

Appendix I

Health impact assessment

Roads and Maritime Services

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Human impact assessment

January 2020

Prepared for

Roads and Maritime Services

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Executive summary

E.1 The project

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the WestConnex M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including allowance for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

E.2 The purpose of this report

This report has been prepared to support the environmental impact statement for the project. The environmental impact statement has been prepared to accompany the application for approval of the project, and address the environmental assessment requirements of the Secretary of the Department of Planning, Industry and Environment ('the Secretary's environmental assessment requirements'). This report presents a Health impact assessment to address the relevant Secretary's environmental assessment requirements.

E.3 Method

A Health impact assessment is a way of determining what the consequences to health (both positive and negative) of some future action (such as this project) may be. It draws on previous experience about impacts from road tunnels and their potential effects on people who live or work around them. It uses this information to predict the impacts of the project on community health.

In this case, this report includes a detailed review of what impacts may occur, who may be exposed to these impacts and whether there is potential for these impacts to result in adverse health effects or positive benefits within the local community. The Health impact assessment presented in this report has been conducted in accordance with national guidance (enHealth 2001, 2012b; Harris 2007), and has involved the following:

- Review of predicted impacts on air quality, noise and vibration during construction and operation of the project. In some cases, the issues identified, such as those during construction, are short-term and can be mitigated/managed through the implementation of specific management measures. For other impacts, such as those from operations or for extended periods of construction from a number of projects, the impacts may occur over a longer period of time and require a more detailed assessment of how these impacts affect health
- Identification and characterisation of the community (including the presence of sensitive receptors such as childcare centres, aged care centres, schools and hospitals) who may be affected by these impacts
- Assessment of air quality impacts on health including:
 - Reviewing the key air pollutants (associated with vehicle emissions) that are predicted from the operation of the project (within the tunnel and outside the tunnel)
 - Identifying guidelines that are based on protection of the health of all members of the population for exposure to these pollutants over a short period of time as well as all day, every day
 - Comparing the predicted impacts with the health based guidelines

- Carrying out a more detailed assessment of potential risks of changes in nitrogen dioxide (NO₂) and particulates, including fine particulate matter (PM) or PM_{2.5} (particulate matter of aerodynamic diameter 2.5 microns (µm) and less) and coarse particulate matter or PM₁₀ (particulate matter of aerodynamic diameter 10 µm and less). The assessment has addressed specific health effects (or health endpoints) associated with exposures to these pollutants. The assessment conducted has evaluated the impact of the project on these health endpoints within the local community
- Assessment of the potential for health issues for users of the tunnel, as well as users of the wider tunnel network
- Valuing/costing the impacts on health relevant to PM based on the NSW Environment Protection Authority (NSW EPA) methodology
- Assessment of noise and vibration impacts on health including:
 - Reviewing the impacts that are predicted from the construction and operation of the project
 - Identifying guidelines that are based on the protection of the health and wellbeing (including sleep disturbance) during all phases of the project, both construction and operation
 - Comparing predicted impacts with the health based guidelines. Where the health based guidelines cannot be met, consideration of the implementation of mitigation/management measures
- Assessment of public safety and contamination
 - This has involved a qualitative assessment, providing an overview of the potential hazards that may affect public safety during construction and operation, including contamination. This review has considered the implementation of mitigation/management measures and whether these can minimise risks to the community
- Assessment of social changes on health associated with the project:
 - This has involved a qualitative assessment. Aspects of the project that have the potential to result in impacts or changes in the community (including traffic, pedestrian and cycle access, property acquisitions and access, visual changes, community access/cohesion and economic impacts) have been evaluated with respect to potential effects on health and wellbeing. In addition, the equity of changes associated with the project has also been evaluated within the community
 - An assessment of construction fatigue, related to community exposure to a number of concurrent construction projects, has also been carried out.

E.4 Conclusions

E.4.1 Air Quality

The following conclusions are made in relation to air quality impacts:

- Impacts associated with dust generated from construction activities require management to ensure impacts on community health are minimised. Measures required to be implemented to minimise dust impacts will be detailed in construction environmental management documentation, as detailed in the Technical working paper: Air quality (ERM, 2020)
- Potential odour associated with the treatment and stockpiling of dredged material at the White Bay construction support site (WHT3) would unlikely be detectable at the nearest receptor
- Impacts on the community outside the tunnel. The project is expected to result in a decrease in total pollutant levels in the community, including a redistribution of impacts associated with vehicle emissions, specifically in relation to emissions derived from vehicles using surface roads. For much of the community, this would result in no change or a small improvement (ie decreased concentrations and health impacts); however, for some areas located near key surface roads, a small increase in pollutant concentration may occur. Potential health impacts associated with changes in air quality (specifically nitrogen dioxide and particulates) within the local community have been assessed and are considered to be tolerable/acceptable

- Impacts within the tunnel. Concentrations of pollutants from vehicle emissions are higher within the tunnel (compared with outside the tunnel), and with the completion of a number of tunnel projects (approved or proposed) there is the potential for exposures to occur within a network of tunnels over varying periods of time, depending on the journey. The assessment of potential exposures inside these tunnels, has indicated:
 - Where windows are up and ventilation is on recirculation, exposure to NO₂ inside vehicles is expected to be below the current health based guidelines. In congested conditions inside the tunnels, it is not considered likely that significant adverse health effects would occur. Placing ventilation on recirculation is also expected to minimise exposures to particulates during travel through the tunnels
 - For motorcyclists, where there is no opportunity to minimise exposure through the use of ventilation, and there is the potential for higher levels of exposure to NO₂. These exposures, under normal conditions, are not expected to result in adverse health effects. When the tunnels are congested, it is expected that motorcyclists would spend less time in the tunnels than passenger vehicles and trucks due to lane filtering, limiting the duration of exposure and the potential for adverse health effects.

E.4.2 Noise and Vibration

The following conclusions are made in relation to noise and vibration:

Construction

- Exceedances of noise management levels (NMLs) during construction have been predicted at receptor buildings, including impacts greater than 15 dB(A). To mitigate this impact, additional mitigation measures are to be implemented to minimise impacts on health for the surrounding community. Additional management measures have also been identified to address and minimise noise impacts from multiple projects that may impact on and result in construction fatigue issues in the community
- To proactively minimise potential risks associated with underwater noise from harbour construction activities, management measures and a proactive communication strategy would be implemented. This would be informed by the final construction methodology, initial piling trials to validate the predicted underwater acoustic thresholds and management areas, and ongoing monitoring.

Operation

For the majority of receptor buildings within the noise catchment areas, there is either a reduction or relatively minor change in operational traffic noise levels due to the project with around one per cent of receptor buildings experiencing increases greater than 2 dB(A) due to the project.

For most properties, the implementation of mitigation measures (including at-property treatment) would reduce overall noise impacts from existing noise (which triggered the need for mitigation for most properties), as well as project related noise. The outcome is expected to be an overall improvement in noise levels within the community (compared with the existing situation) and some potential for improvements in community health.

E.4.3 Public safety and contamination

A review of the potential risks posed to public safety, associated with the project, from issues such as dangerous goods, subsidence, contamination and road safety was carried out. For both construction and operational aspects of the project, no issues were identified that had the potential to result in significant safety risks to the community.

E.4.4 Social

Changes in the urban environment associated with the project have the potential to result in a range of impacts on health and wellbeing of the community. The potential for changes to result in impacts on health and wellbeing is complex. Changes that may occur have the potential to result in both positive and negative impacts. Positive impacts include economic benefits, improved access and reduced travel times and increased pedestrian and cycle access. Negative impacts may occur as a result of traffic changes during construction, property acquisitions, visual changes, noise impacts and changes in access/cohesion of local areas. These impacts may reduce or increase levels of stress and anxiety within the community. In many cases, the negative impacts identified are either short term (associated with construction only) and/or mitigation/management measures have been identified to minimise the potential impacts on community health. The positive impacts relate to the operation of the project, which has the potential for long-term positive health benefits to the community.

Glossary of terms and abbreviations

Term	Definition
ABL	Assessment background noise level.
ABS	Australian Bureau of Statistics.
ACTAQ	NSW Government Advisory Committee on Tunnel Air Quality.
Acute exposure	Contact with a substance that occurs once or for only a short time (up to 14 days).
Absorption	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems.
ATSDR	Agency for Toxic Substances and Disease Register.
AAQ	Ambient air quality.
ANZECC	Australia and New Zealand Environment and Conservation Council.
Background level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.
BaP	Benzo(a)pyrene.
Biodegradation	Decomposition or breakdown of a substance through the action of micro-organisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).
Body burden	The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.
BTX	Benzene, toluene and total xylenes.
Carcinogen	A substance that causes cancer.
CASA	Civil Aviation Safety Authority.
CBD	Central business district.
CCME	Canadian Council of Ministers of the Environment.
CCTV	Closed Circuit Television.
CEMP	Construction Environmental Management Plan.
CHD	Coronary heart disease.
Chronic exposure	Contact with a substance or stressor that occurs over a long time (more than one year) [compare with acute exposure and intermediate duration exposure].
CO	Carbon monoxide.
Community receptor/receiver	Within the wider community within the study area, a number of additional locations, referred to as community receptors, have been identified. These are locations in the local community that more sensitive members of the population, such as infants and young children, the elderly or those with existing health conditions or illnesses, may spend a significant period of time. These locations comprise of hospitals, child care facilities, schools and aged care homes/facilities. These receptors are representative only and are not intended to comprise an exhaustive list of community receptors in the study area.
COPD	Chronic Obstructive Pulmonary Disease.
CPI	Consumer Price Index.
CNVG	<i>Construction Noise and Vibration Guideline</i> (Roads and Maritime, 2016).
CTAMP	Construction Traffic Management and Access Plan.
dB(A)	Decibels (A-weighted).
DE	Diesel exhaust.
DECCW	NSW Department of Environment, Climate Change and Water.

Term	Definition
DEFRA	Department for Environment, Food & Rural Affairs.
DEH	Australian Department of Environment and Heritage.
Detection limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
'Do Minimum'	Air quality, noise and traffic modelling scenario with the full WestConnex (Stages 1, 2 and 3) but without the project, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.
'Do Something'	Air quality, noise and traffic modelling scenario with the full WestConnex (Stages 1, 2 and 3) and with the project but without the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.
'Do Something – cumulative'	Air quality, noise and traffic modelling scenario with the full WestConnex (Stages 1, 2 and 3), the project, the Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and the F6 Extension.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An 'exposure dose' is how much of a substance is encountered in the environment. An 'absorbed dose' is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
DPIE	Department of Planning, Industry and Environment.
DPM	Diesel particulate matter.
DSI	Detailed site investigation.
EC	European Commission.
ED	Emergency department.
EIS	Environmental Impact Statement.
EMF	Electromagnetic field.
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i> (NSW).
EU	European Union.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Also includes contact with a stressor such as noise or vibration. Exposure may be short term [acute exposure], of intermediate duration, or long term [chronic exposure].
Exposure assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.
Exposure pathway	The route a substance takes from its source (where it began) to its endpoint (where it ends), and how people can come into contact with (or get exposed) to it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Genotoxic carcinogen	These are carcinogens that have the potential to result in genetic (DNA) damage (gene mutation, gene amplification, chromosomal rearrangement). Where this occurs, the damage may be sufficient to result in the initiation of cancer at some time during a lifetime.
GRAL	Graz Lagrangian Model.
GRAMM	GRAZ Mesoscale Model.
GSP	NSW State Gross Product.

Term	Definition
Guideline value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organization (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines would have different names, such as investigation level, trigger value and ambient guideline.
HHRA	Human health risk assessment.
HI	Hazard Index.
IARC	International Agency for Research on Cancer.
ICNG	<i>Interim Construction Noise Guideline</i> (NSW DECC, 2009).
IHD	Ischaemic heart disease.
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
Intermediate exposure Duration	Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].
LA1	A-weighted sound level exceeded for one per cent of the measurement period.
LA10	A-weighted sound level exceeded for 10 per cent of the measurement period.
LA90	A-weighted sound level exceeded for 90 per cent of the measurement period.
LAeq	A-weighted equivalent sound level.
L _{Amax}	A-Weighted, maximum sound level.
LGA	Local Government Area.
LOAEL	Lowest observed adverse effect level – The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.
LOR	Limit of Reporting.
Metabolism	The conversion or breakdown of a substance from one form to another by a living organism.
NCAs	Noise catchment areas.
NCG	Noise Criteria Guideline (various, as referenced in the report).
NEPC	National Environment Protection Council.
NEPM	National Environment Protection Measure.
NHMRC	National Health and Medical Research Council.
NMG	Noise Mitigation Guideline (various, as referenced in the report).
NML	Noise management level.
NPfI	NSW Noise Policy for Industry.
NO ₂	Nitrogen dioxide.
NO _x	Nitrogen oxides.
NOAEL	No-observed-adverse-effect-level – The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
NSW	New South Wales
NSW EPA	NSW Environment Protection Authority.
NZ	New Zealand.

Term	Definition
OEH	NSW Office of Environment and Heritage (now DPIE (Environment, Energy and Science)).
OEHHA	Office of Environmental Health Hazard Assessment, California Environment Protection Agency (Cal EPA).
OLS	Obstacle limitation surface.
PAH	Polycyclic aromatic hydrocarbon.
PANS-OPS	Procedures for air navigation systems operations.
PIARC	Name of the World Road Association.
PM	Particulate matter.
PM ₁	Particulate matter below one micron in diameter, often termed very fine particles.
PM _{2.5}	Particulate matter of aerodynamic diameter 2.5 µm and less.
PM ₁₀	Particulate matter of aerodynamic diameter 10 µm and less.
Point of exposure	The place where someone can come into contact with a substance present in the environment [see exposure pathway].
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
ppbv	Parts per billion by volume.
ppm	Parts per million.
Project	Western Harbour Tunnel and Warringah Freeway Upgrade.
RAP	Remedial action plan.
RBL	Rating background level.
Receptor population	People who could come into contact with hazardous substances [see exposure pathway].
Risk	The probability that something would cause injury or harm.
RNP	Road Noise Policy.
Roads and Maritime	NSW Roads and Maritime Services.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].
RWR	Residential, worker and recreational receptors.
SA	Statistical area.
SEIFA	Socio-Economic Index for Areas.
SO ₂	Sulfur dioxide.
Study area	The study area is illustrated in Figure 3-1 which is the area over which impacts to air quality have been considered (referred to as GRAL domain). A smaller area, within this larger area, has been considered for the assessment of noise, soil and vibration impacts.
T90	Distillation temperature where 90 per cent of the fuel is evaporated.
TCEQ	Texas Commission on Environmental Quality.
TEQ	Toxicity equivalent.
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
Toxicity data	Characterisation or quantitative value estimated (by recognised authorities) for each individual chemical for relevant exposure pathway (inhalation, oral or dermal), with special emphasis on dose-response characteristics. The data are based on available toxicity studies relevant to humans and/or animals and relevant safety factors.
Toxicological profile	An assessment that examines, summarises, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.
Toxicology	The study of the harmful effects of substances on humans or animals.
TSP	Total suspended particulates.

Term	Definition
Uncertainty factor	Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure would cause harm to people (also sometimes called a safety factor).
Ultrafines	Particulate matter below 0.1 microns in diameter.
UK	United Kingdom.
US	United States.
USEPA	United States Environmental Protection Agency.
VDV	Vibration dose values.
VOC	Volatile organic compound.
WHO	World Health Organization.
β coefficient	Beta coefficient.
$\mu\text{g}/\text{m}^3$	Micrograms per cubic metre.

1 Introduction

This section provides an overview of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), including its key features and location. It also outlines the Secretary's environmental assessment requirements addressed in this technical working paper.

1.1 Overview

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth, the NSW Government is implementing the *Future Transport Strategy 2056* (Transport for NSW, 2018), a plan that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and to improve transport connectivity with Sydney's northern beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and south, west and north-west of Sydney Harbour. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested harbour crossings.

1.2 The project

Roads and Maritime Services (Roads and Maritime) is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Western Harbour Tunnel and Warringah Freeway Upgrade, which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including infrastructure required for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

Key features of the Western Harbour Tunnel component of the project are shown in Figure 1-1 and would include:

- Twin mainline tunnels about 6.5 kilometres long and each accommodating three lanes of traffic in each direction, connecting the stub tunnels from the M4-M5 Link at Rozelle to the Warringah Freeway and to the Beaches Link mainline tunnels at Cammeray. The crossing of Sydney Harbour between Birchgrove and Waverton would involve a dual, three lane, immersed tube tunnel
- Connections to the stub tunnels at the M4-M5 Link project in Rozelle and to the mainline tunnels at Cammeray (for a future connection to the Beaches Link and Gore Hill Freeway Connection project)

- Surface connections at Rozelle, North Sydney and Cammeray, including direct connections to and from the Warringah Freeway (including integration with the Warringah Freeway Upgrade), an off ramp to Falcon Street and an on ramp from Berry Street at North Sydney
- A ventilation outlet and motorway facilities (fitout and commissioning only) at the Rozelle Interchange
- A ventilation outlet and motorway facilities at the Warringah Freeway in Cammeray
- Operational facilities including a motorway control centre at Waltham Street, within the Artarmon industrial area and tunnel support facilities at the Warringah Freeway in Cammeray
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, signage, tolling infrastructure, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure, CCTV and other traffic management systems.

Key features of the Warringah Freeway Upgrade component of the project are shown in Figure 1-2 and would include:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges at Falcon Street in Cammeray and High Street in North Sydney
- New and upgraded pedestrian and cyclist infrastructure
- New, modified and relocated road and shared user bridges across the Warringah Freeway
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels and the Beaches Link tunnels via on and off ramps, which would consist of a combination of trough and cut and cover structures
- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network
- Upgrades and modifications to bus infrastructure, including relocation of the existing bus layover along the Warringah Freeway
- Other operational infrastructure, including surface drainage and utility infrastructure, signage, tolling, lighting, CCTV and other traffic management systems.

A detailed description of the project is provided in Chapter 5 (Project description) and construction of the project is described in Chapter 6 (Construction work) of the environmental impact statement. The project alignment at the Rozelle Interchange shown in Figure 1-1 and Figure 1-3 reflects the arrangement presented in the environmental impact statement for the M4-M5 Link, and as amended by the proposed modifications. The project would be constructed in accordance with the finalised M4-M5 Link detailed design (refer to Section 2.1.1 of Chapter 2 (Assessment process) of the environmental impact statement for further details).

The project does not include ongoing motorway maintenance activities during operation or future use of residual land occupied or affected by project construction activities, but not required for operational infrastructure. These would be subject to separate planning and approval processes at the relevant times.

Subject to the project obtaining planning approval, construction is anticipated to commence in 2020 and is expected to take around six years to complete.

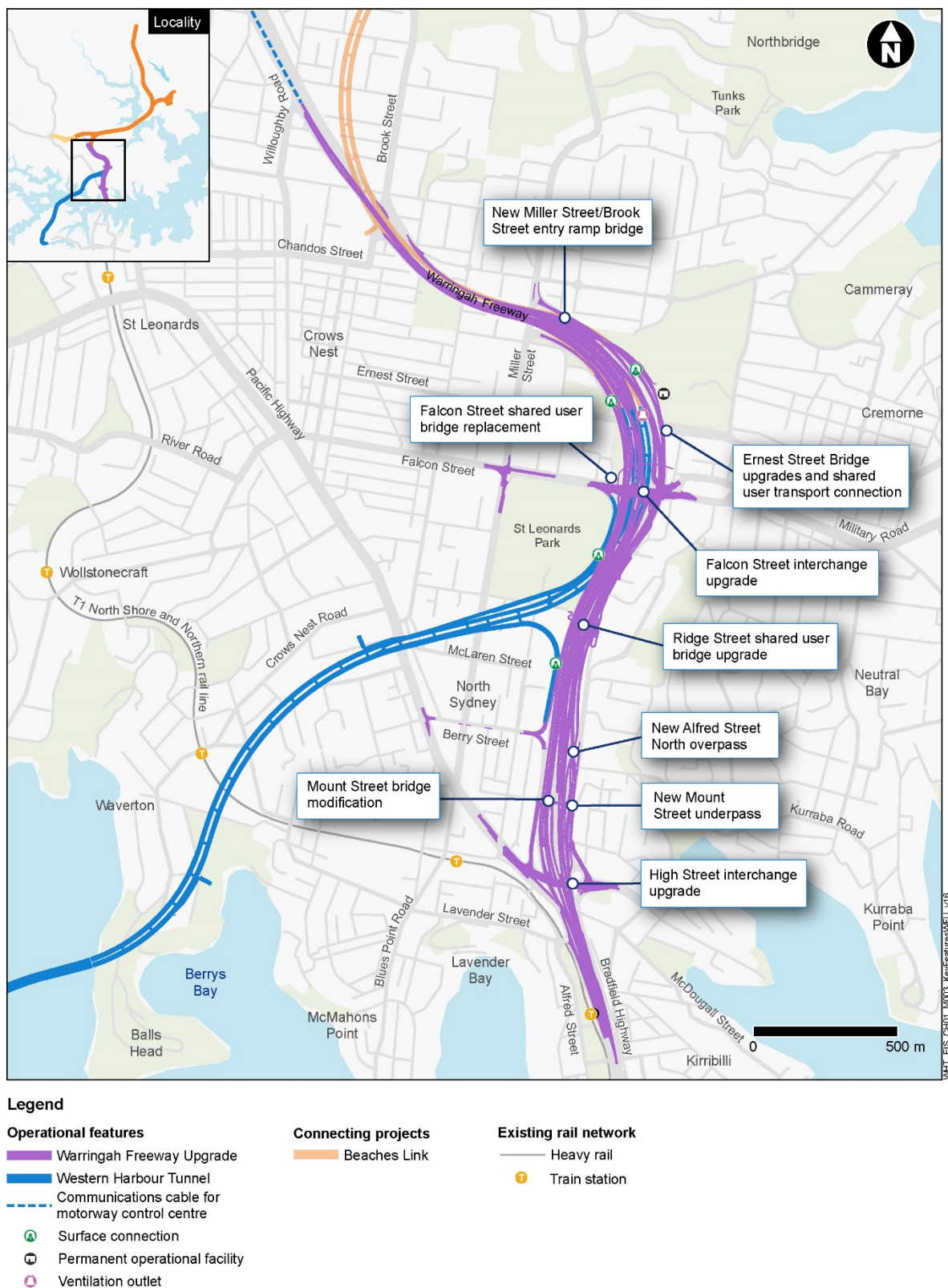


Figure 1-2 Key features of the Warringah Freeway Upgrade component of the project

1.3 Key construction activities

The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline tunnels. However, surface areas would be required to support tunnelling activities and to construct the tunnel connections, tunnel portals and operational ancillary facilities.

Key construction activities would include:

- Early works and site establishment, with typical activities being property acquisition and condition surveys, utilities installation, protection, adjustments and relocations, installation of site fencing, environmental controls (including noise attenuation and erosion and sediment control) and traffic management controls, vegetation clearing, earthworks and demolition of structures, establishment of construction support sites including acoustic sheds and associated access decline acoustic enclosures (where required), construction of minor access roads and the provision of property access, temporary relocation of pedestrian and cycle paths and bus stops, temporary relocation of swing moorings within Berrys Bay and relocation of the historic vessels
- Construction of Western Harbour Tunnel, with typical activities being excavation of tunnel construction accesses, construction of driven tunnels, cut and cover and trough structures and construction of cofferdams, dredging activities in preparation for the installation of immersed tube tunnels, casting and installation of immersed tube tunnels and civil finishing and tunnel fitout
- Construction of operational facilities comprising of a motorway control centre at Waltham Street in Artarmon, motorway and tunnel support facilities and ventilation outlets at the Warringah Freeway in Cammeray, construction and fitout of the project operational facilities that form part of the M4-M5 Link Rozelle East Motorway Operations Complex, a wastewater treatment plant at Rozelle and the installation of motorway tolling infrastructure
- Construction of the Warringah Freeway Upgrade, with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of road furniture, lighting, signage and noise barriers
- Testing of plant and equipment, and commissioning of the project, backfill of access declines, removal of construction support sites, landscaping and rehabilitation of disturbed areas and removal of environmental and traffic controls.

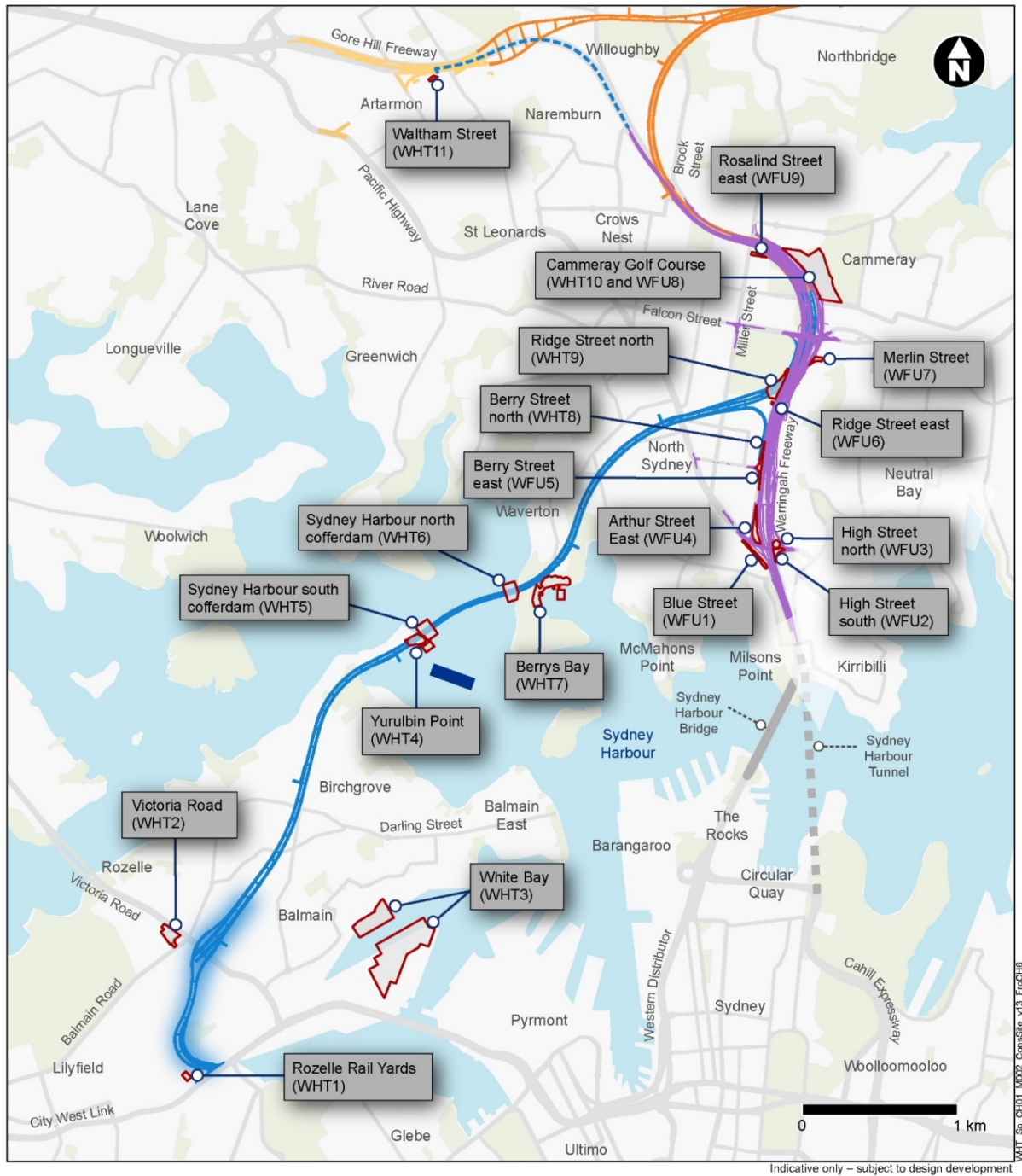
Temporary construction support sites would be required as part of the project (refer to Figure 1-3), and would include tunnelling and tunnel support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities. Construction support sites for Western Harbour Tunnel would include:

- Rozelle Rail Yards (WHT1)
- Victoria Road (WHT2)
- White Bay (WHT3)
- Yurulbin Point (WHT4)
- Sydney Harbour south cofferdam (WHT5)
- Sydney Harbour north cofferdam (WHT6)
- Berrys Bay (WHT7)
- Berry Street north (WHT8)
- Ridge Street north (WHT9)
- Cammeray Golf Course (WHT10)
- Waltham Street (WHT11).

During the construction of the Warringah Freeway Upgrade, smaller construction support sites would be required to support the construction works (as shown on Figure 1-3). These include:

- Blue Street (WFU1)
- High Street south (WFU2)
- High Street north (WFU3)
- Arthur Street east (WFU4)
- Berry Street east (WFU5)
- Ridge Street east (WFU6)
- Merlin Street (WFU7)
- Cammeray Golf Course (WFU8)
- Rosalind Street east (WFU9).

A detailed description of construction works for the project is provided in Chapter 6 (Construction work) of the environmental impact statement.



Legend

Construction features

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Communications cable for motorway control centre
- Fit out and commissioned as part of Western Harbour Tunnel, constructed as part of WestConnex M4-M5 Link

- Construction support sites
- Mooring site

Connecting projects

- Beaches Link
- Gore Hill Freeway Connection

Figure 1-3 Overview of the construction footprint

1.4 Project location

The project would be located within the Inner West, North Sydney and Willoughby local government areas, connecting Rozelle in the south with Naremburn in the north.

Commencing at the Rozelle Interchange, the mainline tunnels would pass under Balmain and Birchgrove, then cross Sydney Harbour between Birchgrove and Balls Head. The tunnels would then continue under Waverton and North Sydney, linking directly to the Warringah Freeway to the north of the existing Ernest Street bridge.

The motorway control centre would be located at Waltham Street, Artarmon, with a trenched communications cable connecting the motorway control centre to the Western Harbour tunnel along the Gore Hill Freeway and Warringah Freeway road reserves.

The Warringah Freeway Upgrade would be carried out on the Warringah Freeway from around Fitzroy Street at Milsons Point to around Willoughby Road at Naremburn. Upgrade works would include improvements to bridges across the Warringah Freeway, and upgrades to surrounding roads.

1.5 Purpose of this report

This report has been prepared to support the environmental impact statement for the project and to address the environmental assessment requirements of the Secretary of the Department of Planning Industry and Environment (formerly Department of Planning and Environment) ('the Secretary's environmental assessment requirements').

This report presents a Health impact assessment associated with impacts identified in relation to air quality, noise and vibration and social aspects, to address the Secretary's environmental assessment requirement. The report has been prepared in accordance with the relevant guidelines as outlined in Section 2.2.1.

1.6 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to the Health impact assessment, and where these requirements are addressed in this report are outlined in Table 1-1.

Table 1-1 Secretary's environmental assessment requirements – Health impact assessment

Secretary's environmental assessment requirements	Where addressed
1. The Proponent must assess the potential health impacts from the construction and operation of the project.	Sections 5 to 9
2. The assessment must:	
(a) describe the current known health status of the potentially affected population	Sections 3
(b) describe how the design of the proposal minimises adverse health impacts and maximises health benefits	Section 2.3
(c) assess human health impacts from the operation and use of the tunnel under a range of conditions, including worst case operating conditions and the potential length of motorway tunnels in Sydney	Sections 5 and 6
(d) human health risks and costs associated with the construction and operation of the proposal, including those associated with air quality, odours, noise and vibration (including residual noise following application of mitigation measures), construction fatigue and social impacts (including from acquisitions) on the adjacent and surrounding areas, as well as opportunity costs (such as those from social infrastructure and active transport impacts) during the construction and operation of the proposal	Sections 5 to 9 (Specific monetary costs for particulate matter as outlined in Section 5.12, noting there are no methods available to provide health costs for any other impacts or benefits)

Secretary's environmental assessment requirements	Where addressed
(e) include both incremental changes in exposure from existing background pollutant levels and the cumulative impacts of project specific and existing pollutant levels at the location of the most exposed receivers and other sensitive receptors (including public open space areas, child care centres, schools, hospitals and aged care facilities)	Section 5
(f) assess the likely risks of the project to public safety, paying particular attention to pedestrian safety, subsidence risks, bushfire risks and the handling and use of dangerous goods	Section 8 (subsidence risks are addressed in Chapter 16 (Geology, soils and groundwater) of the environmental impact assessment)
(g) assess the opportunities for health improvement	Sections 5 to 9
(h) assess the distribution of the health risks and benefits	Sections 5 to 9
(i) include a cumulative human health impact assessment inclusive of in-tunnel, local and regional impacts due to the operation of and potential continuous travel through motorway tunnels and surface roads	Sections 5 to 7. More specifically in relation to cumulative* impacts: Section 5.4 which defines the cumulative emissions scenarios; Sections 5.6.4, 5.7, 5.8.2 and 5.9.4 which address total exposure to emissions from the project plus background concentrations; Sections 6.2 and 6.3 which address cumulative exposures within the tunnel and during extended trips in multiple tunnels.

Note: * The assessment of cumulative impacts, to address the Secretary's environmental assessment requirements has been carried out in this report, where the following terminology has been used. The term "total" refers to the assessment of exposures to background pollutant levels as well as the project, and the term "cumulative" refers to the assessment of impacts from the Western Harbour Tunnel and Warringah Freeway Upgrade as well as the WestConnex projects plus Sydney Gateway, Beaches Link and Gore Hill Freeway Connection and F6 Extension projects.

2 Assessment methodology

2.1 What is a risk or impact assessment?

2.1.1 Risk

Health risk and impact assessments are used extensively in Australia and overseas to assist in decision making on the acceptability of the risks associated with the presence of contaminants or stressors in the environment and assessment of potential risks to the public.

Health risk is commonly defined as the chance of injury, damage, or loss. Therefore, to put oneself or the environment 'at risk' means to participate, either voluntarily or involuntarily, in an activity or activities that could lead to injury, damage, or loss.

Voluntary risks are those associated with activities that we decide to carry out such as driving a vehicle, riding a motorcycle and smoking cigarettes. Involuntary risks are those associated with activities that may happen to us without our prior consent or forewarning. Acts of nature such as being struck by lightning, fires, floods and tornados, and exposures to environmental contaminants are examples of involuntary risks.

2.1.2 Defining risk and impacts

Risks to the public and the environment are determined by direct observation or by applying mathematical models and a series of assumptions to infer risk. No matter how risks are defined or quantified, they are usually expressed as a probability of adverse effects associated with a particular activity. Risk is typically expressed as a likelihood of occurrence and/or consequence (such as negligible, low or significant) or quantified as a fraction of, or relative to, an acceptable risk number.

Risks or impacts from a range of facilities (eg industrial or infrastructure) are usually assessed through qualitative and/or quantitative risk assessment techniques. In general, risk or impact assessments seek to identify all relevant hazards; assess or quantify their likelihood of occurrence and the consequences associated with these events occurring; and provide of an estimate of the risk levels for people who could be exposed, including those beyond the perimeter boundary of a facility. In this report, quantitative risk is assessed in terms of acceptable, tolerable or unacceptable risk. A full explanation of these terms can be found in Annexure C of this report.

2.2 Overall approach

2.2.1 General

The methodology adopted for the conduct of the Health impact assessment is in accordance with national and international guidance that is endorsed/accepted by Australian health and environmental authorities, and includes:

- Harris, P., Harris-Roxas, B., Harris, E. & Kemp, L., *Health Impact Assessment: A Practical Guide*, Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity. University of NSW, Sydney (Harris 2007)
- *Health Impact Assessment Guidelines*. Published by the Environmental Health Committee (enHealth), which is a subcommittee of the Australian Health Protection Committee (AHPC) (enHealth 2001)
- *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards*, 2012 (enHealth 2012b)
- *Schedule B8 Guideline on Community Engagement and Risk Communication*, National Environment Protection (Assessment of Site Contamination) Measure, 1999 (National Environment Protection Council (NEPC 1999 amended 2013b))
- *National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure*, 2003 (NEPC 2003)

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)*, EPA-540-R-070-002, January 2009 (United States Environment Protection Agency (USEPA 2009b)).

More specifically, in relation to the assessment of health impacts associated with exposure to nitrogen dioxide (NO₂) and particulate matter (PM), guidelines available from the NEPC ((Burgers & Walsh 2002; NEPC 1998, 2002, 2003, 2009, 2010)), World Health Organization (WHO) (Ostro 2004; WHO 2003, 2006b, 2006a, 2013a) and the USEPA (USEPA 2005b, 2009a) have been used as required.

In addition, the following has been considered:

- Building Better Health, Health considerations for urban development and renewal in the Sydney Local Health District (NSW Health 2016)
- NSW Health, Healthy Urban Development Checklist, A guide for health services when commenting on development policies, plans and proposals, 2009
- Methodology for Valuing the Health Impacts of Changes in Particle Emissions (EPA 2013)
- Air Quality in and Around Traffic Tunnels (NHMRC 2008)
- State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (SEPP 33).

These guidelines have been used to evaluate health impacts associated with the project that relate to:

- Changes in air quality around the tunnels (within the community) during construction and operation (as presented in Section 5)
- Air quality in the tunnels (as presented in Section 6)
- Changes in the noise environment during construction and operation (as presented in Section 7)
- Impacts on public safety (as presented in Section 8)
- Changes in the social environment, including an overview of the positive and negative impacts of the project on health (as presented in Section 9).

In following this guidance, the following tasks have been completed and are presented in this technical working paper. It should be noted that the Health impact assessment has included both quantitative and qualitative methods. The following tasks primarily relate to the quantitative assessment of impacts. Not all these tasks are relevant for the qualitative assessment of impacts (which is more generally described in Section 2.2.5).

2.2.2 Data evaluation and issue identification

Data evaluation and issue identification involved a review of all available project information that relates to the proposed design and outcomes from relevant specialist studies carried out in relation to air quality within the tunnel itself, air quality within the surrounding community, noise and vibration. Specifically, the assessment has considered existing conditions (in relation to air quality and noise) and estimation of short-term (acute) and long-term (chronic) impacts during construction and operation of the project.

This aspect of the assessment also considered the available guidelines for air quality and noise, whether these guidelines are based on the protection of community health, and if a more detailed evaluation of specific impacts is required. The Health impact assessment has considered a more detailed evaluation of exposures to NO₂ and PM emissions within the surrounding community from the operation of the project. Other pollutants that have also been considered include volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and carbon monoxide (CO). In addition, a review of health risk impacts associated with air quality within the tunnel itself has been included.

2.2.3 Exposure assessment

Exposure assessment involved the identification of populations located in the project study area (see Section 3) which may be exposed to impacts from the project. The existing air and noise environments as well as the health of the existing population have been considered in relation to the

key health effects (with specific health effects termed health endpoints) in this assessment. The assessment has considered both acute and chronic inhalation exposures relevant to the project.

2.2.4 Hazard assessment

The objective of the hazard or toxicity assessment is to identify the adverse health effects and quantitative toxicity values or exposure-response relationships that are associated with the key pollutants and stressors that have been identified and evaluated as part of this assessment. This has been applied to the assessment of exposures to PM and NO₂ where the following steps have been carried out:

- Identify the adverse health effects associated with exposure to the pollutants or stressors. Based on the available information, the most robust health endpoints (effects or outcomes) have been identified. The most robust health endpoints are where a relationship has been firmly (based on sound studies and statistical analysis) established between exposure to PM and a specific health endpoint (effect/outcome)
- Identify the most relevant and robust exposure-response relationship for the quantitative assessment of exposure. The exposure-response relationships are derived from published peer reviewed sources and relate to the identified health endpoints (effects/outcomes)
- The health endpoints and associated exposure-response relationships adopted for this assessment, in particular those associated with NO₂ and PM derived from combustion sources (such as petrol and diesel vehicles) have been selected based on consistency with previous NSW road tunnel projects and follow previous NSW Health advice
- For other pollutants and stressors, national guidelines based on the protection of health have been adopted.

2.2.5 Risk characterisation

Risks have been characterised using quantitative and qualitative assessment methods. For the assessment of NO₂ and PM, the quantitative assessment involved identification of an exposure concentration that relates to the project (ie the change in particulate concentration associated with the project), use of relevant exposure-response relationships (for the health endpoints/effects assessed) to calculate health impacts. This enabled an assessment of an increased annual risk and an increased incidence of the effect occurring within the population of concern. For the assessment of VOCs and PAHs, impacts have been quantified using both a threshold and non-threshold approach. Details on the methodology adopted for the quantification of impacts is presented in Section 5, with Annexure D presenting the basis for determining if risks are considered the acceptable, or unacceptable.

In some cases, such as the assessment of social impact, a qualitative assessment has been carried out. A qualitative assessment does not specifically require the quantification of risk or exposure. Rather, the assessment provides a relative or comparative evaluation of whether the exposure or impact considered is positive or negative and where there may be a negative impact, whether this impact is acceptable or unacceptable in the local population.

The assessment has also considered the level of uncertainty associated with the concept design, and all aspects of the technical studies relied on for the conduct of the Health impact assessment and within the Health impact assessment. The final determination of risks to human health was based on the quantification of risks as well as consideration of these uncertainties (as detailed in Section 10).

2.2.6 Features of the risk assessment

The Health impact assessment has been carried out in accordance with international best practice and general principles and methodology accepted in Australia by groups/organisations such as National Health and Medical Research Committee (NHMRC), NEPC and enHealth. There are certain features of risk assessment methodology that are fundamental to the assessment of the outputs and to drawing conclusions on the significance of the results. These are summarised below:

- The assessment has relied on assessments completed in other technical working papers, specifically in relation to traffic, air quality, noise and vibration, economic and social impacts

- A risk assessment is a tool (that is systematic) that addresses potential exposure pathways based on an understanding of the nature and extent of the impact assessed and the uses of the local area by the general public. The risk assessment is based on an estimation of maximum, or worst case, impacts (air quality, noise and vibration) on the local community and is expected to overestimate the actual risks
- Quantitative conclusions can only be drawn with respect to emissions to air, noise and vibration derived from the project as outlined in the respective technical working papers
- Available statistics in relation to the existing health status of the existing community are presented. However, the Health impact assessment does not provide an evaluation of the overall future health status of the community or any individuals. Rather, it is a logical process of calculating and comparing potential exposure concentrations (acute and chronic) in surrounding areas (associated with the project) with regulatory and published acceptable air concentrations that any person may be exposed to over a lifetime without unacceptable risk to their health. It can also involve calculating an incremental impact that can be evaluated in terms of an acceptable level of risk
- The risk assessment reflects the current state of knowledge regarding the potential health effects of chemicals identified and evaluated in this assessment. This knowledge base may change as more insight into biological processes is gained.

This assessment has focused on key impacts on air quality, noise and vibration and social changes. Other impacts relevant to the health of the community, as outlined in the Secretary's environmental assessment requirements have also been considered.

2.3 Incorporation of health issues into the project design

The design of the project has been carried out as an iterative approach, with considerations included in various aspects of the design to minimise impacts on the community, including on health and wellbeing. Some of the key design considerations that have been incorporated into the project that have minimised impacts to community health include:

- Use of Yurublin Park as a construction support site to avoid impacts on Birchgrove Oval (Yurublin Point construction support site (WHT4))
- Locating cofferdams offshore to avoid direct impacts on private property and foreshore areas
- Use of water based transport to reduce construction vehicles on local roads
- A permit for disposal of suitable dredged material offshore has been submitted to the Commonwealth Department of the Environment and Energy. Disposal of suitable material offshore would be beneficial as it would avoid unnecessary disposal of spoil to landfill, and would reduce the impacts of construction vehicle movements on the local road network
- Improvements to connectivity and amenity for pedestrians and cyclists in the vicinity of the Warringah Freeway, including:
 - Replacement of the existing Ridge Street active transport bridge with a new, wider structure to improve connectivity
 - Provision of a new dedicated cycleway between Miller Street and the Falcon Street pedestrian bridge
 - Improving pedestrian crossings at the Falcon Street ramp connections to improve active transport connections
 - Improving active transport amenity and connectivity as part of the upgrade of the Ernest Street bridge
- Provision of a number of construction support sites with direct access to the motorway or arterial road networks to minimise the amount of construction vehicles along local roads
- Design responses to minimise impacts on St Leonards Park by permanent infrastructure
- Refinement to the Cammeray Golf Course construction support site (WHT10 and WFU8) layout and permanent motorway facilities to maintain a functioning golf course during construction and operation.

In addition, the tunnel ventilation system has been designed to meet the in-tunnel air quality criteria, and to ensure emissions are dispersed so that there are minimal effects on air quality and would operate without portal emissions. The design considerations included ensuring the location, height, diameter and emission rate of the ventilation outlet minimises local air quality impacts.

Noise mitigation measures (road pavement treatments, noise barriers and/or architectural treatments where necessary) have also been identified to address predicted exceedances of operational noise criteria.

Refer to Chapter 4 (Project development and alternatives) of the environmental impact statement for additional details on design considerations.

3 Community profile

3.1 General

This section provides an overview of the communities potentially impacted by the project as defined in the Technical working paper: Air quality (ERM, 2020). The defined area (study area), illustrated in Figure 3-1, identifies the area over which impacts on air quality have been considered (referred to as the GRAL domain (Graz Lagrangian Model)). A smaller area within this larger area has been considered for the assessment of noise, soil and vibration impacts.

In reviewing key aspects of the local communities that are relevant to the conduct of the Health impact assessment, information has been obtained from the Australian Bureau of Statistics (ABS) Census 2016, information relevant to LGAs and health districts (in particular Sydney Local Health District and Northern Sydney Local Health District). In some cases, where local data is lacking, information has been obtained (or compared with) data from larger population areas of Sydney and/or NSW.

3.2 Surrounding area and population

The population considered in this assessment includes those who live or work within the vicinity of the construction support sites, interchanges (ie where the tunnel interfaces with the surface road network), ventilation facilities and the road network, related to the Western Harbour Tunnel and Beaches Link program of works (including the project) as well as the M4-M5 Link.

The study area covers a large number of individual suburbs that sit within the following LGAs:

- Canada Bay
- Inner West (amalgamated from Ashfield, Leichhardt and Marrickville LGAs)
- Sydney
- Woollahra
- Mosman
- North Sydney
- Lane Cove
- Hunters Hill
- Willoughby
- Northern Beaches (amalgamated from Manly, Pittwater and Warringah LGAs)
- Ku-ring-gai.

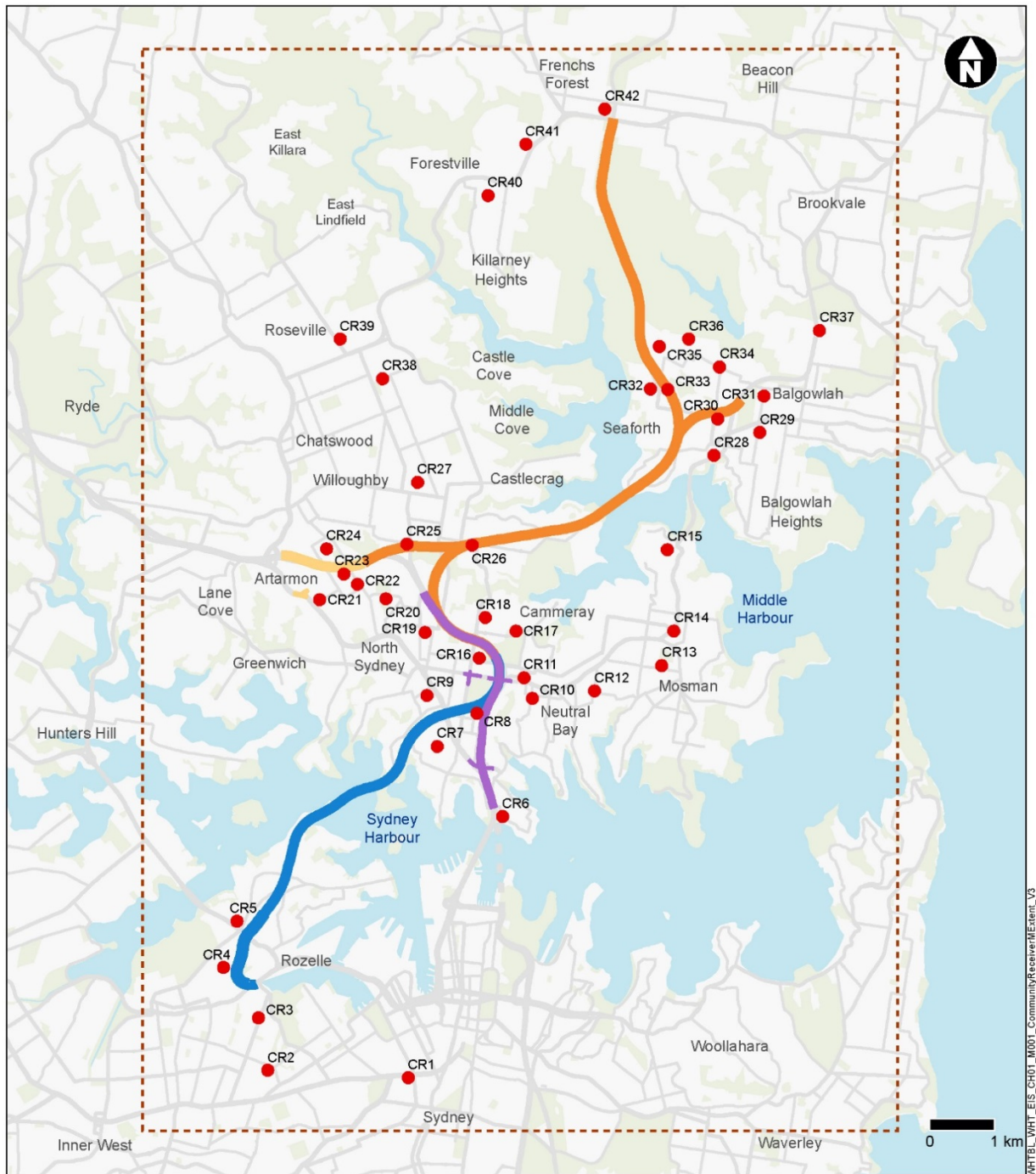


Figure 3-1 Health impact assessment study area

3.3 Sensitive receptors

The assessment of potential impacts on the surrounding community, particularly in relation to air quality, has considered the location where maximum impacts from the project may occur. In addition, impacts in the wider community have also been considered. Within the community, a number of additional locations, referred to as community receptors, have been identified in the suburbs close to the Western Harbour Tunnel and Beaches Link program of works corridor. Community receptors are locations in the local community where more sensitive members of the population, such as infants and young children, the elderly or those with existing health conditions or illnesses, may spend a significant period of time. These locations comprise hospitals, child care facilities, schools and aged care homes/facilities.

Table 3-1 presents a list of the community receptors included in this assessment. The list relates to receptors considered in the assessment of air quality impacts, for which a quantitative assessment of health impacts has been carried out in this report. It is noted that this is representative only and is not intended to comprise an exhaustive list of community receptors in the study area.

The location of the sensitive or community receptors is presented on Figure 3-2.

In addition to these community receptors, a maximum of 35,490 individual receptors (residential, workplace and recreational (RWR) receptors also shown on Figure 3-2) have been modelled in the streets/suburbs located in the study area. These individual RWR receptors represent a range of uses including residential, workplaces or recreational (open space) areas in the surrounding community, as detailed in Table 3-2. The RWR include all other community receptors located in the study area, not only those included in Table 3-1. All these individual receptors have also been considered in this report, so that all sensitive receptors have been adequately addressed.

