0.74	0.582	8.855
Arterial	0.325	0.046	1.105	0.176	12.58	0.147	0.439	0.427	7.557
Commercial arterial	0.611	0.056	1.806	0.217	13.81	0.16	0.295	0.504	7.685
Commercial highway	0.538	0.074	1.444	0.166	8.789	0.111	0.229	0.314	7.654
Highway / freeway	0.711	0.069	1.653	0.136	8.225	0.103	0.213	0.22	8.152
NO_x (season maximum) (g/km)									
Residential	0.039	0.293	0.082	0.407	2.174	1.897	6.224	6.143	0.124
Arterial	0.045	0.262	0.083	0.301	2.348	1.609	5.278	4.511	0.125
Commercial arterial	0.064	0.295	0.105	0.337	2.31	1.688	5.825	5.054	0.123
Commercial highway	0.031	0.249	0.062	0.305	2.585	1.42	4.278	3.647	0.158
Highway / freeway	0.015	0.242	0.044	0.303	2.698	1.387	3.861	2.782	0.187
PM_{10} (season maximum) (g/km)									
Residential	0.001	0.005	0.003	0.012	0.005	0.036	0.096	0.083	0.014
Arterial	0.001	0.005	0.003	0.009	0.004	0.03	0.064	0.054	0.014
Commercial arterial	0.001	0.005	0.003	0.01	0.004	0.037	0.065	0.062	0.014
Commercial highway	0.001	0.005	0.003	0.006	0.005	0.024	0.046	0.037	0.014
Highway / freeway	0.001	0.005	0.004	0.005	0.005	0.021	0.042	0.029	0.014
HC (season maximum) (g/km)									
Residential	0.024	0.03	0.077	0.058	1.583	0.02	0.06	0.04	1.487
Arterial	0.032	0.022	0.079	0.037	0.875	0.013	0.038	0.027	1.022
Commercial arterial	0.047	0.023	0.125	0.038	0.982	0.014	0.039	0.03	1.087
Commercial highway	0.024	0.017	0.06	0.026	0.516	0.009	0.027	0.019	0.764
Highway / freeway	0.019	0.015	0.051	0.022	0.437	0.008	0.024	0.015	0.705

Table A.7: Sixth order polynomial coefficients for speed correction (2026)

Road type	CP	CD	LDCP	LDCD	HDCP	RT	AT	BusD	MC
CO									
A	7E-12	4E-10	1E-11	8E-11	1E-11	3E-11	1E-10	6E-11	0
B	-3E-09	-2E-07	-5E-09	-3E-08	-5E-09	-9E-09	-4E-08	-2E-08	0
C	6E-07	3E-05	9E-07	5E-06	9E-07	1E-06	5E-06	4E-06	0
D	-6E-05	-0.003	-1E-04	-5E-04	-1E-04	-1E-04	-4E-04	-3E-04	0
E	0.005	0.124	0.008	0.021	0.008	0.005	0.013	0.013	0
F	-0.283	-3.011	-0.311	-0.524	-0.311	-0.136	-0.253	-0.347	0
G	5.548	30.16	5.494	6.24	5.494	2.569	3.298	4.938	1
NO_x									
A	6E-11	5E-11	7E-11	1E-10	7E-11	3E-11	2E-11	5E-11	0
B	-2E-08	-2E-08	-3E-08	-5E-08	-3E-08	-1E-08	-6E-09	-2E-08	0
C	4E-06	4E-06	5E-06	8E-06	5E-06	2E-06	9E-07	3E-06	0
D	-3E-04	-3E-04	-4E-04	-7E-04	-4E-04	-1E-04	-7E-05	-3E-04	0
E	0.017	0.014	0.021	0.033	0.021	0.006	0.003	0.014	0
F	-0.408	-0.353	-0.533	-0.833	-0.533	-0.136	-0.09	-0.339	0
G	5.013	4.494	6.353	9.39	6.353	2.356	2.181	4.591	1
PM_{10}									
A	4E-11	7E-11	4E-11	9E-11	4E-11	-1E-11	1E-10	-3E-11	0
B	-1E-08	-3E-08	-2E-08	-4E-08	-2E-08	5E-09	-4E-08	1E-08	0
C	2E-06	4E-06	2E-06	6E-06	2E-06	-8E-07	6E-06	-9E-07	0
D	-2E-04	-4E-04	-2E-04	-5E-04	-2E-04	6E-05	-4E-04	2E-05	0
E	0.01	0.018	0.01	0.022	0.01	-0.002	0.019	0.003	0
F	-0.235	-0.427	-0.238	-0.523	-0.238	0.011	-0.458	-0.166	0
G	3.288	5.202	3.317	6.227	3.317	1.293	5.751	3.803	1
HC									
A	-3E-12	5E-11	6E-11	9E-11	6E-11	5E-11	8E-11	4E-11	0
B	1E-09	-2E-08	-2E-08	-4E-08	-2E-08	-2E-08	-3E-08	-2E-08	0
C	-2E-07	3E-06	4E-06	6E-06	4E-06	3E-06	5E-06	3E-06	0
D	8E-06	-2E-04	-4E-04	-5E-04	-4E-04	-3E-04	-4E-04	-2E-04	0
E	2E-04	0.011	0.017	0.024	0.017	0.012	0.019	0.011	0
F	-0.032	-0.273	-0.451	-0.583	-0.451	-0.304	-0.469	-0.303	0
G	1.607	3.816	5.818	6.87	5.818	4.149	6.106	4.604	1