Table 3-1 Community receptors included in health impact assessment

	Receptor name	Type of receptor	Suburb	LGA
CR1	University of Notre Dame Broadway	University	Chippendale	Sydney
CR2	Laverty Pathology Annandale	Medical centre	Annandale	Inner West
CR3	St Basil's Annandale	Aged care	Annandale	Inner West
CR4	The Jimmy Little Community Centre	Community centre	Lilyfield	Inner West
CR5	Rozelle Public School	Primary School	Rozelle	Inner West
CR6	St Aloysius College	High School	Kirribilli	North Sydney
CR7	Dancing Dingo Family Day Care	Child care	North Sydney	North Sydney
CR8	Wenona School	Primary School	North Sydney	North Sydney
CR9	Mater Hospital	Hospital	North Sydney	North Sydney
CR10	Neutral Bay Public School	Primary School	Neutral Bay	North Sydney
CR11	Neutral Bay Medical Centre	Medical Centre	Neutral Bay	North Sydney
CR12	Puddleducks Child Care Centre	Childcare	Cremorne	North Sydney
CR13	Mosman Public School	Primary School	Mosman	Mosman
CR14	Garrison & Killarney Retirement Centre	Aged care	Mosman	Mosman
CR15	Beauty Point Public School	Primary School	Mosman	Mosman
CR16	Anzac Park Public School	Primary School	Cammeray	North Sydney
CR17	KU Cammeray Preschool	Preschool	Cammeray	North Sydney
CR18	Cammeray Public School	Primary School	Cammeray	North Sydney
CR19	Atchison Preschool	Preschool	Crows Nest	North Sydney
CR20	Berry Cottage Childcare	Child care	Naremburn	Willoughby
CR21	Explore & Develop Artarmon - Early Learning Centre	Preschool	Artarmon	Willoughby
CR22	SBS Child Care	Child care	Artarmon	Willoughby

	Receptor name	Type of receptor	Suburb	LGA
CR23	Butterflies Early Learning Childcare Centre	Child care	Artarmon	Willoughby
CR24	Artarmon Public School	Primary School	Artarmon	Willoughby
CR25	Sue's Childcare Castlevale	Child care	Willoughby	Willoughby
CR26	Northside Baptist Preschool	Preschool	Northbridge	Willoughby
CR27	Willoughby Public School	Primary School	Willoughby	Willoughby
CR28	Peek A Boo Cottage	Child care	Seaforth	Northern Beaches
CR29	St Cecilia's Catholic Primary School	Primary School	Balgowlah	Northern Beaches
CR30	Seaforth Public School	Primary School	Seaforth	Northern Beaches
CR31	Punchinello Kindergarten	Preschool	Balgowlah	Northern Beaches
CR32	Harbour View Children's Centre	Child care	Seaforth	Northern Beaches
CR33	Jacaranda Creative Play Centre	Child care	Seaforth	Northern Beaches
CR34	St James Medical and Cosmetics Centre	Medical Centre	North Balgowlah	Northern Beaches
CR35	KU Bligh Park Preschool	Preschool	North Seaforth	Northern Beaches
CR36	Balgowlah North Public School	Primary School	Balgowlah	Northern Beaches
CR37	Hardi Aged Care Manly Vale	Aged care	Manly Vale	Northern Beaches
CR38	Willoughby Retirement Village	Aged care	Willoughby	Willoughby
CR39	Roseville Public School	Primary school	Roseville	Ku-ring-gai
CR40	UnitingCare Forestville Preschool	Childcare	Forestville	Northern Beaches
CR41	Beehive Kindy	Childcare	Forestville	Northern Beaches
CR42	Northern Beaches Hospital	Hospital	Frenchs Forest	Northern Beaches

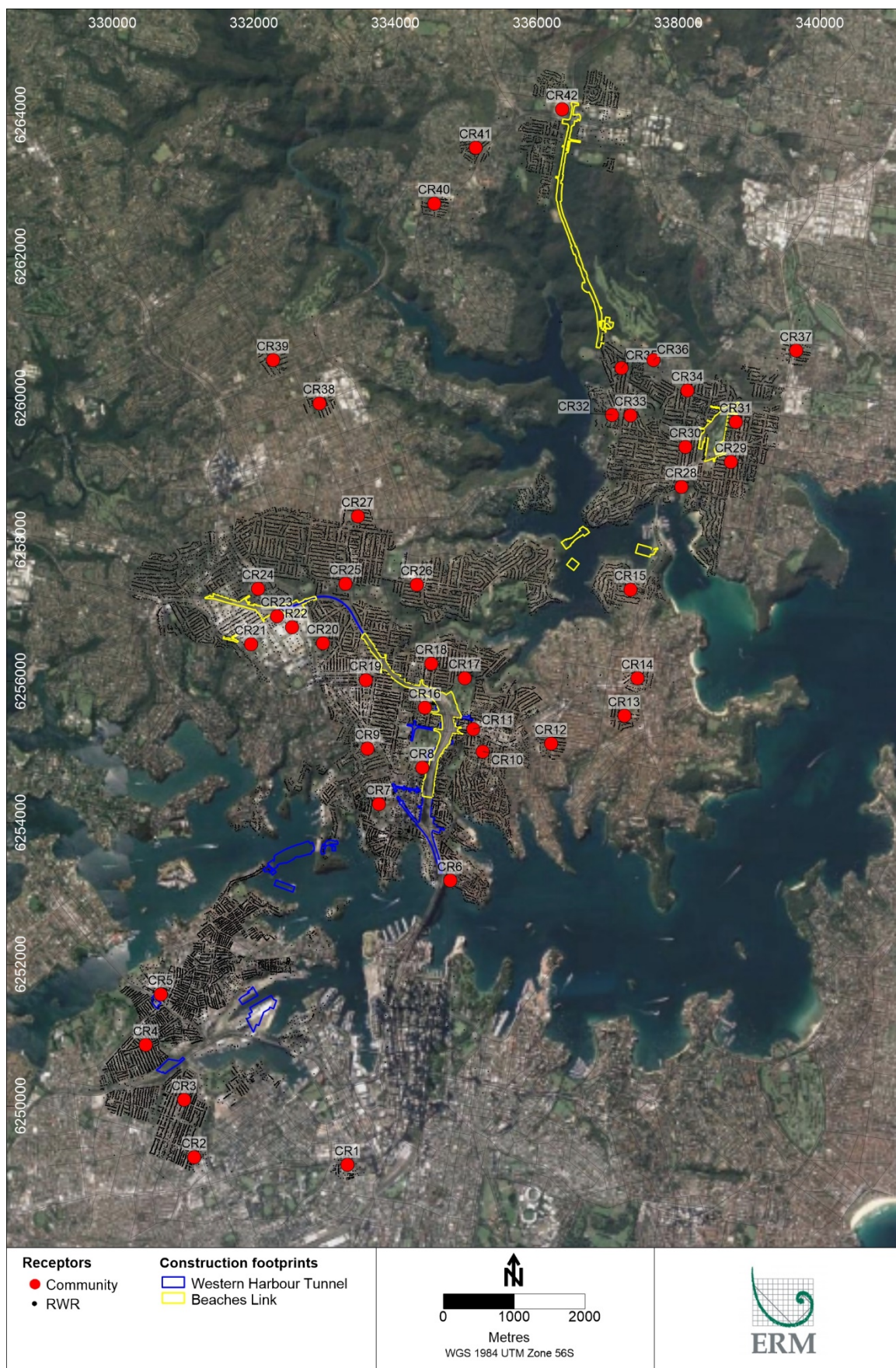


Figure 3-2 Community receptors and RWR receptors evaluated in health impact assessment

Table 3-2 Summary of RWR receptor types

Receptor type	All receptors (‘Do minimum’ scenario) ^(c)		‘Do something’ scenario ^(c)		‘Do something – cumulative’ scenario ^(c)	
	Number	%	Number	%	Number	%
Aged care	31	0.09%	31	0.09%	31	0.09%
Child care/pre-school	124	0.35%	123	0.35%	123	0.35%
Commercial	946	2.67%	944	2.66%	943	2.66%
Community	175	0.49%	175	0.49%	175	0.49%
Further education	13	0.04%	13	0.04%	13	0.04%
Hospital	6	0.02%	6	0.02%	6	0.02%
Hotel	43	0.12%	43	0.12%	43	0.12%
Industrial	484	1.36%	479	1.35%	465	1.31%
Medical practice	62	0.17%	62	0.18%	62	0.18%
Mixed use	813	2.29%	811	2.29%	811	2.29%
Other ^(a)	229	0.65%	219	0.62%	218	0.62%
Park/sport/recreation	317	0.89%	316	0.89%	312	0.88%
Place of worship	76	0.21%	76	0.21%	76	0.21%
Residential	32,036	90.27%	32,032	90.32%	32,022	90.29%
School	135	0.38%	135	0.38%	135	0.38%
Grand Total ^(b)	35,490	100.00%	35,466	100.00%	35,440	100.00%

- a) ‘Other’ includes laboratories, infrastructure, construction sites, wharfs, SES facilities and non-identified locations.
- b) Total of receptor types does not add up to exactly 100 per cent due to rounding
- c) ‘Do Minimum’ - without the project, ‘Do Something’ - with the project, and ‘Do Something cumulative’ - with the project alongside other major motorway projects (refer to Section 5.4)

3.4 Population profile

The population within the study area consists of residents and workers as well as those attending schools, day care centres, hospitals and recreational areas. The composition of the populations located within the study area is expected to be generally consistent with population statistics for the larger individual suburbs that are wholly or partially included in the study area. Population statistics for the LGAs are available from the ABS for the census year 2016 and are summarised in Table 3-3. For the purpose of comparison, the population statistics presented also include the statistics for larger statistical population groups in the area (defined by the ABS SA4) and the larger statistical areas of Greater Sydney and the rest of the NSW (excluding Greater Sydney) (as defined by the ABS).

Table 3-4 presents a summary of a selected range of demographic measures relevant to the population of interest with comparison to statistical areas of Greater Sydney and the rest of NSW (excluding Greater Sydney).

Table 3-3 Summary of population statistics in study area

Location	Total population		% Population by key age groups					
	Male	Female	0–4	5–19	20–64	65+*	1–14*	30+*
Local government areas								
Canada Bay	42,348	45,666	6.2	14.6	64.5	14.7	14.9	62.8
Inner West	88,736	93,302	5.9	13.2	68.7	12.2	14.1	63.8
Sydney	107,852	100,530	3.3	7.4	81.0	8.2	5.9	57.6
Woollahra	25,232	29,009	5.1	15.3	60.9	18.6	14.5	65.6

Location	Total population		% Population by key age groups					
Mosman	13,189	15,290	5.2	17.9	57.7	19.1	16.6	67.1
North Sydney	31,910	35,744	5.7	9.7	70.2	14.4	11.2	68.4
Lane Cove	17,733	18,313	6.7	17.1	62.5	13.7	17.1	62.5
Hunters Hill	6987	7016	5.1	22.1	51.2	21.6	18.1	64.3
Willoughby	35,686	38,624	6.6	18.2	61.6	13.7	18.2	62.4
Northern Beaches	123,507	129,370	6.2	19.2	57.8	16.8	18.6	64.3
Ku-ring-gai	56,657	61,394	5.1	23.0	53.7	18.2	19.4	62.5
Larger local statistical areas (SA4 – includes local government areas)								
Sydney – Eastern Suburbs	129,505	137,524	5.5	14.7	65.5	14.3	14.1	61.5
Sydney – City and Inner South	161,061	154,483	4.1	9.6	76.9	9.4	8.6	58.9
Sydney – Inner West	142,436	150,867	5.9	14.5	66.1	13.5	14.6	61.9
Sydney - Ryde	88,832	93,286	5.9	17.1	62.0	15.1	15.9	61.4
Sydney – North Sydney Hornsby	194,785	210,572	5.9	18.4	60.1	15.6	17.4	63.9
Sydney – Northern Beaches	123,507	129,370	6.2	19.2	57.8	16.8	18.6	64.3
Statistical areas of Sydney and NSW								
Greater Sydney	2,376,766	2,447,221	6.4	18.2	61.4	13.9	17.4	60.4
Rest of NSW (excluding Greater Sydney)	1,301,717	1,341,813	5.8	18.5	55.1	20.6	17.3	64.6

Ref: Australian Bureau of Statistics, Census Data 2016

SA = statistical area

* Age groups specifically relevant to the characterisation of risk

Comparing the populations of the study area to that of Greater Sydney the following it is noted:

- Sydney – City and Inner South have a lower proportion of children (0–14 years), a higher proportion of working aged individuals and a lower proportion of individuals aged over 65 years
- At a LGA level:
 - Sydney, Woollahra, Mosman, Hunters Hill and Ku-ring-gai have a lower proportion of young children (0–4 years)
 - Canada Bay, Inner West, Sydney and North Sydney have a lower proportion, while Hunters Hill and Ku-ring-gai have a higher proportion of children (5–19 years)
 - Hunters Hill and Ku-ring-gai have a lower proportion while Inner West, Sydney and North Sydney have a higher proportion of working age individuals
 - Sydney has a lower proportion while Woollahra, Mosman, Hunters Hill, Northern Beaches and Ku-ring-gai have a higher proportion of individuals aged over 65 years.

The estimated population growth from 2011 to 2036 for these areas are (NSW Planning & Environment, 2016):

- Canada Bay: 53.5 per cent growth
- Inner West: 28.7 per cent growth
- Sydney: 72 per cent growth
- Woollahra: 6.3 per cent growth
- Mosman: 9.9 per cent growth
- North Sydney: 37.3 per cent growth
- Lane Cove: 57.4 per cent growth
- Hunters Hill: 13.2 per cent growth
- Willoughby: 24.6 per cent growth

- Northern Beaches: 18.4 per cent growth
- Ku-ring-gai: 34.8 per cent growth.

The social demographics of an area have some influence on the health of the existing population. As shown in Table 3-4, the population in the study area generally has lower levels of unemployment and higher household income than either greater Sydney or the rest of NSW. However, mortgage repayments and rent are higher in the study area than in either greater Sydney or the rest of NSW.

Table 3-4 Selected demographics of population of interest

Location	Median age	Median household income (\$/week)	Median mortgage repayment (\$/month)	Median rent (\$/week)	Average household size (persons)	Unemployment rate (%)
Local government areas						
Canada Bay	36	2061	2500	565	2.6	5.0
Inner West	36	2048	2600	480	2.4	4.8
Sydney	32	1926	2499	565	2.0	6.0
Woollahra	39	2687	3200	650	2.3	3.3
Mosman	42	2522	3000	560	2.4	3.9
North Sydney	37	2360	2600	575	2.0	3.7
Lane Cove	36	2376	2600	520	2.5	4.4
Hunters Hill	43	2467	3033	490	2.7	3.4
Willoughby	37	2271	2877	580	2.7	5.1
Northern Beaches	40	2178	2800	565	2.7	3.5
Ku-ring-gai	41	2640	3000	650	2.9	4.7
Larger local statistical areas (SA4 – includes local government areas)						
Sydney – Eastern Suburbs	35	2163	2900	580	2.4	4.6
Sydney – City and Inner South	33	1894	2500	550	2.2	5.7
Sydney – Inner West	36	1964	2500	500	2.6	5.5
Sydney – Ryde	37	1919	2383	470	2.7	6.1
Sydney – North Sydney Hornsby	38	2333	2600	555	2.6	4.5
Sydney – Northern Beaches	40	2178	2800	565	2.7	3.5
Statistical areas of Sydney and NSW						
Greater Sydney	36	1750	2167	440	2.8	6.0
Rest of NSW (excluding Greater Sydney)	43	1168	1590	270	2.4	6.6

Source: Australian Bureau of Statistics, Census Data 2016

3.5 Existing health of population

3.5.1 General

The assessment presented in this report has focused on key pollutants that are associated with construction and combustion sources (from vehicles), including VOCs, PAHs, CO, NO₂ and PM (namely PM_{2.5} and PM₁₀). For these pollutants, there are a large number of sources in the study area including other combustion sources (wood-fired heating, domestic cooking, industrial emissions) and non-combustion sources including other local construction/earthworks. Other aspects that affect the health of an individual include personal exposures (such as smoking) and risk taking behaviours.

When considering the health of a local community there are a large number of factors to consider. The health of the community is influenced by a complex range of interacting factors including age,

socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. While it is possible to review existing health statistics for the local areas surrounding the project, and compare them to the Greater Sydney area and NSW, it is not possible or appropriate to be able to identify a causal source, particularly individual or localised sources.

Information relevant to the health of populations in NSW is available from NSW Health for populations grouped by local health districts (where most of the project area is located in the Sydney Local Health District and the Northern Sydney Local Health District¹). Not all of the health data is available for all of these areas.

Most of the health indicators presented in this report are not available for each of the smaller suburbs/statistical areas surrounding the site. Health indicators are only available from a mix of larger areas (that incorporate the study area), namely the Sydney Local Health District and the Northern Sydney Local Health District. There are few health statistics that are reported for the smaller local government areas relevant to this project. The health statistics for these larger areas (and in some cases data for the Greater Sydney area) are assumed to be representative of the smaller population located within these districts and areas.

3.5.2 Health related behaviours

Information in relation to health related behaviours (that are linked to poorer health status and chronic disease including cardiovascular and respiratory diseases, cancer, and other conditions that account for much of the burden of morbidity and mortality in later life) is available for the larger populations within the local health districts in Sydney and NSW. The study population is largely located within the Sydney Local Health District and the Northern Sydney Local Health District. The incidence of these health-related behaviours in these districts, compared with other districts in NSW, and the state of NSW (based on NSW Health data from 2015 and 2016) is illustrated in Figure 3-3.

Review of this data indicates the population in the Northern Sydney, Sydney and South Eastern Sydney local health districts (that include the study area) have lower rates of physical inactivity and of being overweight and obese compared with NSW. Further, the population in the Northern Sydney Local Health District have lower rates of smoking.

¹ A small amount of the study area is located in South Eastern Sydney Local Health District

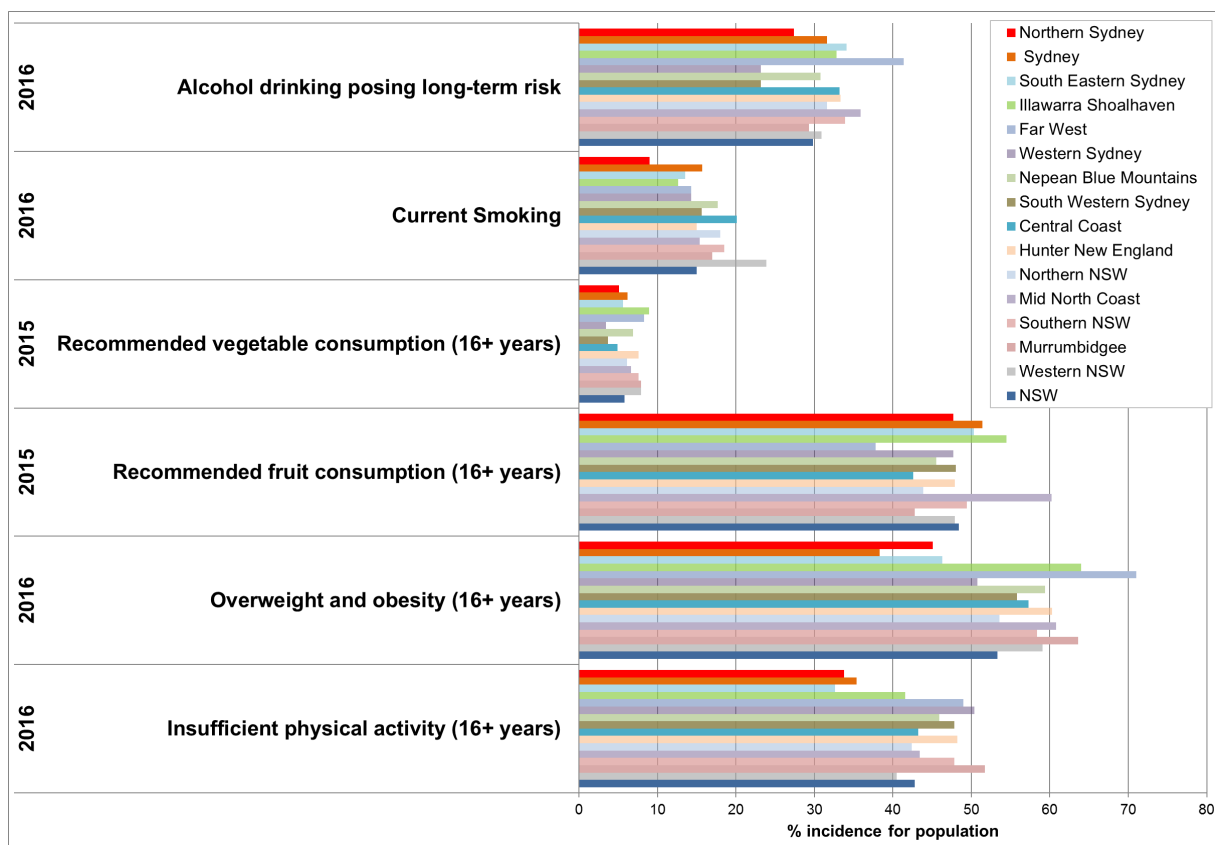


Figure 3-3 Summary of incidence of health-related behaviours (Source: HealthStats NSW, 2018)

Note: these health related behaviours include those where the behaviour/factor may adversely affect health (eg alcohol drinking, smoking, being overweight/obese and inadequate physical activity) and others where the behaviour/factor may positively affect (enhance) health (eg adequate fruit and vegetable consumption).

The study area is located in the Northern Sydney Local Health District, Sydney Local Health District and South Eastern Sydney Local Health District.

3.5.3 Health indicators

Figure 3-4 presents a comparison of the rates of the key mortality indicators based on data from 2011 to 2015 (depending on the available data) for all causes, potentially avoidable, cardiovascular disease, lung cancer and chronic obstructive pulmonary disease (COPD), reported in the larger Northern Sydney, Sydney and South Eastern Sydney local health districts, with comparison to other NSW local health districts (in urban and regional areas) as well as NSW as a whole.

Figure 3-5 presents a comparison of the rates of the hospitalisations for key health effects based on data from 2015–2016 for diabetes, cardiovascular disease, asthma (5–34 years) and COPD (65+ years) reported in the larger Northern Sydney, Sydney and South Eastern Sydney local health districts, with comparison to other NSW local health districts (in urban and regional areas) as well as NSW as a whole.

It is noted that the data reported in these figures is based on statistics that are publicly available from NSW Health. Therefore, some of the statistics for mortality and hospitalisations relate to slightly different health endpoints and/or different age groups. The statistics are included for general comparison and discussion. Actual health statistics considered in the characterisation of risk are presented in Table 3-5.

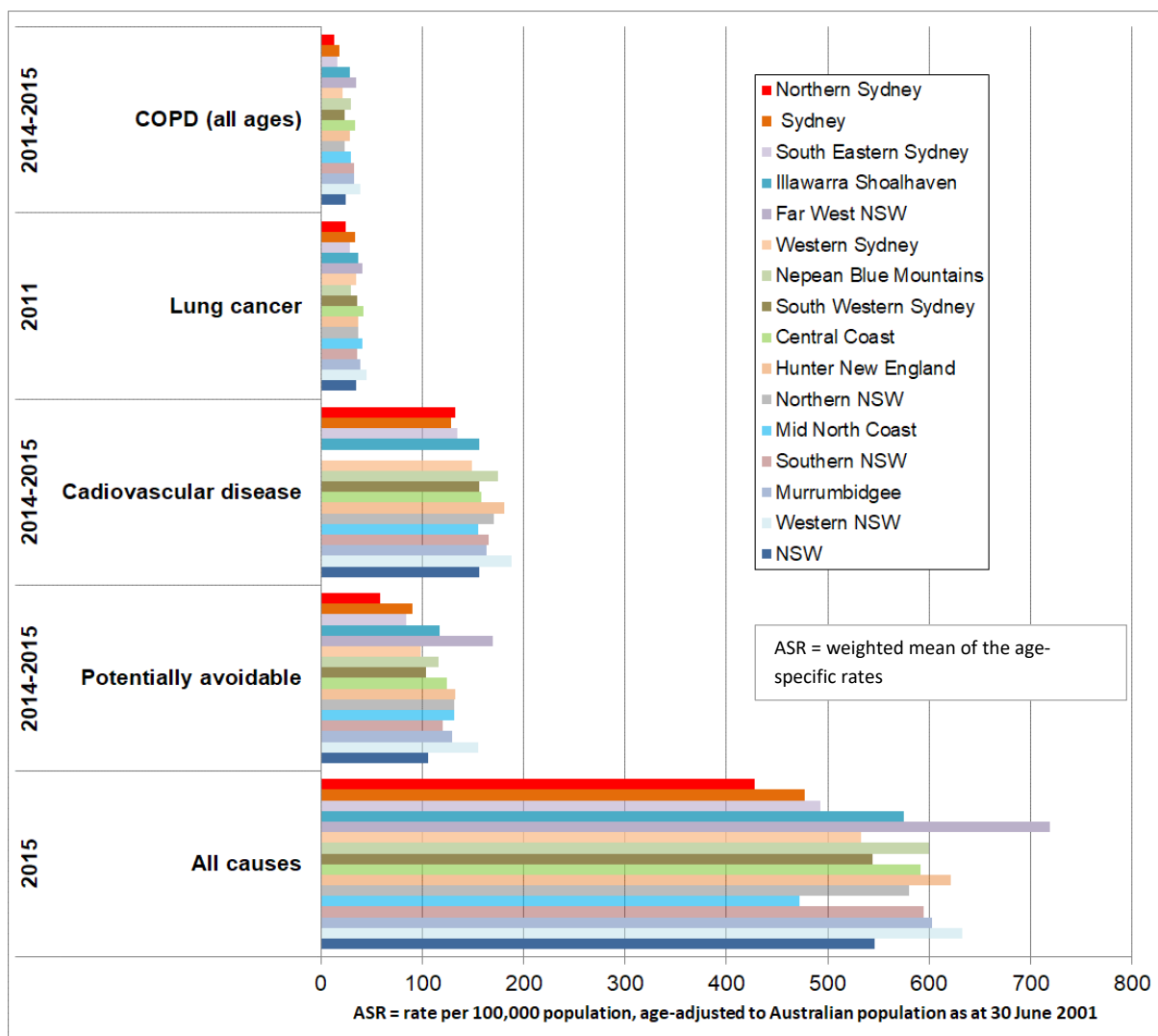


Figure 3-4 Summary of mortality data 2011–2015 (Source: HealthStats NSW, 2018)

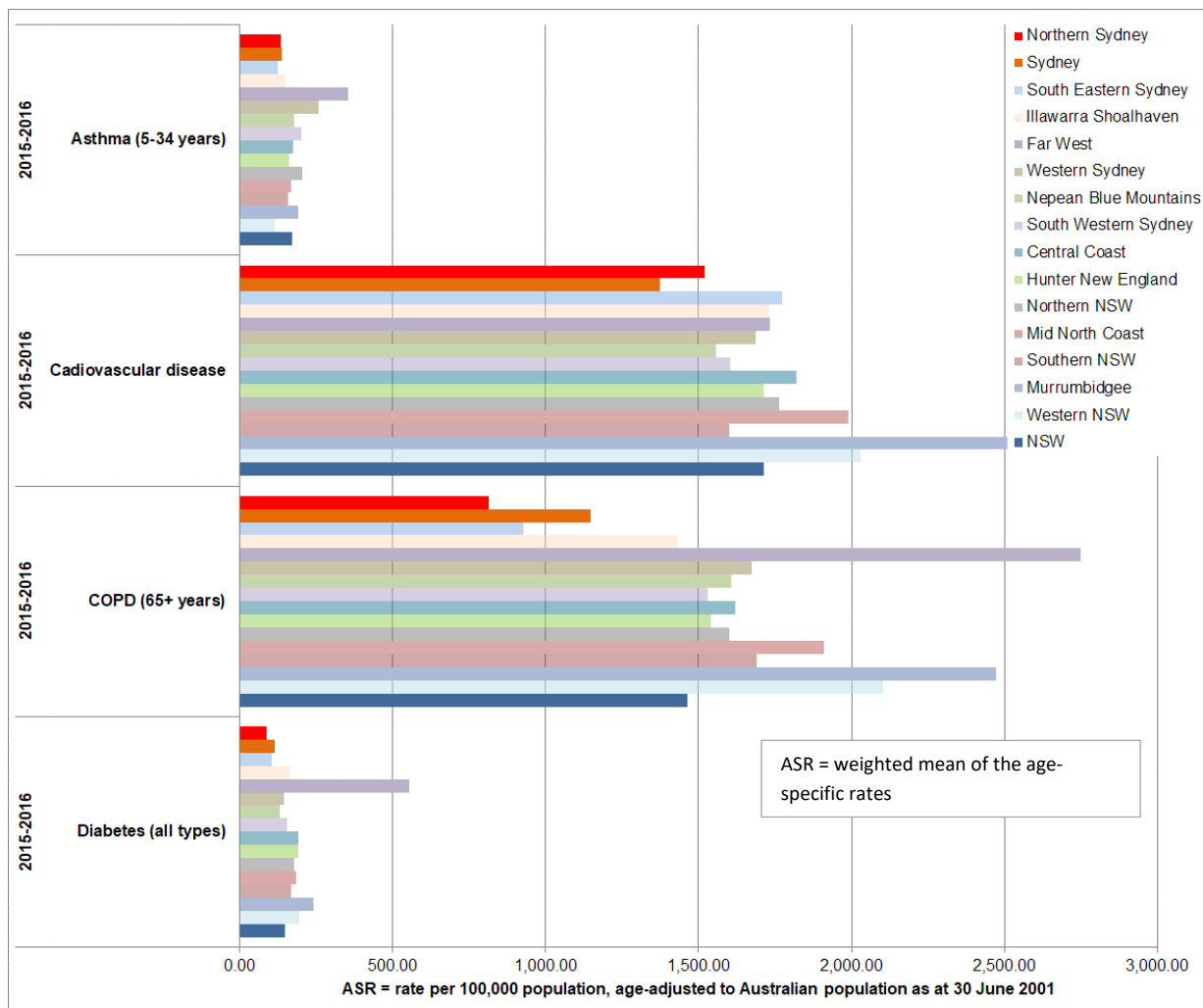


Figure 3-5 Summary of hospitalisation data 2015–2016 (Source: HealthStats NSW, 2018)

Review of the figures presented above indicate that the rate of mortality for the indicators presented in the Northern Sydney, Sydney and South Eastern Sydney local health districts are significantly lower than that reported for NSW, except for lung cancer which was not significant for the Sydney Local Health District.

Review of the figures also show that the rate of hospitalisations for the indicators presented in the Northern Sydney, Sydney and South Eastern Sydney local health districts is significantly lower than that reported for NSW, with the exception for cardiovascular disease hospitalisations in South Eastern Sydney, which is similar to the rate for NSW.

Table 3-5 presents specific health data relevant to mortality and hospitalisations, addressing all cases as well as respiratory and cardiovascular disease. These are data that are specifically relevant to the quantification of exposure to nitrogen dioxide and particulate matter presented in Section 5.

The table presents data, where available, for the slightly smaller population areas in the LGAs in the study area with comparison against data for the Northern Sydney Local Health District, Sydney Local Health District, South Eastern Sydney Local Health District, Sydney and NSW.

In relation to mental health, data from NSW Health indicates the following for adults:

- The rate of high or very high psychological distress reported in 2015 in the Sydney Local Health District (13.9 per cent) is a little higher, and in Northern Sydney (10 per cent) and South Eastern Sydney local health districts (9.3 per cent) a little lower than the state average (11.8 per cent), however none were significantly different
- The rate of high or very high psychological distress in Northern Sydney Local Health District has varied between eight and 15 per cent while in the Sydney Local Health District it has varied between 10 and 15 per cent between 2003 and 2015. In the South Eastern Sydney Local Health District, the rate has declined from around 14 per cent in 2003 to less than 10 per cent in 2015.

Table 3-5 provides other key indicators for mental health.

Review of the data presented in Table 3-5 generally indicates that for the population in the project area, the health statistics (including mortality rates and hospitalisation rates for most of these categories) are variable but generally similar to those reported in the larger local health districts of Northern Sydney, Sydney and South Eastern Sydney and the wider Sydney metropolitan area and slightly lower than the whole of NSW.

For the assessment of potential health impacts from the project, where specific health statistics for the smaller populations within the project area is not available (and not reliable due to the small size of the population), adopting health statistics from the whole of Sydney is considered to provide a representative, if not cautious (eg over estimating existing health issues), summary of the existing health of the population of interest.

There are a number of statistics where no more specific or recent data for the Sydney Metropolitan Area than 2010 is available. Where data is available from 2010 as well as more recently, it is observed that the rate of disease or mortality is reducing with time. Use of data from Sydney Metropolitan Area for 2010 in this assessment is conservative and is expected to overestimate risk.

The rate of antidepressant medication prescriptions is an indicator that can be used to review changes in stress and anxiety levels within a community, and these are presented in Table 3-6. While this data was not directly used in the Health impact assessment to evaluate specific impacts, the data is relevant to assist in ongoing monitoring of potential indicators of changes that increase or decrease stress and anxiety in the community. In relation to the rate of medication prescriptions for antidepressants, the following is noted:

- For 18 years and older the rates are lower than the state average for all regions except 65+ years in Leichhardt
- For 17 years and under the regions of Leichhardt, Eastern Suburbs – North, Chatswood – Lane Cove, and North Sydney – Mosman have higher rates of prescription than the state average.

Table 3-5 Summary of key health indicators

Health indicator Rate per 100,000 population (for the year, or years as referenced) – for each area evaluated																
Mortality																
All causes – all ages	403.3 C	534.2 C	508.0 C	396.0 C	396.4 C	335.0 C	401.6 C	501.7 C	433.5 C	462.3 C	364.6 C	428.0 ^C	477.4 ^C	493.0 ^C	--	546.0 ^C
All causes (non-trauma) ≥30 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	976.5	--
All causes ≥30 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1026	--
Cardiopulmonary ≥30 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	412	--
Cardiovascular – all ages	113.4 C	146.4 C	138.9 C	110.5 C	104.5 C	98.7 ^C	113.3 C	133.6 C	117.2 C	127.4 C	107.7 C	132.0 ^C	128.7 ^C	134.7 ^C	191.8	155.7 ^C
Respiratory – all ages	--	--	--	--	--	--	--	--	--	--	--	32.1 ^A	39.9 ^A	37.8 ^A	51.5	46.8 ^A
Hospitalisations																
Coronary heart disease	288.2 B	276.5 B	378.1 B	426.0 B	334.9 B	333.1 B	308.4 B	328.9 B	324.5 B	453.1 B	358.2 B	423.5 ^E	328.5 ^E	611.9 ^E	--	525.7 ^E
COPD >65 years	--	--	--	--	--	--	--	--	--	--	--	814.0 ^E	1147.3 ^E	928.5 ^E	--	1462.8 ^E
COPD All ages	125.2 B	195.9 B	243.4 B	80.2 B	68.9 ^B	91.3 ^B	77.9 ^B	96.6 ^B	124.2 B	140.6 B	67.7 ^B	126.0 ^E	187.3 ^E	142.4 ^E	--	242.2 ^E
<i>Cardiovascular disease</i>																
All ages	1219.6 B	1329.3 B	1435.3 B	1473 B	1337.6 B	1338.8 B	1309.1 B	1305.2 B	1252.2 B	1677.7 B	1384.3 B	1520.1 ^E	1372.4 ^E	1772.1 ^E	1976	1713.3 ^E
>65 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9235	--
<i>Respiratory disease</i>																
All ages	--	--	--	--	--	--	--	--	--	--	--	1539.0 ^E	1494.3 ^E	1441.8 ^E	2003	1731.3 ^E
>65 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3978	--

Health indicator	Rate per 100,000 population (for the year, or years as referenced) – for each area evaluated															
Asthma																
Asthma hospitalisations (ages 5–34 years)	--	--	--	--	--	--	--	--	--	--	--	134.2 ^E	137.6 ^E	124.0 ^E	--	171.1 ^E
Asthma emergency department hospitalisations (1–14 years)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1209	--
Asthma prevalence (current) for children aged 2–15 years	--	--	--	--	--	--	--	--	--	--	--	17.7% ^C	6.2% ^C	10.2% ^C	--	13.5% ^C
Current asthma for ages 16 and over	--	--	--	--	--	--	--	--	--	--	--	10.0% ^D	9.7% ^D	9.0% ^D	--	11.3% ^D

* Data for Sydney Metropolitan area for 2010 based on hospital statistics as reported for 2010 and population data from the ABS for 2011 (relevant to each age group considered) used in review of exposure and risks to inform recommendations for updating the National Environment Protection Measure (NEPM) Ambient Air Quality (AAQ) (Golder 2013)

All other data has been obtained from Health Statistics New South Wales, where: A: 2013–2015 data B: 2014-15 to 2015-16 data C: 2014-2015 or 2015 data D: 2016 data E: 2015-2016 data

-- No data available

Bold and shaded: Data used in the characterisation of risk

Table 3-6 Summary of key health indicators: Mental health

Age group	Number of prescriptions for antidepressants per 100,000 people, by LGA in 2014-2015										
	Canada Bay	Leichhardt	Sydney City	Inner	Eastern Suburbs North	- Ryde Hunters Hill	Chatswood–Lane Cove	North Sydney Mosman	- Manly	Ku-ring-gai	NSW average
17 years and under	5448	11,195	7284		8245	5582	8499	10,820	7601	7812	8187
18 to 64 years	58,768	82,370	76,303		73,291	60,703	65,234	71,136	65,002	73,023	90,959
65 years and over	139,261	182,025	159,584		164,303	148,900	142,684	151,151	125,163	134,448	179,771

Data from Australian Atlas of Healthcare Variation, Atlas 2015 (note that the Atlas 2017 did not include mental health data)

4 Community concerns

A range of community engagement activities have been and continue to be carried out as part of the project, as outlined in Chapter 7 (Stakeholder and community engagement) of the environmental impact statement. Issues raised during community consultation (conducted in 2017 and 2018) have covered a range of different aspects of the project, as summarised in Table 4-1.

The community have raised concerns for their health, specifically from air quality impacts. While not directly referring to health concerns, issues such as noise and road safety are related to health. In addition, a number of other issues raised may also indirectly affect health and wellbeing.

Table 4-1 Summary of feedback from stakeholders and community engagement

Feedback topic	Number of comments	
	2017	2018
Air quality impacts, location and operation of tunnel ventilation system, potential impact on health	1068	4729
Design – tunnel entry and exit portals, alignment, road connections, depth, project description, suggested design changes, motorway features	928	1566
Transport mode, public transport alternatives, network integration, connectivity, integration with other key projects and proposed infrastructure (eg B-Line, Sydney Metro)	547	1974
Potential property impact on directly and indirectly affected properties, including property value and potential increase in urban density, property condition surveys, property access, property acquisition	501	1756
Construction impact, location of construction sites, temporary impact on support construction, hours of work, night work, spoil transport, cumulative impacts, light spill	383	3475
Potential impact on local streets, rat runs, local road safety, construction traffic, impact on parking spaces, congestion, road network performance, local road connections, increased traffic, cumulative traffic impact, travel time	398	4023
Traffic modelling	273	312
Satisfaction with engagement	151	86
Impact on fauna, flora, vegetation, green spaces, National Parks	177	1676
Need for land bridges and open space	1	2175
Drainage and flooding	2	133
Project cost, cost benefit ratio and tolling	97	437
Support for project	89	184
Dissatisfaction with engagement process, need for further project detail, consideration of different ways to engage with the community and stakeholders including different mediums	81	232
Noise impact, construction noise, cumulative noise impact, road traffic noise changes, noise walls, noise monitoring	73	2646
Cycling, cycleway facilities, active transport	61	336
Oppose project	59	2243
Visual amenity, visual impact of temporary/permanent structures, overshadowing, urban design	21	306
Environmental impact statement process and project approval	18	58
Aboriginal and non-Aboriginal heritage	14	486
Impact on community amenity during construction/operation, neighbourhood character, local business impact	8	39
Project timing	6	80

5 Assessment of changes in air quality on community health

5.1 General

The characterisation of changes in air quality as a result of the project is complex. Full details of the assessment carried out are presented in the Technical working paper: Air quality. This section presents an overview of the key aspects of the assessment carried out and an assessment of potential health impacts associated with the predicted changes in air quality in the local community.

5.2 Existing air quality

When predicting the impact of any new or modified source of air pollution, it is necessary to take into account the way in which the emissions from the source would interact with existing pollutant levels. Defining these existing levels and the interactions can be challenging, especially in a large urban area such as Sydney where there is a complex mix of sources. It is important to consider both the temporal and spatial variation in pollutant concentrations; these fluctuate a great deal on short time scales, but also show cyclical variations. Moreover, in large urban areas there is usually a complex mix of pollution sources, and substantial concentration gradients. Short term meteorological conditions and local topography are also important.

Air quality in the Sydney region has improved over the last few decades. The improvements have been attributed to initiatives to reduce emissions from industry, motor vehicles, businesses and residences.

Historically, elevated levels of CO were generally only encountered near busy roads, but concentrations have fallen as a result of improvements in motor vehicle technology. Since the introduction of unleaded petrol and catalytic converters in 1985, peak CO concentrations in central Sydney have significantly reduced, and the last exceedance of the air quality standard for CO in NSW was recorded in 1998 (NSW DECCW 2010).

While levels of NO₂, sulfur dioxide (SO₂) and CO continue to be below national standards, levels of ozone (O₃) and PM can exceed the standards adopted in NSW (NSW EPA 2016) from time to time.

O₃ and PM concentrations are affected by:

- The annual variability in the weather
- Natural events such as bushfires and dust storms, as well as hazard reduction burns
- The location and intensity of local emission sources, such as wood heaters, transport and industry (NSW OEH, 2015).

The project would be located within an urbanised area of Sydney so it is important that the background air quality considered is representative of existing conditions in the local area.

Assessment of background air quality, including meteorological data, requires the use of data that has been collected from equipment that complies with Australian Standards (to ensure that data is reliable and comparable).

The NSW Department of Planning, Industry and Environment (DPIE) (Environment, Energy and Science) (formerly Office of Environment and Heritage (OEH)) operates a number of monitoring stations in the Sydney area (see Figure 5-1), with the closest stations being located at Rozelle and Lindfield. DPIE (Environment, Energy and Science) has also established a station at Macquarie Park but the monitoring only began in 2017. The other DPIE (Environment, Energy and Science) sites at Liverpool, Randwick, Chullora, Earlwood and Prospect were further away, but were still considered important in terms of characterising air quality in the Sydney region.

In addition, Roads and Maritime has established several long term monitoring stations in response to community concerns relating to the ventilation outlet of the M5 East Motorway tunnel, and to monitor operational compliance of the tunnel with ambient air quality standards. Four of the Roads and

Maritime sites (shown on Figure 5-1 as CBMS, T1, U1, X1) are in the vicinity of the M5 East ventilation outlet. Two Roads and Maritime sites (shown on Figure 5-2 as F1 and M1) are much closer to busy roads near the M5 East Motorway tunnel portals. Other Roads and Maritime ambient air modelling locations established as part of the NorthConnex project (five locations, shown on Figure 5-1 and 5-2 as NCx: 01 to 05) and near the intersection of Epping Road and Longueville Road ('Aristocrat' to assess impacts from the Lane Cove Tunnel) were also considered.

Three project-specific monitoring stations for Western Harbour Tunnel and Beaches Link program of works were established by Roads and Maritime in 2017. One of these was at a background location, and the other two were at locations near busy roads. Given the date of deployment, the time period covered was too short for these to be included in the development of background concentrations and model evaluation.

Sydney Motorway Corporation (SMC) has established a WestConnex monitoring network including monitoring stations at both urban background and near-road stations. Five monitoring stations were introduced in the M4 East area, seven stations in the New M5 area, and two stations in the M4-M5 Link area. Some of the WestConnex monitoring stations were subsequently relocated or decommissioned. Of the WestConnex monitoring stations, only the station near to City West Link was inside the model extent (GRAL domain) for the project.

These monitoring stations are shown on Figure 5-1 and Figure 5-2.

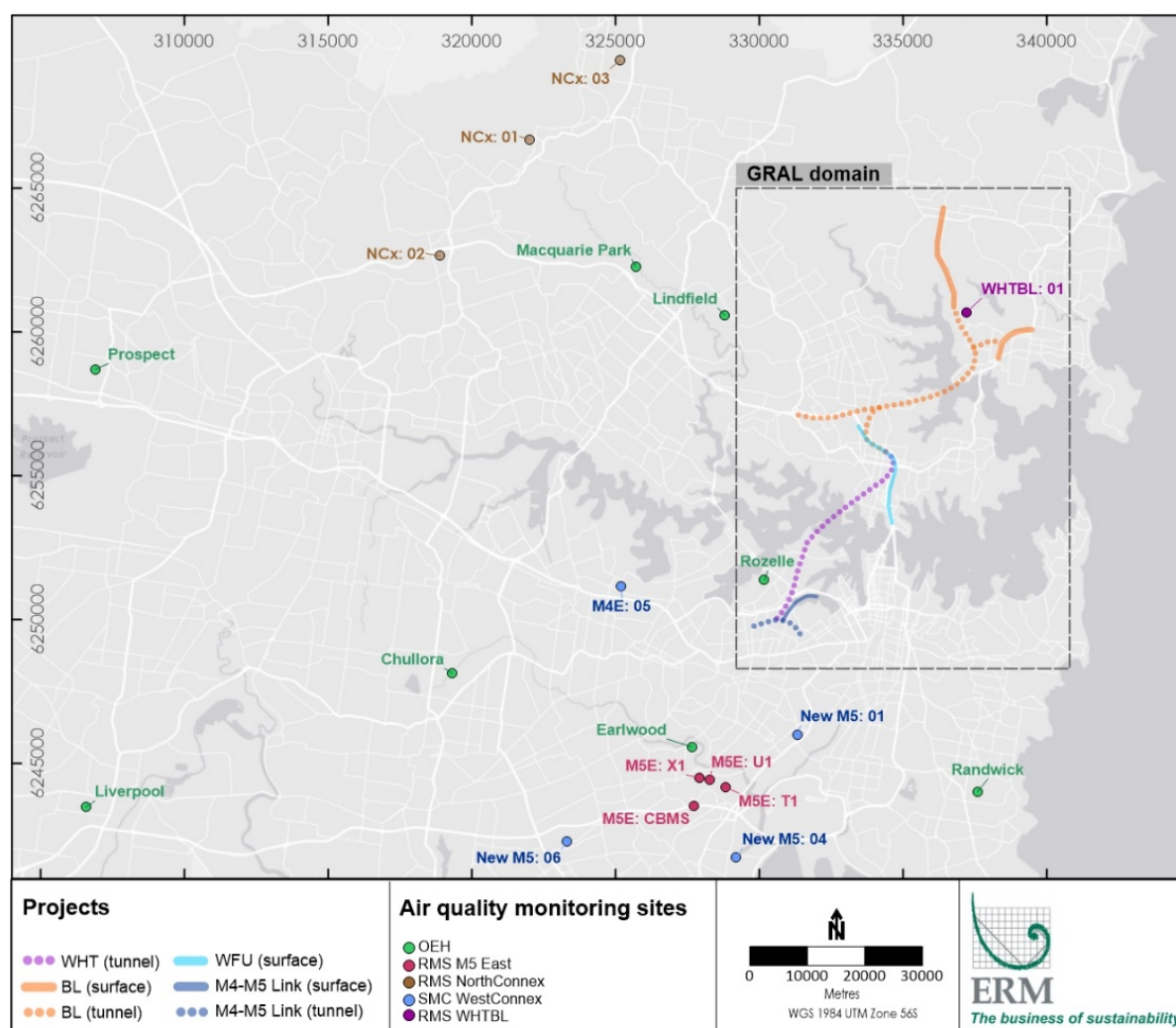


Figure 5-1 Locations of background air quality monitoring sites

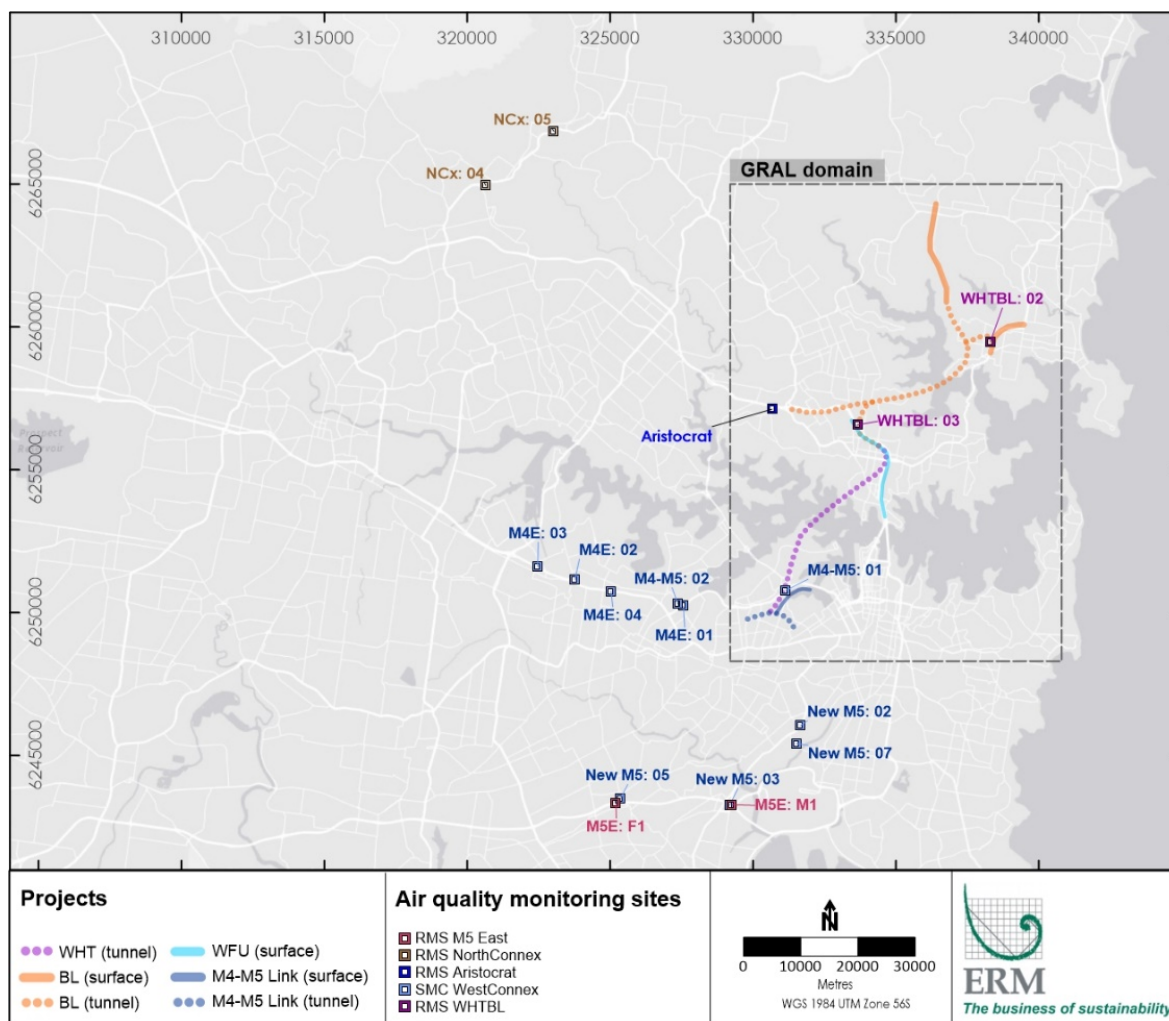


Figure 5-2 Locations of road air quality monitoring sites

Background air quality relevant to the assessment of CO, NO₂ and PM were determined in the Technical working paper: Air quality on the basis of data from these monitoring stations. The background air quality considered in the Technical working paper: Air quality related to air quality in areas away from major roadways, and noted:

- **CO:** Background air concentrations (as one hour and eight hour averages) were below the current air quality guidelines both at any of the background air monitoring sites. A general downward trend in background air concentrations was observed
- **NO₂:** Background air concentrations (as one hour and annual averages) were below the current air quality guidelines both at all background air monitoring sites and at roadside monitoring locations. The concentration of NO₂ has been observed to be generally stable over time. The concentrations reported at roadside monitoring stations were noted to be equal to the highest levels reported at the background monitoring locations
- **O₃:** Background air concentrations (as one hour and four hour averages) exceeded the current air quality guidelines on a few occasions. The most number of times a station exceeded the guideline per year was 18, with many of the stations not exceeding more than five times per year. Annual O₃ concentrations were stable between 2004 – 2016
- **PM₁₀:** Background concentrations of PM₁₀ (as an annual average) were below the current air quality guidelines; however, there were exceedances of the 24 hour average criterion, most notably in the warm and dry year 2009

- **PM_{2.5}:** Long term measurement of annual PM_{2.5} concentrations has only occurred at three DPIE (Environment, Energy and Science) stations Chullora, Earlwood and Liverpool. Concentrations at these stations showed a broadly similar pattern, with a systematic reduction between 2004 and 2012 being followed by a substantial increase in 2013. The main reason for the increase was a change in the measurement method (as the reporting of PM_{2.5} in air varies depending on the type of equipment used). The increases meant that background PM_{2.5} concentrations in the study area during 2014 and 2015 were already very close to or above the annual average criterion of 8 µg/m³. There have been a number of exceedances of the 24 hour average criterion of 25 µg/m³
- **Air toxics:** A number of campaigns have been carried out to determine the levels of air toxics around Sydney. All have found the concentrations remain low and under the respective Air Toxic NEPM investigation levels.

5.3 Overview of air quality impact assessment

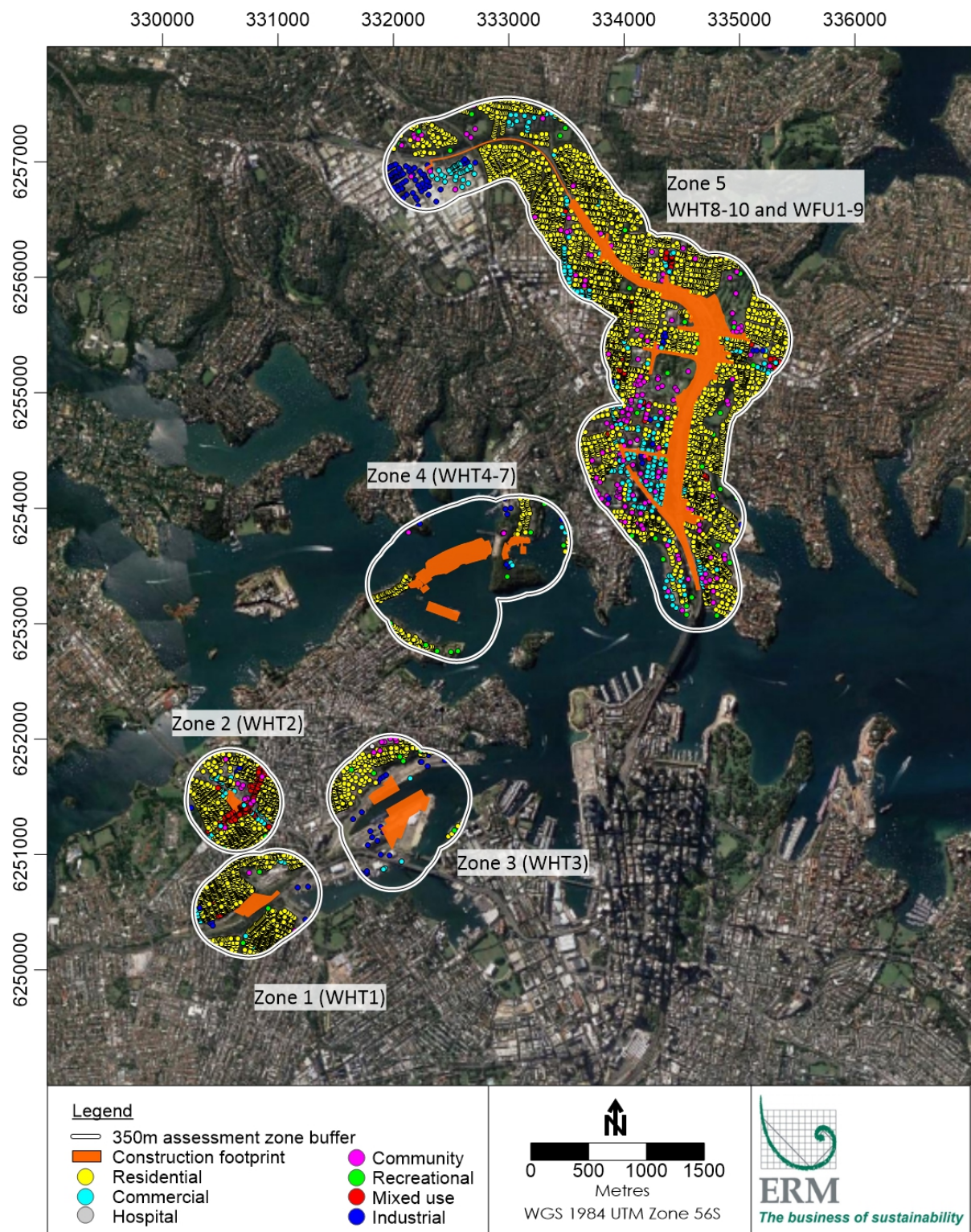
5.3.1 Construction

The Technical working paper: Air quality evaluated impacts on air that may occur during construction. The assessment considered impacts that may occur during tunnelling activities and surface works and involved a qualitative assessment approach. The assessment of construction activities addressed five different construction scenarios or areas, as outlined in Table 5-1 below.

Table 5-1 Construction assessment zones

Assessment Zone	Construction support sites within each assessment zone	Construction works at surface	Indicative construction period
Zone 1	WHT1	Construction works associated with the Rozelle Interchange connection. Fitout of operational infrastructure for Western Harbour Tunnel, including the Rozelle Interchange outlet.	Q2 2023 to Q1 2026
Zone 2	WHT2	No construction works beyond activities associated with WHT2.	Q3 2021 to Q3 2025
Zone 3	WHT3	No construction works beyond activities associated with WHT3.	Q2 2021 to Q3 2025
Zone 4	WHT4, WHT5, WHT6, WHT7	Construction activities associated with WHT4 and WHT7 and construction of the harbour crossing (including dredging and handling of dredged material).	Q2 2021 to Q4 2025 (collectively)
Zone 5	WHT8, WHT9, WHT10, WHT11 WFU1, WFU2, WFU3, WFU4, WFU5, WFU6, WFU7, WFU8, WFU9	Construction works associated with the Western Harbour Tunnel component of the project. Construction works associated with the upgrade and reconfiguration of the Warringah Freeway. Construction works associated with the motorway control centre. Collectively, this would include tunnel dive structures and construction of tunnel portals and ramps, construction of operational ancillary infrastructure, upgrades to interchanges, alterations or upgrades to the surrounding road network, and adjustments to other infrastructure (eg active transport, utilities).	Q4 2020 to Q4 2025 (collectively)

The assessment identified the range of activities during construction, potential emissions from these activities and the location of these activities in relation to sensitive receptors. Figure 5-3 illustrates the location of the sensitive receptors considered in the Technical working paper: Air quality during construction works. The figure also shows the location of the zones considered in each of the construction sites.



For demolition activities, the Work Health and Safety Regulation 2011 (NSW) requires that all hazardous materials are properly removed from buildings prior to any demolition works occurring. This is to prevent workers and the public from being exposed these materials and contaminants during the demolition and other construction works. As such, there is no need to further assess the presence of hazardous building materials during construction activities.

This approach then allocated a risk associated with the generation of dust and impacts on human health in the adjacent community. This approach considered the proximity to the source area and the number and type of receptors present. Impacts associated with nuisance dust, health impacts on the community were evaluated. For all demolition, earthworks, construction and track-out activities, where no mitigation measures are implemented, the risk of impacts on human health were evaluated and considered in terms of the location of sensitive receptors. Risk ratings that varied from low to high were adopted in the review presented in the Technical working paper: Air quality. In relation to health impacts, the following levels of risk were identified for the following zones (see Table 5-1 for scenario details):

- Zone 1: Medium risk for earthworks, construction and track-out
- Zone 2: Medium risk for demolition, earthworks and track-out, and low risk for construction
- Zone 3: Medium risk for earthworks and low risk for track-out
- Zone 4: Medium risk for earthworks and low risk for demolition, construction and track-out
- Zone 5: High risk for all activities.

On this basis, appropriate mitigation measures are required to minimise impacts on the local community during construction.

For almost all construction activities, the aim should be to prevent significant impacts on receptors through the use of effective mitigation. Experience from similar construction projects shows that this is normally possible. Where mitigation measures are appropriately implemented, the Technical working paper: Air quality concluded that the residual risk level would normally be 'not significant'.

However, even with rigorous dust mitigation and management measures in place, it is not possible to guarantee that the dust mitigation measures would be effective all the time. There is the risk that nearby residences, commercial buildings, hotel, cafés and schools in the immediate vicinity of the construction zone might experience some occasional dust impacts. This does not imply that impacts are likely, or that if they did occur, that they would be frequent or persistent. Overall construction dust is unlikely to represent a serious ongoing problem. Any effects would be temporary and relatively short-lived, and would only arise during dry weather with the wind blowing towards a receptor, at a time when dust is being generated and mitigation measures are not being fully effective. The likely scale of this would not normally be considered sufficient to change the conclusion that with mitigation the potential for health effects would be 'not significant'.

Construction air quality management measures would be implemented to cover all construction stages of the project. These measures include site management, use of water carts to minimise dust, monitoring, preparing and maintaining the construction sites, maintenance and controls on vehicles and machinery and construction. Section 9.1 of the Technical working paper: Air quality provides additional details on the dust management measures proposed.

Issues related to health impacts from construction fatigue, where the community may be located close to construction facilities for extended periods of time, as a result of the number of construction projects being carried out, are further addressed in Section 9.7.

As part of the harbour construction activities for the project, a significant amount of material would need to be excavated from beneath the water. This would be done using mechanical dredging, bringing potentially odorous material to the surface. A permit for disposal of suitable dredged material offshore has been submitted to the Commonwealth Department of the Environment and Energy. For material that is unsuitable for offshore disposal, treatment (which would involve the addition of lime or a polymer to the material) would be carried out either on the barges or onshore prior to disposal at an appropriately licenced facility. Treated material would be either directly loaded from the barges into sealed and covered trucks or temporarily stockpiled in a controlled onshore containment area for subsequent rehandling into trucks. An assessment of odour emanating from dredged harbour sediments has been carried out, with handling and treatment occurring onshore at the White Bay construction support site (WHT3). It has identified that odour levels at the nearest receptor would be lower than 0.1 OU (odour units) and would unlikely to be detectable. Management measures would be implemented to ensure any unforeseen odorous material is appropriately handled, stored and treated to minimise any potential risk.

5.3.2 Operation

The assessment of changes in air quality associated with the operation of the project has been carried out on the basis of the tunnel designs specifications and forecasts of tunnel and surface road traffic demand volumes (and speeds) as outlined in the Strategic Motorway Project Model (SMPM). The project does not include portal emissions (ie emissions from the tunnel entrances and exits), however some existing tunnels (Sydney Harbour Tunnel and Eastern Distributor Tunnel) do allow portal emissions and these emissions have been considered in the assessment. The emissions associated with the operation of tunnels which do not allow portal emissions relate to the discharge of air from within the tunnel to atmosphere via 11 ventilation outlets (not all for the Western Harbour Tunnel) outlined below, and shown on Figure 5-4a:

- Existing facility:
 - Outlet A Lane Cove Tunnel (Marden Street, Artarmon)
 - Outlet B Cross City Tunnel (west of Harbour Street, Sydney)
- Future ventilation facilities for the M4-M5 Link:
 - Outlet C M4-M5 Link, Iron Cove Link (Rozelle Rail Yards (mid))
 - Outlet D M4-M5 Link, Iron Cove Link (Rozelle Rail Yards (east))
 - Outlet E Iron Cove Link (Rozelle, near Iron Cove)
- Proposed motorway facilities and ventilation outlets for the Western Harbour Tunnel (subject of this assessment):
 - Outlet F Rozelle Interchange
 - Outlet G Warringah Freeway
- Proposed motorway facilities and ventilation outlets for the Beaches Link:
 - Outlet H Warringah Freeway
 - Outlet I Gore Hill Freeway
 - Outlet J Wakehurst Parkway
 - Outlet K Burnt Bridge Creek Deviation
- The ventilation outlets that would be specific to the project are F and G. The remaining outlets (A, B, C, D, E, H, I, J and K) were included to assess potential cumulative impacts only. Further details of the ventilation facilities considered in the assessment are provided in Technical working paper: Air quality.

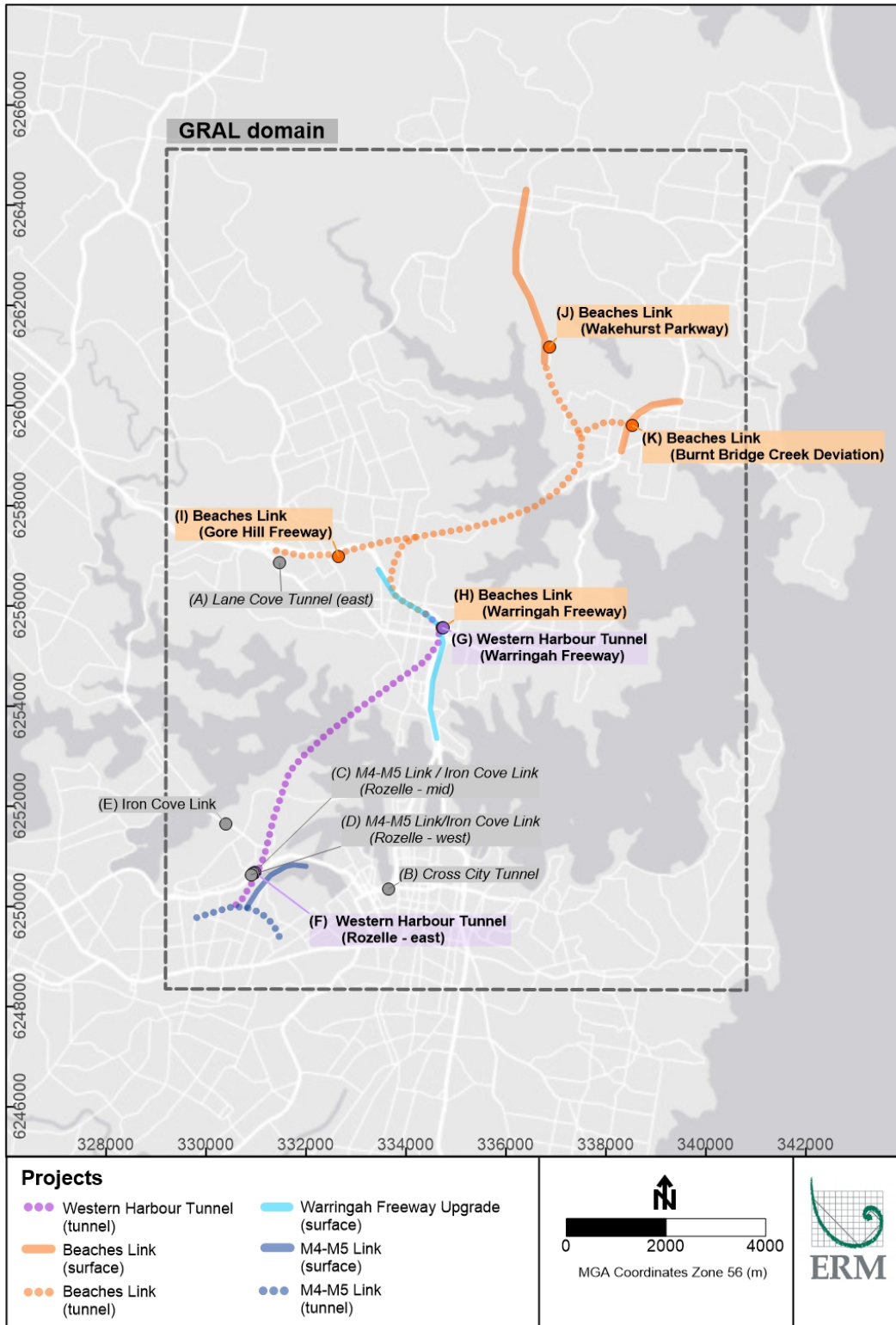


Figure 5-4a Locations of all tunnel ventilation outlets included in the assessment of air quality

The operational ambient air quality assessment was based on the use of the GRAMM-GRAL model system. The model system consists of two main modules: modelling the meteorology (Graz Mesoscale Model – GRAMM) and modelling the pollution dispersion (GRAL).

The GRAL was used in the assessment of potential impacts associated with the project and utilised an air dispersion model to predict changes in ambient air quality within the study area (or modelling domain) associated with a range of emissions scenarios. This model was selected as it has been shown to provide robust/validated results for assessing air quality in complex urban environments and the model enables simultaneous consideration of all the different types of emission sources in the study area (ie local and regional roads, ventilation outlets and other emissions sources of various types). The model has also been used to evaluate the cumulative air quality impacts associated with other tunnel projects in the study area. The air modelling domain (GRAL domain) considered for the project is shown in Figure 3-1.

The modelling considered meteorology relevant to a larger area (red box, or GRAMM domain, on Figure 5-4b) that includes the study area, local terrain, and project-specific emission sources.

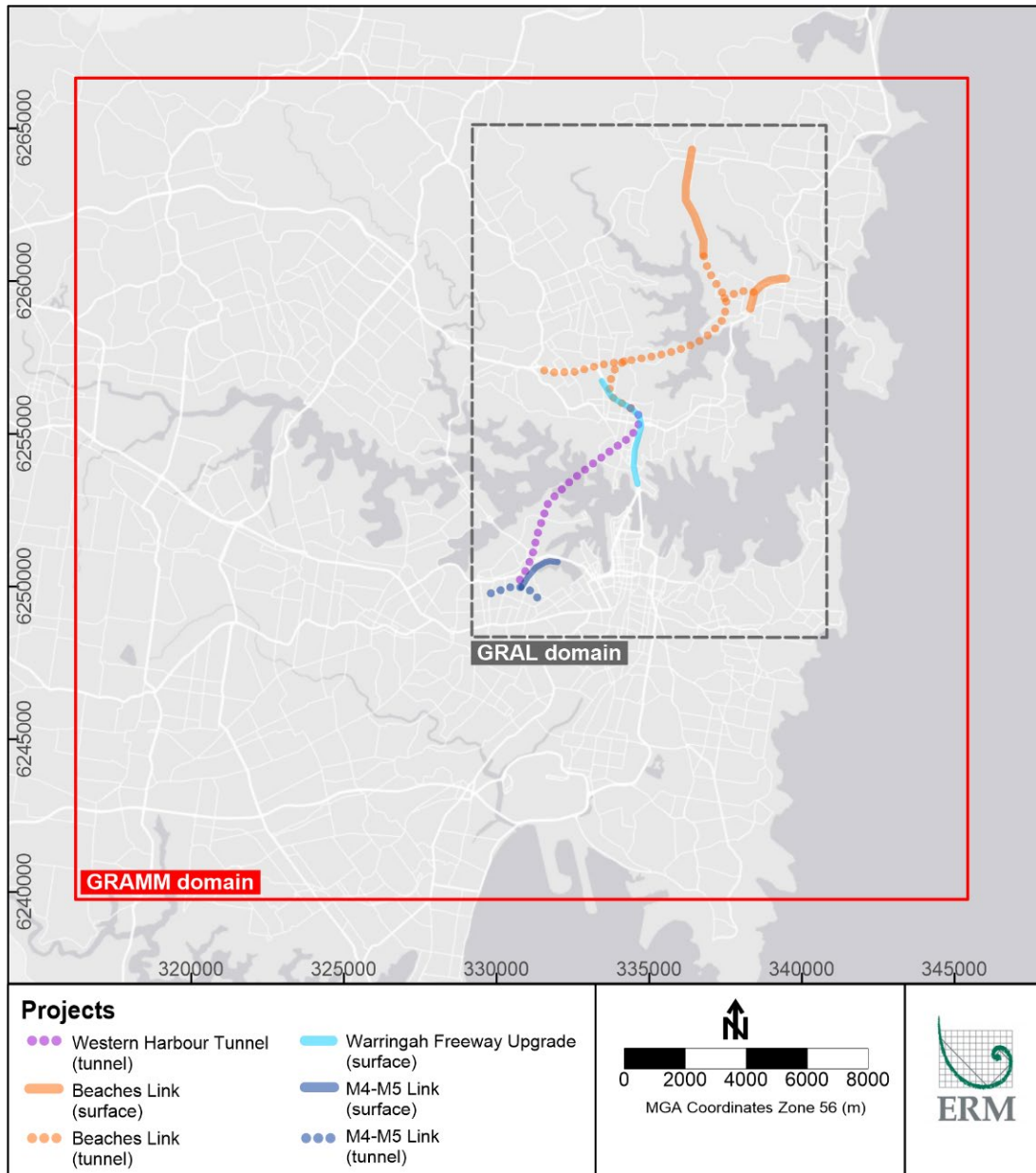


Figure 5-4b Modelling domains for GRAMM and GRAL

The emission sources relevant to the project addressed in the modelling included:

- Emissions from the traffic on the surface road network, including any new roads associated with the project
- Emissions from the existing and proposed ventilation outlets outlined above
- Emissions from the portals of the Sydney Harbour Tunnel and Eastern Distributor Tunnel, where these are currently permitted
- The assessment of cumulative impacts evaluated changes in air quality in the study area from all changes in surface traffic and ventilation outlets associated with all projects in the study area.

When determining the potential emissions to air that may require ventilation from the tunnel, the assessment has considered a range of factors associated with the tunnel design, traffic volumes, vehicle mix and age. In addition, in-tunnel air quality limits have also been considered as discussed further in Section 6. These have been taken to be limits/criteria that are required to be met under all operational circumstances (except emergencies such as fire). The tunnel ventilation system and tunnel operational parameters have been designed to ensure the in-tunnel concentration limits are not exceeded.

The assessment of air quality impacts involved estimation of emissions from vehicles using the tunnel, and other road tunnels under expected traffic conditions (ie operating normally with traffic demands fluctuating over the day with peak and out of peak traffic loads). In addition, a regulatory worst case scenario has been evaluated, which relates to modelling of emissions from the ventilation facilities at the limit expected to be set by the regulators. This is an upper limit that would essentially mean the tunnel is always full of vehicles and trucks. This is not a realistic scenario, but it is required to demonstrate compliance with regulatory air quality objectives.

Additional details on the assessment scenarios and the emission sources considered in the Technical working paper: Air quality are summarised in the following sections.

5.4 Assessment scenarios

The assessment of impacts on air quality associated with operation of the project has considered a range of scenarios that include the existing situation, construction works and various future operational scenarios both with and without the project. In addition, a cumulative scenario, associated with impacts from all the Sydney major road tunnel projects was assessed.

All the air modelling scenarios considered changes in emissions to air from the surface road network as well as the ventilation facilities and portal emissions (from the Sydney Harbour Tunnel and Eastern Distributor Tunnel only) including:

- **'Base case 2016'**: This represents the road network with no new projects or upgrades and was used to establish existing conditions. The main purpose of including a base year was to enable the dispersion modelling methodology to be verified against real world air pollution monitoring data
- **'Do minimum 2027'**: The 'Do minimum 2027' scenario assumes that the WestConnex M4 Widening, WestConnex M4 East, WestConnex New M5, WestConnex M4-M5 Link and King Georges Road Interchange Upgrade are complete. It is called 'do minimum' rather than 'do nothing' as it assumes that ongoing improvements would be made to the broader transport network, including some new infrastructure and intersection improvements to improve capacity and cater for traffic growth
- **'Do something 2027'**: As for the 'Do minimum 2027', but with the project also completed
- **'Do something cumulative 2027'**: As for the 'Do something 2027', but with Sydney Gateway, Western Harbour Tunnel, Warringah Freeway Upgrade and F6 Extension – Stage 1 also completed
- **'Do minimum 2037'**: As for the 'Do minimum 2027', but for 10 years after project opening
- **'Do Something 2037'**: As for the 'Do something 2027', but for 10 years after project opening
- **'Do something cumulative 2037'**: As for the 'Do something cumulative 2027', but with all stages of the F6 Extension also completed, 10 years after project opening.

More specific details associated with each of these scenarios are outlined in the Technical working paper: Traffic and transport (Jacobs, 2020).

Assessment scenarios evaluated in the health risk assessment

Health impacts that may be associated with changes in air quality that are associated with the project have been assessed for the following years and scenarios:

- 'Do something 2027'
- 'Do something cumulative 2027'
- 'Do something 2037'
- 'Do something cumulative 2037'.

The assessment has considered total impacts (ie background plus the project) and changes in air quality associated with the project. The assessment of changes in air quality is based on the predicted air quality impacts for all the local roads plus the project (the 'Do something' scenario) minus the air quality impacts for all the local roads without the project (the 'Do minimum' scenario). The net change in air quality assessed relates to emissions directly from the project as well as changes in emissions on surface roads.

In relation to the operation of the project considered in each of the above scenarios the air quality modelling has been carried out to consider expected traffic demands within the tunnel. The number of vehicles moving through the tunnel varies depending on the hour of the day. Air modelling predictions associated with the expected traffic movements through the tunnel have been used for the assessment of long term/chronic exposures in the local community.

5.5 Vehicle emissions

Emissions from vehicles using the tunnel have been estimated based on an emissions inventory model developed by the NSW EPA and PIARC 2019 (as described in the Technical working paper: Air quality).

5.6 Assessment of volatile organic compounds and polycyclic aromatic hydrocarbons

5.6.1 General

The Technical working paper: Air quality has considered emissions of VOCs and PAHs to air from the project. Both VOCs and PAHs refer to a group of compounds with a mix of different proportions and toxicities. It is the individual compounds within the group that are of importance for evaluating adverse health effects. The composition of individual compounds in the VOCs and PAHs evaluated would vary depending on the source of the emissions. It is important that the key individual compounds present in emissions considered for this project are specified (ie identified and quantified as a percentage of the total VOCs or total PAHs), to ensure that potential impacts associated with exposure to these compounds can be adequately assessed.

VOCs in Sydney air are primarily derived from domestic/commercial sources (54 per cent) with on-road vehicles contributing approximately 24 per cent, industrial emissions eight per cent with the remainder from off-road mobile sources and other commercial sources (OEH, 2012).

VOCs and PAHs from the project are associated with emissions from vehicles assumed to be using the tunnel (and approaches) and surface roads. The makeup of the VOCs and PAHs emissions would depend on the mix of vehicles considered as these pollutants would be emitted in different proportions from petrol and diesel powered vehicles. In addition, the age and the fuel used by the vehicle fleet would affect these emissions. The vehicle fleet mix considered in this project is summarised in Table 5-2.

5.6.2 Volatile organic compounds

VOCs have been modelled in the Technical working paper: Air quality based on emissions from all vehicles considered. The proportion of each of the individual VOCs that may be present in the air is then estimated based on the assumed composition of the vehicle fleet during the different years and the type of fuel used.

Most of the VOC emissions comprise a range of hydrocarbons that are of low toxicity (such as methane, ethylene, ethane, butenes, butanes, pentenes, pentanes and heptanes) (EPA, 2012). From a toxicity perspective, the key VOCs that have been considered for the vehicle emissions are BTX, 1,3-butadiene, acetaldehyde and formaldehyde (consistent with those identified and targeted in studies conducted in Australia on vehicle emissions (Australian Department of Environment and Heritage (DEH, 2003; EPA, 2012)).

The proportion of each key VOCs considered are derived from the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW* (EPA, 2012), for the vehicle fleet assessed in the Technical working paper: Air quality (as summarised above). In relation to passenger vehicles it has been assumed that 60 per cent² of fuel used is E10. It is conservatively assumed that the composition of VOCs in vehicle emissions remains the same over time, and does not improve with enhanced vehicle emissions technology.

Table 5-2 presents a summary of VOCs speciation profile as the weighted percentage, for the VOCs considered for the project in 2027 and 2037. It is noted that the percentage of VOCs is expected to be different in 2037 due to the changes in emissions standards for the vehicle fleet.

Table 5-2 Weighted volatile organic compounds speciation profile for vehicle emissions

VOC	Weighted % of total VOC estimate	
	2027	2037
Benzene	3.9	3.4
Toluene	7.1	5.9
Xylenes	5.9	4.9
1,3-Butadiene	1.1	0.9
Formaldehyde	3.4	4.6
Acetaldehyde	1.6	2.0

5.6.3 Polycyclic aromatic hydrocarbons

PAHs have been considered in the Technical working paper: Air quality as key pollutants that may be derived from diesel powered heavy goods vehicles. The total PAH concentration that may be derived from the project has been determined on the basis of a proportion of the total VOCs. While not all of the PAHs would be volatile, the approach adopted provides an estimate of potential levels of total PAHs that may be in air, as a result of the change in emissions derived from the project.

For the year 2027 and 2037, total PAHs have been estimated to comprise 0.79 and 0.95 per cent respectively of the total VOCs.

In relation to the toxicity of PAHs, this differs significantly for the different individual PAHs that may be present. The detailed review of the potential health impacts associated with exposures to PAHs in air from the project requires an assessment of the key individual PAHs.

² The value of 60 per cent of ethanol in total fuel volume sales comes from the requirement that a minimum of six per cent ethanol in the total volume of petrol sold in NSW as outlined in the *Biofuels Act 2007* (NSW). This equates to selling 60 per cent E10 fuel.

The presence of PAHs in diesel exhaust has been found to be more a function of the PAH content of the fuel than of engine technology. For a given refinery and crude oil, diesel fuel PAH levels correlate with total aromatic content and T90 (distillation temperature where 90 per cent of the fuel is evaporated). Representative data on aromatic content for diesel fuels in Australia is limited; however, emissions tests have been conducted on a range of light and heavy vehicles under different traffic congestion conditions (DEH, 2003). The data presented from these emissions tests is assumed to include fuels commonly used in Australia and are considered to provide an indication of the likely proportions of individual PAHs in diesel exhaust.

The PAHs reported in diesel exhaust by the DEH (now the Commonwealth Department of the Environment and Energy) (DEH, 2003) comprise the 16 most commonly reported (and highest proportion) PAHs present in exhaust. The data available from this study is dated (from vehicles manufactured from 1990 to 1996) and use of this data is likely to provide an overestimation of PAH emissions from current (and future) diesel vehicles. The evaluation of potential health impacts associated with exposure to PAHs from the project requires consideration of the 16 individual PAHs, present at the highest levels in exhaust and which have the most information on chronic health effects.

The toxicity of individual PAHs varies significantly, with some considered to be carcinogenic while others are not carcinogenic. For the carcinogenic PAHs, these are commonly assessed as a group with the total carcinogenic PAH concentration calculated using weighting factors that relate the toxicity of individual carcinogenic PAHs to the most well studied PAH, benzo(a)pyrene. The weighting factors adopted are those presented by the Canadian Council of Ministers of the Environment (CCME, 2010) have been adopted. Other PAHs that are not carcinogenic have been considered separately.

On the basis of this approach, the speciation of individual PAHs (as per cent of total PAHs) has been calculated based on the data from DEH (2003). The data presented relate to emissions that occur in congested or stop/start traffic. This data has been used to be representative of the worst case situation of heavy congested traffic in the project area and is considered to be conservative for expected traffic conditions in the motorway tunnels. The proportion of these individual PAHs, derived from the older data presented by DEH (2003), is considered to be sufficiently representative for the purpose of this assessment. It should be noted that the calculated risks posed by these non-carcinogenic PAHs is very low (refer to Tables 5-9 and 5-10) and any likely variation in the proportioning of these individual PAHs (even if the proportioning was out by 100 per cent) would not change the outcome of the health impact assessment carried out for this project.

Table 5-3 presents a summary of the PAH speciation profile considered in this assessment for the above traffic conditions.

Table 5-3 PAH speciation profile for diesel vehicle emissions

Individual PAH	Per cent of total PAH emissions (PAHs) used to evaluate emissions in 2027 and 2037
Non-carcinogenic PAHs	
Naphthalene	70
Acenaphthylene	4.9
Acenaphthene	2.0
Fluorene	5.0
Phenanthrene	3.4
Anthracene	0.49
Fluoranthene	0.45
Pyrene	0.71
Carcinogenic PAHs	
Benzo(a)pyrene TEQ	4.6

5.6.4 Assessment of health impacts

The change in VOC and PAH concentrations associated with the project is a decrease for most receptors; however, in some areas, there is an increase in concentrations. These changes relate to the redistribution of emissions from vehicles, primarily associated with surface roads. The following evaluation has been carried out to assess the potential health impacts associated with the maximum increases predicted.

The assessment of potential health impacts associated with exposure to changes in VOCs and PAHs concentrations (calculated for individual VOCs and PAHs based on the speciation outlined above) in air within the community has been assessed on the basis of the following:

- For VOCs and PAHs that are considered to be genotoxic carcinogens (consistent with guidance provided by enHealth (enHealth, 2012b)) an incremental lifetime carcinogenic risk has been calculated. For the VOCs and PAHs evaluated in this assessment, a carcinogenic risk calculation has been adopted for the assessment of maximum potential (incremental) increase in benzene, 1,3-butadiene and carcinogenic PAHs (as a benzo(a)pyrene toxicity equivalent or TEQ). The assessment carried out has adopted the calculation methodology outlined in Annexure B, adopting the inhalation unit risk values presented in Table 5-5
- For other VOCs and PAHs, where the health effects are associated with a threshold (ie a level below which there are no effects), the maximum predicted concentration from all sources (ie background plus the project) of individual VOCs and PAHs associated with the project have been compared against published peer-reviewed health based guidelines that are relevant to acute and chronic exposures (where relevant). The health based guidelines adopted (identified on the basis of guidance from enHealth (2012)) are relevant to exposures that may occur to all members of the general public (including sensitive individuals) with no adverse health effects. The guidelines available relate to the duration of exposure and the nature of the health effects considered where:
 - Acute guidelines are based on exposures that may occur for a short period of time (typically between one hour or up to 14 days). These guidelines are available to assess peak exposures (based on the modelled one hour average concentration) that may be associated with VOCs in the air, and are presented in Table 5-4
 - Chronic guidelines are based on exposures that may occur all day, every day for a lifetime. These guidelines are available to assess long term exposures (based on the modelled annual average concentration) that may be associated with VOCs and PAHs in the air, and are presented in Table 5-5.

Table 5-4 Adopted acute inhalation guidelines based on protection of public health

Compound assessed	Acute health based guideline ($\mu\text{g}/\text{m}^3$)	Basis
Volatile organic compounds		
Benzene	580	Acute 1 hour health based guideline, based on depressed peripheral lymphocytes from Texas Commission on Environmental Quality (TCEQ) evaluation (TCEQ, 2013b).
Toluene	15000	Acute 1 hour health based guideline, based on eye and nose irritation, increased occurrence of headache and intoxication in human male volunteers from TCEQ evaluation (TCEQ, 2013a).
Xylenes	7400	Acute 1 hour health based guideline, based on mild respiratory effects and subjective symptoms of neurotoxicity in human volunteers from TCEQ evaluation (TCEQ, 2013e).
1,3-Butadiene	660	Acute 1 hour health based guideline, based on developmental effects derived by the California Office of Environmental Health Hazard Assessment (OEHHA, 2013). The guideline developed is lower than developed by TCEQ (TCEQ, 2007) based on the same critical study.
Formaldehyde	50	Acute 1 hour health based guideline, based on eye and nose irritation in human volunteers from TCEQ evaluation (TCEQ, 2014). This guideline is noted to be lower than the acute guideline available from the WHO (WHO 2000d, 2010) of $100 \mu\text{g}/\text{m}^3$ for formaldehyde.
Acetaldehyde	470	Acute 1 hour health based guideline, based on effects on sensory irritation, bronchoconstriction, eye redness and swelling derived by the California OEHHA (OEHHA, 2013).

Table 5-5 Adopted chronic guidelines and carcinogenic unit risk values based on protection of public health

Compound assessed	Chronic health based guideline	Basis
Threshold guidelines for volatile organic compounds		
Benzene	$30 \mu\text{g}/\text{m}^3$	The most significant chronic health effect associated with exposure to benzene is the increased risk of cancer, specifically leukaemia, which is assessed separately (below). The assessment of other health effects (other than cancer) has been carried out using a chronic guideline derived by the USEPA (USEPA, 2002a) based on haematological effects in an occupational inhalation study (converted to public health value using safety factors). This is the most current evaluation of effects associated with chronic inhalation exposure to toluene and is consistent with the value used to derive the NEPM (NEPC, 1999 amended 2013a) health based guidelines.
Toluene	$5000 \mu\text{g}/\text{m}^3$	Chronic guideline derived by the USEPA (USEPA, 2005a) based on neurological effects in an occupational study (converted to public health value using safety factors). This is the most current evaluation of effects associated with chronic inhalation exposure to toluene and is consistent with the value used to derive the NEPM (NEPC, 1999 amended 2013a) health based guidelines.
Xylenes	$220 \mu\text{g}/\text{m}^3$	Chronic guideline derived by the Agency for Toxic Substances and Disease Register (ATSDR) (ATSDR, 2007) based on mild subjective respiratory and neurological symptoms in an occupational study (converted to public health value using safety factors).
Formaldehyde	$3.3 \mu\text{g}/\text{m}^3$	Formaldehyde is classified by IARC as carcinogenic to humans. The guideline developed by TCEQ (TCEQ, 2013d) is derived on the basis of irritation of the eyes and airway discomfort in humans, with review of carcinogenic and other non-carcinogenic effects found to be adequately protected by this guideline. The guideline is more conservative than derived by the WHO (WHO, 2010).

Compound assessed	Chronic health based guideline	Basis
Acetaldehyde	9 µg/m ³	Chronic guideline derived by the USEPA (USEPA IRIS) based on nasal effects (in a rat study) (converted to a public health value using safety factors). Value is more conservative than more recent evaluations from WHO and Californian OEHHA.
Threshold guidelines for polycyclic aromatic hydrocarbons		
Naphthalene	3 µg/m ³	Chronic guideline from USEPA (USEPA, 1998) based on nasal effects (in a mice study) (converted to a public health value using safety factors) and is consistent with the value used to derive the NEPC (NEPC, 1999 amended 2013a) health based guidelines.
Acenaphthylene	200 µg/m ³ (1)	These are the non-carcinogenic PAHs. Guideline available from the USEPA (USEPA IRIS). Chronic guidelines are based on criteria derived from oral studies (for critical effects on the liver, kidney and haematology) which are then converted to an inhalation value (relevant for the protection of public health, including the use of safety factors) for use in this assessment. The value presented in the above table has been converted from an acceptable dose in mg/kg/day to an acceptable air concentration assuming a body weight of 70 kg and inhalation of 20 m ³ /day (as per (USEPA, 2009b)).
Acenaphthene	200 µg/m ³	
Fluorene	140 µg/m ³	
Phenanthrene	140 µg/m ³ (1)	
Anthracene	1000 µg/m ³	
Fluoranthene	140 µg/m ³	
Pyrene	100 µg/m ³	
Carcinogenic inhalation unit risk values adopted for carcinogenic risk calculation		
Benzene	6x10 ⁻⁶ (µg/m ³) ⁻¹	Benzene is classified as a known human carcinogen by the International Agency for Research on Cancer (IARC). Inhalation unit risk value is from the WHO (WHO 2000d, 2010) and is based on excess risk of leukaemia from epidemiological studies.
1,3-Butadiene	5x10 ⁻⁷ (µg/m ³) ⁻¹	1,3-Butadiene is classified as a known human carcinogen by the International Agency for Research on Cancer (IARC). Inhalation unit risk values are available from a number of agencies, including the WHO, USEPA and TCEQ. The most current evaluation has been carried out by TCEQ (TCEQ, 2013c). This has considered the same studies as WHO and USEPA, but included more recent studies and more relevant dose-response modelling.
Benzo(a)pyrene TEQ	0.087 (µg/m ³) ⁻¹	Benzo(a)pyrene is classified by IARC as a known human carcinogen, which relates to Benzo(a)pyrene as well as all the other carcinogenic PAHs assessed as a Benzo(a)pyrene TEQ value. Inhalation unit risk value is from the WHO (WHO, 2010) and is based on protection from lung cancer for an occupational study associated with coke oven emissions, which are very different from those from diesel emissions, and is expected to be conservative. It is noted that carcinogenic risks associated with lung cancer from diesel particulate matter (which is dominated by the presence of carcinogenic PAHs) is also assessed as outlined in Section 5.9.5 and Annexure B).

¹ No guideline available for individual PAHs, hence a surrogate compound has been used for the purpose of assessment. The surrogate compound is a PAH of similar structure and toxicity. In relation to the surrogates adopted in this evaluation, acenaphthene has been adopted as a surrogate for acenaphthylene, fluoranthene has been adopted as a surrogate for phenanthrene.

Tables 5-6 to 5-10 present a summary of the maximum predicted one hour or annual average concentrations of VOCs and PAHs assessed on the basis of a threshold with comparison against acute and chronic health based guidelines. The table also presents a Hazard Index which is the ratio of the maximum predicted concentration to the guideline. Each individual Hazard Index is added up to obtain a total Hazard Index for all the threshold VOCs and PAHs considered. The total Hazard Index is a sum of the potential hazards associated with all the threshold VOCs and PAHs together assuming the health effects are additive, and is evaluated as follows (enHealth, 2012b):

- A total Hazard Index less than or equal to one means that all the maximum predicted concentrations are below the health based guidelines and there are no additive health impacts of concern

- A total Hazard Index greater than one means that the predicted concentrations (for at least one individual compound) are above the health based guidelines, or that there are at least a few individual VOCs or PAHs where the maximum predicted concentrations are close to the health based guidelines such that there is the potential for the presence of all these together (as a sum) to result in adverse health effects.

The assessment of acute exposures, presented in Table 5-6 and Table 5-7, has compared the maximum predicted total (background or background plus project or program of works) 1-hour average concentration against the relevant acute guidelines. This is the maximum 1-hour average concentration reported anywhere in the project area, regardless of land use.

The assessment of chronic exposures, presented in Table 5-8 and Table 5-9, has compared the maximum predicted total annual average concentration relevant to residential land use against the relevant chronic guidelines. For exposures in other areas, Table 5-8 and Table 5-9 also presents the maximum calculated Hazard Index relevant to exposures in commercial/industrial areas, where the maximum change in VOC concentrations is predicted. The calculated Hazard Index takes into account that these exposures occur for eight hours per day over 240 days per year.

Table 5-10 and Table 5-11 present summaries of the calculated incremental lifetime carcinogenic risk associated with exposure to the maximum predicted change in concentrations of benzene, 1,3-butadiene and carcinogenic PAHs (as benzo(a)pyrene TEQ) in residential areas. The calculations presented assume residents are exposed to these pollutants all day, every day for a lifetime. The calculated carcinogenic risk for these compounds has been summed, in accordance with enHealth guidance where the following has been considered (enHealth, 2012b). The tables also present the calculated total carcinogenic risk relevant to exposures in commercial/industrial areas and have assumed the maximum change in VOCs and PAHs in the commercial/industrial areas. These calculations assume workers are exposed eight hours per day, 240 days per year for 30 years. The calculated risks are considered in conjunction with what are considered negligible, tolerable/acceptable and unacceptable risks as outlined in Annexure C.

The values presented in the tables have been rounded to two significant figures for individual calculations and one significant figure for the total Hazard Index and total carcinogenic risk, reflecting the level of uncertainty in the calculations presented.

The following evaluation is based on the maximum predicted concentration in air for the relevant assessment scenarios for 2027 and 2037 as modelled in the Technical working paper: Air quality. For assessments presented in Table 5-6 to 5-9 the concentrations modelled are the total concentrations, namely background or background plus project or program of works, while in Table 5-10 to 5-11 the concentrations represent the maximum predicted change in the compound assessed. Concentrations in all other areas of the surrounding community are lower than the maximum as evaluated in this assessment. In many locations, the change due to the project is a lowering of VOC and PAH concentrations in air (ie a benefit).

Table 5-6 Assessment of acute exposures to VOCs – 2027

Key VOC	Maximum predicted 1 hour average concentration (background plus project) and calculated Hazard Index					
	'Do minimum 2027'		'Do something 2027' (ie with project)		'Do something cumulative 2027'	
	Maximum concentration (µg/m³)	Hazard Index	Maximum concentration (µg/m³)	Hazard Index	Maximum concentration (µg/m³)	Hazard Index
Benzene	8.7	0.015	7.5	0.013	8.0	0.014
Toluene	15.7	0.0010	13.6	0.0009	14.5	0.0010
Xylenes	13.0	0.0018	11.2	0.0015	12.0	0.0016
1,3-Butadiene	2.3	0.0035	2.0	0.0030	2.1	0.0032
Formaldehyde	7.5	0.15	6.5	0.13	6.9	0.14
Acetaldehyde	3.5	0.007	3.0	0.006	3.2	0.007
Total Hazard Index		0.2		0.2		0.2

Table 5-7 Assessment of acute exposures to VOCs – 2037

Key VOC	Maximum predicted 1 hour average concentration (background plus project) and calculated Hazard Index					
	'Do minimum 2037'		'Do something 2037' (ie with project)		'Do something cumulative 2037'	
	Maximum concentration (µg/m³)	Hazard Index	Maximum concentration (µg/m³)	Hazard Index	Maximum concentration (µg/m³)	Hazard Index
Benzene	5.8	0.010	5.4	0.009	5.1	0.009
Toluene	10.1	0.0007	9.4	0.0006	8.9	0.0006
Xylenes	8.3	0.0011	7.7	0.0010	7.3	0.0010
1,3-Butadiene	1.6	0.0024	1.5	0.0022	1.4	0.0021
Formaldehyde	7.9	0.16	7.3	0.15	6.9	0.14
Acetaldehyde	3.4	0.007	3.2	0.007	3.0	0.0064
Total Hazard Index		0.2	0.2		0.2	

Table 5-8 Assessment of chronic exposures to VOCs and PAHs – 2027

Key VOCs and PAHs	Maximum predicted annual average concentration (background plus project) and calculated Hazard Index					
	'Do minimum 2027'		'Do something 2027' (ie with project)		'Do something cumulative 2027'	
	Max concentration (µg/m³)	Hazard Index	Max concentration (µg/m³)	Hazard Index	Max concentration (µg/m³)	Hazard Index
Benzene	0.48	0.016	0.45	0.015	0.46	0.015
Toluene	0.86	0.0002	0.81	0.0002	0.83	0.0002
Xylenes	0.71	0.003	0.67	0.003	0.68	0.003
Formaldehyde	0.41	0.13	0.39	0.12	0.40	0.12
Acetaldehyde	0.19	0.0211	0.18	0.0199	0.18	0.0202
Naphthalene	0.067	0.022	0.063	0.021	0.064	0.021
Acenaphthylene	0.0047	2.3E-05	0.0044	2.2E-05	0.0045	2.3E-05
Acenaphthene	0.00192	9.6E-06	0.00181	9.0E-06	0.00184	9.2E-06
Fluorene	0.0048	3.4E-05	0.0045	3.2E-05	0.0046	3.3E-05
Phenanthrene	0.0033	2.3E-05	0.0031	2.2E-05	0.0031	2.2E-05
Anthracene	0.00047	4.7E-07	0.00044	4.4E-07	0.00045	4.5E-07
Fluoranthene	0.00043	3.1E-06	0.00041	2.9E-06	0.00041	3.0E-06
Pyrene	0.00068	6.8E-06	0.00064	6.4E-06	0.00065	6.5E-06
Total Hazard Index – Residential		0.2		0.2		0.2
Max Hazard Index – Commercial/Industrial		0.04		0.04		0.04

Table 5-9 Assessment of chronic exposures to VOCs and PAHs – 2037

Key VOCs and PAHs	Maximum predicted annual average concentration (background plus project) and calculated Hazard Index					
	'Do minimum 2037'		'Do something 2037' (ie with project)		'Do something cumulative 2037'	
	Max concentration (µg/m³)	Hazard Index	Max concentration (µg/m³)	Hazard Index	Max concentration (µg/m³)	Hazard Index
Benzene	0.30	0.010	0.31	0.010	0.31	0.010
Toluene	0.51	0.0001	0.54	0.0001	0.54	0.0001
Xylenes	0.42	0.002	0.44	0.002	0.45	0.002
Formaldehyde	0.40	0.12	0.42	0.13	0.42	0.13
Acetaldehyde	0.17	0.0192	0.18	0.0201	0.18	0.0203
Naphthalene	0.058	0.019	0.061	0.020	0.061	0.020
Acenaphthylene	0.0041	2.0E-05	0.0042	2.1E-05	0.0043	2.1E-05
Acenaphthene	0.0017	8.3E-06	0.0017	8.7E-06	0.0018	8.8E-06
Fluorene	0.0041	3.0E-05	0.0043	3.1E-05	0.0044	3.1E-05
Phenanthrene	0.0028	2.0E-05	0.0029	2.1E-05	0.0030	2.1E-05
Anthracene	0.00041	4.1E-07	0.00042	4.2E-07	0.00043	4.3E-07
Fluoranthene	0.00037	2.7E-06	0.00039	2.8E-06	0.00039	2.8E-06
Pyrene	0.00059	5.9E-06	0.00062	6.2E-06	0.00062	6.2E-06
Total Hazard Index – Residential		0.2		0.2		0.2
Max Hazard Index – Commercial/Industrial		0.04		0.04		0.04

Table 5-10 Assessment of incremental lifetime carcinogenic risk – 2027

Key VOC	Maximum predicted change in annual average concentration associated with project and cancer risk			
	'Do something 2027' (ie with project)		'Do something cumulative 2027'	
	Maximum concentration (µg/m³)	ILCR	Maximum concentration (µg/m³)	ILCR
Benzene	0.036	8 x 10 ⁻⁸	0.034	8 x 10 ⁻⁸
1,3-Butadiene	0.0095	2 x 10 ⁻⁹	0.0092	2 x 10 ⁻⁹
Benzo(a)pyrene TEQ	0.00033	1 x 10 ⁻⁵	0.00032	1 x 10 ⁻⁵
Total carcinogenic risk – Residential		1 x 10⁻⁵		1 x 10⁻⁵
Maximum carcinogenic risk – Commercial/Industrial		3 x 10⁻⁶		3 x 10⁻⁶

Note: ILCR = incremental lifetime carcinogenic risk (refer to Annexure B for calculation methodology and Table 5-5 for inhalation unit risk values)

Table 5-11 Assessment of incremental lifetime carcinogenic risk – 2037

Key VOC	Maximum predicted change in annual average concentration associated with project and cancer risk			
	‘Do something 2037’ (ie with project)		‘Do something cumulative 2037’	
	Maximum concentration (µg/m ³)	ILCR	Maximum concentration (µg/m ³)	ILCR
Benzene	0.034	8 x 10 ⁻⁸	0.039	9 x 10 ⁻⁸
1,3-Butadiene	0.0093	2 x 10 ⁻⁹	0.011	2 x 10 ⁻⁹
Benzo(a)pyrene TEQ	0.00044	2 x 10 ⁻⁵	0.00051	2 x 10 ⁻⁵
Total carcinogenic risk – Residential		2 x 10⁻⁵	2 x 10⁻⁵	
Maximum carcinogenic risk – Commercial/Industrial		4 x 10⁻⁶	4 x 10⁻⁶	

Note: ILCR = incremental lifetime carcinogenic risk (refer to Annexure B for calculation methodology and **Table 5-5** for inhalation unit risk values)

For the assessment of acute exposures to VOCs (Table 5-6 and Table 5-7), the calculated Hazard Index associated with exposure to the maximum concentrations predicted is less than one for 2027, 2037 and the cumulative scenario. On this basis, there are no acute risk issues in the local community associated with the project.

For the assessment of chronic exposures to VOCs and PAHs (Table 5-8 to 5-11), the calculated Hazard Index associated with exposure to the maximum concentrations predicted is less than one for 2027, 2037 and the cumulative scenario. The calculated lifetime cancer risks associated with the maximum change in benzene, 1,3-butadiene and carcinogenic PAHs (as benzo(a)pyrene TEQ) are less than or equal to 2x10⁻⁵ and are considered to be tolerable. It is noted that the calculations carried out for PAHs is based on a conservative estimate of the fraction of emissions from vehicles that comprises PAHs (as a percentage of total VOCs). The approach adopted is expected to overestimate concentrations of PAHs in air. Hence the calculations presented are considered to be a conservative upper limit estimate.

On this basis, there are no unacceptable chronic health risk issues in the local community from the potential exposure to VOCs and PAHs associated with the project.

5.7 Assessment of carbon monoxide

Motor vehicles are the dominant source of CO in air (NSW DECCW, 2010). Adverse health effects of exposure to CO are linked with carboxyhaemoglobin (COHb) in blood. In addition, association between exposure to CO and cardiovascular hospital admissions and mortality, especially in the elderly for cardiac failure, myocardial infarction and ischemic heart disease, and some birth outcomes (such as low birth weights) have been identified (NEPC, 2010).

Guidelines are available in Australia from NEPC (NEPC, 2003) and NSW EPA that are based on the protection of adverse health effects associated with CO. Review of these guidelines by NEPC (2010) identified additional supporting studies³ for the evaluation of potential adverse health effects and indicated that these should be considered in the current review of the National Ambient Air Quality NEPM (no interim or finalisation date available). The air guidelines currently available from NEPC are consistent with health based guidelines currently available from the WHO (2005) and the USEPA (2011)⁴, specifically listed to be protective of exposures by sensitive populations including asthmatics, children and the elderly. On this basis, the current NEPC guidelines are considered appropriate for the assessment of potential health impacts associated with the project.

³ Many of the more current studies are epidemiology studies that relate to a mix of urban air pollutants (including particulate matter) where it is more complex to determine the effects that can be attributed to carbon monoxide exposure only.

⁴ Most recent review of the Primary National Ambient Air Quality Standards for Carbon Monoxide published by the USEPA in the Federal Register Volume 76, No. 169, 2011, available from: <http://www.gpo.gov/fdsys/pkg/FR-2011-08-31/html/2011-21359.htm>.

The NEPC ambient air quality guideline for the assessment of exposures to CO has considered lowest observed adverse effect level (LOAEL) and no observed adverse effect level (NOAEL) associated with a range of health effects in healthy adults, people with ischemic heart disease and foetal effects. In relation to these data, a guideline level of CO of nine parts per million (ppm) by volume (or 10 mg/m³ or 10,000 µg/m³ over an 8-hour period was considered to provide protection (for both acute and chronic health effects) for most members of the population. An additional 1.5-fold uncertainty factor to protect more susceptible groups in the population was included. On this basis, the NEPC (and the USEPA) guideline is protective of adverse health effects in all individuals, including sensitive individuals.

The NSW EPA has also established a guideline for 15-minute average (100 mg/m³) and 1-hour average (30 mg/m³) concentrations of CO in ambient air. These guidelines are based on criteria established by the WHO (WHO 2000a) using the same data used by the NEPC to establish the guideline (above) with extrapolation to different periods of exposure on the basis of known physiological variables that affect CO uptake.

Table 5-12 presents a summary of the maximum predicted total 1-hour average and 8-hour average concentrations of CO for the assessment years 2027 and 2037, without the project ('Do minimum'), with the project ('Do something') and for the cumulative scenario ('Do something cumulative').