Table A.8 Sixth order polynomial coefficients for speed correction (2036)

Road type	CP	CD	LDCP	LDCD	HDCP	RT	AT	BusD	MC
CO									
A	3E-13	4E-10	1E-12	8E-11	1E-12	3E-11	1E-10	7E-11	0
B	-1E-10	-2E-07	-6E-10	-3E-08	-6E-10	-1E-08	-4E-08	-3E-08	0
C	3E-08	3E-05	1E-07	5E-06	1E-07	2E-06	5E-06	4E-06	0
D	-3E-06	-0.003	-2E-05	-5E-04	-2E-05	-1E-04	-4E-04	-3E-04	0
E	0.003	0.124	0.004	0.021	0.004	0.006	0.013	0.014	0
F	-0.241	-3.024	-0.248	-0.517	-0.248	-0.175	-0.254	-0.368	0
G	5.396	30.29	5.338	6.177	5.338	2.951	3.339	5.168	1
NO_x									
A	3E-11	5E-11	5E-11	1E-10	5E-11	4E-11	2E-11	7E-11	0
B	-1E-08	-2E-08	-2E-08	-5E-08	-2E-08	-1E-08	-6E-09	-3E-08	0
C	2E-06	4E-06	3E-06	8E-06	3E-06	2E-06	9E-07	4E-06	0
D	-2E-04	-3E-04	-3E-04	-7E-04	-3E-04	-1E-04	-7E-05	-4E-04	0
E	0.008	0.014	0.014	0.033	0.014	0.006	0.003	0.017	0
F	-0.204	-0.353	-0.348	-0.84	-0.348	-0.141	-0.084	-0.416	0
G	3.032	4.494	4.495	9.454	4.495	2.397	2.144	5.297	1
PM_{10}									
A	4E-11	7E-11	4E-11	9E-11	4E-11	-1E-11	1E-10	-2E-11	0
B	-1E-08	-3E-08	-1E-08	-4E-08	-1E-08	5E-09	-4E-08	5E-09	0
C	2E-06	4E-06	2E-06	6E-06	2E-06	-9E-07	6E-06	-3E-07	0
D	-2E-04	-4E-04	-2E-04	-5E-04	-2E-04	7E-05	-5E-04	-3E-05	0
E	0.01	0.017	0.01	0.021	0.01	-0.002	0.02	0.004	0
F	-0.234	-0.412	-0.234	-0.498	-0.234	0.016	-0.484	-0.207	0
G	3.279	5.055	3.279	5.973	3.279	1.264	6	4.369	1
HC									
A	-4E-13	5E-11	1E-10	9E-11	1E-10	6E-11	9E-11	5E-11	0
B	1E-10	-2E-08	-4E-08	-4E-08	-4E-08	-2E-08	-3E-08	-2E-08	0
C	-2E-08	3E-06	7E-06	6E-06	7E-06	3E-06	5E-06	3E-06	0
D	1E-06	-2E-04	-6E-04	-5E-04	-6E-04	-3E-04	-4E-04	-3E-04	0
E	2E-04	0.011	0.028	0.024	0.028	0.013	0.019	0.012	0
F	-0.011	-0.271	-0.693	-0.592	-0.693	-0.326	-0.487	-0.332	0
G	1.179	3.8	7.826	6.962	7.826	4.355	6.3	4.928	1