Table 5-12 Review of potential acute and chronic health impacts – CO

Scenario	Maximum 1-hour average concentration of CO (mg/m ³)			Maximum 8 hour average concentration of CO (mg/m ³)		
	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'
2027						
Maximum	6.0	5.5	5.4	4.2	3.9	3.8
2037						
Maximum	5.1	5.5	4.9	3.5	3.8	3.4
Relevant health based guideline	30 (acute)			10 (chronic)		

All the concentrations of CO presented in the above table are below the relevant health based guidelines. There are no adverse health effects expected in relation to exposures (acute and chronic) to CO in the local area surrounding the project on the basis of the assessment carried out.

5.8 Assessment of nitrogen dioxide

5.8.1 Approach

Nitrogen oxides (NO_x) refers to nitrogen oxide (NO) and NO₂, which are highly reactive gases containing nitrogen and oxygen. Nitrogen oxide gases form when fuel is burnt. Motor vehicles, along with industrial, commercial and residential (eg gas heating or cooking) combustion sources, are primary producers of NO_x.

In Sydney, DPIE (Environment, Energy and Science) (OEH, 2012) estimated that on-road vehicles account for about 62 per cent of emissions of NO_x, industrial facilities account for 12 per cent, other mobile sources account for about 22 per cent, with the remainder from domestic/commercial sources.

In terms of health effects, NO₂ is the only oxide of nitrogen that may be of concern (WHO, 2000b). NO₂ can cause inflammation of the respiratory system and increase susceptibility to respiratory infection. Exposure to elevated levels of NO₂ has also been associated with increased mortality, particularly related to respiratory disease, and with increased hospital admissions for asthma and heart disease patients (WHO, 2013b). Asthmatics, the elderly and people with existing cardiovascular and respiratory disease are particularly susceptible to the effects of NO₂ (Morgan, Broom & Jalaludin, 2013; NEPC, 2010). The health effects associated with exposure to NO₂ depend on the duration of exposure as well as the concentration.

Guidelines are available from the NSW EPA and NEPC (NEPC, 2003) which indicate acceptable concentrations of NO₂. These guidelines are based on protection from adverse health effects following both short term (acute) and longer term (chronic) exposure for all members of the population including sensitive populations like asthmatics, children and the elderly. Recently these guidelines have been reviewed by NEPC (Golder, 2013; NEPC, 2010 and 2014). The review identified additional supporting studies for the evaluation of potential adverse health effects. The reviews carried out to date have not recommended any change to the existing health based guidelines.

When reviewing the available literature on the health effects associated with exposure to NO₂ it is important to consider the following:

- Whether the evidence suggests that associations between exposure to NO₂ concentrations and effects on health are causal. The most current review carried out by the USEPA (USEPA, 2015) specifically evaluated evidence of causation. The review identified that a causal relationship existed for respiratory effects (for short-term exposure with long-term exposures also likely to be causal). All other associations related to exposure to NO₂ (specifically cardiovascular effects, mortality and cancer) were considered to be suggestive
- Whether the reported associations are distinct from, and additional to, those reported and assessed for exposure to PM. Co-exposures to NO₂ and PM complicates review and assessment of many of the epidemiology studies as both these air pollutants occur together in urban areas. There is sufficient evidence (epidemiological and mechanistic) to suggest that some of the health effect associations identified relate to exposure to NO₂ after adjustment/correction for co-exposures with PM (COMEAP, 2015)
- Whether the assessment of potential health effects associated with exposure to different levels of NO₂ can be carried out on the basis of existing guidelines, or whether specific risk calculations are required to be carried out. The current guidelines in Australia for the assessment of NO₂ in air relate to cumulative (total) exposures, and adopt criteria that are considered to be protective of short- and long-term exposures. So, it is relevant that these guidelines be considered in this assessment
- In addition, it is noted that in areas of high traffic congestion (as is the case with the project area evaluated in this assessment) background levels of NO₂ may already be elevated such that use of the existing guideline is limited for the purpose of assessing health impacts from a particular project or activity. For these situations, it is relevant to also evaluate the impact on community health of the change in NO₂ concentration in the local community using appropriate risk calculations. For the conduct of risk assessments in relation to exposure to NO₂, the WHO (WHO, 2013b) identified that the strongest evidence of health effects related to respiratory hospitalisations and to a lesser extent mortality (associated with short-term exposures) and recommend that these health endpoints should be considered in any core assessment of health impacts associated with exposure.

On the basis of the above, assessment of potential health effects associated with exposure to NO₂ has been carried out for this project using both comparison with guidelines (assessing total exposures) and an assessment of incremental impacts on health (associated with changes in air quality from the project).

5.8.2 Assessment of total exposures

Assessment of acute exposures

The NEPC ambient air quality guideline for the assessment of acute (short-term) exposures to NO₂ relates to the maximum predicted total (ie background plus project) 1-hour average concentration in air. The guideline of 246 µg/m³ (or 120 parts per billion by volume) is based on a LOAEL of 409–613 µg/m³ derived from statistical reviews of epidemiological data suggesting an increased incidence of lower respiratory tract symptoms in children and aggravation of asthma. An uncertainty factor of two to protect susceptible people (ie asthmatic children) was applied to the LOAEL (NEPC, 1998). On this basis, the NEPC (and NSW EPA) acute guideline is protective of adverse health effects in all individuals, including sensitive individuals.

Table 5-13 presents a summary of the maximum predicted total 1-hour average concentrations of NO₂ from the modelled scenarios.

Table 5-13 Review of potential acute health impacts – NO₂

Location and scenario	Maximum 1-hour average concentration of NO ₂ (µg/m ³)		
	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'
2027			
Maximum	467	411	446
2037			
Maximum	433	409	437
Acute health based guideline	246	246	246

The maximum total concentrations of NO₂ presented in the above table exceed the acute NEPC guideline of 246 µg/m³ for all the scenarios, with and without the project. The elevated levels listed above are not considered to be representative of exposure concentrations that would occur within the study area. This is due to the combined effect of the approach adopted in the assessment for converting NO_x to NO₂ (that overestimates short-term 1-hour average concentrations), and the use of a contemporaneous assessment of background and project impacts. The contemporaneous approach assumes that the highest background concentrations may occur during the same hour as the maximum incremental change from the project. This results in a very high estimate of total NO₂ concentrations that is not likely to ever occur (refer to the Technical working paper: Air quality for more detailed discussion). As a result, the magnitude of the maximum total concentrations reported for NO₂ over a 1-hour average cannot be used to evaluate the potential for adverse health effects in the community.

As assessment of total concentrations to NO₂ cannot be used to determine the potential for adverse health impacts in the community, and because there is no clear threshold established for community exposures to NO₂, the assessment of incremental exposures is of most relevance. This assessment is presented in Section 5.8.3.

Assessment of chronic exposures

The NEPC ambient air quality guideline for the assessment of chronic (long-term) exposures to NO₂ relates to the maximum predicted total (ie background plus project) annual average concentration in air. The guideline of 62 µg/m³ (or 30 ppbv) parts per billion by volume)) is based on a LOAEL of the order of 40–80 parts per billion by volume (around 75–150 µg/m³) during early and middle childhood years. This can lead to the development of recurrent upper and lower respiratory tract symptoms, such as recurrent 'colds', a productive cough and an increased incidence of respiratory infection with resultant absenteeism from school. An uncertainty factor of two was applied to the LOAEL to account for susceptible people within the population resulting in a guideline of 20–40 parts per billion by volume (38–75 µg/m³) (NEPC, 1998). On this basis, the NEPC (and OEH) chronic guideline is protective of adverse health effects in all individuals, including sensitive individuals.

Table 5-14 presents a summary of the maximum predicted total annual average concentrations of nitrogen dioxide from the modelled scenarios.

Table 5-14 Review of potential chronic health impacts – NO₂

Location and scenario	Maximum annual average concentration of NO ₂ (µg/m ³)		
	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'
2027			
Maximum	43.4	37.7	35.0
2037			
Maximum	39.4	37.6	33.9
Chronic health based guideline	62		

The concentrations of NO₂ presented in the above table are below the chronic NEPC guideline of 62 µg/m³. In addition, the concentrations of NO₂ are lower for the cumulative scenario so there are no adverse health effects expected in relation to chronic exposures to NO₂ as a result of the project.

5.8.3 Assessment of incremental exposures

The evidence base supports quantification of effects of short-term exposure to NO₂, using the averaging time as in the relevant studies. The strongest evidence is for respiratory effects, in particular exacerbation of asthma, with some support also for all-cause mortality. These health endpoints have been evaluated in relation to changes in NO₂ concentrations in air associated with the project within the local community in 2027 and 2037.

The approach adopted for the assessment of incremental exposures is consistent with that adopted for particulates as outlined in Section 5.9.5. This involves the calculation of a change in individual risk, as well as the change in incidence, or the number of cases, that occur in the community as a result of the project.

Table 5-15 presents a summary of the health endpoints considered in this assessment, and the β coefficients relevant to the calculation of a relative risk (refer to Annexure A for details on the calculation of a β coefficient from published studies). The coefficients adopted for the assessment of impacts on mortality and asthma emergency department admissions are derived from the detailed assessment carried out for the current review of health impacts of air pollution carried out by NEPC (Golder 2013) and are considered to be robust.

Table 5-15 Adopted exposure-responses relationships for assessment of changes in NO₂ concentrations

Health endpoint	Exposure period	Age group	Adopted β coefficient (also as per cent) for 1 µg/m ³ increase in NO ₂	Reference
Mortality, all causes (non-trauma)	Short term	All ages*	0.00188 (0.19%)	Relationship derived from modelling carried out for 5 cities in Australia and 1 day lag (EPHC, 2010; Golder, 2013)
Mortality, respiratory	Short term	All ages*	0.00426 (0.43%)	Relationship derived from modelling carried out for 5 cities in Australia and 1 day lag (EPHC, 2010; Golder, 2013)
Asthma emergency department (ED) admissions	Short term	1–14 years	0.00115 (0.12%)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Golder, 2013; Jalaludin et al., 2008)

Note: * Relationships established for all ages, including young children and the elderly

It is noted that while the maximum concentrations of NO₂ are predicted to be lower in the local community with the cumulative operation of the project, the concentrations at individual receptors vary. While the concentrations at many receptors decrease with the operation of the project, there are some receptors where there is a predicted increase, associated with the redistribution of emissions from vehicles using surface roads.

Table 5-16 presents the change in individual risk associated with changes in NO₂ at the maximum impacted receptors relevant to the various land use in the community, as well as the community receptors (refer to Annexure A for methodology for the calculation of individual risks). These individual risks are presented for the operational years 2027 and 2037, including the cumulative scenario. The assessment assumes an individual is exposed at each maximum impacted location over all hours of

the day, regardless of the land use. This has been carried out to address any future changes in land use that may occur. Risks for all other receptors (including other sensitive receptors) are lower than the maximums presented.

All risks are presented to one significant figure, reflecting the level of uncertainty associated with the calculations presented.

Figure 5-5 presents a summary of the calculated change in risk associated with changes in NO₂ concentrations at each community receptor location evaluated. This change is the predicted NO₂ concentrations with the project ('Do something' or 'Do something cumulative') minus the NO₂ concentrations without the project ('Do minimum').

A general discussion of how risk levels are derived are provided in Annexure C including a discussion on what levels are considered to be negligible, tolerable/acceptable and unacceptable. Maximum calculated risk levels are shown in Table 5-16.

Calculations relevant to the characterisation of risks associated with changes in NO₂ concentrations in the community are presented in Annexure D.

Table 5-17 present a summary of the calculated change in incidence of the relevant health effects for the population living in the LGAs within the study area, associated with changes in NO₂ concentrations for 2027 and 2037. All calculations relevant to the LGAs, including calculations for each individual suburb considered in the LGAs, are presented in Annexure E.

Table 5-16 Maximum calculated risks associated with short term exposure to changes in NO₂ concentrations with operation of the project

Scenario and receptor	Maximum change in individual risk from short term exposure to nitrogen dioxide for the following health endpoints		
	Mortality: All causes (all ages)	Mortality: Respiratory (all ages)	Asthma ED Admissions (1–14 years)
‘Do something 2027’ (ie with project)			
Maximum residential	2E-05	4E-06	4E-05
Maximum workplace	1E-05	2E-06	2E-05
Maximum childcare and schools	2E-05	3E-06	3E-05
Maximum aged care	5E-06	8E-07	8E-06
Maximum hospitals/medical	4E-06	7E-07	7E-06
Maximum open space	1E-05	2E-06	2E-05
Maximum from sensitive receptors	2E-05	3E-06	3E-05
‘Do something cumulative 2027’			
Maximum residential	2E-05	3E-06	3E-05
Maximum workplace	2E-05	3E-06	3E-05
Maximum childcare and schools	2E-05	3E-06	3E-05
Maximum aged care	4E-06	8E-07	8E-06
Maximum hospitals/medical	7E-06	1E-06	1E-05
Maximum open space	1E-05	2E-06	2E-05
Maximum from sensitive receptors	1E-05	2E-06	2E-05
‘Do something 2037’ (ie with project)			
Maximum residential	2E-05	4E-06	4E-05
Maximum workplace	2E-05	3E-06	3E-05
Maximum childcare and schools	1E-05	2E-06	2E-05
Maximum aged care	5E-06	9E-07	9E-06
Maximum hospitals/medical	1E-05	2E-06	2E-05
Maximum open space	1E-05	2E-06	2E-05
Maximum from sensitive receptors	1E-05	2E-06	2E-05
‘Do something cumulative 2037’			
Maximum residential	2E-05	3E-06	3E-05
Maximum workplace	2E-05	4E-06	4E-05
Maximum childcare	9E-06	2E-06	2E-05
Maximum aged care	7E-06	1E-06	1E-05
Maximum hospitals/medical	8E-06	1E-06	1E-05
Maximum open space	2E-05	3E-06	3E-05
Maximum from sensitive receptors	1E-05	2E-06	2E-05
Negligible risks	$<1 \times 10^{-6}$		
Tolerable/acceptable risks	$\geq 1 \times 10^{-6}$ and $\leq 1 \times 10^{-4}$		
Unacceptable risks	$>1 \times 10^{-4}$		

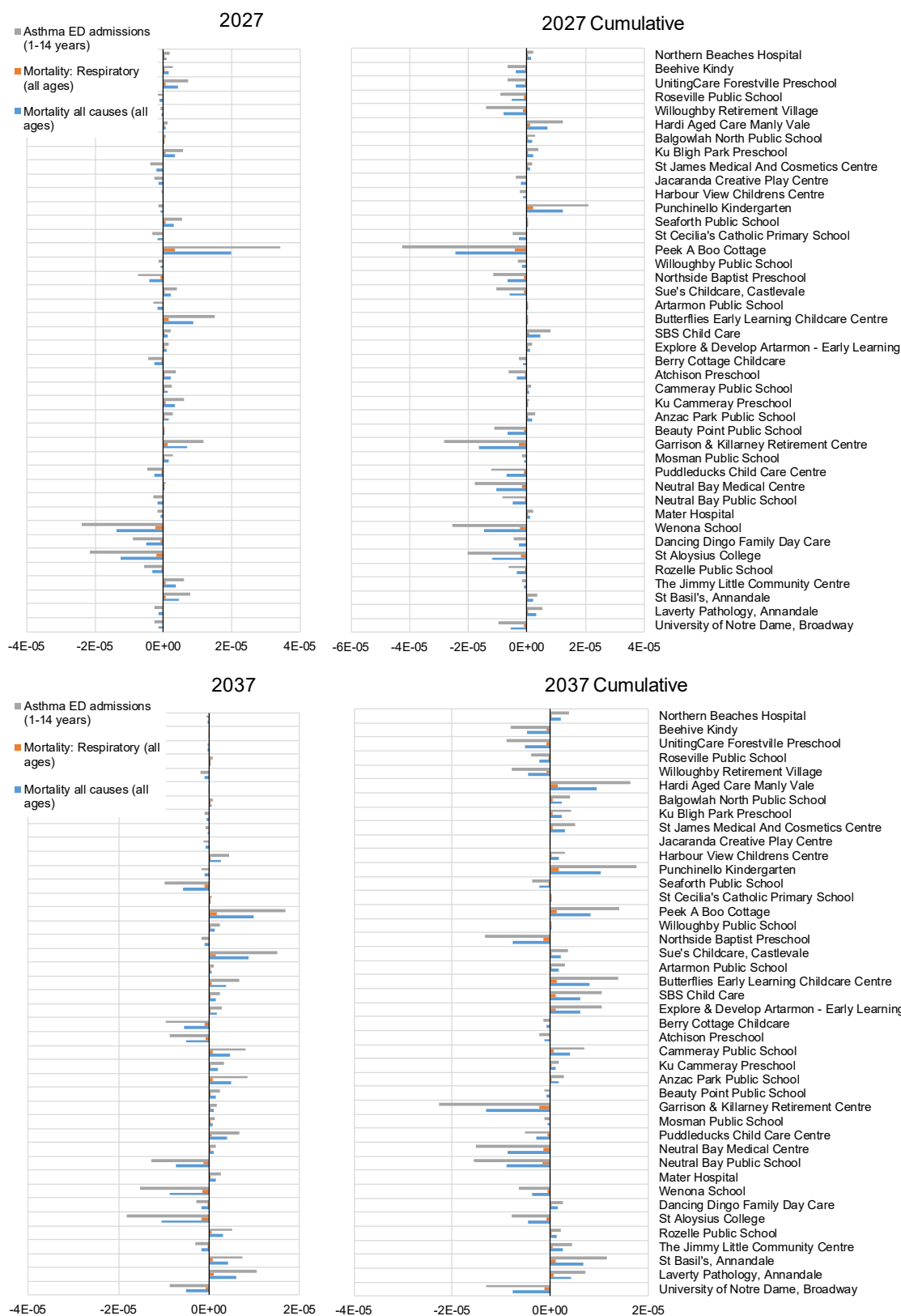


Figure 5-5 Change in calculated risk for key health endpoints associated with changes in NO₂ concentrations at community receptors ('Do-Something' 2027 Scenario and 'Do-Something Cumulative' 2037)

Table 5-17 **Calculated changes in incidence of health effects in population associated with changes in NO₂ concentrations – 2027 and 2037**

LGA	Change in population incidence – number of cases					
	2027			2037		
	Mortality – All Causes	Mortality – Respiratory	Morbidity – Asthma ED Admissions	Mortality – All Causes	Mortality – Respiratory	Morbidity – Asthma ED Admissions
	≥30 years	All ages	1-14 years	≥30 years	All ages	1–14 years
'Do something' (ie with project)						
Canada Bay	-0.00084	-0.00015	-0.00023	-0.0031	-0.00055	-0.00083
North Sydney - Mosman	-0.11	-0.019	-0.028	-0.13	-0.024	-0.034
Sydney Inner West	-0.0060	-0.00082	-0.0012	-0.026	-0.0035	-0.0050
Sydney	-0.53	-0.076	-0.046	-0.30	-0.043	-0.026
Lane Cove - Chatswood	0.025	0.00053	0.0093	0.034	0.0073	0.013
Hunters Hill	0.000026	0.000004	0.000007	0.0012	0.00017	0.0031
Woollahra (Eastern Suburbs - North)	-0.023	-0.0043	-0.0063	-0.010	-0.0019	-0.0028
Northern Beaches	0.012	0.0019	0.0036	-0.00029	-0.000045	-0.000086
Ku-ring-gai	-0.00009	-0.00002	-0.00004	-0.0027	-0.00053	-0.0011
Total for all LGAs	-0.63	-0.094	-0.068	-0.44	-0.067	-0.057
'Do something cumulative'						
Canada Bay	0.00040	0.000072	0.00011	-0.0015	-0.00027	-0.00041
North Sydney - Mosman	-0.31	-0.057	-0.080	-0.36	-0.066	-0.093
Sydney Inner West	0.011	0.0016	0.0022	-0.006	-0.00084	-0.0012
Sydney	-0.64	-0.092	-0.055	-0.47	-0.067	-0.040
Lane Cove - Chatswood	-0.099	-0.022	-0.038	-0.088	-0.019	-0.033
Hunters Hill	-0.00093	-0.00014	-0.00025	0.00076	0.00011	0.00020
Woollahra (Eastern Suburbs - North)	-0.032	-0.0059	-0.0087	-0.027	-0.0050	-0.0073
Northern Beaches	0.015	0.0023	0.0043	-0.035	-0.0054	-0.010
Ku-ring-gai	-0.025	-0.0050	-0.0098	-0.026	-0.0051	-0.010
Total for all LGAs	-1.1	-0.18	-0.19	-1.0	-0.17	-0.20

 Negative value indicates that there is a decrease in incidence associated with the project (ie a potential health benefit)

Review of the individual risks calculated for changes in NO₂ levels associated with the project, indicates the following:

- The maximum risks calculated for exposures in residential areas are less than 1×10^{-4} and are therefore considered to be tolerable/acceptable
- The maximum risks calculated for exposures in commercial/industrial areas are less than 1×10^{-4} and are therefore considered to be tolerable/acceptable
- All maximum risks calculated for continuous exposures in childcare centres, schools, aged care homes and open space areas are below 1×10^{-4} and considered to be tolerable/acceptable
- All risks calculated for exposures at community receptors are below 1×10^{-4} and considered to be tolerable/acceptable. It is noted that for many of the community receptors the impact of the project is a lowering of risk (negative risk values presented in Figure 5-4).

Review of the calculated impacts in terms of the change in incidence of the relevant health effects associated with exposure to NO₂ in the community, indicates the following:

- The total change in the number of cases relevant to the health effects evaluated, for both 2027 and 2037 is negative, meaning a decrease in incidence as a result of the project. The number of cases, however is small, with a decrease of approximately one case. This change would not be measurable within the community
- Most individual LGAs show a total decrease in health incidence. There are a few LGAs (Lane Cove, Hunters Hill and Northern Beaches) where there is an increase. These increases and decreases are also small in individual LGAs for all health effects considered. As a result, these changes would not be measurable in the community
- The incidence calculations presented in Table 5-17 are the totals for each LGA. Within these LGAs are a number of smaller suburbs. The calculated change in incidence relevant to each of these suburbs has also been evaluated, as presented in Annexure E. Review of the incidence calculated for the individual suburbs indicates that these predominantly relate to small decreases in health incidence with some suburbs showing an increase. The largest increase in health incidence for any individual suburb is less than one case/person. There are no individual suburbs within the LGAs where there is a change incidence that is of significance or would be measurable.

5.9 Assessment of particulate matter

5.9.1 Particle size

PM is a widespread air pollutant with a mixture of physical and chemical characteristics that vary by location (and source). Unlike many other pollutants, PM includes a broad class of diverse materials and substances, with varying morphological, chemical, physical and thermodynamic properties, with sizes that vary from less than 0.005 micrometres (or microns) to greater than 100 microns. Particles can be derived from natural sources such as crustal dust (soil), pollen and moulds, and other sources that include combustion and industrial processes. Secondary PM is formed via atmospheric reactions of primary gaseous emissions. The gases that are the most significant contributors to secondary particulates include nitrogen oxides, ammonia, sulfur oxides, and certain organic gases (derived from vehicle exhaust, combustion sources, agricultural, industrial and biogenic emissions).

Numerous epidemiological studies⁵ have reported significant positive associations between particulate air pollution and adverse health outcomes, in particular mortality as well as a range of adverse cardiovascular and respiratory effects.

⁵ Epidemiology is the study of diseases in populations. Epidemiological evidence can only show that this risk factor is associated (correlated) with a higher incidence of disease in the population exposed to that risk factor. The higher the correlation the more certain the association. Causation (ie that a specific risk factor actually causes a disease) cannot be proven with only epidemiological studies. For causation to be determined a range of other studies need to be considered in conjunction with the epidemiological studies.

The potential for PM to result in adverse health effects is dependent on the size and composition of the PM. The common measures of PM that are considered in the assessment of air quality and health risks are:

- Total suspended particulates (TSP): This refers to all PM with an equivalent aerodynamic particle⁶ size generally below 50 to 100 microns in diameter⁷. It is a fairly gross indicator of the presence of dust with a wide range of sizes. Larger particles (termed 'inspirable', comprise particles around 10 microns and larger) are of less concern and more of a nuisance as they would deposit out of the air (measured as deposited dust) close to the source and, if inhaled, are mostly trapped in the upper respiratory system⁸ and do not reach the lungs. Smaller particles (smaller than 10 microns, termed 'respirable') tend to be transported further from the source and are of greater concern with respect to human health as these particles can penetrate into the lungs (see following point). Not all of the dust characterised as TSP is relevant for the assessment of health impacts, and TSP as a measure of impact, has not been further evaluated in this assessment. The assessment has only focused on particulates of a size where significant associations have been identified between exposure and adverse health effects
- PM₁₀ (particulate matter less than 10 microns in diameter), PM_{2.5} (particulate matter less than 2.5 microns in diameter), PM₁ (particulate matter less than one micron in diameter, often termed very fine particles) and ultrafines (particulate matter less than 0.1 microns in diameter): These particles are small and have the potential to penetrate beyond the body's natural clearance mechanisms of cilia and mucous in the nose and upper respiratory system, with smaller particles able to further penetrate into the lower respiratory tract⁹ and lungs. Once in the lungs adverse health effects may result (OEHHA, 2002).

Evaluation of size alone as a single factor in determining the potential for particulate toxicity is difficult since the potential health effects are not independent of chemical composition. There are certain particulate size fractions that tend to contain certain chemical components, such as metals in fine particulates (less than PM_{2.5}) and crustal materials (like soil) in the coarse mode (PM_{2.5} to PM₁₀). In addition, different sources of particulates have the potential to result in the presence of other pollutants in addition to PM. For example, combustion sources, prevalent in urban areas, result in the emission of PM (more dominated by PM_{2.5}) as well as gaseous pollutants (such as NO₂ and CO). This results in what is referred to as co-exposure, and is an issue that has to be accounted for when evaluating studies that come from studying health effects in large populations exposed to pollution from many sources (as is the case in urban air).

Where co-exposure is accounted for, the available science supports that exposure to fine PM (less than 2.5 microns, PM_{2.5}) is associated (and shown to be causal in some cases) with health impacts in the community (USEPA, 2012). A more limited body of evidence suggests an association between exposure to larger particles, PM₁₀ and adverse health effects (USEPA, 2009a; WHO, 2003).

⁶ The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density one gram per cubic metre.

⁷ The size, diameter, of dust particles is measured in micrometers (microns).

⁸ The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

⁹ The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

It is noted that when assessing potential health impacts associated with changes in PM concentrations, the studies relied on for establishing associations (between changes in concentrations in air and health effects) are large epidemiological studies. These studies relate changes in health indicators with changes in measured concentrations of PM. As a result, the particle size fractions addressed in these studies relate to the fractions measured in the urban air environment studies. In relation to measuring PM in urban air, the following should be noted:

- The measurement of PM in urban air most commonly reports PM₁₀. This is the concentration of PM less than or equal to 10 microns in diameter (and includes the smaller fractions of PM_{2.5} and very fine particles). The measurement techniques for PM₁₀ are well established and provide stable, robust, verifiable data that is considered to be consistently reported across all countries. In addition, there is a longer and more extensive history/database of PM₁₀ data. This means this data on PM₁₀ collected in different parts of a city, in different parts of a country and by different countries can be compared against each other. This is the key reason why many of the epidemiological studies have looked at associations between PM₁₀ and various health effects
- The measurement of PM_{2.5} is becoming more common in urban environments. This is the concentration of PM less than or equal to 2.5 microns in diameter (and includes the smaller fractions of very fine particles and ultrafines). The measurement techniques used for PM_{2.5} are less well established resulting in data that varies depending on the type of equipment used and how it is set up and maintained. Due to either a lack of monitoring data or the inconsistency of monitoring data some epidemiology studies have assessed associations between PM_{2.5} and health effects by using PM₁₀ data and assuming that a certain percentage of PM₁₀ comprises PM_{2.5}. Some studies have directly used measurements of PM_{2.5} in urban air. Even where these measurement issues are considered, the studies still clearly show strong relationships between changes in PM_{2.5} concentrations and health effects
- The measurement of ultrafine particles is difficult (using equipment that is less robust/stable and provides variable data) and has not been carried out in most urban air environments. As a result, there are no robust epidemiological studies that relate changes in ultrafine particle levels and health effects that can be used in a risk assessment. There is sufficient data available to confirm that motor vehicles are a key source of ultrafine particles. Available studies in animals and humans have identified a range of adverse health effects associated with exposure to ultrafine particulates. However the studies do not show that short-term exposure to ultrafine particulates have effects that are significantly different from those associated with exposure to PM_{2.5} (HEI, 2013).

When assessing health impacts from fine particulates, the robust associations of effects (that are based on large epidemiology studies primarily from the US and Europe) have been determined on the basis of PM_{2.5}, as PM_{2.5} is what is commonly measured in urban air. No robust associations (that can be used in a quantitative assessment) are available for PM₁ and the current science is inconclusive in relation to ultrafine particulates. The associations developed for PM_{2.5} would include a significant contribution from PM₁ (as PM₁ comprises a significant proportion of PM_{2.5}) and health effects observed for PM₁ would be captured in the studies that have been conducted on the basis of PM_{2.5}. It is important that the quantitative evaluation of potential health impacts adopts robust health effects associations and utilises PM measures that are collected in the urban air environment. The further assessment of exposure to fine particulate matter has focused on particulates reported/evaluated as PM_{2.5}.

5.9.2 Health effects

Adverse health effects associated with exposure to PM have been well studied and reviewed by Australian and international agencies. Most of the studies and reviews have focused on population-based epidemiological studies in large urban areas in North America, Europe and Australia, where there have been clear associations determined between health effects and exposure to PM_{2.5} and to a lesser extent, PM₁₀. These studies are complemented by findings from other key investigations conducted in relation to the characteristics of inhaled particles; deposition and clearance of particles in the respiratory tract; animal and cellular toxicity studies; and studies on inhalation toxicity by human volunteers (NEPC, 2010).

PM has been linked to adverse health effects after both short-term exposure (days to weeks) and long-term exposure (months to years). The health effects associated with exposure to PM vary widely (with the respiratory and cardiovascular systems most affected) and include mortality and morbidity effects.

In relation to mortality, short-term exposures relate to the increase in the number of deaths due to existing (underlying) respiratory or cardiovascular disease. For long-term exposures, this relates to mortality rates over a lifetime, where long-term exposure is considered to accelerate the progression of disease or even initiate disease.

In relation to morbidity effects, this refers to a wide range of health indicators used to define illness that have been associated with (or caused by) exposure to PM. Effects are primarily related to the respiratory and cardiovascular system and include (Morawska, Moore & Ristovski, 2004; USEPA, 2009a):

- Aggravation of existing respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits)
- Changes in cardiovascular risk factors such as blood pressure
- Changes in lung function and increased respiratory symptoms (including asthma)
- Changes to lung tissues and structure
- Altered respiratory defence mechanisms.

These effects are commonly used as measures of population exposure to PM in community epidemiological studies (from which most of the available data in relation to health effects is derived), and are more often grouped (through the use of hospital codes) into the general categories of cardiovascular morbidity/effects and respiratory morbidity/effects. The available studies provide evidence for increased susceptibility for various populations, particularly older populations, children and those with underlying health conditions (USEPA, 2009a).

There is consensus in the available studies and detailed reviews that exposure to fine particulates, PM_{2.5}, is associated with (and causal to) cardiovascular and respiratory effects and mortality (all causes) (USEPA 2012). Similar relationships have also been determined for PM₁₀; however, the supporting studies do not show relationships as clear as those shown with PM_{2.5} (USEPA, 2012).

There are a number of studies that have been carried out where other health effects have been evaluated. These studies are suggestive (but do not show effects as clearly as the effects noted above) of an association between exposure to PM_{2.5} and reproductive and developmental effects as well as cancer, mutagenicity and genotoxicity (USEPA, 2012). IARC (2013) has classified PM as carcinogenic to humans based on data relevant to lung cancer.

Other studies have been reviewed to determine relationships/associations between PM exposure (either PM₁₀ or PM_{2.5}) and a wide range of other health effects and health measures including mortality (for different age groups), chronic bronchitis, medication use by adults and children with asthma, respiratory symptoms (including cough), restricted work days, work days lost, school absence and restricted activity days (Anderson et al., 2004; EC, 2011; Ostro, 2004; WHO, 2006a). While these relationships/associations have been identified, the exposure-response relationships established are not as strong as those discussed above. Also, the available baseline data does not include information for many of these health effects which means it is not possible to carry out a quantitative assessment.

5.9.3 Approach to the assessment of particulate exposures

There is sufficient evidence to demonstrate, in relation to the assessment of exposures to PM, that there is an association between exposure to PM_{2.5} (and to a lesser extent PM₁₀) and effects on health that are causal. The effects related to exposures to PM_{2.5} (or PM₁₀) alone (ie without co-exposures).

The available evidence does not suggest that there is a threshold below which health effects do not occur, so there are likely to be health effects associated with background levels of PM_{2.5} and PM₁₀, even where the concentrations are below the current guidelines. Guidelines are currently available for the assessment of PM_{2.5} and PM₁₀ in New South Wales (DEC, 2005) and Australia (NEPC 2002,

2003, 2016). These guidelines are not based on any acceptable level of risk, rather they are based on levels that are desirable in the community to balance background/urban sources with lowering impacts on health and cost savings in the health system.

The air quality goals relate to average or regional exposures by populations from all sources, not to localised 'hot-spot' areas such as locations near industry, busy roads or mining. They are intended to be compared against ambient air monitoring data collected from appropriately sited regional monitoring stations. In some cases, there may be local sources (including busy roadways and industry) that result in background levels of PM₁₀ and PM_{2.5} that are close to, equal to, or in exceedance of the air quality goals. Where impacts are being evaluated from a local source, it is important to not only consider total impacts associated with the project (carried out using the current air quality goals) but also evaluate the impact of changes in air quality within the local community.

This assessment has been carried out to consider both cumulative exposure impacts (refer to Section 5.9.4) and incremental exposure impacts associated with changes in PM_{2.5} and PM₁₀ concentrations that are associated with the project (refer to Section 5.9.5).

5.9.4 Assessment of total exposures

The assessment of cumulative exposures to PM_{2.5} and PM₁₀ is based on a comparison of the total concentrations predicted in 2027 and 2037 (ie without the project ('Do minimum'), with the project and for the cumulative scenario, all of which include background exposures) with the relevant air quality guidelines/standards available from the NEPC and NSW EPA. The current NEPC and NSW EPA air quality goals and guidelines/standards for PM are presented in Table 5-18. These guidelines/standards are for cumulative impacts and should also be considered in conjunction with incremental impact calculations presented in Section 5.9.5.

Table 5-18 Air quality guidelines/standards for particulates

Pollutant	Averaging period	Criteria (µg/m ³)	Reference
PM ₁₀	24 hour	50	(NEPC, 2016; NSW EPA, 2016)
	Annual	25	(NSW EPA, 2016)
PM _{2.5}	24 hour	25 with goal of 20 by 2025	(NEPC, 2016)
	Annual	8 with goal of 7 by 2025	

The following is noted in relation to the current NEPC guidelines (NEPC 1998, 2010, 2014):

- The guideline was derived through a review of appropriate health studies by a technical review panel of the NEPC where short-term exposure-response relationships for PM and mortality and morbidity health endpoints were considered
- Mortality health impacts were identified as the most significant and were the primary basis for the development of the guideline
- On the basis of the available data for key air sheds in Australia, the criteria listed in Table 5-18 was based on analysis of the number of premature deaths that would be avoided and associated cost savings to the health system (using data from the US). The development of the goal is not based on any acceptable level of risk
- The assessment carried out considered exposures and issues relevant to urban air environments that are expected to also be managed through the PM guideline. These issues included emissions from vehicles and wood heaters.

Table 5-19 presents a comparison of the NEPC guidelines with those established by the WHO (WHO, 2005), the EU and the USEPA (2012). The standards established by the NEPC for PM_{2.5} (and adopted in this assessment) are similar to but slightly more conservative (health protective) than those provided by the WHO, EU and the USEPA. The NEPC and NSW EPA PM₁₀ guidelines are also similar to those established by the WHO and EU; however, the guidelines are significantly lower than the 24-hour average guideline available from the USEPA.

Table 5-19 Comparison of particulate matter air quality goals

Pollutant	Averaging period	Criteria/guidelines/goals			
		NEPC and NSW EPA	WHO (2005)	EU #	USEPA (2012)
PM ₁₀	24 hour	50 µg/m ³	50 µg/m ³	50 µg/m ³ as limit value with 35 exceedances permitted each year	150 µg/m ³ (not to be exceeded more than once per year on average over three years)
	Annual	25 µg/m ³	20* µg/m ³	40 µg/m ³ as limit value	NA
PM _{2.5}	24 hour	25 µg/m ³ (with goal of 20 by 2025)	25 µg/m ³	N/A	35 µg/m ³ (98th percentile, averaged over three years)
	Annual	8 µg/m ³ (with goal of 7 µg/m ³ by 2025)	10* µg/m ³	25 µg/m ³ as target value from 2010 and limit value from 2015. 20 µg/m ³ as a three year average (average exposure indicator) from 2015 with requirements for ongoing percentage reduction and target of 18 µg/m ³ as three year average by 2020	12 µg/m ³ (annual mean averaged over three years)

Notes:

Current EU Air Quality Standards available from <http://ec.europa.eu/environment/air/quality/standards.htm>

* The WHO Air Quality guidelines are based on the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95 per cent confidence in response to PM_{2.5} in the ACS study (Pope et al. 2002). The use of a PM_{2.5} guideline is preferred by the WHO (WHO, 2005).

The NEPM air quality standards for PM_{2.5} and PM₁₀ relate to total concentrations in the air (from all sources including the project). The background air quality data that has been used in the Technical working paper: Air quality for this project is summarised in Section 5.2 and generally relates to urban air quality in areas located away from major roadways. The background data includes a contribution of PM that is derived from vehicles that utilise the existing road network (but not representative of locations adjacent to main roadways). Use of this background data would result in some double counting of the contribution of vehicle emissions to air quality in the local area, as the project has then modelled emissions from surface roads and added these to the background.

Table 5-20 and Table 5-21 present a summary of the maximum total 24-hour average and annual average concentrations of PM_{2.5} and PM₁₀ relevant to the assessment of emissions in 2027 and 2037, for the project and for the cumulative case.

Table 5-20 Review of total PM concentrations – 24-hour average

Location and scenario	Maximum 24 hour average PM _{2.5} concentration (µg/m ³)			Maximum 24 hour average PM ₁₀ concentration (µg/m ³)		
	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'	'Do minimum'	'Do something'	'Do something cumulative'
2027						
Maximum	37.2	35.1	33.9	71.2	67.1	69.1
Maximum residential	33.8	32.8	31.6	66.3	63.9	63.2
Maximum commercial	37.2	32.3	31.7	71.2	67.0	64.3
2037						
Maximum	36.3	34.2	33.9	70.9	70.0	68.3
Maximum residential	34.0	32.0	31.3	67.2	63.6	63.0
Maximum commercial	36.3	33.1	32.4	68.2	64.6	65.7
Guideline	25 20 by 2025 (goal)			50		

Table 5-21 Review of total PM concentrations – annual average

Location and scenario	Maximum annual average PM _{2.5} concentration (µg/m ³)			Maximum annual average PM ₁₀ concentration (µg/m ³)		
	'Do minimum'	'Do something' (ie with project)	'Do something cumulative'	'Do minimum'	'Do something'	'Do something cumulative'
2027						
Maximum	14.2	11.8	11.9	26.0	23.5	23.5
Maximum residential	11.7	11.0	10.9	22.3	21.3	21.2
Maximum commercial	14.2	11.2	11.3	26.0	22.8	22.4
2037						
Maximum	14.3	11.9	11.9	26.3	24.1	23.4
Maximum residential	11.8	11.2	10.6	22.9	21.6	21.3
Maximum commercial	14.3	11.2	11.1	26.3	22.6	22.9
Guideline	8 7 by 2025 (goal)			25		

Due in large part to the existing levels of PM_{2.5} in air within the existing urban environment, the maximum total/cumulative concentrations of PM_{2.5} are above the guidelines for both a 24-hour average and an annual average (including the 2025 goal). These elevated background levels would be present in the community regardless of the construction and operation of the project. Concentrations of total PM_{2.5}, however, are essentially unchanged to slightly lower in most cases within the local community with the operation of the project along with the operation of all road tunnel projects.

The maximum cumulative concentrations of PM₁₀ presented in the tables above are above the 24-hour average, but not for the annual average guidelines where the project or cumulative scenarios have been considered. The elevated levels of total PM₁₀ is due to the existing levels of PM₁₀ in air within the existing urban environment. These elevated background levels would be present in the community regardless of the construction and operation of the project. Concentrations of total PM₁₀; however, are essentially unchanged in most cases within the local community with operation of the project.

To further address potential risks to human health that may be associated with localised changes (or redistribution) in exposures to PM_{2.5} and PM₁₀ that relate to the project, an assessment of incremental impacts has been carried out and are presented in Section 5.9.5.

5.9.5 Changes in air quality associated with project

Methodology for assessment of PM_{2.5} and PM₁₀

A detailed assessment of potential health effects associated with exposure to changes in air quality as a result of the project has been carried out. As no threshold has been determined for exposure to PM_{2.5} or PM₁₀, the assessment of impacts on health has utilised robust, published, quantitative relationships (exposure-response relationships) that relate a change in PM_{2.5} or PM₁₀ concentration with a change in a health indicator. Annexure A presents an overview of the methodology adopted for using exposure-response relationships for the assessment of health impacts in a community.

This report has presented an assessment of changes in risk associated the predicted changes in air quality, as well as a change in population health impacts (as would be measured by changes in mortality statistics or hospital admissions) related to changes in exposures to particulates in the surrounding community.

For the assessment of changes in PM exposures in the community, the assessment has focused on health effects and exposure-response relationships that are robust and relate to PM_{2.5}, being the more important particulate fraction size relevant for emissions from combustion sources. Assessment of PM₁₀ has also been included.

The specific health effects (or endpoints) evaluated in this assessment have been identified and include the following:

Primary health endpoints:

- Long-term exposure to PM_{2.5} and changes in all-cause mortality (equal or greater than 30 years of age)
- Short-term exposure and changes to the rate of hospitalisations with cardiovascular and respiratory disease (equal or greater than 65 years of age).

Secondary health endpoints (to supplement the primary assessment):

- Short-term exposure to PM₁₀ and changes in all-cause mortality (all ages)
- Long-term exposure to PM_{2.5} and changes in cardiopulmonary mortality (equal or greater than 30 years of age)
- Short-term exposure to PM_{2.5} and changes in cardiovascular and respiratory mortality (all ages)
- Short-term exposure to PM_{2.5} and changes in emergency department admissions for asthma in children aged 1–14 years.

Table 5-22 presents a summary of the health endpoints considered in this assessment, the relevant health impact functions (from the referenced published studies) and the associated β coefficient relevant to the calculation of a relative risk (refer to Annexure A for details on the calculation of a β coefficient from published studies).

The health impact functions presented in this table are considered to be the most current and robust values, and are appropriate for the quantification of potential health effects for the health endpoints considered in this assessment.

Table 5-22 Adopted health impact functions and exposure-responses relationships

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 $\mu\text{g}/\text{m}^3$	Adopted β coefficient (as per cent) for 1 $\mu\text{g}/\text{m}^3$ increase in PM	Reference
Primary assessment health endpoints					
PM _{2.5} : Mortality, all causes	Long term	≥30yrs	1.06 [1.04-1.08]	0.0058 (0.58)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500,000 participants in the US) with adjustment for seven ecologic (neighbourhood level) covariates (Krewski et al. 2009). This study is an extension (additional follow-up and exposure data) of the work carried out by Pope (2002), is consistent with the findings from California (1999–2002) (Ostro et al. 2006) and is more conservative than the relationships identified in a more recent Australian and New Zealand study (EPHC 2010).
PM _{2.5} : Cardiovascular hospital admissions	Short term	≥65yrs	1.008 [1.0059–1.011]	0.0008 (0.08)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 0 (exposure on same day) (strongest effect identified) (Bell, M. L. 2012; Bell, Michelle L. et al. 2008).
PM _{2.5} : Respiratory hospital admissions	Short term	≥65yrs	1.0041 [1.0009–1.0074]	0.00041 (0.041)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 2 (exposure 2 days previous) (strongest effect identified) (Bell, M. L. 2012; Bell, Michelle L. et al. 2008).
Secondary assessment health endpoints					
PM ₁₀ : Mortality, all causes	Short term	All ages*	1.006 [1.004–1.008]	0.0006 (0.06)	Based on analysis of data from European studies from 33 cities and includes panel studies of symptomatic children (asthmatics, chronic respiratory conditions) (Anderson et al. 2004).
PM _{2.5} : Mortality, all causes	Short term	All ages*	1.0094 [1.0065–1.0122]	0.00094 (0.094)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009).

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 $\mu\text{g}/\text{m}^3$	Adopted β coefficient (as per cent) for 1 $\mu\text{g}/\text{m}^3$ increase in PM	Reference
PM _{2.5} : Cardio-pulmonary mortality	Long term	≥ 30 yrs	1.14 [1.11–1.17]	0.013 (1.3)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500,000 participants in the US) with adjustment for seven ecologic (neighbourhood level) covariates (Krewski et al. 2009).
PM _{2.5} : Cardiovascular mortality	Short term	All ages*	1.0097 [1.0051–1.0143]	0.00097 (0.097)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009).
PM _{2.5} : Asthma (emergency department admissions)	Short term	1–14 years	–	0.00148 (0.148)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Jalaludin et al. 2008).
PM _{2.5} : Respiratory mortality (including lung cancer)	Short term	All ages*	1.0192 [1.0108–1.0278]	0.0019 (0.19)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009).

Note: * Relationships established for all ages, including young children and the elderly

The assessment of health impacts for a population associated with exposure to PM has been carried out utilising the methodology presented by the WHO (Ostro, 2004) (also outlined in Annexure A) where the exposure-response relationships (presented in Table 5-22) have been directly considered.

A change in relative risk has then been calculated on the basis of the following:

- Estimates of the changes in PM_{2.5} and PM₁₀ exposure levels due to the project in 2027 and 2037 (as provided in the Technical working paper: Air quality) for the scenarios assessed with the project, the cumulative impacts from all road tunnel projects at each of the community receptors (see Figure 3-2) as well as the maximum off-site residential and workplace receptors from the RWR receptors
- Baseline incidence of the key health endpoints that are relevant to the population exposed (see Table 3-5)
- Exposure-response relationships expressed as a percentage change in health endpoint per µg/m³ change in particulate matter exposure (see Table 5-22).

The change in incidence of each health indicator relevant to changes in PM_{2.5} exposures in the local community (for the population exposed) has been calculated on the basis of the following:

- The relative risk has been calculated for a population weighted annual average incremental increase in PM_{2.5} concentrations (using the approach outlined above) based on the smallest statistical division provided by the ABS within a suburb (ie mesh blocks – which are small blocks that cover an area of about 30 urban residences). For each mesh block in a suburb, the average change in PM_{2.5} concentration has been calculated and multiplied by the population living in the mesh block (data available from the ABS for the 2016 census year). The weighted average has been calculated by summing these calculations for each mesh block in a suburb and dividing by the total population in the suburb (ie in all the mesh block)
- A change in the number of cases associated with the change in PM_{2.5} impact evaluated in the population within the study area has been calculated (refer to Annexure A for details on the methodology). The calculation is carried out utilising the baseline incidence data relevant for the endpoint considered (see Table 3-5) and the population (for the relevant age groups) present in the suburb (see Table 3-3).

Methodology for assessing exposure to diesel particulate matter

In addition to the above exposure-response relationships, potential exposure to diesel particulate matter (DPM) derived from the project has been evaluated.

Diesel exhaust is emitted from 'on-road' diesel engines (vehicle engines) and can be formed from the gaseous compounds emitted by diesel engines (secondary particulate matter). After emission from the exhaust pipe, diesel exhaust undergoes dilution and chemical and physical transformations in the atmosphere, as well as dispersion and transport in the atmosphere. The atmospheric lifetime for some compounds present in diesel exhaust ranges from hours to days.

Available evidence indicates that there are human health hazards associated with exposure to DPM. The hazards include acute exposure-related symptoms, chronic exposure related non-cancer respiratory effects, and lung cancer. The non-cancer health effects associated with exposure to DPM are adequately addressed on the basis of the current PM_{2.5} and PM₁₀ guidelines. However, the potential for exposure to DPM resulting in an increased risk of lung cancer in the community requires further consideration. Annexure B presents the methodology adopted for the assessment of lung cancer risks associated with exposure to DPM. In summary, the following has been assumed/carried out:

- It has been conservatively assumed that 100 per cent of PM_{2.5} predicted in the local community is derived from diesel vehicles and comprises DPM
- An incremental lifetime risk of lung cancer has been calculated (refer to Annexure B for methodology) on the basis of the inhalation toxicity value available from the WHO (1996).

Acceptability of health impacts

Based on the methodology outlined above, potential health impacts associated with the project have been assessed on the basis of two calculations:

- Calculation of an annual risk for each health endpoint. This is a change in risk that differs from the baseline risk (or incidence) of the effect occurring for any member of the population, where exposed to the change in PM concentration estimated
- Calculation of a change in incidence of the health effect occurring within the population exposed. This calculates the change in the number of cases (mortality or hospitalisations) that may occur for the population assumed to be exposed to the changes in PM concentration estimated.

A number of factors need to be considered to determine if the calculated annual risk or change in incidence within a population associated with PM impacts from the project may be considered to be acceptable. These are discussed further in Annexure C.

It is noted that the change in risk and health incidence calculated in this assessment includes negative values (where there is a lower risk and incidence of health effects in the community with the operation of the project) and positive values (where there is an increase in risk and health incidence in the community with the operation of the project).

Any negative values are related to improved health impacts in the community and are considered acceptable. The following discussion relates to the evaluation of positive values.

Risk:

While it is not possible to provide a rigid definition of acceptable risk due to the complex and context-driven nature of the challenge, it is possible to propose some general guidelines as to what might be an acceptable risk for specific development projects.

If a level of less than 10^{-6} (one chance in a million) were retained as a level of increased risk that would be considered as a negligible risk in the community, then the level of risk that could be considered to be tolerable would lie between this level and an upper level that is considered to be unacceptable.

While there is no guidance available on what level of risk is considered to be unacceptable in the community, a level in excess of 10^{-4} for increased risk (one chance in 10,000) has been generally adopted by health authorities as a point where risk is considered to be unacceptable. This level has been adopted in the development of drinking water guidelines (that impact on whole populations) (for exposure to carcinogens as well as for annual risks of disease (Fewtrell & Bartram, 2001)) and in the evaluation of exposures from pollutants in air (NSW DEC, 2005).

Between an increased risk level considered negligible (less than 10^{-6}) and unacceptable (greater than 10^{-4}) lie risks that may be considered to be tolerable or even acceptable. Tolerable risks are those that can be tolerated (and where the best available, and most appropriate, technology has been implemented to minimise exposure) to realise some wider community benefit.

In a societal context, risks are inevitable and any new development would be accompanied by risks which are not amenable or economically feasible to reduce below a certain level. It is not good policy to impose an arbitrary risk level to such developments without consideration of the many factors that should be considered to determine what is 'tolerable' or 'acceptable'.

For this project, the calculated risks have been considered to be tolerable when in the range of greater than or equal to 10^{-6} and less than or equal to 10^{-4} of increased risk and where the increased incidence of the health impacts are considered to be insignificant.

Population incidence:

The assessment of changes in incidence of particular health indicators in the community results in the calculation of a change in the number of cases (of mortality, hospital or emergency department admissions) within the population evaluated.

As discussed in Annexure C, where changes in air quality associated with this project are well below 10 cases per year, they are considered to be within the normal variability of health statistics, and these changes would not be measurable in any health statistics for the area. For evaluating impacts from this project, a more conservative tenfold margin of safety has been included to determine what changes in incidence may be considered negligible within the study population.

This means that changes in the population incidence of any health effect evaluated that is less than one case per year are considered negligible.

Calculated risks and population incidence for operation of the project

Review of the changes in PM concentrations predicted in 2027 and 2037 indicates that for a number of receptors in the local community, the project results in a decrease in the concentration of PM_{2.5} and PM₁₀. For a number of receptors there is an increase in the concentration of PM_{2.5} and PM₁₀, which relates to the redistribution of emissions on surface roads in the study area, not from emissions but from the ventilation facilities (as discussed in the Technical working paper: Air quality). This is illustrated on Figure 5-6, which presents a contour plot of the change in annual average PM_{2.5} concentrations associated with the project in the cumulative scenario in the assessment year 2037. For a number of areas, the change is negative (ie a decrease in PM_{2.5} concentrations due to the project); however, for some areas adjacent to roadways in the Western Harbour Tunnel and Beaches Link program of works corridor (eg City West Link in Rozelle, Gore Hill Freeway in Cammeray and Artarmon, Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway) the change is positive (ie an increase in PM_{2.5} concentrations due to the project).

Based on the methodology outlined above, Table 5-23 and Table 5-24 present the calculated individual risk associated with changes in PM_{2.5} and PM₁₀ concentrations at the maximum impacted residential, childcare, schools, aged care, hospital, commercial/industrial and open space areas as well as the maximum impacted community receptor, for the operational years 2027 and 2037. The changes in PM_{2.5} and PM₁₀ concentration considered in the risk calculations are also included in the tables.

The calculated change in risk at the maximum receptors represents the worst case impact associated with the project. Risks for all other receptors would be lower than calculated for the maximum receptors.

Figure 5-7 shows the calculated risks for each of the community receptors, associated with the primary health endpoints evaluated in this assessment for the project's operations in 2027 and 2037.

All calculated individual risks are presented in Annexure F.

Table 5-25 and Table 5-26 present a summary of the calculated change in incidence of the relevant health effects for the population living in the LGAs within the study area, associated with changes in PM_{2.5} concentrations for 2027 and 2037. All calculations relevant to the LGAs, including calculation for each individual suburb considered in the LGAs, are presented in Annexure G.

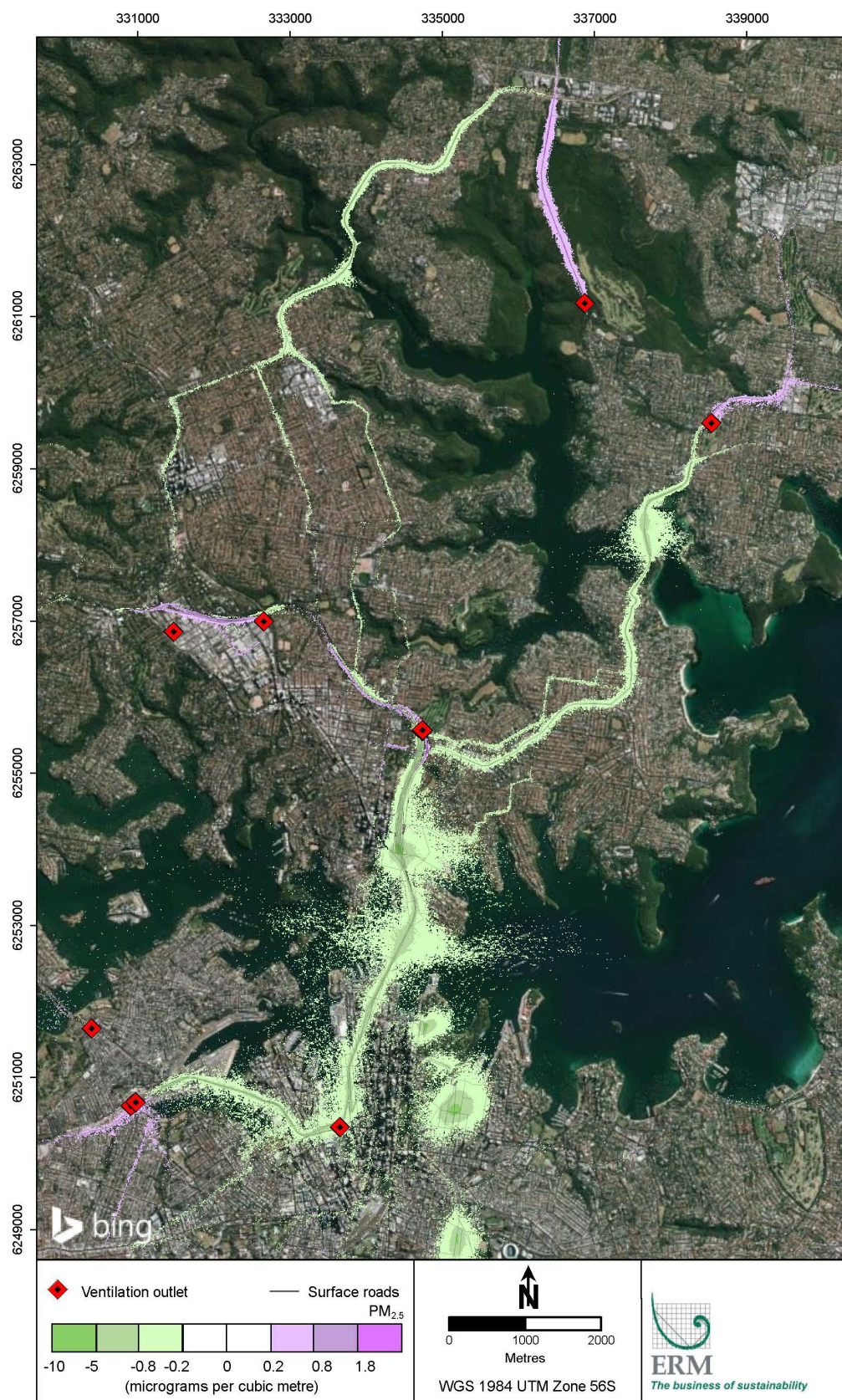


Figure 5-6 Contour plot showing change in annual average PM_{2.5} concentrations associated with the project in the 'Do something cumulative 2037' scenario

Table 5-23 **Calculated individual risk associated with changes in PM_{2.5} and PM₁₀ concentrations – project operations in 2027**

Receptor	Change in annual average concentration (µg/m³)		Calculated risks for health endpoints									
			PM _{2.5} : Mortality, all causes	PM _{2.5} : Cardiovascular hospitalisations	PM _{2.5} : Respiratory hospitalisations	PM ₁₀ : Mortality, all causes	PM _{2.5} : Mortality, all causes	PM _{2.5} : Mortality, cardiopulmonary	PM _{2.5} : Mortality, cardiovascular	PM _{2.5} : Mortality, respiratory	PM _{2.5} : Asthma emergency department hospitalisations	Diesel Particulate Matter Lung cancer
			PM ₁₀	PM _{2.5}	Long-term ≥30 yrs	Short-term ≥65 yrs	Short-term ≥65 yrs	Short-term all	Short-term all	Long-term ≥30 yrs	Short-term all	Short-term all
‘Do something 2027’ (ie with project)												
Maximum residential	1.01	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05	2E-05
Maximum childcare	0.30	0.16	9E-06	1E-05	3E-06	8E-07	6E-07	8E-06	2E-07	9E-08	3E-06	5E-06
Maximum schools	0.17	0.19	1E-05	1E-05	3E-06	4E-07	8E-07	1E-05	2E-07	1E-07	3E-06	6E-06
Maximum aged care	0.36	0.10	6E-06	7E-06	2E-06	9E-07	4E-07	5E-06	1E-07	6E-08	2E-06	3E-06
Maximum hospital	0.16	0.14	8E-06	1E-05	2E-06	4E-07	6E-07	7E-06	2E-07	9E-08	3E-06	5E-06
Maximum commercial/ industrial	0.46	0.31	2E-05	2E-05	5E-06	1E-06	1E-06	2E-05	4E-07	2E-07	6E-06	1E-05
Maximum open space	0.43	0.20	1E-05	1E-05	3E-06	1E-06	8E-07	1E-05	3E-07	1E-07	4E-06	7E-06
Maximum community receptors	0.34	0.13	8E-06	1E-05	2E-06	9E-07	5E-07	7E-06	2E-07	8E-08	2E-06	5E-06
‘Do something cumulative 2027’												
Maximum residential	0.61	0.51	3E-05	4E-05	8E-06	2E-06	2E-06	3E-05	7E-07	3E-07	9E-06	2E-05
Maximum childcare	0.25	0.27	2E-05	2E-05	4E-06	6E-07	1E-06	1E-05	3E-07	2E-07	5E-06	9E-06
Maximum schools	0.35	0.33	2E-05	2E-05	5E-06	9E-07	1E-06	2E-05	4E-07	2E-07	6E-06	1E-05
Maximum aged care	0.29	0.13	8E-06	1E-05	2E-06	7E-07	5E-07	7E-06	2E-07	8E-08	2E-06	4E-06
Maximum hospital	0.19	0.21	1E-05	2E-05	3E-06	5E-07	8E-07	1E-05	3E-07	1E-07	4E-06	7E-06

Receptor	Change in annual average concentration ($\mu\text{g}/\text{m}^3$)		Calculated risks for health endpoints									
			PM _{2.5} : Mortality, all causes	PM _{2.5} : Cardiovascular hospitalisations	PM _{2.5} : Respiratory hospitalisations	PM ₁₀ : Mortality, all causes	PM _{2.5} : Mortality, all causes	PM _{2.5} : Mortality, cardiopulmonary	PM _{2.5} : Mortality, cardiovascular	PM _{2.5} : Mortality, respiratory	PM _{2.5} : Asthma emergency department hospitalisations	Diesel Particulate Matter Lung cancer
			Long-term ≥30 yrs	Short-term ≥65 yrs	Short-term ≥65 yrs	Short-term all	Short-term all	Long-term ≥30 yrs	Short-term all	Short-term all	Short-term 1–14 yrs	Long-term all
Maximum commercial/ industrial	0.61	0.40	2E-05	3E-05	7E-06	2E-06	2E-06	2E-05	5E-07	2E-07	7E-06	1E-05
Maximum open space	0.46	0.28	2E-05	2E-05	5E-06	1E-06	1E-06	1E-05	4E-07	2E-07	5E-06	1E-05
Maximum community receptors	0.29	0.15	9E-06	1E-05	2E-06	7E-07	6E-07	8E-06	2E-07	9E-08	3E-06	5E-06
Negligible risks			<1 x 10 ⁻⁶									
Tolerable/acceptable risks			≥1 x 10 ⁻⁶ and ≤1 x 10 ⁻⁴									
Unacceptable risks			>1 x 10 ⁻⁴									

Table 5-24 **Calculated individual risk associated with changes in PM_{2.5} and PM₁₀ concentrations – project operations in 2037**

Receptor	Change in annual average concentration (µg/m ³)		Calculated risks for health endpoints									
			PM _{2.5} : Mortality, all causes	PM _{2.5} : Cardiovascular hospitalisations	PM _{2.5} : Respiratory hospitalisations	PM ₁₀ : Mortality, all causes	PM _{2.5} : Mortality, all causes	PM _{2.5} : Mortality, cardiopulmonary	PM _{2.5} : Mortality, cardiovascular	PM _{2.5} : Mortality, respiratory	PM _{2.5} : Asthma emergency department hospitalisations	Diesel Particulate Matter Lung cancer
	PM ₁₀	PM _{2.5}	long-term ≥30 yrs	short-term ≥65 yrs	short-term ≥65 yrs	short-term all	short-term all	long-term ≥30 yrs	short-term all	short-term all	short-term 1–14 yrs	long-term all
'Do something 2037' (ie with project)												
Maximum residential	1.34	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05	2E-05
Maximum childcare	0.29	0.22	1E-05	2E-05	4E-06	7E-07	9E-07	1E-05	3E-07	1E-07	4E-06	7E-06
Maximum schools	0.29	0.15	9E-06	1E-05	2E-06	7E-07	6E-07	8E-06	2E-07	9E-08	3E-06	5E-06
Maximum aged care	0.11	0.10	6E-06	7E-06	2E-06	3E-07	4E-07	5E-06	1E-07	6E-08	2E-06	3E-06
Maximum hospital	0.21	0.11	7E-06	8E-06	2E-06	5E-07	4E-07	6E-06	1E-07	7E-08	2E-06	4E-06
Maximum commercial/ industrial	0.47	0.35	2E-05	3E-05	6E-06	1E-06	1E-06	2E-05	4E-07	2E-07	6E-06	1E-05
Maximum open space	0.51	0.24	1E-05	2E-05	4E-06	1E-06	1E-06	1E-05	3E-07	1E-07	4E-06	8E-06
Maximum community receptors	0.45	0.19	1E-05	1E-05	3E-06	1E-06	8E-07	1E-05	2E-07	1E-07	3E-06	6E-06
'Do something cumulative 2037'												
Maximum residential	1.11	0.57	3E-05	4E-05	9E-06	3E-06	2E-06	3E-05	7E-07	3E-07	1E-05	2E-05
Maximum childcare	0.25	0.13	7E-06	9E-06	2E-06	6E-07	5E-07	7E-06	2E-07	8E-08	2E-06	4E-06
Maximum schools	0.31	0.43	3E-05	3E-05	7E-06	8E-07	2E-06	2E-05	6E-07	3E-07	8E-06	1E-05
Maximum aged care	0.12	0.10	6E-06	7E-06	2E-06	3E-07	4E-07	5E-06	1E-07	6E-08	2E-06	3E-06
Maximum hospital	0.31	0.19	1E-05	1E-05	3E-06	8E-07	7E-07	1E-05	2E-07	1E-07	3E-06	6E-06

Receptor	Change in annual average concentration ($\mu\text{g}/\text{m}^3$)		Calculated risks for health endpoints									
			PM _{2.5} : Mortality, all causes	PM _{2.5} : Cardiovascular hospitalisations	PM _{2.5} : Respiratory hospitalisations	PM ₁₀ : Mortality, all causes	PM _{2.5} : Mortality, all causes	PM _{2.5} : Mortality, cardiopulmonary	PM _{2.5} : Mortality, cardiovascular	PM _{2.5} : Mortality, respiratory	PM _{2.5} : Asthma emergency department hospitalisations	Diesel Particulate Matter Lung cancer
	PM ₁₀	PM _{2.5}	long-term ≥30 yrs	short-term ≥65 yrs	short-term ≥65 yrs	short-term all	short-term all	long-term ≥30 yrs	short-term all	short-term all	short-term 1–14 yrs	long-term all
Maximum commercial/ industrial	0.83	0.47	3E-05	3E-05	8E-06	2E-06	2E-06	3E-05	6E-07	3E-07	8E-06	2E-05
Maximum open space	0.60	0.29	2E-05	2E-05	5E-06	2E-06	1E-06	2E-05	4E-07	2E-07	5E-06	1E-05
Maximum community receptors	0.30	0.18	1E-05	1E-05	3E-06	8E-07	7E-07	1E-05	2E-07	1E-07	3E-06	6E-06
Negligible risks			<1 x 10 ⁻⁶									
Tolerable/acceptable risks			≥1 x 10 ⁻⁶ and ≤1 x 10 ⁻⁴									
Unacceptable risks			>1 x 10 ⁻⁴									

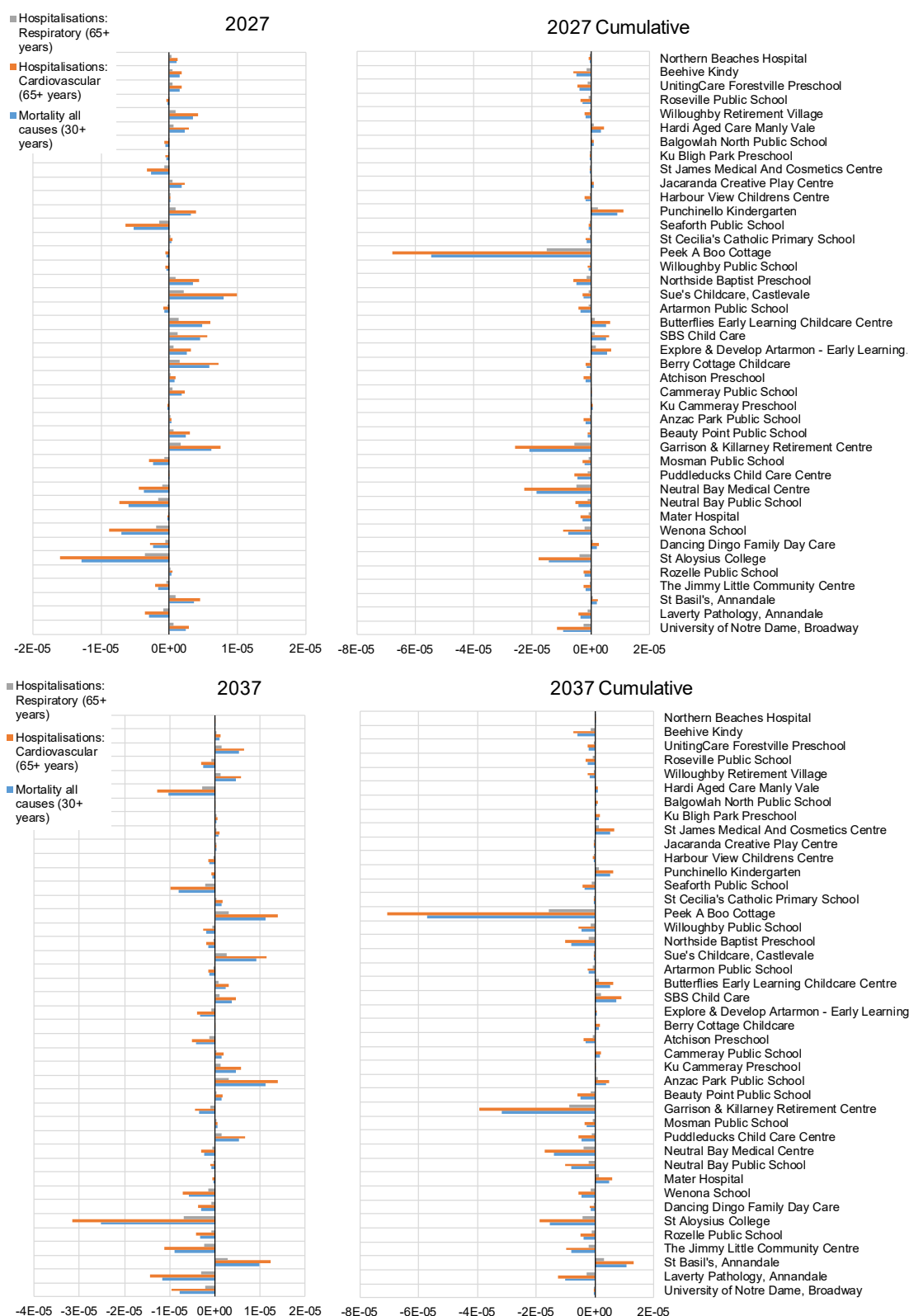


Figure 5-7 Calculated change in individual risk at community receptors from change in PM_{2.5} concentrations (primary health endpoints) – project in ‘Do-something 2027’ scenario and ‘Do-something cumulative 2037’ scenario.


Table 5-25 **Calculated changes in incidence of health effects in population associated with changes in PM_{2.5} concentrations – project in 2027**

LGA	Change in population incidence – number of cases							
	Primary indicators			Secondary indicators				
	Mortality – All Causes	Hospitalisations – Cardiovascular	Hospitalisations – Respiratory	Mortality – All causes	Mortality – Cardiopulmonary	Mortality – Cardiovascular	Mortality – Respiratory	Morbidity – Asthma ED admissions
	≥30 years	≥65 years	≥65 years	All ages	≥30 years	All ages	All ages	1–14 years
‘Do something 2027’ (ie with project)								
Canada Bay	0.00074	0.00022	0.000047	0.000075	0.00067	0.000022	0.000019	0.000053
North Sydney - Mosman	-0.10	-0.037	-0.0082	-0.0083	-0.094	-0.0025	-0.0025	-0.0078
Sydney Inner West	0.017	0.0040	0.00089	0.0022	0.015	0.00064	0.00042	0.0011
Sydney	-0.041	-0.0072	-0.0016	-0.0057	-0.037	-0.0016	-0.0011	-0.0013
Lane Cove - Chatswood	0.0076	0.0021	0.00046	0.00077	0.0068	0.00022	0.00019	0.00063
Hunters Hill	0.00077	0.00032	0.000071	0.000095	0.00069	0.000026	0.000019	0.000065
Woollahra (Eastern Suburbs - North)	-0.020	-0.0070	-0.0016	-0.0019	-0.018	-0.00055	-0.00048	-0.0013
Northern Beaches	0.0030	0.00099	0.00022	0.00035	0.0027	0.000098	0.000075	0.00026
Ku-ring-gai	-0.00019	-0.000068	-0.000015	-0.000017	-0.00017	-0.0000053	-0.0000048	-0.000018
Total for all LGAs	-0.14	-0.044	-0.010	-0.012	-0.12	-0.0037	-0.0033	-0.0083
‘Do something cumulative 2027’								
Canada Bay	0.0056	0.0016	0.00036	0.00057	0.0050	0.00016	0.00014	0.00040
North Sydney - Mosman	-0.016	-0.0057	-0.0012	-0.0013	-0.014	-0.00038	-0.00038	-0.0012
Sydney Inner West	0.14	0.033	0.0073	0.018	0.13	0.0052	0.0034	0.0092
Sydney	-0.33	-0.058	-0.013	-0.046	-0.30	-0.013	-0.0091	-0.010
Lane Cove - Chatswood	0.054	0.015	0.0033	0.0055	0.049	0.0016	0.0014	0.0045
Hunters Hill	0.0044	0.0018	0.00040	0.00054	0.0039	0.00015	0.00011	0.00037
Woollahra (Eastern Suburbs - North)	0.040	0.014	0.0031	0.0038	0.036	0.0011	0.00095	0.0026
Northern Beaches	0.11	0.035	0.0076	0.012	0.096	0.0034	0.0026	0.0093
Ku-ring-gai	0.000051	0.000019	0.0000041	0.0000047	0.000046	0.0000014	0.0000013	0.0000048
Total for all LGAs	0.0027	0.036	0.0079	-0.0064	0.0023	-0.0017	-0.00081	0.015

 Negative value indicates that there is a decrease in incidence associated with the project (ie a potential health benefit)

Table 5-26 **Calculated changes in incidence of health effects in population associated with changes in PM_{2.5} concentrations – project in 2037**

LGA	Change in population incidence – number of cases							
	Primary Indicators			Secondary Indicators				
	Mortality – All Causes	Hospitalisations – Cardiovascular	Hospitalisations – Respiratory	Mortality – All causes	Mortality – Cardiopulmonary	Mortality – Cardiovascular	Mortality – Respiratory	Morbidity – Asthma ED Admissions
	≥30 years	≥65 years	≥65 years	All ages	≥30 years	All ages	All ages	1–14 years
‘Do something 2037’ (ie with project)								
Canada Bay	0.00090	0.00026	0.000058	0.000091	0.00081	0.000026	0.000023	0.000064
North Sydney - Mosman	-0.11	-0.041	-0.0090	-0.0091	-0.10	-0.0028	-0.0027	-0.0085
Sydney Inner West	0.016	0.0038	0.00084	0.0021	0.014	0.00060	0.00039	0.0011
Sydney	-0.22	-0.040	-0.0087	-0.031	-0.20	-0.0088	-0.0061	-0.0069
Lane Cove - Chatswood	0.032	0.0088	0.0019	0.0033	0.029	0.00096	0.00082	0.0027
Hunters Hill	-0.000098	-0.000041	-0.0000090	-0.000012	-0.000088	-0.0000033	-0.0000024	-0.0000083
Woollahra (Eastern Suburbs - North)	-0.0029	-0.0010	-0.00023	-0.00028	-0.0026	-0.000080	-0.000070	-0.00019
Northern Beaches	-0.0062	-0.0020	-0.00045	-0.00071	-0.0056	-0.00020	-0.00015	-0.00054
Ku-ring-gai	-0.0043	-0.0016	-0.00035	-0.00040	-0.0039	-0.00012	-0.00011	-0.00041
Total for all LGAs	-0.30	-0.072	-0.016	-0.036	-0.27	-0.010	-0.0079	-0.013
‘Do something cumulative 2037’								
Canada Bay	-0.0011	-0.00033	-0.000073	-0.00012	-0.0010	-0.000034	-0.000029	-0.000082
North Sydney - Mosman	-0.36	-0.13	-0.028	-0.028	-0.32	-0.0086	-0.0084	-0.027
Sydney Inner West	0.012	0.0029	0.00064	0.0016	0.011	0.00045	0.00030	0.00081
Sydney	-0.60	-0.11	-0.023	-0.084	-0.54	-0.024	-0.016	-0.019
Lane Cove - Chatswood	-0.069	-0.019	-0.0042	-0.0070	-0.062	-0.0020	-0.0017	-0.0057
Hunters Hill	-0.00066	-0.00027	-0.000061	-0.000081	-0.00059	-0.000022	-0.000016	-0.000056
Woollahra (Eastern Suburbs - North)	-0.039	-0.014	-0.0031	-0.0038	-0.035	-0.0011	-0.00095	-0.0026
Northern Beaches	-0.0078	-0.0025	-0.00056	-0.00088	-0.0070	-0.00025	-0.00019	-0.00068
Ku-ring-gai	-0.016	-0.0056	-0.0012	-0.0014	-0.014	-0.00044	-0.00039	-0.0015
Total for all LGAs	-1.1	-0.27	-0.060	-0.12	-0.97	-0.036	-0.028	-0.055

 Negative value indicates that there is a decrease in incidence associated with the project (ie a potential health benefit)

Review of the calculated changes in risk indicates the following in relation to impacts associated with the expected operation of the project in 2027 and 2037, including the cumulative scenario:

- The maximum risks calculated for exposures in residential areas are less than 1×10^{-4} and considered to be tolerable/acceptable
- The maximum risks calculated for exposures in commercial/industrial areas are less than 1×10^{-4} and considered to be tolerable/acceptable
- All maximum risks calculated for continuous exposures in childcare centres, schools, aged care homes and open space areas are below 1×10^{-4} and considered to be tolerable/ acceptable.

Review of the calculated impacts in terms of the change in incidence of the relevant health effects for PM_{2.5} in the community, indicates the following:

- The total change in the number of cases relevant to the health effects evaluated, for both 2027 and 2037 including the cumulative scenarios are mostly negative, meaning an overall decrease in incidence as a result of the project. The exception is a number of health endpoints for the 'Do something 2027' scenario where the incidence generally sits close to zero with some minor positive and some minor negative values. The number of cases for all scenarios, however is very small, less than one for all health effects considered. As a result, these changes would not be measurable within the community
- For 2037 scenarios, more than half of the individual LGAs show a total decrease in health incidence. There are a few LGAs where there is an increase. For 2027 scenarios there are more suburbs with increases in health incidence. These increases and decreases are very small, being less than one for all health effects considered within each individual LGA. As a result, these changes would not be measurable in the community
- The incidence calculations presented in Table 5-25 and Table 5-26 are the totals for each LGA. Within these LGAs are a number of smaller suburbs. The calculated change in incidence relevant to each of these suburbs has also been evaluated, as presented in Annexure G. Review of the incidence calculated for the individual suburbs indicates that these predominantly relate to small decreases in health incidence with some suburbs showing an increase. The largest increase in health incidence for any individual suburb is less than one case, so there are no individual suburbs within the LGAs where there is a change incidence that is of significance or would be measurable.

Elevated receptors

The calculations presented in the above relate to inhalation exposures that may occur at ground level (ie within typical low to medium density residential homes and commercial/industrial properties).

The Technical working paper: Air quality has conducted a screening assessment of potential issues related to exposures that may occur at elevated receptors to identify areas that may need to have more detailed analysis, and where future development controls may be required for high-rise buildings, in particular close to the ventilation outlets. This has been carried out on the basis of evaluating predicted concentrations of PM_{2.5} at 10 metres, 20 metres, 30 metres and 45 metres above the ground level, representative of potential exposures that may occur in multi-storey buildings. The review carried out by ERM (2020) indicates that more than 90 per cent of the buildings have a height of less than 10 metres, with less than 0.5 per cent having a height of 40 metres or more. The assessment has evaluated impacts at 10 metres, 20 metres, 30 metres and 45 metres across the whole study area at all receptor locations, regardless of whether a multi-storey building is present or not at those heights. A further assessment was also completed at receptor locations where existing buildings do occur at the assessed heights.

Impacts that are derived from changes in emissions from surface roads are expected to decrease with height above the roadway; however, in areas closest to the ventilation outlets, there is the potential for increased impacts with height. The assessment of potential impacts relevant to elevated receptors has focused on the worst case scenario, the year 2037 where cumulative impacts from the Western Harbour Tunnel and Beaches Link program of works, Sydney Gateway, F6 Extension and WestConnex projects are included. The maximum change in annual average PM_{2.5} relevant to this scenario has been evaluated. As the approach adopted in the Technical working paper: Air quality is a screening level assessment no other pollutants have been evaluated.

Table 5-27 presents the calculated risks associated with the maximum predicted change in PM_{2.5} concentrations at a height of 10 metres, 20 metres, 30 metres and 45 metres above ground level throughout the study area (ie at all receptor locations). These maximum impacts do not relate to existing multi-storey buildings, rather these are the maximum impacts anywhere in the study area and have been included to evaluate potential future receptor locations. It is noted that there are no restrictions to building heights within 300 metres of the Rozelle Interchange outlet. Within 300 metres of the Warringah Freeway outlet, current planning controls for permissible habitable structures restrict buildings to below 20 metres.

Table 5-27 Calculated individual risk associated with changes in PM_{2.5} concentrations – ‘Do something cumulative 2037’ scenario for elevated receptors

Health endpoint	Maximum calculated			
	10 m height	20 m height	30 m height	45 m height
Annual average concentration				
PM _{2.5} (µg/m ³)	0.37	0.24	0.48	2.06
Primary health indicators: PM _{2.5}				
Mortality all causes (long term effects, ages 30+)	2 x 10 ⁻⁵	1 x 10 ⁻⁵	3 x 10 ⁻⁵	1 x 10 ⁻⁴
Cardiovascular hospitalisations (short term effects, ages 65+)	3 x 10 ⁻⁵	2 x 10 ⁻⁵	4 x 10 ⁻⁵	2 x 10 ⁻⁴
Respiratory hospitalisations (short term effects, ages 65+)	6 x 10 ⁻⁶	4 x 10 ⁻⁶	8 x 10 ⁻⁶	3 x 10 ⁻⁵
Secondary health indicators: PM _{2.5}				
Mortality all causes (short term effects, all ages)	1 x 10 ⁻⁶	2 x 10 ⁻⁶	2 x 10 ⁻⁶	8 x 10 ⁻⁶
Mortality, cardiopulmonary (long term effects, ages 30+)	2 x 10 ⁻⁵	1 x 10 ⁻⁵	3 x 10 ⁻⁵	1 x 10 ⁻⁴
Mortality, cardiovascular (short term effects, all ages)	5 x 10 ⁻⁷	3 x 10 ⁻⁷	6 x 10 ⁻⁷	3 x 10 ⁻⁶
Mortality, respiratory (short term effects, all ages)	2 x 10 ⁻⁷	1 x 10 ⁻⁷	3 x 10 ⁻⁷	1 x 10 ⁻⁶
Asthma emergency department hospitalisations (1–14 years)	7 x 10 ⁻⁶	4 x 10 ⁻⁶	9 x 10 ⁻⁶	4 x 10 ⁻⁵
Negligible risks	<1 x 10 ⁻⁶			
Tolerable/acceptable risks	≥1 x 10 ⁻⁶ and ≤1 x 10 ⁻⁴			
Unacceptable risks	>1 x 10 ⁻⁴			

Note: Shaded cells indicate calculated risks that are considered unacceptable

For elevated receptors at 10 metres, 20 metres and 30 metres height, the calculated risks range from negligible to tolerable/acceptable. It is noted that the maximum increases predicted in Table 5-27 are not in areas where elevated receptors are currently present. Review of the existing buildings indicates that the maximum increase in PM_{2.5} for existing elevated receptors within this height range is 0.18 µg/m³, where the maximum individual risk is 1 x 10⁻⁵.

For elevated receptors at 45 metres height, the maximum increase in PM_{2.5} and individual risks are higher, with the maximum individual risk exceeding 1 x 10⁻⁴, which is considered unacceptable. These maximum increases in PM_{2.5} and individual risks are at locations close to the ventilation outlets, where there are no buildings of that height present. However, the maximum predicted increase in PM_{2.5} at an existing building that is approximately 45 metres in height is 0.05 µg/m³, where the maximum individual risk is 4 x 10⁻⁶, significantly lower than presented in Table 5-27.

On this basis, potential risks associated with existing exposures to PM_{2.5} at elevated receptors is considered to be tolerable/acceptable; however, the following should be noted:

- For potential future buildings that are up to 30 metres in height that may be constructed near ventilation outlets, potential risks associated with exposure to PM_{2.5} are considered tolerable/acceptable
- For potential future buildings that are proposed to be constructed with heights over 30 metres, and within 300 metres of the ventilation outlets, planning controls (that include a more detailed assessment of pollutants) should be developed. However, this would not necessarily preclude such development. Further consideration at rezoning or development application stage would be required

- The Technical working paper: Air quality has identified that land use considerations would be required to manage the interaction between the project and future development for buildings with habitable structures about 20 metres and within 300 metres of the ventilation outlets
- Roads and Maritime would assist Inner West Council, North Sydney Council and the DPIE (as appropriate) in determining relevant land use considerations applicable to future development in the immediate vicinity of ventilation outlets for inclusion in Local Environmental Plans or Development Control Plans, where required, to manage interactions between the project and future development. This may include procedures for identifying the requirement for consultation with Roads and Maritime for proposed rezoning or development applications.

5.10 Assessment of regulatory worst-case scenario.

A regulatory worst case scenario has been evaluated in the Technical working paper: Air quality. This is based on the situation where emissions to air from the tunnel ventilation outlets occur at the maximum discharge limits at all hours of the day. This may occur in the event of a breakdown or accident and may result in a short period of time where emissions from the tunnel ventilation facility are higher than during normal operations. Such situations are not planned and where they occur, the duration of the event is not expected to last for longer than a few hours.

The assumptions underpinning the all regulatory worst case scenarios were conservative and resulted in contributions from project ventilation outlets that were much higher than those that could ever occur under any operational conditions in the tunnel.

A worst case situation for impacts on health results in short-term changes in air quality. Health effects identified and evaluated in this assessment that relate to changes in short-term concentrations of PM_{2.5} require further assessment. The assessment of short-term health impacts has utilised the methodology outlined in Annexure A with the parameters selected to be relevant to a 1-hour or 24-hour exposure period (as relevant to each pollutant). The assessment has considered short-term change in air concentrations associated with maximum emissions from the ventilation outlets from the project tunnels in the 'Do something cumulative 2037' scenario.

Risk calculations can be carried out for the short-term change in air quality associated with each of these scenarios. How often these events occur during any one year may result in some contribution to the total annual individual risk calculated for the expected operation of the project. The frequency of a worst case traffic scenario occurring is not known, so for the purpose of this assessment, some conservative assumptions have been adopted.

Table 5-28 presents the calculated change in individual risk associated with residential exposure to worst-case emissions of PM_{2.5}. The table includes the assumptions adopted for the assessment.

Review of the maximum calculated changes in risk associated with short-term changes in PM_{2.5} (Table 5-28) concentration under the worst case scenarios evaluated indicates:

- The maximum change in short-term risk associated with worst case scenarios occurring on any one day is negligible
- Where it is conservatively assumed that the worst case scenario occurs one day each week for a year (and the maximum changes impact occurs at the same receptor location every time), the maximum individual risk increases
- The total maximum individual risk increases to, but does not exceed 1×10^{-4} and there are no unacceptable risks identified in the community surrounding the project
- The calculated maximum individual risks are in the range 1×10^{-6} to 1×10^{-4} and are considered to range from negligible to tolerable/acceptable.

On the basis of the above, emissions from the ventilation outlets during a worst case scenario (such as a breakdown or accident) has the potential to increase individual risks; however, the maximum individual risks (even where conservative assumptions are adopted) are considered to be tolerable/acceptable.

Table 5-28 Maximum calculated risks associated with short-term residential exposure changes in PM_{2.5} concentrations: regulatory worst case 'Do something cumulative 2037' scenario

Scenario	Maximum change in individual risk for the following short-term health endpoints					
	Cardiovascular hospitalisations (65 years+)	Respiratory hospitalisations (65 years+)	Mortality all causes (all ages)	Mortality cardiovascular (all ages)	Mortality respiratory (all ages)	Asthma ED admissions (1–14 years)
The project						
Maximum annual risk – expected operations	4 x 10 ⁻⁵	9 x 10 ⁻⁶	3 x 10 ⁻⁶	7 x 10 ⁻⁷	3 x 10 ⁻⁷	1 x 10 ⁻⁵
Increase in risk for 1 day of worst-case emissions (24 hours which is highly conservative)	1 x 10 ⁻⁶	3 x 10 ⁻⁷	8 x 10 ⁻⁸	2 x 10 ⁻⁸	1 x 10 ⁻⁸	3 x 10 ⁻⁷
Increase in risk assuming worst-case event occurs 1 day each week (52 days per year)*	7 x 10 ⁻⁵	2 x 10 ⁻⁵	4 x 10 ⁻⁶	1 x 10 ⁻⁶	6 x 10 ⁻⁷	2 x 10 ⁻⁵
Maximum annual risk – expected conditions plus worst-case event**	1 x 10 ⁻⁴	3 x 10 ⁻⁵	7 x 10 ⁻⁶	2 x 10 ⁻⁶	9 x 10 ⁻⁷	3 x 10 ⁻⁵
Negligible risks	< 1 x 10 ⁻⁶					
Tolerable/acceptable risks	≥ 1 x 10 ⁻⁶ and ≤ 1 x 10 ⁻⁴					
Unacceptable risks	> 1 x 10 ⁻⁴					

* Assumes that the maximum predicted impact occurs at the same location (receptor) every day the worst-case event occurs. With changes in meteorology in the local area the 24-hour maximum concentration is expected to change in concentration and location over different days. Hence this assumption is conservative

** Assumes the maximum annual average impact and maximum short-term change occur that the same location (receptor) 1 day per week, for the whole year. This is conservative as the concentration and location of maximum impacts would vary depending on the meteorological conditions, in particular the wind direction. The meteorological conditions would not be the same for each worst-case event that has been assumed to occur.

5.11 Sensitivity analysis

The Technical working paper: Air quality included a number of sensitivity tests to evaluate the key ventilation outlet parameters such as the influence of ventilation outlet temperature, ventilation outlet height and the influence of buildings near the tunnel outlets.

In addition, an analysis has been undertaken in the Technical working paper: Air quality to determine the impact from emissions from the ventilation outlets where the regulatory emission limit for the ventilation outlets were reached for at least one hour every day. This was undertaken for the 2027 'Do something cumulative' emissions scenario, with ground level concentrations predicted for the ten most impacted RWR receptors surrounding each ventilation outlet.

It is considered highly unlikely that all outlets would be operating at the emission limit simultaneously. The analysis is considered to be conservative as it describes a three-fold increase in emission estimations over the expected traffic case. In the case of 24-hour averages, the diurnal pattern coincides with worst-case dispersion meteorology, while in the case of annual averages it assumes this exaggerated profile occurs every day of the year.

While this scenario is considered to be conservative, risk calculations for potential impacts on health have been carried out for the change in PM_{2.5} (for the primary health endpoints), for the 'Do something cumulative 2027' scenario.

It is noted that the assessment of impacts related to the project (presented in Sections 5.8 and 5.9) addressed impacts from the ventilation facilities as well as the redistribution of traffic on surface roads.

The assessment presented in this section only relates to impacts associated with the ventilation facilities. This relates to predicted impacts associated with emissions to air from the ventilation facilities only when the project is operating under the expected traffic scenario, as well as the sensitivity test, where the traffic volume in the tunnel is higher, with one hour of each day where concentrations discharged to air meet the emissions limit.

By only presenting impacts associated with emissions from the ventilation facilities, this does not account for the redistribution of traffic on surface roads that, in many areas, results in a reduction in particulate concentrations in air within the community. As a result, the calculated risk does not reflect the change in risk relevant to the community where the whole project (roads plus ventilation facility) is considered.

Table 5-29 presents the maximum calculated risk, from all receptors, associated with the change in PM_{2.5}, associated with emissions to air from the ventilation facilities only for the expected traffic conditions and the sensitivity test. It is noted that the maximum change in PM_{2.5} concentrations are predicted for a receptor located in the area surrounding the Rozelle Interchange ventilation outlet. For this assessment the maximum change in PM_{2.5} evaluated in the area surrounding the Rozelle Interchange ventilation outlet and the Warringah Freeway ventilation outlet have been presented.

Table 5-29 **Calculated individual risk associated with maximum changes in PM_{2.5} concentrations associated with emissions from ventilation facilities: sensitivity test – ‘Do something cumulative 2027’ scenario**

Health endpoint – Primary health indicators	Maximum calculated*	
	Expected traffic	Sensitivity test
Most impacted receptor surrounding the Rozelle Interchange ventilation outlet		
Mortality all causes (long term effects, ages 30+)	1 x 10 ⁻⁵	3 x 10 ⁻⁵
Cardiovascular hospitalisations (short term effects, ages 65+)	1 x 10 ⁻⁵	3 x 10 ⁻⁵
Respiratory hospitalisations (short term effects, ages 65+)	2 x 10 ⁻⁶	8 x 10 ⁻⁶
Most impacted receptor surrounding the Warringah Freeway Interchange ventilation outlet		
Mortality all causes (long term effects, ages 30+)	5 x 10 ⁻⁶	1 x 10 ⁻⁵
Cardiovascular hospitalisations (short term effects, ages 65+)	7 x 10 ⁻⁶	2 x 10 ⁻⁵
Respiratory hospitalisations (short term effects, ages 65+)	1 x 10 ⁻⁶	4 x 10 ⁻⁶
Negligible risks	<1 x 10 ⁻⁶	
Tolerable/acceptable risks	≥1 x 10 ⁻⁶ and ≤1 x 10 ⁻⁴	
Unacceptable risks	>1 x 10 ⁻⁴	

* Maximum impacted receptor surrounding the ventilation outlets

Review of the maximum calculated changes in risk associated with changes in PM_{2.5} concentrations associated with emissions from the ventilation facilities that relate to the sensitivity test scenario evaluated indicates the following:

- For PM_{2.5} the sensitivity test shows a small increase in the maximum calculated risks. The calculated risks, however remain low and are considered tolerable/acceptable.

On the basis of the above, emissions from the ventilation outlets, where the sensitivity test scenario is considered, has the potential to result in a small change in PM_{2.5} risks. However the maximum individual risks associated with PM_{2.5} are considered to remain tolerable/acceptable. As noted above, these risks are expected to be conservative and are unlikely to reflect impacts from the project as they have not included any consideration of the redistribution of traffic on surface roads.

5.12 Valuing particulate matter impacts

The Secretary's environmental assessment requirements (as outlined in Section 1.6) necessitate the assessment of health impacts to also evaluate costs to the community. More specifically, the Secretary's environmental assessment requirements have indicated that costs should be evaluated on the basis of the guidance document *Methodology for Valuing the Health Impacts of Changes in Particle Emissions* (EPA, 2013).

This guideline has developed an approach for use in Australia that is based on the approach developed in the UK. The approach adopted is simplistic, relating health costs in the community to changes in total tonnes of PM_{2.5} emitted. This calculation has generalised the health impacts associated with changes in PM_{2.5} exposures as emitted to air and does not specifically address how people are exposed to these emissions (this is assumed to occur). The Technical working paper: Air quality has calculated the tonnes of PM_{2.5} relevant to each of the scenarios evaluated for this project. This relates to the total tonnes of PM_{2.5} emitted to air and this shows, when comparing to the 'Do minimum' scenario:

- No change and a small decrease in total emissions in the 'Do something' 2027 and 2037 scenarios respectively
- An increase in total emissions in the 'Do Something cumulative' 2027 and 2037 scenarios respectively.

However, the assessment of potential health effects associated with the change in PM_{2.5} concentrations the community are exposed to are different, and as discussed in Section 5.9.5, Table 5-25 and Table 5-26, the project is associated with a decrease in incidence, or the number of cases, relevant to mortality and hospitalisations (ie a health benefit). These impacts (ie the change in number of cases), ideally should be those that are considered in valuing the health impacts. Where this is considered, a reduction in health costs should be calculated; however, that is not the case with the methodology outlined by NSW EPA (2013) which is only based on the change in total tonnes of PM_{2.5} emitted. As a result, the calculations presented are not representative of health costs related to the project.

When applying the NSW EPA (2013) methodology, the project area has been assumed to be 'urban large' (noting there are no definitions in the guidance in relation to determining this), where the damage costs listed are \$593,617 per tonne of PM_{2.5} in 2011 prices. In today's prices, based on the inflation calculator from the Reserve Bank of Australia¹⁰ the damage cost is \$664,773 per tonne of PM_{2.5}. Following this approach, the damage costs/savings associated with PM_{2.5} are calculated to be:

- \$0 in 2027 and minus \$132,955 (saving) in 2037, when comparing the change in total emissions between the 'Do minimum' and the 'Do something' scenarios
- \$797,728 (cost) in 2027 and \$5,517,616 (cost) in 2037, when comparing the change in total emissions between the 'Do minimum' and the 'Do something cumulative' scenarios.

As noted above, these costs/savings are not considered to be fully representative of the actual health costs/savings for the project, given the focus of the methodology outlined by NSW EPA (2013).

¹⁰ <http://www.rba.gov.au/calculator/annualDecimal.html>

6 Assessment of in-tunnel air quality

6.1 General

In-tunnel air quality was assessed to evaluate the health consequences for customers using both the project and the extended tunnel network operating in compliance with approval conditions and design criteria.

The operational in-tunnel limits for CO and NO₂ in several Sydney road tunnels are shown in Table 6-1.

Table 6-1 Operational in-tunnel limits in Sydney road tunnels

Tunnel	CO concentration (ppm, rolling average)			NO ₂ concentration (ppm)
	3 min	15 min	30 min	15 min
Cross City Tunnel	200	87	50	N/A
Lane Cove Tunnel	–	87	50	N/A
M5 East Tunnel	200	87	50	N/A
NorthConnex	200 ^(a)	87 ^(b)	50 ^(b)	0.5 ^(b)
WestConnex M4 East				
WestConnex New M5				
WestConnex M4-M5 Link				

Notes:

(a) In-tunnel single point exposure limit

(b) In-tunnel average limit along tunnel length

Sources: NHMRC (2008), Longley (2014c), PIARC (visibility), NSW Government (2015, 2016a, 2016b)

The tunnel ventilation system for the project was designed to ensure air quality within the tunnel would be maintained at or below the design criteria shown in Table 6-2, independent of the adjacent M4-M5 Link or Beaches Link tunnels.

Table 6-2 In-tunnel air quality limits for ventilation design

Pollutant/ parameter	Concentration limit	Units	Type of measurement	Averaging period
CO	87	ppm	Average along tunnel	Rolling 15 minute
CO	50	ppm	Average along tunnel	Rolling 30 minute
CO	200	ppm	Maximum in tunnel	Rolling 3 minute
NO ₂	0.5	ppm	Average along tunnel	Rolling 15 minute
Visibility*	0.005	m ⁻¹	Maximum in tunnel	Rolling 15 minute

Source: Roads and Maritime design criteria

* Visibility is an important design criteria for in-tunnel safety. Visibility is reduced by the scattering and absorption of light by suspended particulate matter. From a health perspective, exposure to particulate is of relevance. However, such an assessment is limited by the short duration of exposure in tunnels compared with the longer exposure times (24 hours and one year) for which the health effects of ambient particles have been established. Moreover, there is no safe minimum threshold for particles, and so visibility cannot reliably be used as a criterion for health risk (NHMRC, 2008). Hence visibility limits within the tunnel have not been further evaluated.

Based on current guideline concentrations and car emission technologies, the NO₂ criteria is the hardest to achieve and is the pollutant that determines the required air flows and drives the design of ventilation for in-tunnel pollution.

Cumulative impacts have been assessed in accordance with the NSW Government Advisory Committee on Tunnel Air Quality (ACTAQ) 'In-tunnel air quality (NO₂) policy' (ACTAQ, 2016). The policy requires tunnels to be '*designed and operated so that the tunnel average nitrogen dioxide (NO₂) concentration is less than 0.5 ppm as a rolling 15 minute average*'.

For the project and the associated integrated analysis of WestConnex, the F6 Extension and the proposed Beaches Link tunnels, the 'tunnel average' has been interpreted as a 'route average', being the length-weighted average pollutant concentration over a portal-to-portal route through the system. Tunnel average NO₂ has been assessed for every possible route through the system with this assessment considering the highest average NO₂ concentration.

The tunnel ventilation system would be designed and operated so that the in-tunnel air quality limits in Table 6-2 are not exceeded, and are consistent with those in the conditions of approval for NorthConnex and other approved WestConnex projects.

The tunnel ventilation design does not allow for portal emissions. The design utilises longitudinal ventilation (assisted by jet fans – also used for emergency operation) with extraction near the exit portals to the ventilation facilities, as conceptually illustrated below.

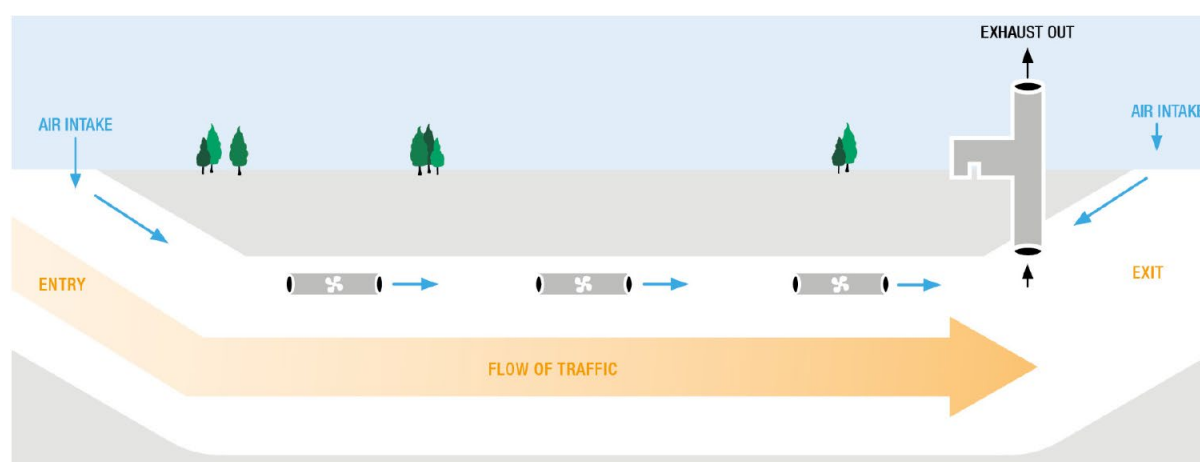


Figure 6-1 Conceptualisation of longitudinal tunnel ventilation and portal extraction

Concentrations in the project tunnels are expected to vary depending on:

- Time of day: Pollutant concentrations within the tunnels have been estimated to vary by a factor of up to two (depending on the particular pollutant and location within the main alignment tunnels) from periods of low traffic to peak traffic
- Location within the mainline tunnels relative to ventilation facilities: Concentrations of pollutants would gradually increase from the tunnel entrance to the next offtake to a ventilation outlet.

The assessment of potential exposures that may occur in the tunnel has been carried out with consideration of these factors. In addition, the following has also been considered:

The project:

- The time spent within the Western Harbour Tunnel would be limited, taking around five to six minutes to travel the full distance of the tunnel (when travelling at the speed limit of 80 kilometres per hour). During peak times the time of travel may be slightly longer depending on the speed of traffic flow in the tunnels. Concentrations would not be the same in all parts of the tunnels, with concentrations increasing with distance from the entry portal. The amount of time exposed to the maximum concentration would be short (around one minute), with the average exposure through the whole tunnel lower than the maximum (at the end of the tunnel or ventilation outlet exhaust point)
- The concentration of pollutants within the vehicle itself would be lower than outside the vehicle, particularly where all windows are closed when inside the tunnel, as most vehicles have filters on the air intake. Where the air conditioning/ventilation in the car is set to recirculation, this would

limit the contribution of air derived from within the tunnel to the air within the vehicle. Measurements conducted by NSW Health in relation to the M5 East Tunnel (NSW Health 2003) identified that closing car windows and switching the ventilation to recirculation can reduce exposures by about 70–75 per cent for CO and NO₂, 80 per cent for fine particulates and 50 per cent for VOCs. Further testing of the reduction in NO₂ levels inside vehicles using road tunnels was commissioned by Roads and Maritime in 2016 (PEL, 2016), where recirculation was found to reduce exposures by around 70 per cent.

Assessment of cumulative exposures in tunnels:

- It is expected that users of the Western Harbour Tunnel may also use part of other connecting tunnels for their trip. This may include the Beaches Link tunnels, WestConnex and the F6 Extension. This means motorists may be travelling inside a tunnel for a longer distance and time. Given the layout of the tunnels, it is unlikely anyone would utilise the full length of the tunnels; however, consideration has been given to the use of the full network including a 30 kilometres trip from the New M5 portal to the Wakehurst Parkway and 28 kilometres trip from the F6 Extension to the Wakehurst Parkway. Exposures that may occur during longer duration trips in these connecting tunnel networks are considered below
- There may be individuals who utilise the network of tunnels in the Sydney area on a frequent basis, throughout the day. This may include taxi drivers, courier drivers and some truck drivers. More frequent exposures in these tunnels are considered below.

The following provides further discussion on the range of concentrations predicted within the tunnels, as documented in Western Harbour Tunnel and Warringah Freeway Upgrade Ventilation Report (WSP/ARUP, 2020), an annexure to Technical working paper: Air quality.

6.2 Carbon monoxide

Under normal operations, the average concentration of CO predicted in the Western Harbour Tunnel while travelling in both directions (including cumulative scenarios) is less than four ppm (refer to Tables 7.1 – 7.8 in Western Harbour Tunnel and Warringah Freeway Upgrade Ventilation Report (WSP/ARUP, 2020)). Even under a worst case scenario, the maximum estimated average concentration would be 5.2 ppm.

In relation to the CO concentrations predicted within the tunnels, the following is noted:

- The maximum one hour average concentration of CO in the tunnels is predicted to be less than six ppm in all scenarios, including worst case scenarios. These concentrations are lower than the health based guideline of 25 ppm (one-hour average) established by the WHO (WHO, 2010) and 34 ppm established by the USEPA (NHMRC, 2008). The concentrations are lower than PIARC in-tunnel limits (Longley, 2014)
- The NHMRC (2008) has published measured concentrations of CO from a range of tunnels in Sydney and around the world. The measured concentrations come from a number of different studies where the averaging time for the collection of the data varies significantly. This makes it difficult to directly compare the range of reported concentrations with the concentrations predicted in this assessment (ie not comparing data reported over similar averaging/exposure periods). While noting this difficulty in comparing the data, a range of average concentrations of CO have been reported from six to 38 ppm (NHMRC, 2008). The predicted hourly average concentration in the project tunnel is within the range reported in other tunnels
- The tunnel is designed to meet in-tunnel limits for CO. While actual concentrations in the tunnel are expected to be lower than these limits, where the limits are met the following can be noted:
 - The in-tunnel limit for CO of 87 ppm as a rolling 15-minute average is similar to the health based guideline of 90 ppm (15-minute average) established by the WHO (WHO, 2010)
 - The in-tunnel limit for CO of 50 ppm as a rolling 30 minute average is the same as the health based guideline of 50 ppm (30 minute average) established by the WHO (WHO, 2000d).

On the basis of the above, there are no health issues of concern related to in-tunnel exposures to CO within the Western Harbour Tunnel, or within longer journeys that include the Western Harbour Tunnel.

6.3 Nitrogen dioxide

The Western Harbour Tunnel and Warringah Freeway Upgrade Ventilation Report (WSP/ARUP, 2020) has modelled average NO₂ concentrations across specified tunnel lengths for selected time periods. Tables 6-2 and 6-3 present the average concentration of NO₂ predicted through the tunnel travelling either northbound or southbound, during selected hours of the day for the 2037 'Do something' scenario (ie under normal operating conditions). Figures 6-2 and 6-3 show the change in NO₂ concentrations through the tunnel.

Exposures that may occur within the Western Harbour Tunnel and Beaches Link Tunnel, which are part of the combined tunnel predictions for the 'Do something cumulative 2037' scenario, are presented in Tables 6-4 and 6-5. Figures 6-4 and 6-5 show the change in NO₂ concentrations within the cumulative scenarios.

Table 6-2 'Do something 2037' predicted average NO₂ tunnel concentrations (northbound) through the tunnel (ppm) (WSP/ARUP 2020)

Period	Entry	Rozelle Interchange	Rozelle Interchange	M4-M5 Link	M4-M5 Link
	Exit	North Sydney	Warringah Freeway Upgrade	Warringah Freeway Upgrade	North Sydney
		6.4 km	7.1 km	6.3 km	5.7 km
7.00 to 9.00		0.20	0.22	0.24	0.22
9.00 to 15.00		0.20	0.22	0.24	0.22
15.00 to 18.00		0.17	0.18	0.20	0.18
18.00 to 7.00		0.11	0.11	0.12	0.11

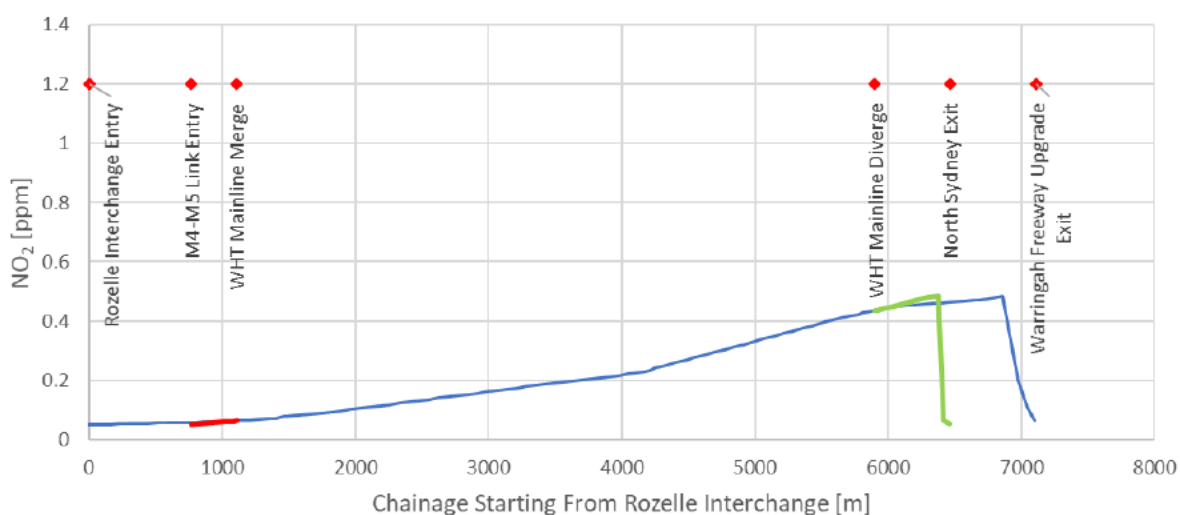


Figure 6-2 Highest NO₂ concentrations along tunnel routes – 'Do something 2037' northbound – 9.00 am to 3.00 pm (WSP/ARUP 2020)

Table 6-3 'Do something 2037' predicted average NO₂ tunnel concentrations (southbound) through the tunnel (ppm) (WSP/ARUP 2020)

Period	Entry	Warringah Freeway Upgrade	Warringah Freeway Upgrade	Warringah Freeway Upgrade	North Sydney	North Sydney	North Sydney
	Exit	M4-M5 Link	M115 Rozelle	M116 Rozelle	M4-M5 Link	M115 Rozelle	M116 Rozelle
		6.3 km	7.1 km	7.0 km	5.5 km	6.3 km	6.2 km
7.00 to 9.00		0.12	0.14	0.13	0.13	0.14	0.14
9.00 to 15.00		0.12	0.14	0.14	0.13	0.14	0.14
15.00 to 18.00		0.12	0.13	0.13	0.12	0.13	0.13
18.00 to 7.00		0.07	0.072	0.072	0.071	0.074	0.074

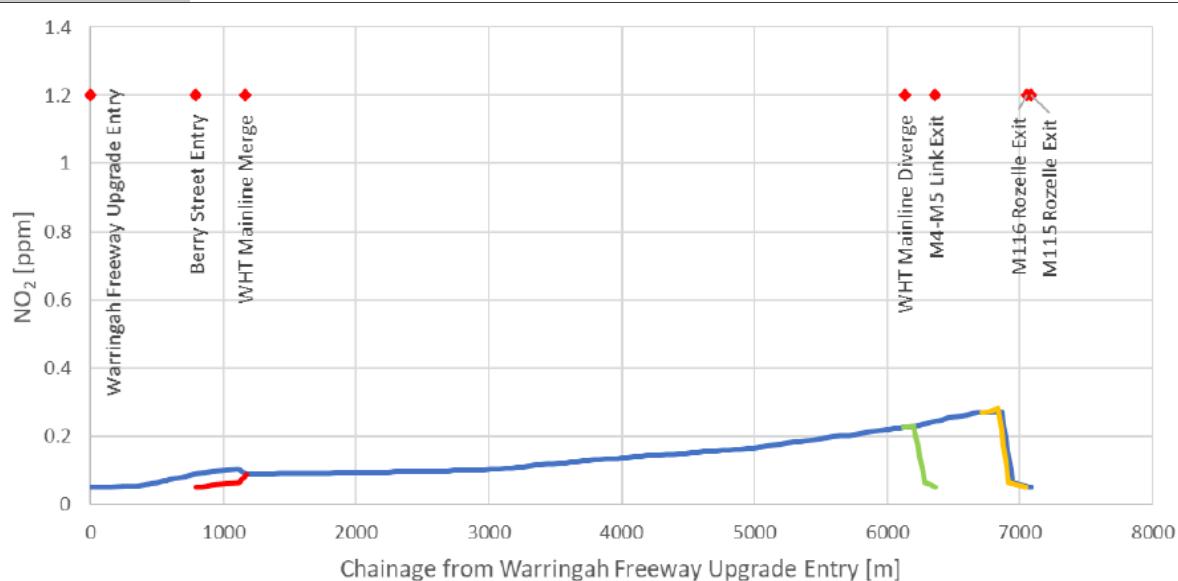


Figure 6-3 Highest NO₂ concentrations along tunnel routes – 'Do something 2037' southbound – 9.00 am to 3.00 pm (WSP/ARUP 2020)

Table 6-4 'Do something cumulative 2037' predicted average NO₂ tunnel concentrations (northbound) (ppm) (WSP/ARUP, 2020)

Time period	Entry	Rozelle Interchange	Rozelle Interchange	M4-M5 Link	M4-M5 Link	Rozelle Interchange	M4-M5 Link	Rozelle Interchange	Rozelle Interchange	M4-M5 Link	M4-M5 Link
	Exit	North Sydney	Warringah Freeway Upgrade	Warringah Freeway Upgrade	North Sydney	WHT-BL connection ¹	WHT-BL connection ¹	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway
		6.5 km	7.2 km	6.6 km	6.0 km	7.5 km	6.9 km	14.6 km	15.7 km	13.8 km	14.9 km
7.00 to 9.00		0.227	0.246	0.269	0.250	0.246	0.269	0.187	0.204	0.194	0.212
9.00 to 10.00		0.224	0.243	0.266	0.247	0.243	0.267	0.200	0.225	0.208	0.233
10.00 to 15.00		0.224	0.243	0.266	0.247	0.243	0.267	0.200	0.225	0.208	0.233
15.00 to 16.00		0.220	0.220	0.239	0.242	0.220	0.241	0.193	0.224	0.201	0.232
16.00 to 17.00		0.217	0.220	0.240	0.239	0.220	0.241	0.194	0.225	0.202	0.234
17.00 to 18.00		0.217	0.220	0.240	0.238	0.220	0.241	0.195	0.226	0.203	0.231
18.00 to 19.00		0.136	0.123	0.131	0.147	0.123	0.131	0.109	0.119	0.112	0.122
19.00 to 7.00		0.136	0.122	0.131	0.132	0.123	0.131	0.109	0.118	0.112	0.122

¹WHT-BL – Tunnel connection of Western Harbour Tunnel to Beaches Link

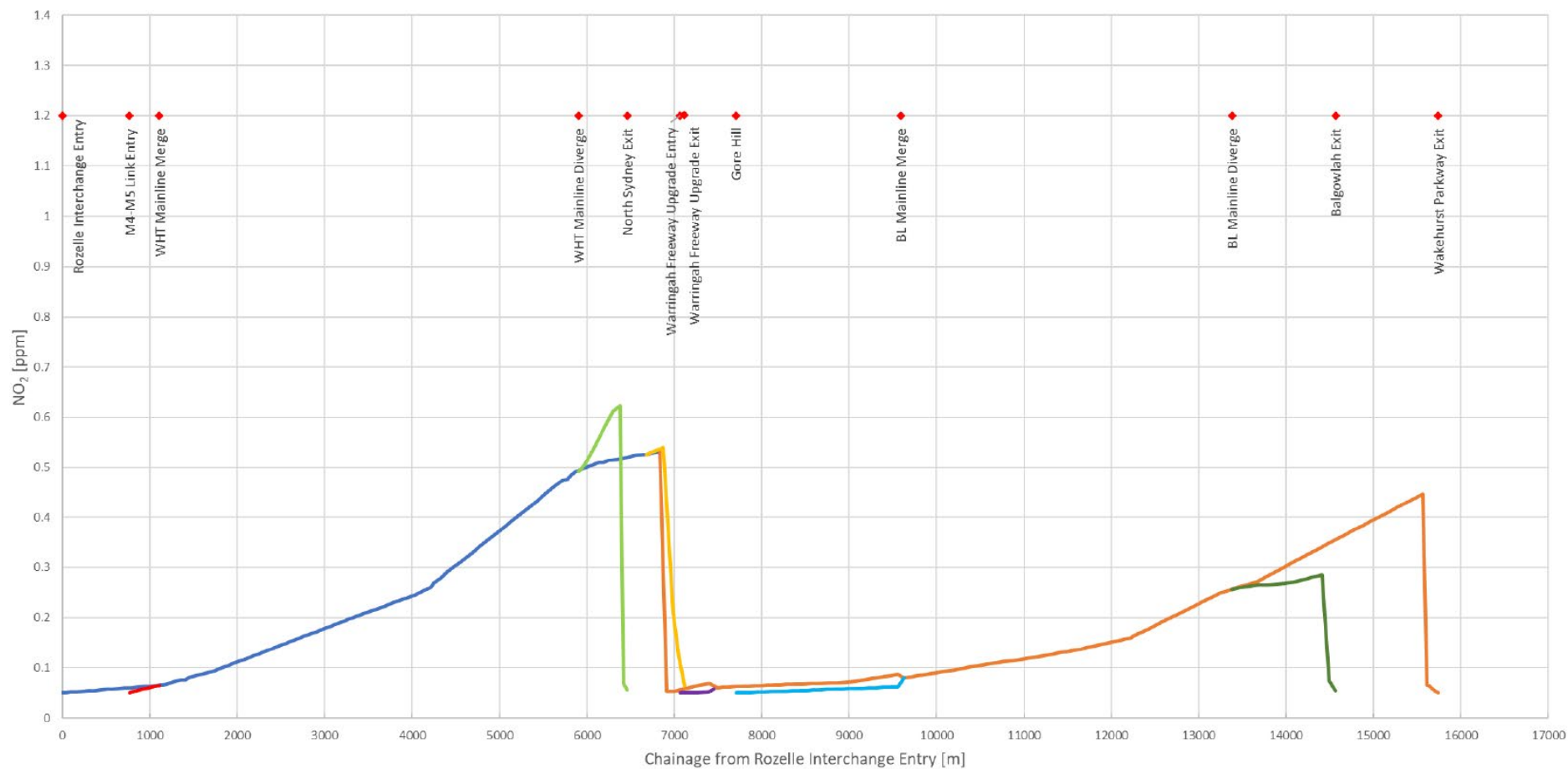


Figure 6-4 Highest NO₂ concentrations along tunnel routes – ‘Do something cumulative 2037’ northbound – 7.00 am to 9.00 am (WSP/ARUP, 2020)

Table 6-5 'Do something cumulative 2037' predicted average NO₂ tunnel concentrations (southbound) (ppm) (WSP/ARUP, 2020)

Time period	Entry	BL-WHT ¹	BL-WHT ¹	WFU	WFU	North Sydney	North Sydney	North Sydney	BL-WHT ¹	WFU	Wake-hurst Parkway	Wake-hurst Parkway	Wake-hurst Parkway	Balgow-lah	Balgow-lah	Balgow-lah
	Exit	Rozelle M116	Rozelle M115	Rozelle M116	Rozelle M115	Rozelle M116	Rozelle M115	M4-M5 Link	M4-M5 Link	M4-M5 Link	Rozelle M116	Rozelle M115	M4-M5 Link	Rozelle M116	Rozelle M115	M4-M5 Link
		7.0 km	7.1 km	7.0 km	7.1 km	6.2 km	6.3 km	5.5 km	6.3 km	6.3 km	15.7 km	15.8 km	15.0 km	14.5 km	14.6 km	13.8 km
7.00 to 8.00		0.150	0.150	0.150	0.150	0.157	0.157	0.143	0.137	0.136	0.174	0.173	0.169	0.184	0.184	0.179
8.00 to 9.00		0.151	0.150	0.150	0.150	0.157	0.157	0.143	0.137	0.136	0.175	0.175	0.170	0.185	0.185	0.181
9.00 to 10.00		0.147	0.146	0.146	0.146	0.154	0.153	0.140	0.134	0.133	0.163	0.163	0.158	0.172	0.172	0.168
10.00 to 15.00		0.148	0.146	0.147	0.146	0.155	0.153	0.140	0.134	0.133	0.162	0.162	0.157	0.172	0.171	0.167
15.00 to 16.00		0.145	0.152	0.144	0.152	0.152	0.160	0.138	0.131	0.131	0.147	0.150	0.141	0.155	0.159	0.150
16.00 to 17.00		0.143	0.146	0.143	0.146	0.150	0.153	0.136	0.130	0.130	0.146	0.147	0.140	0.154	0.155	0.148
17.00 to 18.00		0.144	0.147	0.144	0.147	0.152	0.155	0.138	0.131	0.131	0.147	0.148	0.142	0.155	0.157	0.150
18.00 to 19.00		0.082	0.082	0.082	0.082	0.084	0.084	0.080	0.078	0.078	0.089	0.089	0.088	0.093	0.093	0.091
19.00 to 6.00		0.082	0.082	0.082	0.082	0.084	0.084	0.080	0.078	0.078	0.089	0.089	0.087	0.092	0.092	0.091

Time period	Entry	BL-WHT ¹	BL-WHT ¹	WFU	WFU	North Sydney	North Sydney	North Sydney	BL-WHT ¹	WFU	Wake-hurst Parkway	Wake-hurst Parkway	Wake-hurst Parkway	Balgow-lah	Balgow-lah	Balgow-lah
	Exit	Rozelle M116	Rozelle M115	Rozelle M116	Rozelle M115	Rozelle M116	Rozelle M115	M4-M5 Link	M4-M5 Link	M4-M5 Link	Rozelle M116	Rozelle M115	M4-M5 Link	Rozelle M116	Rozelle M115	M4-M5 Link
		7.0 km	7.1 km	7.0 km	7.1 km	6.2 km	6.3 km	5.5 km	6.3 km	6.3 km	15.7 km	15.8 km	15.0 km	14.5 km	14.6 km	13.8 km
6.00 to 7.00		0.084	0.084	0.084	0.084	0.086	0.086	0.082	0.080	0.079	0.091	0.091	0.090	0.095	0.095	0.094

¹ BL-WHT – Tunnel connection of Beaches Link to Western Harbour Tunnel

² WFU – Warringah Freeway Upgrade

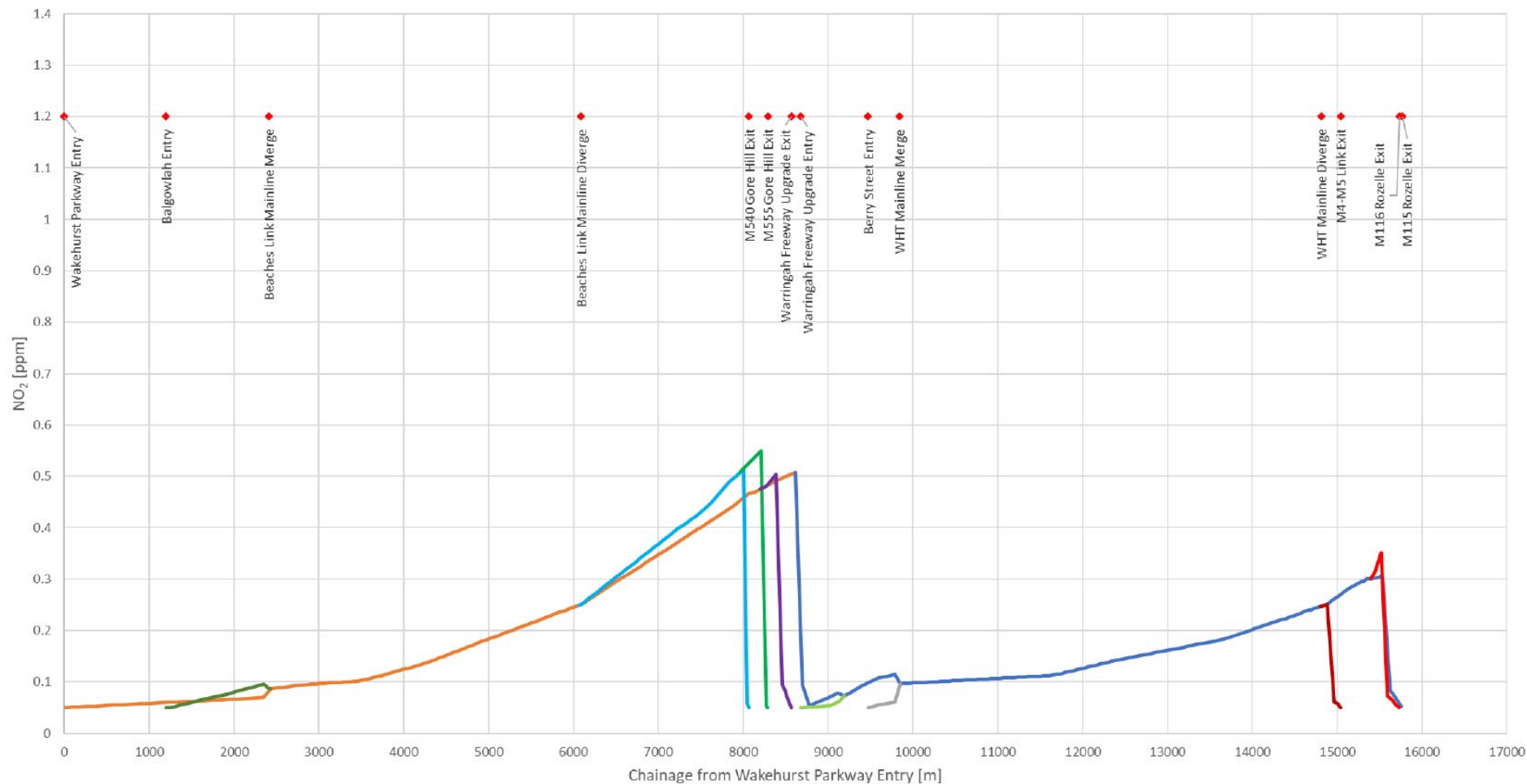


Figure 6-5 Highest NO₂ concentrations along tunnel routes – ‘Do something cumulative 2037’ southbound – 8.00 am to 9.00 am (WSP/ARUP 2020)

The following is noted in relation to the NO₂ concentrations predicted within the 'Do something cumulative' in 2037:

- The average concentrations in the tunnels would vary throughout the day, with the average concentration through the entire tunnel (trip average) expected to be (at most) around 0.25 ppm
- The maximum in-tunnel concentrations at any point in the tunnel, estimated for travelling at between 77 and 80 kilometres per hour through the mainline tunnel and 55–63 kilometres per hour along the tunnel ramps, would vary from less than 0.1 ppm when entering the tunnels, depending on the direction of travel, to just under 0.5 ppm at the North Sydney or Warringah Freeway Upgrade exit when travelling northbound. All concentrations in all parts of the tunnel are under the in-tunnel limit of 0.5 ppm (noting that the in-tunnel limit applies to a 15 minute average). The average exposure over this whole trip is estimated at 0.24 ppm (with windows down). Lower average concentrations may occur with windows up and ventilation on recirculation.

The concentrations discussed above relate to NO₂ levels inside the tunnels, not inside the vehicles. A study of NO₂ concentrations inside vehicles travelling in Sydney and using existing road tunnels was commissioned by Roads and Maritime in 2016 (PEL, 2016) to better understand the relationship between NO₂ outside the vehicle, and inside the vehicle. The study involved a range of vehicles considered representative of the existing vehicle fleet, travelling through existing tunnels in Sydney and simulating travel times between 45 minutes and 60 minutes over a distance of 30 kilometres.

The concentration of NO₂ that entered a vehicle depended on the concentration outside the vehicle as well as the air exchange rate relevant to the individual vehicle. The air exchange rate depends on the ventilation, whether on recirculation or not, and a range of factors relevant to the vehicle air tightness, or leakiness.

Within existing tunnels investigated in the study, trip average concentrations of NO₂ would be generally less than 0.15 ppm; however, during periods of high traffic volumes and a high proportion of heavy vehicles, the trip average concentrations inside existing tunnels could exceed 0.5 ppm, with levels up to 0.7 ppm. Inside these tunnels with high external concentrations of NO₂, the average concentrations inside the vehicles, when ventilation was on recirculation, would be less than 0.2 ppm.

The study found that the use of ventilation on recirculation can significantly reduce concentrations of NO₂ inside vehicles. The ratio of indoor to outdoor concentrations ranged from 0.06 ppm to 0.32 ppm. This is consistent with the findings from a NSW Health study on vehicles using the M5 East tunnels (NSW Health, 2003), where an indoor to outdoor ratio of 0.25 ppm to 0.3 ppm was determined for NO₂ where ventilation was set to recirculation. When ventilation was not set to recirculation the concentration of NO₂ was higher inside the vehicles, and in some cases accumulated inside the vehicle after travelling through short tunnels.

Health effects of short-duration exposures to nitrogen dioxide

Short-term exposure to NO₂ has been shown to cause respiratory health effects and is suspected of causing other health impacts such as cardiovascular effects (US EPA, 2016). The concentration at which these impacts occur was subject to a review in 2015 (Jalaludin, 2015). This review, which has been used to develop the NSW NO₂ in-tunnel guideline, evaluated available studies in relation to health effects from in-tunnel and short-term exposures to NO₂. The review evaluated studies associated with exposures that occur for less than 30 minutes as well as those with exposures of more than 60 minutes.

In relation to the available studies (18 studies) that relate to exposures of 30 minutes or less, the following was identified (Jalaludin, 2015):

- There were no effects identified in relation to lung function for individuals exposed to NO₂ between 0.12 ppm and 0.5 ppm
- The results for inflammatory markers (physiological measures that indicate the respiratory system or other systems in the body are dealing with inflammation) are mixed
- An effect of exposure to NO₂ and airway responsiveness was identified in individuals with asthma

- There is no clear evidence of a dose-response relationship for exposure and airway responsiveness for NO₂ levels at or below 0.5 ppm
- The effects observed for airway responsiveness may be transient. There is no clear evidence that repeated exposure to NO₂ leads to cumulative effects.

In relation to the available studies (14 studies) that relate to exposures of 60 minutes or more, the following was identified (Jalaludin, 2015):

- There were no effects identified in relation to lung function for individuals exposed to NO₂ between 0.3 ppm and 4 ppm
- The results for inflammatory markers are mixed, however overall, inflammatory markers increased after exposure to NO₂
- An effect of exposure to NO₂ and airway responsiveness was identified
- Insufficient data is available to determine any cardiovascular effects (or otherwise)
- One study indicated the effects were attenuated with repeated exposures.

In relation to the available studies (eight studies) from road tunnels, busy roads and subways, the following was identified (Jalaludin, 2015):

- Exposure to NO₂ was in the range of less than 0.2 ppm (in seven studies) to 0.5 ppm (in one study)
- There were no effects identified in relation to lung function
- Both upper and lower respiratory symptoms were commonly reported after exposure to road tunnel and subway environments
- The results for inflammatory markers are mixed
- The effects on airway responsiveness were unclear.

More recently, another review (enRiskS, 2018) was carried out to consider NO₂ exposures of up to 60 minutes. This review supported the conclusions of the Jalaludin report, even for exposures of NO₂ up to 60 minutes. It found that for NO₂ exposures 0.5 ppm or less, the strongest evidence for effects was seen on airways responsiveness, and generally in asthmatics. These effects, if detected, were small and not defined to be clinically relevant.

However, there were limitations in the studies, in particular the small number of participants and the lack of subjects who are more sensitive to effects of NO₂. Further, when considering the studies conducted in road tunnels, busy roadways and in subways, it is important to note that NO₂ is only part of a complex mixture of air pollution, including PM_{2.5}, and determining health effects that may be only related to NO₂ is difficult.

For the assessment of short duration exposures to NO₂ in road tunnels, Australia and a number of other jurisdictions, have established guidelines. These guidelines are based on the available short-term studies which have been considered in the review presented by Jalaludin (2015) and enRiskS (2018).

Table 6-6 presents a summary of the available guidelines for the assessment of short duration exposures to NO₂ within tunnels.

Table 6-6 Summary of NO₂ guidelines for in-tunnel exposures

Jurisdiction/Project	Guideline	Averaging period	Nature of guideline (tunnel design or compliance)
NSW (ACTAQ, 2016)	0.5 ppm tunnel average	15 minutes	Design and compliance
NorthConnex and WestConnex	0.5 ppm tunnel average	15 minutes	Design and compliance
Brisbane City Council/Clem 7 and Legacy Way tunnels	1 ppm tunnel average	N/A	Design
PIARC	1 ppm tunnel average	N/A	Design
New Zealand	1 ppm	15 minutes	Design
Belgium	0.5 ppm tunnel average	<20 minutes	Design
France	0.4 ppm tunnel average	15 minutes	Design
Norway	0.75 ppm at the midpoint of the tunnel 1.5 ppm at the end of the tunnel	15 minutes	Design and compliance
Hong Kong	1 ppm	5 minutes	Design

Further consideration of potential exposures within tunnels

The average concentration of NO₂ has been calculated for all sections of tunnels within the combined (cumulative) tunnel network travelling in different directions. These are estimates of the average concentration of NO₂ inside each of the tunnel segments and for a range of different trips that may take place within the tunnel network. These estimates have been presented for expected traffic conditions. Exposure to NO₂ within the tunnels during each of these scenarios has been further considered in this assessment.

With windows up and ventilation on recirculation, the concentrations that may be present inside vehicles would be lower. The concentrations of NO₂ inside the vehicle is the point of exposure and what should be considered in relation to the potential for health effects.

In-vehicle NO₂ levels have been taken to be equal to the in-tunnel average when travelling through tunnels for the segment travelled multiplied by 0.3, the upper end of the range of ratios for indoor:outdoor NO₂ levels from the studies carried out. Under normal traffic conditions, it is estimated that passengers in a vehicle travelling through the Sydney tunnel network system (M5 Kingsgrove portal to the Wakehurst Parkway exit) would be exposed to an average NO₂ concentration of 0.1 ppm for less than one hour, provided the vehicle has the windows up and air ventilation on recirculation. As such, no significant health effects are expected to occur.

No cumulative modelling was carried out for congested traffic conditions (traffic moving at as little as 20 kilometres per hour). However, under congested conditions, average NO₂ concentrations within the Western Harbour Tunnel were estimated to be below 0.5 ppm. The M4-M5 Link project environmental impact statement provided a cumulative congested assessment of average NO₂ concentration for vehicles travelling through the Sydney tunnel network which was also estimated to be below 0.5 ppm. The Beaches Link and Gore Hill Freeway Connection project assessment has also estimated average NO₂ concentrations to be below 0.5 ppm under congested traffic conditions. As all tunnel networks have predicted an average concentration of 0.5 ppm under congested conditions, it is taken that the average NO₂ concentrations would be below 0.5 ppm. It is noted that the longest assessment of tunnel travel distance is 30 kilometres; however, it is unlikely that anyone would travel at 20 kilometres per hour for the whole 30 kilometres, rather they would exit the tunnel system. As such, it is unlikely that anyone would be exposed for over one hour under congested conditions.

For individuals using other modes of transport, the following can be noted:

- Individuals using motorbikes would not have the opportunity to reduce exposure inside the tunnel through the use of ventilation controls. However, the time spent inside tunnels when under congestion would be less than for other users, particularly in heavy traffic, as motorcyclists can lane filter when traffic is travelling at 35 kilometres per hour and slower. This would limit the amount of time that motorcyclists spend inside the tunnels, even during worst case congested conditions
- Individuals travelling in buses may also be exposed to NO₂ inside the bus. It is understood that NSW buses have air conditioning and ventilation systems that include recirculation, with new buses¹¹ allowing a minimum of 10 per cent fresh air at all times to maximise passenger comfort and minimise excess levels of carbon dioxide (CO₂). Buses may also be leakier than passenger vehicles, resulting in more outdoor air entering the bus; however, the volume of air inside a bus is much greater than in a passenger vehicle so air entering from outdoors would be mixed in a larger volume.

No data is available for the air exchange rates in Sydney buses. Published data suggests highly variable values in the range of 2.6 to 4.55 air changes per hour for more modern school buses and 16 air exchanges per hour for an older (pre-1998) bus (Knibbs, de Dear & Atkinson, 2009). Adopting the NO₂ model established by Roads and Maritime (PEL, 2016), a well ventilated older bus with 16 air exchanges per hour results in an indoor:outdoor ratio for NO₂ of 0.3, the same as measured for the older/leakier vehicles considered in the Roads and Maritime study. A lower ratio is calculated for a tighter modern bus. The adjustment of 0.3 to calculate indoor air concentrations of NO₂ inside passenger vehicles can also be applied to buses.

Potential exposures within the tunnels during expected traffic conditions for motorcycles or passengers in vehicles where ventilation recirculation is not adopted is estimated to be no greater than an average of 0.35 ppm. The concentrations are below the 15-minute average guideline, which would be relevant for travel by motorcycle through most of the travel segments. Travel through longer segments (up to 30 kilometres) may take longer. The available health data (enRiskS, 2018) does not suggest that exposures for a period of up to an hour would be of greater concern than for 15 minutes. As such, no significant health effects are expected to occur.

It is noted that the 15-minute average guideline may not be protective of all health effects for all individuals as the available studies relied on to evaluate potential health effects do not include severe asthmatics. As such, there may be the potential for some severely asthmatic individuals to experience some minor change in respiratory response after using the tunnels, particularly when congested.

During an extreme congestion scenario, while average NO₂ concentrations are higher, the time spent inside the tunnels under these conditions would remain short for motorcyclists. The average NO₂ levels within the tunnel can be compared against the 15-minute average guideline. Average NO₂ concentrations in the travel segments are below this guideline and so no significant adverse health effects are expected for motorcyclists using the tunnels under these conditions. However, the potential for asthmatic individuals to experience some minor change in respiratory response after using the tunnels (under extreme congestion conditions) cannot be excluded.

During extreme congestion, for passengers in vehicles where advice to keep windows up and ventilation on recirculation is not adopted, the duration of exposure would be longer than assumed for motorcyclists. It is not likely that such exposures would result in adverse health effects; however, the potential for asthmatic individuals to experience some minor change in respiratory response after using the tunnels (under extreme congestion conditions) cannot be excluded.

Repeated use of tunnels also requires consideration. The available data on health effects associated with short-duration exposures indicates the effects are transient, ie only relate to the peak exposure that has occurred. Repeated exposures that may occur as a result of morning peak and afternoon peak travel, have not been considered to be additive. Provided the average NO₂ concentrations that occur during the travel times in the vehicle are below the health based guidelines, which is expected

¹¹ <http://www.transport.nsw.gov.au/sites/default/files/b2b/busreform/bus-specification-double-deck-two-door-city.pdf>

to be the case for the expected traffic conditions, then no significant adverse health effects are expected.

For individuals involved in occupations that may require more regular use of the road network, such as taxi and courier drivers, there is the potential for these individuals to make more frequent and varied trips over different travel segments in any one day. For these drivers, it is important that they keep their windows up and ventilation on recirculation to minimise exposures throughout the day.

6.4 Particulate matter

There are no health based guidelines available for the assessment of short-duration exposures to PM within a tunnel. In-tunnel criteria relate to visibility (and safety in using the tunnel). It is expected that the concentration of PM within the tunnel would be higher than ambient air concentrations, and the concentration of PM would increase with increasing distance travelled through the tunnel.

Potential concentrations of PM inside the tunnel are derived from exhaust as well as non-exhaust sources. Non-exhaust sources include tyre and brake wear and dust from surface road wear and the resuspension of road dust. The modelling of PM and visibility issues within the tunnel has considered both sources.

The characteristics of PM derived from exhaust and non-exhaust sources would be different. The available evidence suggests that non-exhaust particles are generally larger than exhaust particles. It is likely that non-exhaust particles are greater than 10 micrometres in diameter; however, this is not well characterised. Where the particles are larger than 10 micrometres in diameter, they are of less importance in terms of potential health effects, with stronger health effects relevant to exposure to particles less than 2.5 micrometres in diameter. The tunnel design and air quality assessment is based on non-exhaust PM emission factors that relate to PM₁₀ and PM_{2.5} from relevant emissions studies.

PM from exhaust is expected to be largely fine particulates, ie PM₁₀ and PM_{2.5}, that are of importance to health.

The following is noted in relation to the PM concentrations predicted within the tunnel:

- The in-tunnel concentrations for PM are taken to be PM₁₀ concentrations where concentrations of PM_{2.5} are likely to comprise a significant portion of the PM₁₀ concentration, particularly for exhaust emissions
- PM₁₀ concentrations within the tunnels are dominated by non-exhaust sources (including tyre and brake wear, dust from surface road wear and resuspension of road dust)
- The maximum concentration of PM₁₀ in the tunnels evaluated are up to 0.2 mg/m³ for the '2037 Do something cumulative' scenario. The average concentration in the tunnels would be lower than the peak concentration predicted, with this level being lower when windows are up and ventilation is on recirculation
- As a significant proportion of in-tunnel PM is non-exhaust, regular cleaning of tunnel roadways may reduce these levels.

Review of short duration exposure to particles

Assessing potential short-duration exposures to particles should note:

- The NHMRC (2008) has published measured concentrations of particulates (as PM_{2.5} and PM₁₀) from a range of tunnels in Sydney and around the world. The measured concentrations come from a number of different studies where the sampling methodology and averaging time for the collection of the data varies significantly. This makes it difficult to directly compare the range of reported concentrations with the concentrations predicted in this assessment (ie not comparing data reported over similar averaging/exposure periods). While noting this difficulty in comparing the data, the range of average concentrations of PM_{2.5} reported typically range from around 0.03 to 0.343 mg/m³ (AMOG, 2012; NHMRC, 2008). These levels are based on data with averaging times that vary from one hour averages, peak hour averages, daytime averages to 24 hour averages

- The exposure-response relationships for PM that have been established on the basis of adverse health effects from short-term exposures relate to changes in the health effects associated with variability in 24-hour average concentrations of PM_{2.5} in urban air. They do not relate to much shorter variations in PM_{2.5} exposure that may occur within a 24-hour period, where there may be exposures over a few minutes to higher levels of PM_{2.5}. No guidelines are currently available for assessing potential health effects that may occur as a result of exposures to particulates that may occur for minutes (or even an hour)
- Recent review (WHO, 2013b) of available studies in relation to short duration (less than 24 hour) exposures to particulates indicates the following:
 - Epidemiological and clinical studies have demonstrated that sub-daily exposures to elevated levels of PM can lead to adverse physiological changes in the respiratory and cardiovascular system, in particular exacerbation of existing disease. This is generally consistent with the outcome of studies reviewed and considered by the USEPA (USEPA, 2009a)
 - The studies available do not cover a range of exposure concentrations, nor do they adequately address other variables such as co-pollutants (gases) or repeated short-duration exposures
 - The studies have not determined if a one hour exposure would lead to a different response than a similar dose spread over 24 hours, or if an exposure-response can be determined
 - Exposures that occur during the use of various transportation methods (such as in-vehicles) have been found to contribute to and affect 24 hour personal exposures.

The urban epidemiology studies (on which exposure-response relationships are based and have been used in this assessment) utilise health data for adverse health effects from an urban population, where the urban population would have been exposed to ambient levels of PM (as measured by air monitoring stations) as well as fluctuations that occur throughout the day during various daily activities including in-vehicle exposures (and others such as cooking). These large urban studies have related health effects to regional ambient (urban) air concentrations. They have not measured daily (or longer term) personal exposures to PM, but such fluctuations would occur within the population exposed and would be expected to be accounted for within the health data considered in the epidemiology studies. Specific health effects from the short duration variations in particulate exposures throughout any specific day cannot be determined from these studies. It is important to consider if exposures to PM_{2.5} in the project tunnels would be consistent with other tunnels or in-vehicle exposures (during commuting in an urban environment), where the following can be considered:

- Exposure to PM within vehicles varies with the intensity of the traffic, the age of the vehicle the choice of ventilation used within the vehicle and the type of fuel used (Knibbs, de Dear & Morawska 2010). Levels of PM_{2.5} reported in vehicles in Europe (ETC, 2013) vary from 0.022 to 0.085 mg/m³ for passenger cars and 0.026 to 0.13 mg/m³ for bus travel
- Levels of PM_{2.5} that have been measured within cars while commuting in Sydney (where tunnel travel was not part of the study) range from 0.009 to 0.045 mg/m³ (NSW Health, 2004)
- Keeping windows closed and switching ventilation to recirculation has been shown to reduce exposures to particulates inside the vehicle by up to 80 per cent (NSW Health, 2003). While noting no guidelines are availability for very short duration exposures, this would further reduce exposure to motorists.

6.5 Carbon dioxide issues

To minimise exposures to NO₂ and particulates in tunnels, the above assessment has relied on Roads and Maritime providing advice to motorists using the proposed tunnels to wind up windows and place ventilation in recirculation. Health issues that may arise from such advice relate to the potential build-up of CO₂ inside the vehicle. An assessment of in-cabin levels of CO₂ and potential effects on the health and safety of drivers travelling through tunnels over varying distances and times, was completed by Roads and Maritime in 2017 (enRiskS, 2017). Based on this study for vehicles that may include between one and five occupants, travelling through tunnels for up to an hour, the levels of CO₂ were not expected to adversely affect driver safety.

Assessment of potential exposures that may occur for periods of time up to two hours, where ventilation is left on recirculation indicates that there may be levels of CO₂ inside a vehicle where there are one or more passengers that may affect an already fatigued driver.

It is noted that there is a general lack of guidance or regulations in terms of the design or use of ventilation systems in vehicles in Australia. There is also currently no advice to drivers on the suitable use of ventilation in various circumstances, to minimise the potential for effects on already fatigued drivers.

Where Roads and Maritime provides specific advice to drivers entering road tunnels to put ventilation on recirculation, EnRiskS (2017) recommended that further advice is provided that recirculation should be switched off at some point after using the tunnel network and not left on for an extended period of time.

6.6 Overall assessment

Concentrations of pollutants from vehicle emissions are higher within the tunnel (compared with outside the tunnel), and with the completion of a number of tunnel projects (approved or proposed) there is the potential for exposures to occur within a network of tunnels over varying periods of time, depending on the journey. The assessment of potential exposures inside these tunnels has indicated:

- Where windows are up and ventilation is on recirculation, exposure to NO₂ inside vehicles is expected to be below the current health based guidelines. In congested conditions inside the tunnels, it is not considered likely that significant adverse health effects would occur. Placing ventilation on recirculation is also expected to minimise exposures to particulates during travel through the tunnels
- For motorcyclists, where there is no opportunity to minimise exposures through the use of ventilation, there is the potential for higher levels of exposure to NO₂ and particulates. These exposures, under normal conditions, are not expected to result in adverse health effects. When the tunnels are congested it is expected that motorcyclists would spend less time in the tunnels than passenger vehicles and trucks, limiting the duration of exposure and the potential for adverse health effects
- For individuals who regularly use tunnels for commuting or as part of their employment there is the potential for repeated exposures to higher levels of NO₂ and particulates during the day. While these exposures are not likely to be additive, in terms of potential health effects, it is important that these road users utilise ventilation on recirculation whenever they are using the tunnels
- Where advice is provided to place ventilation on recirculation when using the tunnel or the proposed network of tunnels, it is not expected to result in CO₂ levels inside the vehicle that may adversely affect driver safety. However, where Roads and Maritime provides specific advice to drivers entering road tunnels to put ventilation on recirculation, it is recommended that further advice is provided that recirculation should be switched off at some point after using the tunnel network and not left on for an extended period of time.

7 Assessment of changes in noise and vibration on community health

7.1 General

A detailed assessment of noise and vibration impacts associated with the project is presented in the Technical working paper: Noise and vibration (Renzo Tonin & Associates, 2020).

The Technical working paper: Noise and vibration and the corresponding chapters of the environmental impact statement has been reviewed to determine if the predicted impacts have the potential to affect the health of the surrounding community, and if impacts are predicted, whether they can be effectively mitigated. The assessment of noise has considered impacts at a number of different receptors (termed noise receivers, or receivers within the Technical working paper: Noise and vibration).

The assessment of noise during construction and operations involved consideration of impacts at 89 noise catchment areas (NCAs) (NCA 1.1 to NCA 38.3) presented in Annexure I.

7.2 Existing noise environment

7.2.1 General

To carry out the noise assessment required for the project, the existing background noise quality needed to be assessed as the guidelines that relate to noise impacts from a specific project are based on levels allowable above background.

7.2.2 Ambient noise monitoring

Existing ambient noise was measured at 41 locations (refer to Annexure I for locations) between June 2017 and November 2017. Monitoring was carried out by a noise logger which measures the noise level over the sample period and then determines L_{A1} , L_{A10} , L_{A90} , L_{Amax} and L_{Aeq} levels of the noise environment. The A-weighting is a frequency filter applied to represent how the human ear hears sound. The L_{A1} , L_{A10} and L_{A90} levels are the levels exceeded for one per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} level is the maximum noise levels due to individual noise events. The L_{A90} level is taken as the background noise level also known as the rating background level (RBL).

7.2.3 Background noise levels

Based on the monitoring carried out, RBLs have been calculated for use in the noise assessment in accordance with the *NSW Noise Policy for Industry* (NPfI). The RBLs calculated relate to specific time periods, namely daytime, evening and night-time.

The RBLs were determined for the assessment of construction noise for different periods of the day: daytime, evening and night-time for Monday to Friday, Saturday and Sunday. The RBLs determined at each of the monitoring locations varied from 40 to 73 decibels (dB(A)) during the daytime, 37 to 71 dB(A) during the evening and 32 to 55 dB(A) during the night-time.

Background noise levels relevant for evaluating operational impacts involved the use of an energy averaged noise level (L_{Aeq}) that relates to exposures over the daytime (15 hours from 7.00 am to 10.00 pm) and night-time (nine hours from 10.00 pm to 7.00 am). During the daytime, L_{Aeq} 15-hour noise levels ranged from 60 to 79 dB(A). During the night-time, L_{Aeq} 9-hour noise levels ranged from 54 to 74 dB(A)).

7.3 Noise assessment criteria

7.3.1 General

The NSW EPA has prepared a number of guidance documents with regard to the types of noise that are considered in relation to construction and operation of the project. The *NSW NPfl* (NSW EPA, 2017), the *NSW Road Noise Policy* (RNP) (NSW DECCW, 2011), and the *Interim Construction Noise Guideline* (ICNG) (NSW DECC, 2009) are all relevant to the assessment of noise generated by this project. In all these policies, there is discussion of the need to balance the economic and social benefits of activities that may generate noise with the protection of the community from the adverse effects of noise. The noise assessment criteria adopted relate to levels of noise that can be tolerated or permitted above background before some adverse effect (annoyance, discomfort, sleep disturbance or complaints) occurs.

The *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) (CNVG) outlines Roads and Maritime's approach to assessing and mitigating construction noise. The *Noise Mitigation Guide* (Roads and Maritime, 2016) applies to the assessment and management of noise during operations. These guidelines are considered in addition to the other relevant policy and guidelines from the NSW EPA.

For the assessment of noise impacts from the project, a range of guidelines and criteria have been adopted for the assessment of:

- Construction – including ground-borne noise, vibration, blasting and underwater noise and vibration
- Operation – relevant to road noise and fixed facilities.

The following sections provide an overview of the guidelines adopted for each of these aspects. In particular, the basis for the guidelines and relevance to the protection of health and wellbeing is noted.

7.3.2 Construction noise management levels and sleep disturbance criteria

People are usually more tolerant to noise and vibration during the construction phase of projects than during normal operation. This response results from recognition that the construction emissions are of a temporary nature – especially if the most noise-intensive construction impacts occur during the less sensitive daytime period. For these reasons, acceptable noise and vibration levels are normally higher during construction than during operations.

Construction often requires the use of heavy machinery which can generate high noise and vibration levels at nearby buildings and receptors. For some equipment, there is limited opportunity to mitigate the noise and vibration levels in a cost-effective manner and so the potential impacts should be minimised by using feasible and reasonable management techniques.

At any particular location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receptors, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are carried out, and the character of the noise or vibration emissions.

The Technical working paper: Noise and vibration has considered construction noise impacts associated with construction activities for the project, proposed to occur from 2020 to 2026. There are some areas within the community where construction impacts from a number of road projects are proposed, with these works occurring over a longer period of time. Further discussion on issues related to these longer duration impacts, ie construction fatigue, are further addressed in the Section 9.7.

The ICNG has been adopted for the assessment of noise during construction works (NSW DECC 2009). These guidelines require that noise impacts from the project be predicted at sensitive receptors. These noise levels are then compared with the project specific assessment thresholds, referred to as noise management levels (NMLs), which are based on an increase above background levels. Where an exceedance occurs, the guidelines require that the proponent must apply all feasible

and reasonable work practices to minimise impacts. The NMLs are based on levels of noise above background that may result in reactions (or complaints) by the community. The levels are based on some reaction (noise affected) and a strong reaction (highly noise affected).

Levels of noise allowable outside standard work hours, particularly at night, are lower than those permitted during normal work hours. Where construction works are planned to extend over more than two consecutive nights, a sleep disturbance assessment is required to be carried out. The following has been considered based on the available information on the levels of noise that result in sleep disturbance:

- A maximum internal noise level below 50–55 dB(A) is considered unlikely to cause awakening
- One or two noise events per night, with a maximum internal noise level of 65–70 dB(A) are not likely to significantly affect health and wellbeing.

The project has considered that an open window provides up to 10 dB(A) attenuation of noise from outdoors to indoors. Buildings where windows are fixed or cannot otherwise be opened may achieve a greater noise level performance.

The NPfl sets trigger levels for when a detailed maximum noise level event assessment should be carried out for night-time noise. This is when the noise level exceeds:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus five dB, whichever is greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is greater.

For the assessment of sleep disturbance, a sleep disturbance criterion of $L_{Amax} \leq L_{A90(15min)} + 15 \text{ dB(A)}$ has been adopted.

The assessment of noise impacts during construction has been carried out based on 89 NCAs (assumed to have background noise levels consistent with the background noise monitoring location within each catchment area).

The ICNG does not provide direct reference to an appropriate criterion to assess the noise arising from construction traffic on public roads. However, it does refer to the *Road Noise Policy* which presents a discussion on assessing feasible and reasonable mitigation measures. In assessing feasible and reasonable mitigation measures, an increase of up to two dB(A) represents a minor impact that is considered barely perceptible to the average person. So, the noise goal applied to traffic movements on public roads generated during the construction phase of the project is an increase in existing road traffic noise levels of no more than two dB(A).

The potential for sleep disturbance should be assessed where construction would be carried out during the night-time period. The current approach to identifying potential sleep disturbance impacts is to predict maximum noise levels and assess against a screening criterion 15 dB(A) above the RBL during the night-time period (10.00 pm–7.00 am) as discussed above.

7.3.3 Ground-borne noise criteria

The CNVG provides residential NMLs for ground-borne noise, which are applicable when ground-borne noise levels are higher than the corresponding airborne construction noise levels such as might occur during tunnelling. The CNVG provides ground-borne noise levels at residences for evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home. The following ground-borne noise levels are applicable for residences:

- Evening 40 dB(A) L_{Aeq} (15 minute)
- Night-time 35 dB(A) L_{Aeq} (15 minute).

For commercial properties, an internal ground-borne noise level of 50–55 dB(A) as L_{Aeq} (15 minute) has been adopted to identify impacts, while for childcare centres, an internal ground-borne noise level of 40 dB(A) as L_{Aeq} (15 minute) has been adopted. For hospitals, classrooms and places of worship, an internal ground-borne noise level of 45 dB(A) as L_{Aeq} (15 minute) has been adopted.

These guidelines are applicable during tunnelling and other construction activities.

7.3.4 Vibration criteria

The effects of vibration on buildings can be divided into three main categories:

- **Human comfort:** Those in which the occupants or users of the building are inconvenienced or possibly disturbed. These guidelines are of most relevance to the assessment of community health. Intermittent vibration has been evaluated on the basis of the NSW EPA guideline *Assessing Vibration: A Technical Guideline* (NSW DEC, 2006), which is based on vibration dose values (VDV). The criteria for VDV are based on the potential for annoyance (based on the level of vibration over the assessment period). Guidelines for continuous and impulsive vibration are dependent on the time of day they occur and the activity taking place that could be affected
- **Building contents:** Those where the building contents may be affected. As people perceive floor vibration well before levels are likely to cause damage to building contents and structures, for most areas controlling vibration to manage human comfort would also address damage to building contents. No separate criteria are adopted to evaluate this aspect; however, the impact of vibration on sensitive equipment housed in the buildings has been considered, with vibration criterion set for computer, medical and scientific equipment
- **Structural damage:** Those in which the integrity of the building or the structure itself may be prejudiced (structural damage). Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure. The assessment of potential structural damage has been carried out in accordance with Australian Standard AS2187, British Standard BS 7385 and German Standard DIN 4150:Part 3-1999 (DIN, 1999). These guidelines include criteria relevant to addressing blasting activities. A lower criterion has been applied to heritage structures as a conservative assumption (as it assumes the structure is unsound). Where heritage items are above the screening criterion, further investigation is required on the structural integrity of the heritage item.

7.3.5 Underwater noise and vibration effect thresholds

In-water construction activities have the potential to generate underwater acoustic pressures sufficient to impact recreational water users, in particular swimmers and scuba divers. When evaluating potential impacts related to underwater noise, these differ based on the source type and frequency range. As a result, potential health and wellbeing issues related to pile driving activities that results in an impulsive noise waveform, and dredging that has a constant tone (or sweep) are expected to be different. There is limited research available regarding acceptable underwater sound pressure levels. However based on the information available, a precautionary guideline of 145 dB re 1µPa has been adopted for the assessment of potential underwater noise impacts.

Underwater hearing threshold has been estimated anywhere from 70 dB re 1µPa to 120 dB re 1µPa with dizziness, vertigo and auditory changes noted from 167 dB re 1µPa (Parvin, 2005).

7.3.6 Operational noise criteria

Operational noise impacts have been evaluated on the basis of the RNP, with additional guidance and criteria provided within Roads and Maritime's *Noise Criteria Guideline* (NCG) and *Noise Mitigation Guideline* (NMG) (NSW DECCW, 2011; NSW Roads and Maritime, 2015). The principles underlying the guidance documents are:

- Criteria are based on the road development type a residence is affected by due to the road project
- Adjacent and nearby residences should not have significantly different criteria for the same road
- Criteria for the surrounding road network are assessed where a road project generates an increase in traffic noise greater than two dB(A) on the surrounding road network
- Existing quiet areas are to be protected from excessive changes in amenity due to traffic noise.

The project consists of both new and redeveloped roads or road sections according to the definitions in the guidance documents and so both road types need to be considered in developing project-specific limits.

For residential areas, criteria are established for properties near either freeway/arterial/sub-arterial roads or local roads. These criteria relate to noise levels during the daytime (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am). Night-time noise criteria are aimed at minimising sleep disturbance. Criteria are also available to assessed noise exposures in other types of buildings, including schools, places of worship, open space, childcare, aged care and hospital facilities.

Operational traffic noise from the surrounding road network also required some consideration, with criteria (ie an increase by more than two dB(A)) established to determine if such impacts need to be considered further.

Guidelines are also available to evaluate maximum noise levels from roadways, such as those from individual vehicles or trucks (eg engine braking).

The assessment has evaluated noise from the operation of fixed facilities, namely the jet-fans within the tunnels, ventilation facilities, substations and water treatment plants. It is expected this would also be carried out during the detailed design phase of the project. Noise from these facilities would need to be assessed on the basis of criteria in the NPfI.

The current approach to assessing potential sleep disturbance is in accordance with the RNP (NSW DECCW 2011). The RNP provides a review of research into sleep disturbance. From the research to date, the RNP concludes that:

- Maximum internal noise levels of 50–55 dB(A) L_{AFmax} are unlikely to awaken people from sleep
- One or two events per night, with maximum internal noise levels of 65 to 70 dB(A) L_{AFmax} , are not likely to affect health and wellbeing significantly.

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB(A) lower than external noise levels. Based on a worst case minimum attenuation, with windows open, the first conclusion above suggests that short term external noises of 60 dB(A) to 65 dB(A) are unlikely to cause awakening reactions. The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dB(A) to 80 dB(A) L_{AFmax} are not likely to affect health and wellbeing significantly.

7.4 Overview of noise and vibration assessment

7.4.1 Construction impacts

Construction noise

Construction noise modelling and assessment has been carried out in accordance with the applicable NSW legislation and guidelines. Noise mitigation has been recommended in accordance with these guidelines, taking into consideration current international practices, health impacts of noise and to protect vulnerable people.

Noise that may be generated during construction has been modelled based on the type of equipment to be used, where the equipment is to be used in relation to the community receptors, the hours of work, the duration of the activities carried out and the local terrain. The assessment is based on the proposed approach to construction of the project. Construction works and program would be refined during further design development and construction planning once a construction contractor has been appointed.

The assessment has considered a range of standard noise mitigation measures, ie those that would be a standard requirement for a range of construction activities. In some situations, impacts from construction noise and vibration may be unavoidable, particularly where works are carried out in close proximity to the community. Where this occurs the Roads and Maritime CNVG includes a range of additional mitigation measures to manage these impacts. These measures include actions to notify and provide warning to the community and/or to offer respite or alternate accommodation.

A reasonable worst case assessment has been applied within each noise catchment area in accordance with the CNVG, assuming reasonable and feasible mitigation measures are implemented. A typical or expected case has also been assessed for surface road works (eg works along the Warringah Freeway) to better reflect the actual construction noise levels from these activities.

The reasonable worst-case scenario is conservative because it assumed all equipment expected to be used at a given site would be operating simultaneously, at a worst case intensity, and with a worst case orientation during a 15-minute period. The reasonable worst case scenario would not typically occur and so actual construction noise levels are likely to be lower.

In reality, construction noise impacts vary greatly depending on the location of the construction activity within the works area, the distance between noise sources and the nearby receptors, the noise intensity of the activity and the time of day.

However, in both instances, for the reasonable worst case and typical construction scenarios, the noise intensive activities would change and vary over an individual day, evening or night time period.

For each area assessed, construction noise levels are assessed at the most affected façade of a receptor building, and noise levels presented in the assessment reflect the noise level for the receptor with the highest predicted noise level in each NCA. Noise levels would be less than those presented in the assessment where receptors are further away from the construction works or have increased shielding (ie from nearby tall buildings).

The noise modelling, which included the addition of all reasonable and feasible mitigation measures, identified noise impacts in excess of the criteria for standard and out of hours construction period (refer to Technical working paper: Noise and vibration for further detail).

The assessment has also addressed the impact of cumulative and consecutive construction works on noise from a number of different infrastructure projects. This is further discussed in Section 9.7.

Potential noise impacts from movement of construction vehicles

Potential increases in noise for sensitive receptors due to construction traffic has been assessed separately from the assessment of noise from other construction activities. Heavy vehicles involved in construction are expected to travel via existing major roadways with minimal use of local roads; however, exceedances above criteria have been identified at Berrys Bay and Cammeray Golf Course.

Ground-borne construction noise

Ground-borne noise occurs when works are being carried out under the ground surface or in some other fashion that results in the vibrations from noise moving through the ground rather than the air. This project involves tunnelling so many of the more significant noise activities would be present at depth (with a large proportion of the main tunnels at depths of 10 to greater than 50 metres), where activities are expected to occur 24 hours per day.

The modelling has addressed the worst case situation when the tunnelling is occurring immediately beneath a sensitive receptor. The tunnelling equipment would move at about 20 to 30 metres per week (on average) so ground-borne noise may be over night-time NMLs for up to three weeks. Ground-borne noise would consist of roadheader tunnelling which would occur 24 hours a day and rock hammer tunnelling which could be kept to standard work hours.

While the construction scenarios evaluated are subject to further design and construction planning, and are likely to change, assessment of noise impacts from the construction scenario evaluated identified the following:

- Up to 22 residential buildings could experience ground-borne noise levels between 35 and 40 dB(A) and one residential building could experience ground-borne noise levels above 40 dB(A). Evening and night-time ground-borne NMLs have the potential to be exceeded at these receivers. One sensitive receptor (theatre) also exceeds the applicable 40 dB(A) criterion for this receptor type
- For rock hammer tunnelling, a large number of residential receptor buildings have been identified as exceeding the night-time NML (above 35 dB(A) or the evening NML (above 40 dB(A), should this activity occur outside standard work hours. Two hundred and seventy-one residential receptor buildings have been identified as exceeding the daytime criteria, with 35 non-residential sensitive receptors that may be affected by ground-borne noise. Rock-hammering work would be programmed outside evening and night time periods to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Vibration impacts

A range of the equipment to be used during construction has the potential to cause unacceptable levels of vibration. Managing the potential for such vibration to actually cause discomfort or structural damage at sensitive receptor locations is based on ensuring suitable separation distances between the equipment and the receptor locations.

In summary, for construction scenarios evaluated (and is subject to further design and construction planning):

- Vibration levels from the roadheader would be below the vibration limit for human comfort at all receivers. For tunnelling using rock hammers, up to 258 receptor buildings would potentially be exposed to construction vibration levels above the human comfort criteria. For these receivers, standard and additional mitigation measures from the CNVG would be implemented, which may include notification and respite
- All buildings would be below the screening criterion for structural or cosmetic damage from tunnelling activity. Five heritage buildings would potentially exceed the vibration screening criterion for heritage buildings during rock breaking tunnelling. These buildings would be subject to further investigation
- Surface works would be required within minimum working distances from receptor buildings during significant vibration generating activities. As a result, a number of receptor buildings would be above the screening criterion for human comfort and/or cosmetic damage to structures.

Vibrational impacts have the ability to cause stress which can lead to health impacts (see Section 9.9). Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be managed.

Management of construction noise (including ground-borne and vibration impacts)

It is proposed to develop further mitigation and management measures specific to the sites of impact to address the impacts identified, as discussed in the Technical working paper: Noise and vibration (Section 6). The aim of these mitigation measures is to reduce noise and vibration to levels that comply with the management goals, which would then be protective of health. If it is not possible to achieve compliance with these goals, health impacts for the affected community are likely.

Actions proposed to limit the impact of noise and vibration, as outlined in detail Section 6.4 of Technical working paper: Noise and vibration, include:

- Early staged installation of noise mitigation measures for properties that have been identified as eligible for at-property treatment from operational noise impacts, where practical (see Section 7.4.2)
- Development and implementation of Construction Noise and Vibration Management Plans to manage these works. This plan would provide focus on the mitigation and management measures required outside standard construction hours in addition to standard mitigation and management measures
- Community consultation to inform the community of the most effective noise mitigation and management strategy that would suit nearby sensitive receivers during the detailed design process
- Scheduling highly intrusive noise activities, where reasonable and feasible, to standard construction hours to limit the number of highly affected receptors, and with consideration of respite periods
- Use of temporary acoustic screens for construction works generating moderately intrusive to highly intrusive noise levels. Temporary noise screens can provide 5–10 dB noise reduction
- Detailed construction programming to provide respite
- Development of a project specific out of hours work protocol, which classifies the works based on the level of impact and the triggers for respite as negotiated with the community
- The enactment of minimum vibration distances for sensitive receptors
- Monitoring to assess the effectiveness of mitigation measures.

Construction noise and vibration mitigation and management measures would be reviewed during detailed design, with consideration of cumulative and consecutive construction impacts during detailed design to reflect the contractor's preferred constructability approach. These would be detailed in site-specific construction noise and vibration impact statements.

Following the implementation of all reasonable and feasible mitigation measures, it is not always possible for the noise impacts to achieve the recommended management goals or vibration criteria for all impacted receptors. Where this is the case, additional mitigation measures such as alternative accommodation and respite periods, as outlined in the Technical working paper: Noise and vibration should be implemented to manage the noise and vibration impacts from the project.

Underwater impacts

Piling in Sydney Harbour would be carried out for the construction of Sydney Harbour south (WHT5) and Sydney Harbour north (WHT6) cofferdams. Piling would predominately consist of vibratory piling (in harbour sediments) and impact piling (through rock). Impact piling would generate higher potential impact compared to vibratory piling.

Sound pressure levels during the installation of piles and dredging would exceed the precautionary guideline of 145 dB re 1µPa (Jasco 2019). The various headlands and islands that are located near the construction noise source, such as Birchgrove, Ballast Point, Balls Head, Blues Point and Goat Island, are expected to reduce or block acoustic energy that would otherwise propagate through Sydney Harbour (Jasco, 2019). The exceedance of the precautionary guideline would depend on the proximity to construction activities, lessening as distance from construction activities increases. The distances of this exceedance would be better understood in the initial phases of works through monitoring. As detailed in the environmental impact statement, the piling program would be refined during further design development to consider reasonable and feasible program alternatives and appropriate environmental management measures to minimise underwater noise impacts.

For divers, a sudden increase in sound pressure levels can potentially startle (when the sound is unannounced), cause discomfort, and with increasing sound pressure can cause dizziness and vertigo. Some startled divers subject to excessive sound pressure levels can potentially place themselves in a life-threatening situation.

It is therefore important that a hierarchy of risk management measures are implemented for divers and recreational swimmers within the area where exceedances of the precautionary guideline of 145 dB re 1µPa.

To proactively minimise potential noise impact, management measures and a proactive communication strategy would be informed by:

- Final construction methodologies and mitigation measures for piling activities, as refined during detailed construction planning
- Monitoring during piling activities to validate the predicted underwater acoustic thresholds and management areas, and to further adapt management measures (as required). This includes monitoring program with an initial trial of piling with corresponding communication measures to validate the predicted underwater acoustic thresholds and management areas. The monitoring results and management areas would be peer-reviewed prior to implementation to ensure they are appropriately protective of health
- Management measures according to the type of works occurring and the extent to which exceedances of the precautionary guideline are predicted (the management zone). Management measures would be reviewed and, if required, amended over the piling program to reflect monitoring outcomes.

The communication tools and management measures that would be contemplated within the management zone include:

- Coordination of piling programs with the planned activities of key recreational stakeholders to minimise interaction with planned or peak activity periods of these stakeholders, where feasible and reasonable

- Communication of the piling program and management area so that recreational users know when the piling, dredging and other noise generating activities would be taking place, what they can expect, and the zones to minimise the possibility of being startled from a sudden increase in sound pressure underwater
- Direct communication with key local recreational stakeholders during the piling and dredging program to provide up-to-date scheduling
- Use of advertisements, signage, letter box drops and project updates to communicate the implementation of a management area during the works. This could include floating markers or signage on approach to the construction work
- Surveillance within the areas in which the precautionary guideline level is exceeded to proactively monitor users prior to and during relevant activities that could pose a risk to recreational users.

7.4.2 Operational impacts

Assessment of operational noise impacts has been carried out by modelling noise that would be associated with the project. The assessment evaluated impacts on the community on side of the main project road alignment as well as the community adjacent to a number of collector roads, sub-arterial and arterial roads associated with City West Link, Warringah Freeway and Pacific Highway.

The noise modelling has been carried out to address impacts associated with the project in 2027 and 2037, including a cumulative scenario. The modelling has evaluated noise impacts at the façade of all buildings, including on all floors of multi-storey buildings. An assessment was carried out to determine how well the model estimated noise impacts based on a current scenario. The modelled and measured results were found to be within acceptable tolerances, which are +/- 2 dB(A).

The assessment of operational noise impacts considered the following:

- 'Do minimum' (ie without the project): the noise assessment considered the existing road alignment with existing noise barriers and features within the road corridor evaluated, and traffic demands predicted without the project
- 'Do something' (ie with the project) and 'Do something cumulative (ie with the project and other major road projects): the noise assessment considered the proposed design of the project, traffic demands predicted with the project, as well as other major road projects. The assessment has been initially carried out with consideration of existing noise barriers and the reference design pavement for all new sections, which is then used to inform options for additional noise mitigation.

The additional noise mitigation measures considered in the assessment include:

- Quieter pavement surfaces
- New or increased height noise barriers (where four or more properties are identified that are close together). Such measures are capable of achieving the following:
 - 5 dB(A) reduction at representative receptors for barrier heights of up to five metres
 - 10 dB(A) reduction at representative receptors for barrier heights above five metres and up to eight metres.

There are some properties where the requirements for barriers cannot be met, in which case at-property treatment of individual receptors or homes would be considered. At-property treatment would be considered where residual impacts remain after all feasible and reasonable measures have been exhausted. Such measures depend on the age and condition of the property. In general, architectural treatments should aim to reduce noise levels in habitable rooms by 10 dB(A).

The noise modelling identified that:

- A significant number of receptors would have decreased noise levels due to the project (around 57 per cent in the 'Do something 2037' scenario). In the 'Do something cumulative 2037' scenario, 60 per cent of receptor buildings would experience reductions in road traffic noise

- The Warringah Freeway Upgrade is predicted to reduce traffic noise levels at a significant number of receptor buildings (average around 75 per cent), mainly due to the redistribution of traffic moving into the tunnels
- In the 'Do something 2037' scenario, around one per cent of receptor buildings within the NCAs are predicted to experience increases in traffic noise of more than 2 dB(A) due to the project. This remains unchanged where the cumulative impacts of traffic from the project and other major projects is considered ('Do something cumulative 2037')
- Around 429 and 481 receptor buildings would require additional noise mitigation under the 'Do something 2037' and 'Do something cumulative 2037' scenario respectively. Following consideration of low noise pavement and noise barriers, around 371 receptor buildings would remain eligible for consideration for at-property treatment.

For the majority of receptor buildings within the noise catchment areas, there is either a reduction or relatively minor change in traffic noise levels (less than 2 dB(A)) due to the project. As such, the requirement for additional noise mitigation is likely to be the result of the high existing road traffic noise levels in exceedance of the cumulative limit criterion or traffic noise levels being acute (day LAeq(15hour) \geq 65 dB(A) or night LAeq(9hour) \geq 60 dB(A)). These elevated noise levels would be present without the project and hence the implementation of noise mitigation would result in lower levels of noise experienced at these receptors (when compared with the no project scenario).

With some exceptions, the location of receptor buildings where changes in noise levels exceed 2 dB(A) are as follows:

- In the Rozelle Interchange study area (as defined in the Technical working paper: Noise and Vibration), at buildings along Johnston Street
- in the Warringah Freeway corridor at buildings in proximity to the freeway corridor, or buildings that overlook the freeway (eg multi-storey apartments) and are predicted to be above the noise criteria guideline level in the absence of the project.

Peak/maximum noise levels (L_{Amax}) may potentially increase in NCA3.3 to the west of The Crescent and the City West Link, NCA4.1 – 4.3 to the north of the City West Link and NCA23.1 to the east of the Warringah Freeway.

In relation to the fixed facilities, no noise exceedances are predicted to occur.

7.5 Health outcomes relevant to noise

7.5.1 General

Environmental noise has been identified (I-INCE, 2011; WHO, 2011, 2018) as a growing concern in urban areas because it has negative effects on quality of life and wellbeing and has the potential for causing harmful physiological health effects. With increasingly urbanised societies, impacts of noise on communities have the potential to increase over time.

Deciding on the most effective noise management options in a specific situation is not just a matter of defining noise control actions to achieve the lowest noise levels or meeting arbitrarily chosen criteria for exposure to noise. The goal should be designed to achieve the best available compromise between the benefits to society of reduced exposure to community noise versus the costs and technical feasibility of achieving the desired exposure levels given the project. On the one hand, there are the rights of the community to enjoy an acceptably quiet and healthy environment. On the other hand, there are the needs of the society for new or upgraded facilities, industries, roads, and recreation opportunities, all of which typically produce more community noise (I-INCE, 2011; WHO, 2011, 2018).

Sound is a natural phenomenon that only becomes noise when it has some undesirable effect on people or animals. Unlike chemical pollution, noise energy does not accumulate either in the body or in the environment, but it can have both short-term and long-term adverse effects on people. These health effects include (WHO, 1999, 2011, 2018):

- Sleep disturbance (sleep fragmentation that can affect psychomotor performance, memory consolidation, creativity, risk-taking behaviour and risk of accidents)

- Annoyance
- Cardiovascular health
- Hearing impairment and tinnitus
- Cognitive impairment (effects on reading and oral comprehension, short and long-term memory deficits, attention deficit).

Other effects for which evidence of health impacts exists, and are considered to be important, but for which the evidence is weaker, include:

- Effects on quality of life, well-being and mental health (usually in the form of exacerbation of existing issues for vulnerable populations rather than direct effects)
- Adverse birth outcomes (pre-term delivery, low birth weight and congenital abnormalities)
- Metabolic outcomes (type 2 diabetes and obesity).

Within a community, the severity of the health effects of exposure to noise and the number of people who may be affected are schematically illustrated in Figure 7-1.

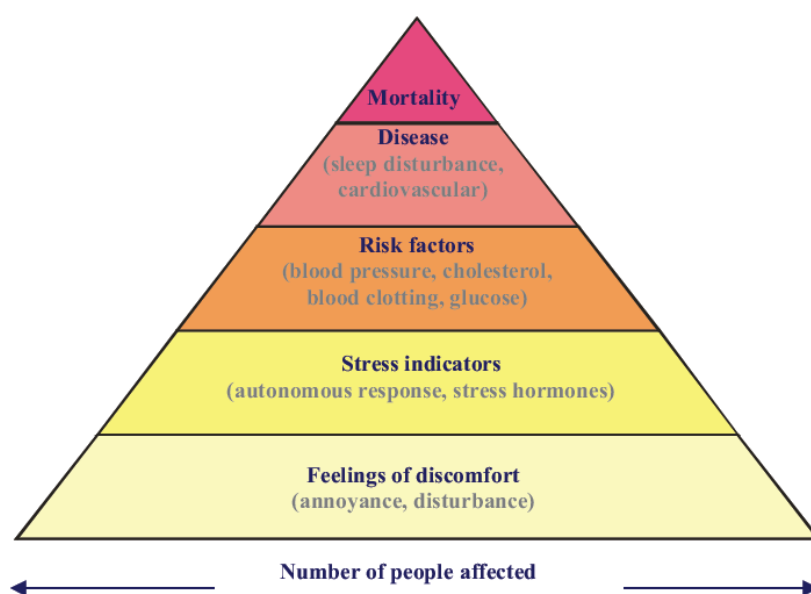


Figure 7-1 Schematic of severity of health effects of exposure to noise and the number of people affected (WHO, 2011)

Often, annoyance is the major consideration because it reflects the community's dislike of noise and their concerns about the full range of potential negative effects, and it affects the greatest number of people in the population (I-INCE, 2011; WHO, 2011, 2018).

There are many possible reasons for noise annoyance in different situations. Noise can interfere with speech communication or other desired activities. Noise can contribute to sleep disturbance which has the potential to lead to other long-term health effects. Sometimes noise is just perceived as being inappropriate in a particular setting without there being any objectively measurable effect at all. In this respect, the context in which sound becomes noise can be more important than the sound level itself (I-INCE, 2011; WHO, 2011, 2018).

Different individuals have different sensitivities to types of noise and this reflects differences in expectations and attitudes more than it reflects any differences in underlying auditory physiology. A noise level that is perceived as reasonable by one person in one context (eg in their kitchen when preparing a meal) may be considered completely unacceptable by that same person in another context (eg in their bedroom when they are trying to sleep). In this case the annoyance relates, in part, to the intrusion from the noise. Similarly, a noise level considered to be completely unacceptable by one person, may be of little consequence to another even if they are in the same room. In this

case, the annoyance depends almost entirely on the personal preferences, lifestyles and attitudes of the listeners concerned (I-INCE, 2011; WHO, 2011, 2018).

Perceptible vibration (eg from construction activities) also has the potential to cause annoyance or sleep disturbance and so adverse health outcomes in the same way as airborne noise. However, the health evidence available relates to occupational exposures or the use of vibration in medical treatments. No data is available to evaluate health effects associated with community exposures to perceptible vibrations (I-INCE, 2011; WHO, 2011, 2018).

It is against this background that an assessment of potential noise impacts of the project on health was carried out.

Any assessment of noise impacts needs to consider the relevant criteria established for a new or existing (or upgraded) facility or activity. Where there are impacts in excess of these guidelines, an assessment of noise mitigation is required to be carried out.

7.5.2 Health impacts from traffic noise

Road traffic noise is caused by the combination of rolling noise (noise from tyres on the roadway) and propulsion noise (from engine, exhaust and transmission).

A number of large international studies are available that have specifically evaluated health impacts associated with exposure to road traffic noise. Where exposure to road traffic noise is associated with, or can be shown to be causal to, adverse health effects, an exposure-response relationship is often established. The main health effects that have been studied in these types of investigations in relation to road traffic noise are annoyance, sleep disturbance, cardiovascular disease, stroke and memory/concentration (cognitive) effects. The most recent review of noise and impacts on health, presented by the WHO (2018) included a detailed review of the available literature, including impacts specifically related to road noise.

These are further discussed below.

Cardiovascular effects

There is substantial evidence that hypertension and more importantly blood pressure measurements are an independent risk for cardiovascular disease. Cardiovascular diseases are the class of diseases that involve the heart or blood vessels, both arteries and veins. These diseases can be separated by end target organ and health outcomes. Strokes reflecting cerebrovascular events and ischaemic heart disease (IHD) or coronary heart disease (CHD) are the most common representation of cardiovascular disease.

A link between noise and hypertension is relatively well established in the relevant literature. Whilst there is no consensus on the precise causal link between the two, there are a number of credible hypotheses. A leading hypothesis is that exposure to noise could lead to triggering of the nervous system (autonomic) and endocrine system which may lead to increases in blood pressure, changes in heart rate, and the release of stress hormones. Depending on the level of exposure to excess noise, the duration of the exposure and certain attributes of the person exposed, this can cause an imbalance in the person's normal state (including blood pressure and heart rate), which may make a person hypertensive (consistently increased blood pressure) which can then lead to other cardiovascular diseases (DEFRA, 2014). This hypothesis is illustrated in Figure 7-2.

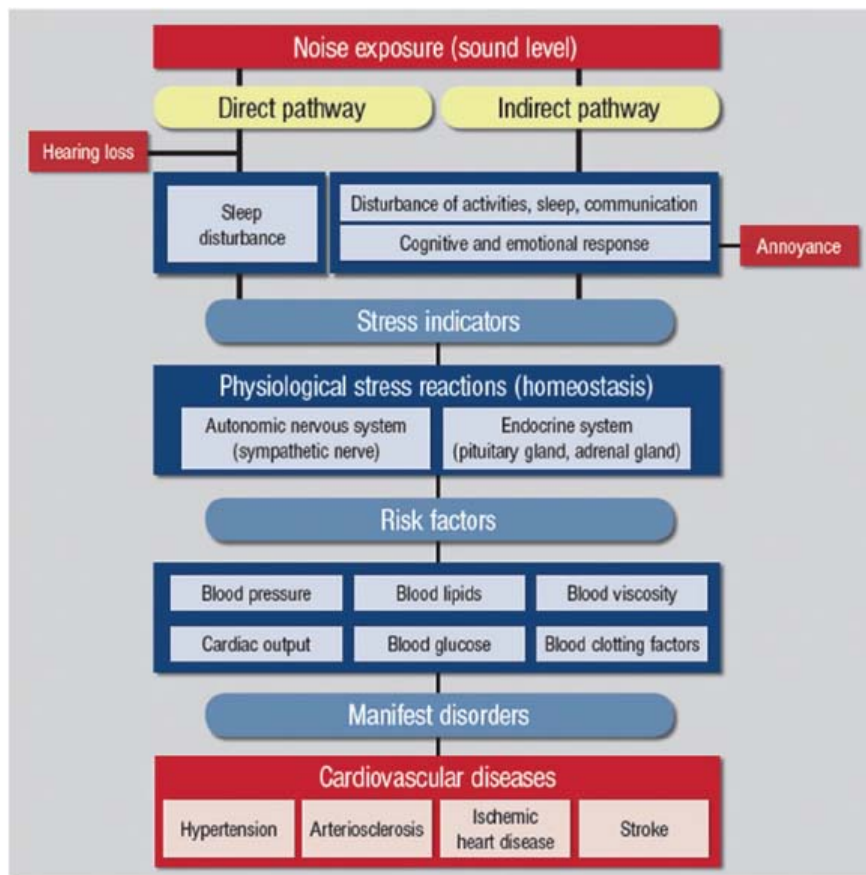


Figure 7-2 Noise reaction model/hypothesis (Babisch, 2014)

The available studies regarding road traffic noise and cardiovascular disease risk largely involve meta-analysis (ie statistical analysis that combines the results of multiple scientific studies). A number of studies have been published by Babisch (Babisch, 2002, 2006, 2008, 2014; van Kempen & Babisch, 2012) and others (WHO, 2018) have provided the basis for a number of exposure-response relationships adopted for the assessment of cardiovascular health effects associated with road-traffic noise.

In relation to hypertension the most relevant recent study (van Kempen & Babisch, 2012) involved analysis of 27 studies between 1970 and 2010, where a relationship between road traffic noise and hypertension was determined. This relates to the incidence of hypertension in the population and has been adopted by the European Commission for the assessment of health impacts of road noise in Europe (EEA, 2014). Review by the WHO (2018) considered that the available studies on the incidence of hypertension and road noise provided evidence that was rated very low quality. The relationship recommended by the WHO relates to a non-statistically significant outcome in relation to hypertension. On this basis the relationship as adopted by the European Commission (EEA, 2014) has been used in this assessment.

For the assessment of IHD, the WHO (WHO, 2018) has carried out a meta-analysis of three cohort studies and four case-control studies that investigated a relationship between road noise and the incidence of IHD. The meta-analysis involved 67,224 participants (from 7033 cases). The relationship established by the WHO, which is specific to road noise, has been adopted in this assessment. The relationship established was considered to be based on high quality evidence.

Review of the incidence of stroke and road noise by the WHO (2018) determined that the available cohort studies and cross-sectional studies showed mixed outcomes, with the evidence rated very low to moderate quality. In relation to the risk of stroke from exposure to noise, there are limited meta-analysis type studies available and the studies available combine the risks from noise from road and air transport. A more specific study that just investigated the link between road traffic noise and

cardiovascular disease/mortality has been carried out in London (Halonen et al. 2015). This was a large epidemiological study that identified statistically significant associations between road traffic noise (as modelled to residential dwellings) and hospital admissions for stroke and all-cause mortality. The relationships identified related to exposure to day and evening noise as $L_{Aeq,16h}$. The study corrected for confounders such as $PM_{2.5}$ and NO_2 exposures and has been considered suitable for use in this assessment. The relative risk identified for hospital admissions for stroke is equivalent to that identified from a meta-analysis of air and road noise (Houthuijs et al. 2014).

The relationships determined in the above studies relate to noise exposures in excess of a threshold. The threshold for where these effects are of significance are generally equal to or above the noise criteria adopted for the assessment of operational noise impacts. It is noted, however that in areas already affected by noise at levels above these thresholds, the guidelines relate to an increase in noise attributed to the project, with a guideline of 2 dB(A) adopted. Where an increase in noise by 2 dB occurred in a noise environment above the threshold for effects, this change in noise would not be associated with unacceptable cardiovascular risks (where the above exposure-response relationships were considered). In areas where existing or predicted total noise levels (as L_{den}) are 55 dB(A) and higher, an increase of 5 dB(A) would result in an increase in mortality risks (all causes, all ages) that would be considered unacceptable.

Annoyance and sleep disturbance

Changes in annoyance and sleep disturbance associated with noise are considered to be pathways for the key health indicators listed above. However, these issues are of importance to the local community and so it is relevant to consider the changes in levels of annoyance and sleep disturbance as a result of noise from the operation of the project within the community.

Annoyance

Annoyance is a feeling of displeasure associated with any agent or condition known or believed by an individual or group to adversely affect them. Annoyance following exposure to prolonged high levels of environmental noise may also result in a variety of other negative emotions, for example feelings of anger, depression, helplessness, anxiety and exhaustion (EEA, 2014).

Annoyance levels can be reliably measured by means of an International Organisation for Standardization/Technical Standard (ISO/TS) 15666:2003 defined questionnaire, which has enabled the identification of relationships between annoyance and noise sources. The European Commission (EC, 2002) conducted a review of the available data and provided recommendations on relationships that define the percentage of persons annoyed (%A) and the percentage of persons highly annoyed (%HA) to total levels of noise reported as L_{DEN} (ie average noise levels during the day, evening and night). These relationships have also been reviewed by the WHO (2018), where the key outcome of %HA was considered most appropriate for determining actions and outcomes in relation to road noise. Hence this assessment has focused on %HA.

It is noted that the published studies that evaluate noise annoyance and define the %HA have been conducted at different times, using different questionnaires and hence the relationships determined from these studies tend to vary. This makes quantification of noise annoyance impacts challenging.

The available noise guidelines have been developed to address noise annoyance within the community. At most receptor locations, the change in noise exposure as a result of the project is a reduction. However where noise levels are predicted to increase by 2 dB(A), this has the potential to result in a small increase in individuals highly annoyed by noise. The increase in noise annoyance is not considered to be significant.

Where an increase in noise of 5 dB(A) is considered (consistent with the increase in noise identified in the discussion above that may be associated with unacceptable increases in mortality), this would result in an increase in the number of individuals that may be considered highly annoyed by noise. While noting the challenges in quantifying the %HA by noise, where the noise-response relationship developed from a systematic review of studies specific to road noise (Guski, Schreckenberg &

Schuemmer, 2017) is adopted for environments where noise levels are in the range 45 and 75 dB(A) (as L_{den})¹², increases in noise less than 5 dB(A) would not be considered to result in a significant increase in the %HA.

Sleep disturbance

It is relatively well established that night time noise exposure can have an impact on sleep (WHO, 2009, 2011). Noise can cause difficulty in falling asleep, awakening and alterations to the depth of sleep, especially a reduction in the proportion of healthy rapid eye movement sleep. Other primary physiological effects induced by noise during sleep can include increased blood pressure, increased heart rate, vasoconstriction, changes in respiration and increased body movements (WHO, 2011). Exposure to night-time noise also may induce secondary effects, or so-called after effects. These are effects that can be measured the day following exposure, while the individual is awake, and include increased fatigue, depression and reduced performance.

Studies are available that have evaluated awakening by noise, increased mortality (ie increase in body movements during sleep), self-reported chronic sleep disturbances and medication use (EC, 2004). The most easily measurable outcome indicator is self-reported sleep disturbance, where there are a number of epidemiological studies available. From these studies the WHO (WHO, 2009, 2011, 2018) identified an exposure response relationship that relates to the percentage of persons sleep disturbed (%SD) and highly sleep disturbed (%HSD) to total levels of noise reported as L_{night} (ie average noise levels during night, which is an 8-hour time period, as measured outdoors). The relationship adopted relates to the assessment of road-traffic noise, with other relationships for air and rail traffic noise. These relationships have been adopted by the WHO (2009, 2011), UK and European Environment Agency (DEFRA, 2014; EEA, 2010, 2014). Review by the WHO (2018), considered that the key outcome of %HSD was considered most appropriate for determining actions and outcomes in relation to road noise. Hence this assessment has focused on %HSD.

For night time noise levels between 45 and 65 dB(A), increases in noise levels at night time of 5, 10, 15 and 20 dB(A) may result in an approximate 3, 7, 12 and 18 per cent increase respectively in individuals who are highly sleep disturbed.

The available noise guidelines include criteria to address sleep disturbance that are based on the above studies and relationships. Hence compliance with these guidelines would address health impacts associated with sleep disturbance in the community.

Cognitive effects

There is evidence for effects of noise on cognitive performance in children such as lower reading performance (WHO, 2011). A major study was carried out in the EU – RANCH – and this study was reviewed in WHO (2011).

The study found an exposure response relationship between noise and cognitive performance in children for aircraft noise but the relationship between performance and noise for road traffic was much less clear (Stansfeld et al. 2005a; Stansfeld et al. 2005b; WHO, 2011, 2018). WHO (2011) used the aircraft noise relationships to assess the impact of noise on children's cognitive performance. For this project, it was not considered appropriate to use the relationships based on the impacts of aircraft noise. The same study showed that road traffic alone did not show an association between road traffic noise and adverse changes in children's cognitive functions studied (reading comprehension, episodic memory, working memory, prospective memory or sustained attention), nor with sustained attention, self-reported health, or mental health.

Individual road noise events

It is noted that noise impacts can also occur because of individual noise events, such as engine braking or loud exhausts. The noise measures adopted above for the assessment of the health

¹² The relationship adopted from Guski et al (2017) is relevant to flatter landscapes (ie with alpine and Asian studies excluded, which include significant terrain features)

effects of noise relate to an average/equivalent sound level over different time periods, which, when measured, would include individual noise events. This is the preferred approach for evaluating annoyance and other health effects related to noise (NSW DECCW, 2011). Individual noise events are of most significance in relation to the assessment of sleep disturbance. The available research indicates that one or two individual noise events per night, with a maximum indoor noise level of 65-70 dB(A) are not likely to affect health and wellbeing (NSW DECCW, 2011). Criteria have been adopted to address maximum noise events, however it is noted that it is not possible to model all individual noise events as these relate to individual vehicles or trucks and individual driving behaviour that cannot be predicted.

7.6 Assessment of noise related health impacts from the project

In relation to this project, potential noise impacts have been assessed against Australian (more specifically NSW) criteria that have been established on the basis of the relationship between noise and health impacts. The criteria developed for use in the assessment for control of noise come from policy documents developed by the NSW Government including the Noise Policy for Industry (NPfI) (EPA, 2017), the NSW Interim Construction Noise Policy, and the RNP (NSW DECC, 2009; NSW DECCW, 2011; NSW EPA, 2000). All of these policies are based on the health effects of noise outlined in the reviews published by the following organisations:

- World Health Organization – *Environmental Noise Guidelines for the European Region* (WHO, 2018)
- World Health Organization – *Guidelines on Community Noise – Health effects of noise* (WHO, 1999)
- World Health Organization – *Night Noise Guidelines for Europe* (WHO, 2009)
- International Institute of Noise Control Engineering – *Guidelines for Community Noise Impact Assessment and Mitigation* (I-INCE, 2011)
- Environmental Health Council of Australia – *The health effects of environmental noise – other than hearing loss* (enHealth, 2004).

Various attempts have been made to assess the effect (measured by average reported annoyance, sleep disturbance or a similar type of effect) from community noise (measured by long term average sound levels) to develop exposure-response relationships. As individual reactions to noise are so varied, these studies need large sample sizes to obtain reasonable correlation between the noise exposure and the response. Any dose-response relationship determined from large studies over a range of communities and cultures would not necessarily represent the reaction of individuals or small communities. These exposure-response relationships are of value for macro-scale (ie whole urban environment scale) strategic assessment purposes where individual differences are not important; however, they are not as useful when considering potential impacts on a small population located close to a specific project/activity.

For a number of the noise guidelines (including the RNP), the criteria have been established on the basis of noise annoyance, which is considered to be the more sensitive effect and an effect that is assumed to precede the physiological effects. As a result, these guidelines are designed to be protective of all adverse health effects. Other guidelines are based on specific sensitive health effects such as sleep disturbance for the assessment of night-time noise.

As guidelines/criteria that are based on the protection of health are available to assess construction and operational noise impacts associated with this project, the assessment of potential health impacts has focused on whether the guidelines/criteria established can be met. Where the guidelines cannot be met then there is the potential for the above adverse health effects to occur in the community adjacent to the project.

In most cases, when developing management limits for the project, it has been assumed that there is a 10 dB(A) difference between noise inside and outside of a building with windows open. This assumption is sourced from the RNP. Further consideration of this assumption raises a number of issues including:

- Internal noise levels are defined in the RNP as those measured in the centre of a habitable room so if activities (like sleeping or concentrating) happen at the edge of a room they may be more impacted by noise than might be expected
- The RNP refers to windows being open sufficient to provide adequate ventilation as discussed in the Building Code of Australia. The Building Code of Australia does not require that residential buildings have significant levels of ventilation and, as a result, opening a window sufficient to provide the minimum ventilation required is unlikely to mean that the window is completely open or even that more than one window in a room is opened. Sufficient ventilation may result from the existing drafts in a building (with no windows open) or the opening of two windows only for the entire building. Assuming that the 10 dB(A) change in noise applies for all situations where windows are open is not appropriate
- Consequently, the use of this assumption in setting noise management limits for this project may need to be reviewed when designing property specific noise mitigation measures (to be carried out in consultation with the property owner).

Construction noise

A significant number of residential receptor buildings are predicted to experience noise levels above the noise management levels where mitigation measures beyond those as detailed in Chapter 6 (Construction works) of the environmental impact statement (eg acoustic sheds) has not been considered. This is particularly evident in NCAs in the vicinity of the Warringah Freeway, where works would occur adjacent to densely populated residential areas. The exceedances identified would occur only during noise intensive activities such as site establishment (eg demolition and vegetation clearing and grubbing), bulk earthworks, excavation and impact piling, road sawing and concrete pours.

Maximum night time noise levels would be generated during truck arrival, unloading, and departure; rock-hammering, some dredging activities; and from air-brakes or metal-on-metal bangs during road tie-in, resurfacing works and oversized deliveries. In some instances, maximum noise levels at night are predicted to exceed noise management by more than 15dB(A) and therefore exceed the sleep disturbance screening level (refer to Section 7.3.2). Maximum noise levels at night are also predicted to exceed the awakening reaction levels at a number of receivers.

Long-term (ie over a year or more) noise increases of greater than 5 dB(A) have been associated with unacceptable mortality risks, along with an unacceptable increase in highly annoyed receptors. During construction the noise impacts may not occur over a long-term hence the potential for health impacts would be lower. Further an increase in 15 dB(A) has been associated with a 12 per cent increase in highly sleep disturbed receptors. For short-term impacts that may occur during construction, where noise levels increase by 15 dB(a) or more there is the potential for a larger number of residents to experience sleep disturbance.

In reality, exceedances of the noise management level and the number of impacted residential receptor buildings would vary over the duration of construction given:

- Construction noise levels are assessed at the most affected façade of a receptor building, and noise levels presented in the assessment reflect the noise level for the receptor building with the highest predicted noise level in each NCA. Predicted noise levels would be less than those presented in the assessment where receptors are further away from the construction works or have increased shielding (ie from nearby tall buildings)
- In practice, not all plant would typically operate all the time and actual noise levels would be lower than predicted. Further, particularly highly noisy activities (eg piling) would be intermittent and may be subject to respite periods
- The assessment results present the highest noise level that could result over the entire stage (eg highest noise level during the demolition of a bridge) and does not show an individual 15-minute period. In reality, noise intensive activities would change and vary over an individual day, evening or night time period
- The predicted noise levels are only likely to occur when works are at the closest point to each receptor building. However, for many work areas, construction activities move around and so construction noise impacts may be lower than predicted

- Implementation of further mitigation and management measures, as identified in Section 6 of Technical working paper: Noise and vibration, would be essential to minimise health-related impacts due to construction activity.

A Construction Noise and Vibration Management Plan, and detailed Construction Noise and Vibration Statements, would be prepared during the detailed design to document how all feasible and reasonable mitigation measures would be considered and implemented (refer to Section 6 of Technical working paper: Noise and vibration), and periodic monitoring conducted to monitor the performance and effectiveness of these measures. This includes management approaches for works that would occur outside standard construction hours. Following the implementation of all reasonable and feasible mitigation measures, additional measures may need to be implemented to manage residual noise and vibration impacts (refer to Section 6.10 of Technical working paper: Noise and vibration), and to minimise potential health impacts.

Operational noise

The operational noise assessment identified a significant number of receptor buildings that exceed the NCG noise criteria level in the 'Do something 2037' and 'Do something cumulative 2037' scenarios. For the majority of these receptor buildings, exceedance of the noise criteria is a result of existing noise levels, rather than due to the project. For the majority of receptor buildings within the noise catchment areas, there is either a reduction or relatively minor change in traffic noise levels due to the project with around one per cent of receptor buildings experiencing increases greater than 2 dB(A) due to the project.

As such, any requirement for additional noise mitigation is likely to be the result of the high existing road traffic noise levels resulting in the exceedances of the cumulative limit criterion or traffic noise levels being acute (day $L_{Aeq}(15\text{hour}) \geq 65 \text{ dB(A)}$ or night $L_{Aeq}(9\text{hour}) \geq 60 \text{ dB(A)}$).

In areas where there is a reduction in traffic noise, there would be associated health benefits in these communities.

Where noise impacts of 5 dB(A) and greater are considered, which has been identified in Section 7.5.2 as a level where there is the potential for elevated or unacceptable health impacts, the following should be noted:

- At Rozelle Interchange study area, no receiver building would experience an increase in noise due to the project of 5 dB(A) or more
- At Warringah Freeway, a total of six receiver buildings (for 2037 'Do something' scenario) and three receptor buildings (for 2037 'Do something cumulative' scenario) would experience an increase of 5dB(A) or more. These are immediately adjacent to the Warringah Freeway or are multi-storey building in proximity to the freeway corridor and these are properties where additional mitigation measures have been identified.

Following consideration of mitigation measures such as pavements and barriers, around 371 receiver buildings in the Warringah Freeway study area are eligible for consideration for at property treatment. For the Rozelle Interchange study area, the receivers identified for at-property treatment would be either mitigated under the M4-M5 Link's Minister's Conditions of Approval (Condition E87), or potential increase in traffic noise is more than 2 dB(A) due to multiple projects and mitigation measures would be confirmed during further design development.

For most properties the implementation of mitigation measures as detailed in Section 6 of Technical working paper: Noise and vibration (including at-property treatment) would reduce overall noise impacts from existing noise which triggered the need for mitigation, as well as project related noise. The outcome is expected to be an overall improvement in noise levels within the community (compared with the existing situation) and some potential for improvements in community health.

At-property noise mitigation measures are typically used to minimise residual impact after reasonable and feasible at-source and path controls have been exhausted. However, at-property treatments can be considered the primary method for minimising road traffic noise impact in the following circumstances:

- In areas with low density of properties eligible for consideration of noise mitigation
- Where noise barriers are ineffective (eg. where eligible properties are located above the first floor within a multi-storey building)
- Where other forms of noise mitigation measures have been shown not to be reasonable and feasible
- Where the applicable noise criterion is assessed in an indoor environment.

The objective of architectural treatment of properties is to provide effective relief from excessive noise when windows and doors are kept closed. The overall goal of at-property noise mitigation is to achieve similar indoor acoustic amenity to those experienced in an indoor environment where the external noise criteria have been met. In most instances, assuming brick construction and standard glazing, having windows and doors closed when the external noise criterion is met equates to internal noise levels that are consistent with the best practice design goal set out in the Australian Standard AS 2107 and NSW Government's Guideline for new developments next to busy roads. The extent of noise mitigation required depends on how much the road traffic noise criterion is exceeded by at each affected dwelling.

From a health perspective, where at-property treatment is required to minimise noise exposures (in excess of relevant guidelines), the following should be considered:

- Where specific individuals do not take up the recommended at-property treatments, there is the potential for road traffic noise to result in adverse health effects including increased levels of noise annoyance and sleep disturbance
- The implementation of at-property treatments may impact on individual use of outdoor space, where available on an individual property. This is not an issue for residential units, however where at-property treatments relate to low-medium density residential homes, this may impact on use of outdoor areas. Impacts on the use and enjoyment of outdoor areas due to increased noise may result in increased levels of stress at individual properties.

Overall, the number of properties where increases in noise at levels that may be of concern to health as a result of the project is minimal (three to six properties). Where noise mitigation measures proposed are implemented, no significant health impacts are expected for these properties. For the majority of the community road noise impacts would be reduced as a result of the project, resulting in some health benefits.

8 Public safety and contamination

8.1 General

This section provides a review of the potential risks posed to public safety, associated with the project. This section also presents a review of health impacts associated with the presence and management of contamination (in soil or water) relevant to the project.

This section only addresses risks to the community, ie risks that only have the potential to adversely affect the community. Issues relevant to workplace health and safety during construction (including contamination remediation) and operation have not been further discussed or addressed.

Evaluation of public safety has considered the hazard and risk assessment, presented in Chapter 21 (Hazards and risk) of the environmental impact statement. This assessment was carried out having regard to State Environmental Planning Policy No.33 – Hazardous and Offensive Developments (SEPP 33) and identified and addressed risks during construction and operation. Pedestrian safety aspects are addressed in detail in the traffic and transport assessment (Technical working paper: Traffic and transport). Issues from these assessments specifically relevant to public health and safety have been further detailed in this section.

Health impacts associated with contamination have been assessed on the basis of Technical working paper: Contamination (Jacobs, 2020b).

Health impacts associated with subsidence have been assessed on the basis of Chapter 16 (Geology, soils and groundwater) of the environmental impact statement.

8.2 Public safety

8.2.1 Construction

A range of potential hazards have been identified that have the potential to affect public safety during construction. These are outlined in Table 8-1, along with discussion on the risks that may be posed by these hazards. Not all the hazards identified in the hazard and risk assessment have been included in the table, only those where there is the potential for risks to public safety.

On the basis of the information provided in Table 8-1 there are no issues related to construction that have the potential to result in significant safety risks to the community.

Table 8-1 Overview of public safety hazards and risks: Construction

Hazard: Public safety	Risk to public safety	Management measures
Storage and handling of dangerous goods on construction sites that may impact on the off-site community	Low The storage would comply with screening thresholds prescribed under SEPP 33.	All materials would be stored in accordance with the Australian Dangerous Goods Code of Practice, including the use of bunding, ventilation of areas where gases are stored, locating stores of these materials away from sensitive areas, and maintaining a register and inventory.
Transport of dangerous goods and hazardous substances on public roads within the community	Low The quantities and frequency of transport for these chemicals is low and within prescribed thresholds.	All materials are to be transported in accordance with relevant standards, codes and practices.
Ground movement including subsidence, that may affect community areas overlying the tunnel	Low, based on the summary provided in Chapter 23 (Hazards and risks) of the environmental impact statement and evaluation of maximum impact of subsidence as 'slight' and 'very slight' in Chapter 16 (Geology, soils and groundwater) of the environmental impact statement.	Geotechnical investigations have been carried out to develop certainty around the ground conditions where construction would occur. Primary support for the project tunnels would be installed as the excavation progresses. Building/structure condition surveys would be carried out as applicable prior to commencement of construction. Any impacts from settlement caused by the project would be rectified to the condition prior to construction works.
Acid sulfate soils, that may result in acidification and the mobilisation of metals, adversely impacting groundwater that can then migrate off-site	Low	Acid sulfate management measures would be developed to mitigate the potential risks associated with the disturbance of acid sulfate soils.

Hazard: Public safety	Risk to public safety	Management measures
Contamination, specifically the presence of hazardous materials and works in areas where contamination is present in soil, which may result in contaminants migrating off-site and affecting the community	Low	<p>Potentially contaminated areas directly affected by the project would be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the <i>Contaminated Land Management Act 1997</i>.</p> <p>This includes, but is not limited to, further investigations in potential areas of environment interest in the project footprint. If contamination posing a risk to human or ecological receptors is identified, a Remediation Action Plan will be prepared.</p>
Interactions between maritime traffic and tunnel infrastructure	Low	Maritime traffic restrictions would be put in place to ensure vessels do not interact with construction activities.
Damage to underground utilities, affecting roadways and services provided to the community	Low	A Utilities Management Strategy has been prepared for the project that identifies management options, including relocation or adjustment of the utilities. This would include consultation with utilities and service infrastructure providers to mitigate the risk of unplanned or unexpected disturbance of utilities.
Bushfire or fire risks that may spread off-site and affect neighbouring properties	Low	The bushfire risk assessment concluded that all areas of the project are considered to have a bushfire risk level of 'low'.
Aviation risks, specifically works that may affect the safety of aircraft using Sydney Airport	Low	The Civil Aviation Safety Authority (CASA) stipulates requirements for the construction and operation of new infrastructure that has the potential to influence aviation safety. These requirements are in place to minimise aviation risks.

Hazard: Public safety	Risk to public safety	Management measures
Traffic and trucks on surface roads and the potential for changes in public safety	Low	The implementation of traffic management measures would assist in managing potential safety impacts. Possible measures would include limiting heavy vehicle access near schools and child care centres during drop-off and pick-up times, or during community events that attract large numbers of visitors. Ongoing consultation and communication with managers and users of community facilities about haulage activities and potential safety risks would also assist in managing potential impacts. The implementation of education and awareness programs for construction workers and transport operators about potential road safety impacts would also help to ensure safety for children and local communities.
Pedestrian and cycle safety	Low Construction and surface road works may require temporary detours for pedestrians and cyclists.	Alternative safe pedestrian and cycle access would be provided where it is practical and safe to do so.

8.2.2 Operation

A range of potential hazards have been identified that have the potential to affect public safety during the operation of the project, principally in relation to traffic accidents. These are outlined in Table 8-2, along with discussion on the risks that may be posed by these hazards. Not all the hazards identified in the hazards and risk assessment have been included in the table, only those where there is the potential for risks to public safety.

On the basis of the information provided in Table 8-2 there are no issues related to the operation of the project that have the potential to result in significant safety risks to the community.

Table 8-2 Overview of public safety hazards and risks: Operation

Hazard: Public safety	Risk to public safety	Management measures
Storage, handling and transport of dangerous goods required for maintenance of the project, that may impact on the off-site community	<p>Low</p> <p>The storages are minor, with limited and infrequent transport of these materials required.</p>	All materials would be stored and transported in accordance with the relevant legislation and codes.
Transport of dangerous goods and hazardous substances in project tunnels	<p>Low</p> <p>The transport of these materials would be prohibited within the tunnels (as per Road Rules 2014, 300-2 NSW rule: carriage of dangerous goods in prohibited areas).</p>	Signage would be provided near tunnel entry portals advising of the restrictions to ensure compliance.
Traffic accidents (including pedestrian and cycle safety)	<p>Low to moderate (however the risk is considered to be reduced with the project).</p> <p>All use of public roadways carries an inherent risk of vehicle collision.</p> <p>The project has been designed to minimise these risks for travel within the tunnels.</p>	<p>The project design incorporates all feasible and reasonable traffic safety measures including in relation to geometry, pavement, lighting and signage, pedestrian and cyclist facilities, consistent with current Australian Standards, road design guidelines and industry best practice. The project has been designed to meet appropriate fire and life safety requirements in the tunnel.</p> <p>A reduction of four crashes per year is estimated.</p> <p>The project would involve a reduction in traffic demand on some roadways, which has the potential to reduce crash rates, and improve pedestrian and cyclist safety.</p>

Hazard: Public safety	Risk to public safety	Management measures
Interactions between maritime traffic and tunnel infrastructure	Low	<p>The project has been designed so that the existing depth in the main channel would be maintained to provide sufficient clearance for all harbour traffic in Sydney Harbour.</p> <p>The immersed tube tunnels would be placed in a dredged trench on the bed of Sydney Harbour and then backfilled with a combination of locking fill and rock armour to secure the tunnel on the bed of the harbour and protect the tunnel from impact loading. The immersed tube tunnel units would be designed to protect against falling and dragging anchors, sinking vessels and high currents and/or propeller wash.</p>
Subsidence	Low, based on the evaluation of maximum impact of subsidence as 'slight' and 'very slight' in Chapter 16 of the environmental impact statement (Geology, soils and groundwater).	Building/structure condition surveys would be carried out as applicable prior to commencement of construction. Any impacts from settlement caused by the project would be rectified to the condition prior to construction works.
Aviation risks	Low	The project design has considered airspace protection and associated risk and hazards. This has included an assessment of plume rise. Design of lighting and the ventilation facilities to ensure they meet the safety requirements set by the Department of Infrastructure, Transport, Cities and Regional Development and CASA would be carried out at the detailed design phase.

8.3 Contamination and groundwater

Contamination risk issues to the community are more relevant to the construction phase of the project because exposure to contaminated soil, sediment or groundwater would most likely occur during the excavation and construction phase, if not appropriately managed. The interaction with contamination and the community during the operations phase is primarily related to spills and accidents associated with the completed motorway. The Technical working paper: Contamination has considered the location of the construction activities in relation to known areas of contamination in soil, sediment and groundwater, as well as issues associated with the impact of construction on the environment, where the community may be exposed.

8.3.1 Construction

In relation to construction works, the following areas of contamination have been identified (Figure 8-1), and ranked as posing a medium or high risk¹³:

- Rozelle Railyards (W1) – High risk. Potential underground storage tanks and infilling materials
- Easton Park Rozelle (W2) – Moderate risk. Infilled land
- Yurublin Park, Birchgrove (W3) – Moderate risk. Slag and ash fill material
- Birchgrove Peninsula and Park (W4) – Moderate risk. Slag and ash fill material
- Sydney Harbour (W5) – High risk. Contamination of sediments due to urban/industrial/maritime land uses
- Wharf, Balls Head Road (W6) – Moderate risk. Commercial/ industrial maritime land use
- Former bulk fuel storage, Balls Head Road (W7) – Moderate risk. Fuel tanks
- Waverton Park, Woolcott Road, Waverton (W8) – High risk. Infill land
- Warringah Freeway (W9 – W18). High to moderate risk. Deposition of vehicle particulates and infill land
- Balmain (W19). Moderate risk. Leaks and spills from underground storage infrastructure
- Factories/warehouses, Waltham Street, Artarmon (W20). Moderate risk. Commercial/ industrial land use.

¹³ The level of risk depends on the likelihood of contamination being present and the potential vertical and lateral contamination distribution range.

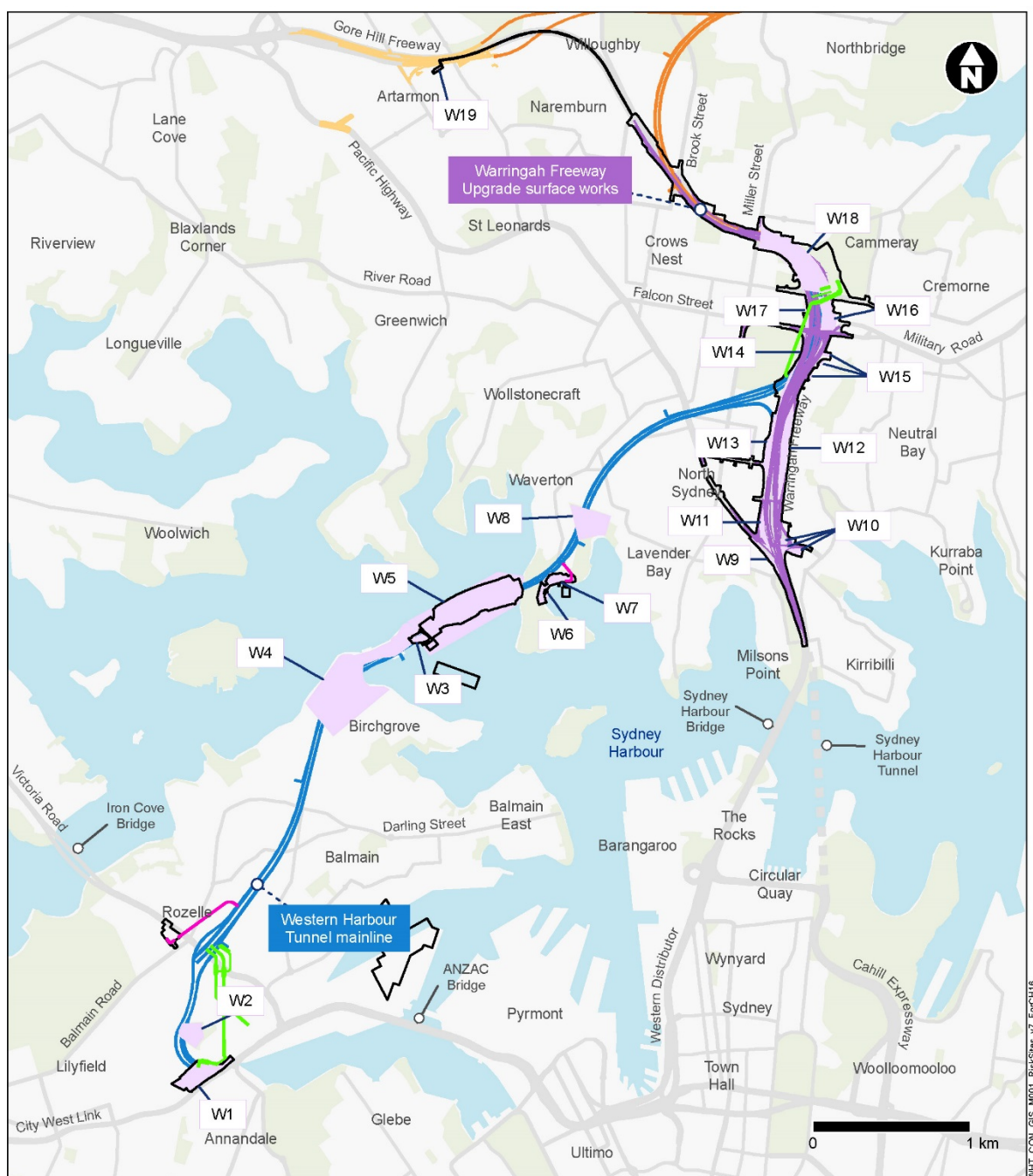


Figure 8-1 Areas of environmental interest with assigned moderate to high exposure risk rankings

The Technical working paper: Contamination outlines the potential areas of contamination and recommends further investigations be carried out in these areas (where appropriate) to determine the extent of contamination. Should significant contamination be identified measures including the development of appropriate Remediation Action Plans are suggested.

For the situation where there is the discovery of previously unidentified contaminated material, this would be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime, 2013) and detailed in the Construction Environmental Management Plan (CEMP).

During tunnelling works, groundwater would be extracted, collected, treated and discharged. Temporary wastewater treatment plants would be set up at Rozelle Rail Yards (WHT1), Victoria Road (WHT2), Yurublin Point (WHT4), Berrys Bay (WHT7) and Cammeray Golf course (WHT10) construction support sites. Temporary wastewater treatment plants would be designed so that discharges would not worsen water quality in the receiving waterways. The surface water receiving bodies in the vicinity of the project that have the potential to be impacted if discharges from wastewater treatment plants is not effectively addressed include Rozelle Bay, Sydney Harbour and Willoughby Creek.

Where existing groundwater contamination is identified within and/or adjacent to the operational areas of the project, appropriate engineering controls would be installed to either remove the risk of contaminated groundwater ingress into below ground structures (namely tunnels) or manage the risk to receptors via appropriate treatment prior to disposal or reuse. Groundwater inflows would be treated at the Rozelle operational wastewater treatment plant, which would be designed to treat key indicators of concern to a level that is consistent with the ANZECC/ARMCANZ (2000) water quality guidelines and the NHMRC (2008) recreational water quality guidelines. Meeting these objectives would require contaminant levels to be sufficiently low that they do not affect the health of the community using these waterways for recreation.

Harbour sediments

For harbour sediments, sediment sampling was carried out within the Sydney Harbour crossing and at the proposed locations for the White Bay (WHT3) and Berrys Bay (WHT7) construction support sites (Douglas Partners and Golder Associates, 2017; Jacobs, 2020b).

The results of the sediment sampling indicated that selected contaminants were generally detected above available guideline criteria (ANZG, 2018; Commonwealth of Australia, 2009; NEPC, 1999 amended 2013c) in samples collected from between zero and one metre below the surface of the sediment. This included metals (arsenic, copper, mercury, lead, silver and zinc), PAHs, total recoverable hydrocarbons (TRH), organochlorine pesticides (OCPs) and tributyltin.

Minor detections of selected contaminants above guideline levels were detected in samples collected from depths of about 1.5 metres.

While the guidelines noted above relate to the protection of the environment (marine waters), these guidelines would also be protective of human health where recreational exposures may occur in the vicinity of the works.

The nominated guidelines (detailed above) do not include criteria for PFAS and dioxins. PFAS (Perfluorooctanoic acid - PFOA, Perfluorooctane sulfonic acid - PFOS, Perfluorohexane sulfonic acid - PFHxS and Perfluorobutanoic acid - PFBA) and dioxins were detected above laboratory levels of reporting in sediment samples collected for Western Harbour Tunnel. Dioxins were detected above laboratory levels of reporting in sediment samples collected from White Bay (PFAS analysis was not carried out on White Bay sediment samples). PFAS and dioxin analysis was not carried out on sediment samples collected from Berrys Bay.

Where sediments require excavation and removal to facilitate construction, there are several potential options for the disposal of sediments. These include:

- Offshore disposal – A permit for offshore disposal of suitable dredged material has been submitted to the Commonwealth Department of the Environment and Energy. The appropriateness of offshore disposal would need to be assessed in accordance with the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009)
- Landfill disposal – Sediments requiring disposal to landfill would be assessed in accordance with the *Waste Classification Guidelines* (NSW EPA, 2014). Landfill disposal is likely to be appropriate for both clean and contaminated sediments.

The dredging methodology aims to manage potential exposure risks due to the presence of contaminants in the harbour sediments. This includes the use of the following when excavating and removing material that is unsuitable for offshore disposal:

- A backhoe dredge (BHD) with a clamshell (closed bucket) attachment working in conjunction with hopper barges (with no overflow). This method would significantly reduce the loss of sediments into the water column
- Silt curtains.

The dredging technique would minimise the risk of sediment and contaminants within the sediments being mobilised into the water during dredging. This control in conjunction with the behaviour of sediment bound contaminants, means it is unlikely that water quality would be significantly impacted by contaminants mobilised from dredging and marine construction activities (Cardno, 2020).

Sediment plume modelling based on the above dredging methodology is documented in the Technical working paper: Hydrodynamics and dredge plume modelling (Royal HaskoningDHV, 2020) indicates that:

- The majority of the sediment deposition due to the dredging activity occurs within and next to the dredging footprint. The deposition is concentrated at the north-eastern end of the dredging footprint, within the north-eastern portion of the dredging footprint and along the shoreline next to the Coal Loader Wharf
- Lower levels of sedimentation also occur in Balls Head Bay and within the other embayments that line Sydney Harbour. This is expected given the lower tidal current speeds in these embayments (ie as demonstrated by the embayments being depositional environments).

Additional investigations would be required to determine the final extent (laterally and vertically) and separation of clean and contaminated sediments to facilitate disposal. Appropriate management measures would be developed to remove or suitably reduce the contamination risks from sediments during construction activities. Where sediments are disturbed as part of construction activities, sediment transport and distribution within the water column would need to be appropriately managed so as not to cause harm to benthic and marine ecosystems and/or adversely reduce water quality (to protect marine environments as well as human health).

Piling is proposed within the sediments of Sydney Harbour to facilitate construction of temporary wharf structures for the White Bay (WHT3), Yurulbin Point (WHT4) and Berrys Bay (WHT7) construction support sites. The Technical Report: Marine water quality (Cardno, 2020) indicated the following with respect to sediment mobilisation associated with piling activities:

“Construction activities (ie piling, construction of temporary wharf facilities and vessel movements) are likely to lead to mobilisation of bed sediments within shallower waters and formation of short lived localised plumes that disperse rapidly into the ambient waters. These activities and the plumes generated are likely to lead to elevated total suspended solids concentrations over small areas and for periods less than 10 minutes. These small plumes are unlikely to lead to any measurable effects”.

Where the proposed management measures are adopted it is expected that there would be negligible impacts to human health in the event that recreational exposures occur in areas surrounding the proposed works.

9 Assessment of changes in social aspects on community health

9.1 General

The WHO defines health as ‘a (dynamic) state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity’. Hence the assessment of health should include both the traditional/medical definition that focuses on illness and disease as well as the broader social definition that includes the general health and wellbeing of a population.

The assessment of changes in air quality and noise on the health of the local community (presented in Sections 5, 6 and 7) addressed key aspects that have the potential to directly affect health.

This section has more specifically evaluated changes in the community that have the potential to indirectly affect the health and wellbeing of the community. This section also provides a review of whether there are any impacts that are likely to be more significant in any section of the community, and if these areas may result in inequitable impacts on the health of the population. This may affect population groups that may be advantaged or disadvantaged based on age, gender, socioeconomic status, geographic location, cultural background, aboriginality, current health status or existing disability. The evaluation presented in this section provides a qualitative evaluation of potential health impacts on the community.

Within an urban environment there are a wide range of complex factors (acting and interacting at different scales) that can affect health and wellbeing. This is conceptualised in Figure 9-1 (presented by the International Council for Science and similar to that defined by the WHO) (ICSU, 2011), that also presents a summary of the outcomes of this assessment. The broad range of factors identified may result in either positive or negative impacts on health and wellbeing. It is noted that no single element or determinant acts in isolation. Health and wellbeing in the urban environment depends on the sum of the total interactions between many factors. It is within this complex model that changes associated with the project, as well as the other road projects, have been evaluated in relation to impacts on health and wellbeing.

The Technical working paper: Socio-economic assessment (Jacobs, 2020c) and Technical working paper: Traffic and transport provides details in relation to many of the social impacts associated with the project. Aspects that are specifically relevant to potential impacts on the health and wellbeing of the community, either positive or negative, have been further highlighted in this section.

9.2 Changes in traffic, access and connectivity

Roads and freeways can divide residential communities hindering social contact. The presence of busy roads inhibits residents from socialising and children from playing or accessing nearby recreational areas. Heavy traffic also affects child development (WHO, 2000c). Children learn how to make responsible decisions, how to behave in different situations and develop a relationship with their environment and community through independent mobility. Where children have the opportunity to be able to play in local streets or safely access local parks they have been found to have twice as many social contacts as those where such activities are prevented by heavy traffic or unsafe conditions (WHO, 2000c).

Social connectedness and relationships are important aspects of feeling safe and secure. Streets with heavy traffic have been associated with fewer neighbourhood social support networks and has been linked to adverse health outcomes (WHO 2000c). Any temporary and permanent changes to the access to social infrastructure, community resources or to other desirable locations (such as employment, study, friends and family) and safety to movement may affect community networks and in turn trigger community severance.

Community severance effects often occur during major transportation projects (during construction and operation) due to detours in the local road network, changes to active and public transport routes, and connector roads receiving an increase or decrease in traffic movements. The changes to the road networks highlighted in the ‘construction’ section may contribute to feelings of community severance and disconnection.

Construction

Potential impacts during construction include the area around Rozelle, Birchgrove, and areas in the vicinity of the Warringah Freeway.

During construction, potential short-term impacts on access and connectivity would generally result from:

- Temporary changes to road conditions near construction activities, including partial and full road closures, temporary diversions and access changes, removal of some on-street parking, and reductions in speed limits, resulting in delays and disruptions for motorists and other road users
- Increased construction traffic on roads within the study area, including heavy vehicles used to deliver materials and equipment and construction worker vehicles, potentially impacting on road safety for motorists, pedestrians and cyclists if not appropriately managed
- Potential disruptions to public transport services, including from the temporary closure of Birchgrove Wharf, and changes to road conditions and the temporary relocation of some bus stops near to construction works for safety, resulting in possible delays and disruptions for bus users and changes in bus access for some people
- Changes to pedestrian and cycle access near to construction works, resulting in possible disruptions
- Temporary changes to access to private properties near construction works, with suitable access arrangements implemented in consultation with affected property owners
- Relocation of around ten swing-moorings in the vicinity of the Berrys Bay construction support site (WHT7) to provide safe access to and from the site. Relocated moorings would be placed as close as possible to their original locations during construction and would be restored where possible to their original position on completion of the project.

A number of roads that would experience potential disruptions due to construction activity or would be used by construction traffic are also used to access social infrastructure, including schools, child care, churches, and open space, sport and recreation facilities. Construction traffic and access management measures would be prepared for each construction support site, detailing temporary road closures, parking arrangements and traffic control procedures.

Without the implementation of feasible and reasonable mitigation measures, an increase in construction traffic and heavy vehicles on these roads would impact the performance of some roads and road intersections particularly during morning and evening peak hours and may impact community perceptions about safety for users of these facilities. The potential impacts would be addressed through the implementation of management measures and through ongoing engagement with stakeholders (refer to Chapter 8 (Construction traffic and transport) in the environmental impact statement).

If unmitigated, these construction changes have the potential to result in increased levels of stress and anxiety in the local community (see Section 9.9). These impacts, however, are expected to occur during the period of construction only and the range of mitigation measures to reduce these impacts are provided in Chapter 8 (Construction traffic and transport) in the environmental impact statement.

Operation

The project would improve regional access and connectivity for motorists and other road users by providing an alternate crossing of Sydney Harbour. The project would improve travel times for road users on key corridors (such as the Western Distributor, Sydney Harbour Bridge, Sydney Harbour Tunnel and the Victoria Road corridor), improving traffic flow and journey times for buses, freight and other vehicles accessing key commercial and employment centres including the Sydney CBD and North Sydney. As detailed in Technical working paper: Traffic and transport, the greatest benefits would be for trips travelling between North Sydney and Rozelle. This trip is currently circuitous, requiring travel via the ANZAC Bridge, the Western Distributor and the Sydney Harbour Bridge. The project would allow the bypass of these three highly congested sections of motorway and reduce travel times by up to 75 per cent.

Localised traffic and transport impacts, including localised delays and increased traffic demands on some roads and intersections, may result from the operation of the project at either end of the project where it would integrate with the existing transport network. These localised delays would generally be offset by large travel time benefits provided by the project at the broader network level. The impacts of increase traffic demands and delays in the North Sydney area would be further minimised through the North Sydney Integrated Transport Program, which is being developed by Transport for NSW.

Traffic congestion and long commuting times can contribute to increased levels of stress and fatigue, more aggressive behaviour and increased traffic and accident risks on residential and local roads as drivers try to avoid congested areas (Hansson et al. 2011). Increased travel times reduce the available time to spend on healthy behaviours such as exercise or engage in social interactions with family and friends. Long commute times are also associated with sleep disturbance, low self-rated health and absence from work (Hansson et al. 2011). Reducing travel times and road congestion is expected to reduce these health impacts.

Public transport

Access to public transport is important, particularly for people who cannot or are unable to drive (such as the elderly and those with disabilities). Lack of good access to public transport for these individuals can result in increased feelings of isolation, helplessness and dependence.

During construction of the project:

- Potential delays and disruptions of bus services on the wider road network is expected. Changes to local bus services near to construction works would also occur, including the possible temporary relocation of some bus stops located close to the construction footprint. Delays or short-term changes in local routes and bus priority infrastructure may also be required due to temporary road closures. This may result in minor travel time increases. Early and ongoing engagement with bus operators and bus users about changes to local bus routes and bus stops would be carried out during construction. This would assist in managing potential impacts on commuters
- Construction of the project would require around seven closures of Sydney Harbour to maritime traffic between Birchgrove and Berrys Bay for a period of about 48 hours. Ferry services would be impacted during the closure of Sydney Harbour, with passengers travelling via the F3 Parramatta River line and F8 Cockatoo Island line required to use replacement bus or alternate services. Recreational marine traffic would also not be able to use this section of Sydney Harbour during the closure
- The temporary closure of the existing Birchgrove Ferry Wharf for a period of about 48 month may require people to use alternative modes (eg bus) or to access ferry services such as the Balmain Ferry Wharf, which is located about two kilometres from Birchgrove Ferry Wharf. This may require some passengers to walk further distances to access alternative modes of transport. Opportunities to relocate the Birchgrove Ferry Wharf would be investigated.

From a public transport network perspective, the project, once complete, is expected to generally improve bus services currently operating on the Sydney Harbour Bridge through reduced congestion and increased reliability during peak periods. However, some bus travel times are forecast to be maintained or would increase as a result of the project, particularly through Miller Street and Berry Street, North Sydney and northbound along Victoria Road at Rozelle. These localised delays would generally be offset by large travel time benefits provided by the project at the broader network level. The project itself would facilitate the operation of express buses that would provide direct access between major centres on the Lower North Shore and Inner West

Pedestrian and cycle access

Walking and cycling have many health benefits including maintaining a healthy weight and improved mental status (Hansson et al. 2011; Lindström, 2008; Wen & Rissel, 2008; WHO, 2000c).

There is currently a network of cycle paths in the area, comprising a mix of separated off-road, dedicated cycleways and dedicated on-road, cycling lanes. During construction, temporary alterations and diversions to pedestrian and cyclist networks have the potential to affect commuter departure times, travel durations, movement patterns and accessibility. Construction and operation of the project

would result in changes to pedestrian and cycle access, including temporary and permanent closures or diversions of some pathways and pedestrian bridges. This includes:

- Temporary closure of shared user paths or dedicated bridges than span Warringah Freeway in the vicinity of Ernest Street, Falcon Street and Ridge Street
- Permanent closure of the shared user underpass on the eastern side of the Falcon Street Bridge. The new alternative route via Military Road would result in users having to travel an additional 380 metres, increasing their travel time. However, existing pedestrian and cyclist volumes at this underpass are low and the overall impacts of the closure are expected to be minor.

Temporary access arrangements would consider the needs of all pedestrians and cyclists, including children, the elderly and people with disability. Where suitable alternative access is not available nearby, early notification would be provided about changes to allow users of the cycle path to plan their trips.

While the opportunity to walk or cycle in the project area would be maintained, the alterations and changes to travel distances and amenity may detract from the experience, increase perceptions of safety risks and potentially deter people from enjoying an active lifestyle or feeling connected with their community. Hence it is important that the diversions and detours are safe and perceived by the community to be a safe and convenient alternative.

Once completed, the project would include a range of changes to the active transport network in the areas surrounding the Warringah Freeway (eg Ernest Street, Falcon Street, Bridge Street and High Street) (Technical working paper: Traffic and transport. New or replacement shared user paths and bridges would be provided at a number of locations, including High Street, Ernest Street and Ridge Street. Overall these changes are anticipated to result in improved transport links in the vicinity of the Warringah Freeway.

Improvements in the active transport network, including improvements in transport connections, would have a positive benefit on community health. Where active transport opportunities are improved and offer safe alternatives to driving and public transport, they can encourage more active recreation and commuting activities.

Impacts on health and emergency services

The existing arterial roads and the local road network are currently used by emergency services to travel to and from call-outs. Construction of the project may require temporary traffic diversions, road occupation, temporary road closures and alternative property access arrangements. Emergency vehicles would be provided either by an alternative detour route, or under traffic control as part of the site specific construction traffic and access management controls.

9.3 Property acquisitions

The project has been designed and developed to minimise the need for property acquisitions. Wherever possible, construction support sites have been located to minimise the overall property acquisition requirements, as well as impacts on sensitive areas. Of particular note are:

- At Warringah Freeway, the project has been designed along the existing road alignment as much as possible to avoid impacts to St Leonards Park
- At Cammeray Golf Course, the construction and operational footprint has been designed to enable the continued use of the site as a golf course during and following construction.

However, the project does require property acquisition as well as other temporary and permanent impacts on land use.

The acquisition and relocation of households and businesses due to property acquisition can disrupt social networks and affect health and wellbeing due to raised levels of stress and anxiety. This includes increased levels of stress and anxiety during the process of negotiating reasonable compensation. The purchase of and moving into a house can be one of the most significant events in a person's life. Both a house and a workplace are central to daily routine with the location of these premises influencing how a person may travel to/from work or study, the social infrastructure and businesses they visit and the people they interact with.

Impacts associated with property acquisition would be managed through a property acquisition support service that would provide the following:

- Affected households would have access to a counselling service that would assist people through the property acquisition process and, where necessary, provide referrals to more specialised experts
- A community relations support toll-free telephone line is to be established to respond to any community concerns or requests for translation services
- A property acquisition factsheet that outlines the process and provides further information for concerned residents is to be prepared and made available online and in hard copy at project information centres.

All acquisition required for the project would be carried out in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* and the *Land Acquisition Information Guide* (NSW Government, 2014). Relocation and some other categories of expenses would be claimable under this Act. Roads and Maritime has started consultation with affected property owners and will continue to engage with property owners and other affected stakeholders about specific property impacts, including the acquisition and compensation process.

9.4 Green space

Green space within urban areas includes green corridors (paths, rivers and canals), grassland, parks and gardens, outdoor sporting facilities, playing fields and children play areas. Epidemiological studies have been carried out that show a positive relationship between green space and health and wellbeing (de Vries et al. 2003; Health Scotland, 2008; Kendal et al. 2016; Maas et al. 2006; Mitchell & Popham, 2007). The outcomes of these international studies from the literature did depend on the quality of the available green space. They showed that green space areas in low socio-economic areas often had poor facilities, higher levels of graffiti, vacant/boarded up buildings and lower levels of safety. These studies showed that such spaces had few health benefits.

The health benefits of green space in urban areas include the following (Health Scotland, 2008; Kendal et al. 2016; Lee & Maheswaran, 2011):

- Green space areas that include large trees and shrubs can protect people from environmental exposures associated with air pollution, noise and extreme temperature (by regulating microclimates and reducing the urban heat island effect)
- Reduced morbidity
- Improved opportunities for physical activity and exercise. The benefits depend on a range of factors including the distance, ease of access, size of green space, location in relation to connectivity to residential or workplace areas, attractiveness, available facilities (particularly where used by specific sporting clubs) and multi-use (ie including children play areas, garden, seating, sporting facilities that can be used by a wide range of the community for different purposes)
- Improved mental health and feelings of wellbeing, particularly lower stress levels
- Improve opportunities for social interactions.

Green space areas in urban areas may also present some hazards, such as attracting antisocial behaviours (particularly in isolated areas), providing areas for drug or sexual activity and unintentional injuries from sports or use of playground equipment. It has also been found that individuals from ethnic or minority groups and those with disabilities are less frequent users of use green spaces areas.

There are a number of existing sporting/recreational facilities and parks in the project area that would be impacted by the project. These include sporting fields, parks and reserves, playgrounds. These impacts are summarised below:

- Temporary and permanent loss of a portion of land, including recreation land at Cammeray Golf Course – noting that the Western Harbour Tunnel and Beaches Link program of works has been designed to enable the golf course to remain operational during construction and operation. While the construction works may deter some from accessing and using this area during

construction, ensuring the golf course remains open during these works would enable active use to continue, minimising potential health impacts

- Temporary use of public open space areas for construction sites (for example, Yurulbin Park and St Leonards Park), resulting in the temporary loss of access to and use of land within the construction footprint. It is noted that alternate green space is available in the project area and are accessible by the community. Hence the potential for this temporary access to affect community health is minimal
- Reduced amenity due to construction activities and construction sites and changes in noise, dust and visual environment, detracting from the use and enjoyment for users of social infrastructure near the project. This may affect the desirability of active recreational use of some areas. Other recreational areas are available and accessible in the community, hence the potential impact on community health is considered to be minimal.

Table 9-1 provides a more specific summary of the open space areas impacted by construction and operation.

Table 9-1 Impacts to green space during construction and operation

Construction impacts to open space	Operational impacts to open space
Yurulbin Park and Birchgrove Wharf	
Yurulbin Park would be used to support the construction of the project, including excavation of access shaft and driven mainline tunnels, and tunnel fitout. The construction site would be required for about 4.5 years. Potential impacts on surrounding uses, including public transport access to the Birchgrove Wharf, associated with the use of the park for construction.	After construction, the project would not have any ongoing impacts on the use of Yurulbin Park and Birchgrove Wharf.
St Leonards Park	
Construction of the project would require the temporary use of land within St Leonards Park for a construction site and construction of the tunnel connection to the Warringah Freeway. The site would be required for about 18 months. This would result in the temporary loss of access to and use of land within the construction footprint, temporarily disrupting the use of this land for informal recreation. During construction, the presence of construction works and increased noise, dust and construction traffic would temporarily diminish amenity of nearby facilities and other areas of the park. In particular, amenity impacts may occur for users of the North Sydney Bowls Club, North Sydney Oval and Bon Andrews oval due to their proximity to construction works. Clearing of mature trees would be required along the Warringah Freeway for construction. The loss of these would temporarily impact on the landscape and visual amenity of the park until new trees or landscaping becomes established.	Kerb and footpath adjustment works would occur on Miller Street southbound around the intersection with Falcon Street as part of construction of the project. These works would provide a new dedicated lane for left turning traffic from Falcon Street westbound to Miller Street southbound. Further review of the impacts in this area are currently being carried out and permanent impacts to St Leonards Park would be minimised or, where possible, eliminated. However, should the project require the permanent acquisition of a small area of St Leonards Park to accommodate these upgrades to the Falcon Street/Miller Street intersection this is not expected to impact on the ongoing use or functioning of the park and facilities within the park.

Construction impacts to open space	Operational impacts to open space
Cammeray Golf Course	
<p>The impacted section of the golf course adjoins the Warringah Freeway corridor and Ernest Street. Construction and longer term operation of the Warringah Freeway motorway facilities would require reconfiguration of the course prior to construction. This would require changes to some holes on the golf course (for example, reducing the length of fairways) but would allow the course to remain operational during construction.</p> <p>During construction, increased noise, dust and construction traffic may impact on the amenity of the golf course for some users and may also deter some people from using the golf course during the construction phase.</p> <p>The continued use of parts of the site by the Beaches Link and Gore Hill Freeway connection project would delay the reinstatement of residual land to open space.</p>	<p>The project would occupy parts of the site as acquired to accommodate motorway facilities, an access road and car park areas. This would require the reconfiguration of the golf course to allow its ongoing use.</p> <p>The establishment of the operational facilities would change the visual setting of this location, when viewed from within the golf course and adjoining sporting facilities, and surrounding locations, including the Warringah Freeway and Ernest Street.</p> <p>Landscaping would be provided to reduce the visual impacts of these facilities when viewed from some locations.</p>
ANZAC Park	
<p>Construction of the project would require the temporary lease of land within ANZAC Park to support access for construction activities. This would result in the temporary loss of access to and use of land for informal recreation, although access would be maintained to other areas within the park for these activities. During construction, the presence of construction works and increased noise, dust and construction traffic would temporarily diminish amenity within areas of the park outside of the construction site.</p>	<p>After construction, the project is not expected to impact on the ongoing use or functioning of the park and facilities within the park.</p>
ANZAC Avenue Reserve	
<p>During construction, the presence of construction works, and increased noise, dust and construction traffic, associated with the Warringah Freeway Upgrade may temporarily diminish amenity within the reserve. This may detract from the use and enjoyment of the reserve for some users.</p>	<p>The project would require the permanent strip acquisition of a small area of ANZAC Avenue Reserve to accommodate the widening of the Warringah Freeway. This is not expected to impact on the ongoing use or functioning of the park and facilities within the park.</p>

Construction impacts to open space		Operational impacts to open space	
Merlin Street Reserve			
Merlin Street Reserve would be used as a construction site to support the Warringah Freeway Upgrade. Following construction, the reserve would be rehabilitated and reinstated and would be available for ongoing informal recreation uses. The use of the park for construction would result in the temporary loss of access to, and use of, open space within the construction footprint. This would temporarily disrupt the use of this land for informal recreation activities.		The project would permanently impact a strip of Merlin Street Reserve to accommodate the widening of the Warringah Freeway. This is not expected to impact on the ongoing use of the reserve.	
Rose Avenue Reserve			
During construction, increased noise, dust and construction traffic may impact on the amenity of the reserve for some users due to works for the Warringah Freeway Upgrade. This reserve has very limited recreational values and amenity of the reserve is currently impacted by traffic using the Warringah Freeway. Clearing of some existing vegetation within this reserve may be required during construction, potentially impacting on landscape and visual amenity from surrounding areas.		The project would permanently affect a strip of Rose Avenue Reserve to accommodate the widening of the Warringah Freeway. This is not expected to impact on the ongoing use of the reserve.	
Jeafreson Jackson Reserve			
During construction, increased noise, dust and construction traffic may impact on the amenity of the reserve for some users due to works for the Warringah Freeway Upgrade, including the demolition and replacement of the Falcon Street shared user bridge. The use of the park for construction would result in the temporary loss of access to, and use of, open space within the construction footprint and would temporarily disrupt the use of this land for informal recreation activities. Potential impacts associated with temporary disruption to access and connectivity during the demolition and reconstruction of this bridge. Clearing of some existing vegetation within this reserve may be required during construction, potentially impacting on landscape and visual amenity for park users and from surrounding areas.		After construction, the project is not expected to impact on the ongoing use of the reserve.	

9.5 Visual changes

Visual amenity can be described as the pleasantness of the view or outlook of an identified receptor or group of receptors (eg residences, recreational users). Visual amenity is an important part of an area's identity and offers a wide variety of benefits to the community in terms of quality of life, wellbeing and economic activity. For some individuals, changes in visual amenity can increase levels of stress and anxiety. These impacts, however, are typically of short duration as most people adapt to changes in the visual landscape, particularly within an already urbanised area. As a result, most changes in visual impacts are not expected to have a significant impact on the health of the community.

During construction, visual amenity throughout the project area has the potential to be affected by factors such as the removal of established vegetation, the installation of hoardings and/or the visual appearance of construction sites. In some areas, the acoustic sheds and hoardings required to manage noise impacts during construction are large and may cause overshadowing. Further factors may include the alteration of view corridors to heritage, open space, water bodies or the city skyline.

The operational project would include changes to local visual amenity due to the presence of new and amended infrastructure (including motorway facilities, ventilation outlets, water treatment plants, substations, bridges and drainage channels), landscaping and urban design features. Where long term visual impacts would be negative, mitigation measures including landscape screening would be utilised where feasible to reduce these impacts.

Visual impacts associated with the construction and operation of the project would vary depending on the nature of the changes to the environment and the sensitivity of the visual receivers. Design development has been influenced by urban design principles that have been established for the project including integrating the project elements and infrastructure into the surrounding environment. A detailed review and finalisation of architectural treatment of the project operational infrastructure would be carried out during further design development.

9.6 Equity

The health effects associated with impacts related to transport projects are not equally distributed across the community. Groups at higher risk, or more sensitive to impacts, include:

- Elderly
- Individuals with pre-existing health problems
- Infants and young children
- Individuals with disabilities
- Individuals who live in areas of higher levels of air or noise pollution.

Often the impacts can accumulate in the same areas, which may already have poorer socio-economic and health status, most commonly due to the affordability of housing in areas that are closer to main roads, industry or rail infrastructure. Disadvantaged urban areas are commonly characterised by high traffic volumes, higher levels of air and noise pollution, feelings of insecurity and lower levels of social interactions and physical activity in the community.

To further evaluate potential equity issues associated with the project, the location of impacts identified in relation to air quality, noise and traffic were reviewed individually and in combination, in conjunction with available information on the location of sensitive community groups.

In many urban areas housing prices are lower on main roadways. The median house prices in the study area are variable, however in most areas they are consistent with the Sydney average. Some public housing is located in the study area; however, these properties are mixed in with privately owned property such that there are no specific areas with higher populations of public housing tenants. Hence there are no social equity issues identified in relation to the change in air quality in the local community.

There are no areas identified in the local community where the combined impact from changes in noise and air quality would be different from the conclusions presented for the individual assessment of air quality and noise impacts.

No local government areas in the study area have been identified as disadvantaged, based on the 2016 Census Data – Socio-Economic Index for Australia (SEIFA). Therefore, no project related air quality or noise impacts have been identified as impacting a low socioeconomic local government area.

In relation to broader equity aspects the project, along with the WestConnex program of works (M4-M5 Link, M4 East and New M5), the projects are aimed at improving access to the area from outer lying areas in the west. The SEIFA for populations in the outer west are lower, indicating they are more disadvantaged, than populations in the study area. Improving access and travel times for these more disadvantaged populations provides the potential for health benefits such as those that are

derived from improved employment opportunities, decreased travel times (and potentially more time available for other active, family or community activities) and reduced levels of stress and anxiety.

9.7 Construction fatigue

Construction fatigue relates to receptors that experience construction impacts from a variety of projects over an extended period of time with few or no breaks between construction periods. Construction fatigue typically relates to traffic and access disruptions, noise and vibration, air quality, visual amenity and social impacts from projects that have overlapping construction phases or are back to back.

The assessment of construction fatigue in this report includes the following projects that may immediately precede or overlap with the timing of the construction of the project, or have been recently completed, comprising:

- M4-M5 Link
- Glebe Island Concrete Batching Plant and Aggregate Handling facility
- Glebe Island Multi-User Facility
- Sydney Metro City & Southwest (Chatswood to Sydenham) (including the White Bay truck marshalling yard)
- Sydney Metro West
- The New Sydney Fish Markets
- Projects within North Sydney (eg commercial developments)
- Beaches Link and Gore Hill Freeway Connection.

The area is also subject to ongoing urban development, with many of the LGAs in the study area projected to have significant population growth (refer to Section 3.4).

As outlined in Chapter 27 (Cumulative impacts) of the environmental impact statement, the areas of greatest potential for cumulative impacts in Rozelle and White Bay in the south, and in North Sydney and Cammeray in the north.

Based on the environmental impact assessments the project and for those projects listed above, potential impacts considered most likely to result in construction fatigue include construction traffic and parking, construction noise and vibration, visual and amenity impacts, and impacts to community perceptions of public health and safety.

These impacts are most likely to be generated by interactions between the project, the M4-M5 Link, projects in White Bay and Glebe Island, the Beaches Link and Gore Hill Freeway Connection project, Sydney Metro City & Southwest (Chatswood to Sydenham) project and Sydney Metro West.

Without mitigation, key cumulative impacts leading to construction fatigue would include temporary and prolonged increases in traffic volumes, decreased air quality, construction noise and vibration, decreased visual amenity and land use changes.

Where these impacts occur for extended periods of time, there is the potential that increased levels of stress and anxiety may also continue for extended periods of time. Health effects associated with stress and anxiety are further discussed in Section 9.9.

The design and construction methodology has been developed with consideration of these issues, and attempts to mitigate many of these issues where possible. The community consultation framework presented in Chapter 7 (Stakeholder and community engagement) and Appendix E (Community consultation framework) of the environmental impact statement has also been developed with consideration of complaint fatigue and includes procedures to proactively manage this issue where possible.

9.8 Economic aspects

The construction expenditure of the project would be of significant benefit to the economy. This expenditure would inject economic stimulus benefits into the local, regional and state economies. Ongoing or improved economic vitality is of significant health benefit to the community. Employment

opportunities would grow in the region through the potential increase in business customers and through the increase in demand for construction workers. The increase in demand for labour may increase wages in the region, particularly for construction workers, who would be in high demand.

It is noted that both positive and negative effects may occur for some businesses during construction activities. While construction activities may bring greater demand from construction workers, lack of access to businesses through reduced parking and physical barriers could impact on local economies. Specific consultation would be carried out with businesses potentially impacted during construction. Consultation would aim to identify specific potential construction impacts for individual businesses. Based on consultation with businesses that are potentially impacted, feasible and reasonable measures would be identified and implemented to minimise business impacts. This may include (but not be restricted to) measures to maintain pedestrian access, visibility and parking (Jacobs, 2020c).

During operation, the project would be beneficial for employee and customer access, servicing and delivery, and demand for services across most centres. Some centres would also benefit from improvements in passing trade, character and amenity and business visibility. Due to the reconfiguration of access points to some centres (eg Crows Nest) or increased traffic demands, some centres may experience a marginal decline in employee and customer access and passing trade. These effects are minor in comparison to the broader benefits across the region.

Freight and commercial vehicle movements are an important component of the economy. Numerous industries are dependent upon efficient transport to service operational requirements. Transport for NSW estimated that freight and logistics contributed \$66 billion to NSW State Gross Product (GSP) in 2011, this represented 13.8 per cent of NSW GSP at the time.

The project would provide substantial travel time savings for freight vehicles, improving their productivity and increasing the efficiency of the freight network, particularly for trips that currently use Sydney Harbour Bridge. Improvements in the efficiency and reliability of these transport networks would likely result in increased productivity, reduced costs and broader economic benefits for these workforces.

Road tolling

The implementation of road tolls can have direct impacts on the management of congestion, which has an impact on economic productivity, and social elements such as stress, time with family and friends, cost and environmental amenity such as reduced traffic emissions.

One impact is the potential to increase congestion volumes on surrounding roads as a result of toll avoidance. The use of a toll road can also increase the cost of living and can exacerbate social inequality. Specifically, the impact of roads tolls on households can be assessed as a function of household income, urban spatial structure, and available mobility choices. Depending on the travel routes of individuals, and the individual economic situation, there would be a proportion of the population that avoid the use of tollways due to affordability.

In July 2019, the NSW Government implemented a toll relief initiative to ease the cost of living for frequent NSW toll road users through the provision of half-priced or free vehicle registration.

9.9 Stress and anxiety issues

A number of changes within the community (discussed in Sections 9.2 to 9.8) have the potential to affect levels of stress and anxiety. Some changes may result in a lowering of feelings of stress and anxiety, and there are others that may result in higher levels within the community. In addition, construction fatigue (as discussed in Section 9.7) from the combined road tunnel projects, other infrastructure projects and ongoing urban developments associated with urban growth, may result in elevated levels of stress and anxiety for extended periods of time.

Chronic and persistent negative stress, or distress, can lead to many adverse health problems including physical illness and mental, emotional and social problems. Response to stress would vary between individuals with genetic inheritance and personal/environmental experiences of importance (Schneiderman, Ironson & Siegel, 2005).

An acute stressful event results in changes to the nervous, cardiovascular, endocrine and immune systems, more commonly known as the “fight or flight” response (Schneiderman, Ironson & Siegel, 2005). Unless there is an accident or other significant event, such acute stress events are not expected to be associated with construction or operation of the project.

For shorter-term events, stress causes the immune system to release hormones that trigger the production of white blood cells, that fight infection and other disease-fighting elements. This response is important for fighting injuries and acute illness. However, this activity within the body is not beneficial if it occurs for a long period of time. Hormones released during extended or chronic stress can inhibit the production of cytokines (the messengers that allow cells to talk together to fight infection) lowering the body’s ability to fight infections. This makes some individuals more susceptible to infections and may also experience more severe infections. It can also trigger a flare up of pre-existing autoimmune diseases (which are a range of diseases where the immune system gets confused and starts attacking healthy cells) (Mills, Reiss & Dombeck, 2008; Schneiderman, Ironson & Siegel, 2005).

Other physiological effects associated with chronic stress include (Brosschot, Gerin & Thayer, 2006; McEwen, Bruce S. 2008; McEwen, B. S. & Stellar, 1993; Mills, Reiss & Dombeck, 2008; Moreno-Villanueva & Bürkle, 2015):

- Digestive disorders, with hormones released in response to stress causing a number of people to experience stomach ache or diarrhoea, with appetite also affected in some individuals (resulting in under-eating or over-eating)
- Chronic activation of stress hormones can raise an individual's heart rate, cause chest pain and/or heart palpitations and increase blood pressure and blood lipid (fat) levels. Sustained high levels of cholesterol and other fatty substances can lead to atherosclerosis and other cardiovascular disease and sometimes a heart attack (Pimple et al. 2015; Seldenrijk et al. 2015)
- Cortisol levels, release at higher levels with stress, play a role in the accumulation of abdominal fat, which has been linked to a range of other health conditions
- Stress can cause muscles to contract or tighten, and cause tension aches and pains (Ortego et al. 2016).

Some individuals respond to elevated levels of stress by taking up or continuing unhealthy stress coping strategies such as smoking, drinking or overeating, all of which are associated with significant health risks. Chronic levels of stress have also been found to cause or exacerbate existing mental health issues, including mood disorders such as depression and anxiety, cognitive problems, personality changes and problem behaviours. It can also affect individuals with pre-existing bipolar disorders.

By-products of stress hormones can act as sedatives (chemical substances which cause us to become calm or fatigued). When such hormone by-products occur in large amounts (which would happen under conditions of chronic stress), they may contribute to a sustained feeling of low energy or depression. Habitual patterns of thought which influence appraisal and increase the likelihood that a person would experience stress as negative (such as low self-efficacy, or a conviction that you are incapable of managing stress) can also increase the likelihood that a person would become depressed. It is normal to experience a range of moods, both high and low, in everyday life. While some “down in the dumps” feelings are a part of life, sometimes, people fall into depressing feelings that persist and start interfering with their ability to complete daily activities, hold a job, and enjoy successful interpersonal relationships (Mills, Reiss & Dombeck, 2008; Schneiderman, Ironson & Siegel, 2005).

Some people who are stressed may show relatively mild outward signs of anxiety, such as fidgeting, biting their fingernails, tapping their feet, etc. In other people, chronic activation of stress hormones can contribute to severe feelings of anxiety (eg racing heartbeat, nausea, sweaty palms, etc.), feelings of helplessness and a sense of impending doom. Thought patterns that lead to stress (and depression, as described above) can also leave people vulnerable to intense anxiety feelings (Mills, Reiss & Dombeck, 2008).

Anxiety or dread feelings that persist for an extended period of time; which cause people to worry excessively about upcoming situations (or potential situations); which lead to avoidance; and cause people to have difficulty coping with everyday situations may be symptoms of one or more anxiety disorders (Mills, Reiss & Dombeck, 2008).

More generally, it must be noted that urbanisation, or increased urbanisation, regardless of specific projects has been found to affect levels of stress and mental health (Srivastava, 2009). These impacts are greater where there is urbanisation without improvements in infrastructure to improve equitable access to employment and social areas/communities (Srivastava, 2009).

The role of either acute or long-term environmental stress on the health of any community, in general and for specific project(s), including the project, cannot be quantified. There are a wide range of complex factors that influence health and wellbeing, specifically mental health. It is not possible to determine any specific outcomes that may occur as a result of a specific project, or number of projects. However, it is noted that within any urban environment there would be a wide range of stressors present from infrastructure projects as well as other urban developments that may or may not contribute to the health effects outlined above.

It is noted that the project along with the other approved road tunnel projects aim to improve infrastructure, connections and access within the urban environment. Hence on a broader scale, the longer-term projects, while requiring long-term management to minimise construction impacts, may assist in reducing stress and associated physiological and mental health impacts within the urban environment.

9.10 Overall assessment

Within an urban environment there are a wide range of complex factors (acting and interacting at different scales) that can affect health and wellbeing. This is conceptualised in Figure 9-1, presented by the International Council for Science and similar to that defined by the WHO (ICSU, 2011). The factors identified may result in either positive or negative impacts on health and wellbeing. It is noted that no single element or determinant acts in isolation. Health and wellbeing in the urban environment depends on the sum of the total interactions between many factors.

Potential impacts related to this project are summarised on the figure, showing both positive and negative impacts. The figure illustrates the complexity of making definitive conclusions in relation to health impacts in the community. However, it is noted that where negative impacts have been identified, impacts to the community are minimised through the implementation of appropriate mitigation or management measures.

10 Uncertainties

10.1 General

Any assessment of health risk or health impact incorporates data and information that is associated with some level of uncertainty. In most cases, where there is uncertainty in any of the key data or inputs into an assessment of health risk or health impact, a conservative approach is adopted. This approach is adopted to ensure that the assessment presents an overestimation of potential health impacts, rather than an underestimation. It is therefore important to provide some additional information on the key areas of uncertainty for the Health impact assessment to support the conclusions presented.

10.2 Population health data

There are limitations in the use of this data for the quantification of impact and risk. This data is derived from statistics recorded by hospitals and doctors, reported by postcode of residence, and are dependent on the correct categorisation of health problems upon presentation at the hospital. There may be some individuals who may not seek medical assistance particularly with less serious conditions and hence there is expected to be some level of under-reporting of effects commonly considered in relation to morbidity. Quantitatively, the baseline data considered in this assessment is only a general indicator (not a precise measure) of the incidence of these health endpoints.

10.3 Exposure concentrations

The concentration of various pollutants in air (ie exposure concentrations) and noise levels relevant to different locations in the community have been calculated on the basis of a range of input assumptions and modelling. Details of these are presented within the relevant technical working papers.

10.3.1 Traffic modelling

Assessment of potential impacts of the project on air and noise has relied on the modelling of traffic demand changes (refer to Technical working paper: Traffic and transport). The traffic demand modelling has forecast population growth projections over the Sydney metropolitan area.

10.3.2 Air quality

An assessment on the scale of the project is a complex, multi-step process which involves various different assumptions, inputs, models, and post-processing procedures. There is an inherent uncertainty in each of the methods used to estimate emissions and concentrations, and there are clearly limits to how accurately any impacts in future years can be predicted. Conservatism is built into predictions to ensure that a margin of safety is applied (ie to minimise the risk that any potential impacts are underestimated).

The operational air quality assessment for the project has been conducted, as far as possible, with the intention of providing 'accurate' or 'realistic' estimates of pollutant emissions and concentrations. The general approach has been to use inputs, models and procedures that are as accurate as possible, except where the context dictates that a degree of conservatism is sensible. An example of this is the estimation of the maximum one hour NO₂ concentration during a given year. Any method which provides a 'typical' or 'average' one hour NO₂ concentration would tend to result in an underestimate of the likely maximum concentration, and therefore a more conservative approach is required. However, the scale of the conservatism can often be quite difficult to define, and this can sometimes result in some assumptions being overly conservative. Skill and experience is required to estimate impacts that err on the side of caution but are not unreasonably exaggerated or otherwise skewed. By demonstrating that a deliberate overestimate of impacts is acceptable, it can be confidently predicted that the actual impacts that are likely to be experienced in reality would also lie within acceptable limits.

A number of conservative assumptions and approaches have been adopted in the assessment of air quality impacts, which include:

- Emissions model adopted overestimate emissions and concentrations within the tunnels (by a factor of 1.7 to 3.3)
- Assessment of total concentrations at receptor locations has adopted a contemporaneous approach. For the assessment of impacts it is assumed that the background concentration estimated occurs at the same time as the maximum predicted air quality impact from the project. It is unlikely that this would occur, and as a result the predicted maximum total concentration would be an overestimate. It is noted that it is not possible to know the true total (background plus project) concentration at any location.

A comparison of modelled and measured air concentrations was carried out to evaluate the performance of the modelling approach adopted (as presented in Annexure H of Technical working paper: Air quality). It found the modelling approach to have provided conservative estimates of exposure concentrations throughout the study area. Specifically,

- For PM₁₀ the results suggested that the use of modelling should give good (and slightly conservative) estimates of the annual PM₁₀ concentration
- For NO_x the results suggest that the estimated total annual mean and short-term NO_x concentrations ought to be quite conservative for most of the modelling domain.

10.3.3 Noise assessment

The noise impact assessment incorporates information on traffic volumes and composition from the traffic model and other information on the design of the project. The modelling also incorporates measured background noise levels and a range of inputs and assumptions in relation to noise generated from the project. The model has also included a range of standard or expected noise mitigation measures.

The model used in the assessment was validated based on existing information and traffic information and found to predict noise impacts within acceptable levels of variability, namely the difference between measured and modelled noise levels is \pm two dB(A).

10.4 Approach to the assessment of risk for particulates

10.4.1 General

The available scientific information provides a sufficient basis for determining that exposure to particulate matter (particularly PM_{2.5} and smaller) is associated with adverse health effects in a population. The data is insufficient to provide a thorough understanding of all of the potential toxic properties of particulates to which humans may be exposed. Over time it is expected that many of the current uncertainties would be refined with the collection of additional data, however some uncertainty would be inherent in any estimate. The influence of the uncertainties may be either positive or negative.

Overall, the epidemiological and toxicological data on which the assessment presented in this technical working paper are based on current and robust information for the assessment of risks to human health associated with the potential exposure to particulate matter from combustion sources.

10.4.2 Exposure-response functions

The choice of exposure-response functions for the quantification of potential health impacts is important. For mortality health endpoints, many of the exposure-mortality functions have been replicated throughout the world. While many of these have shown consistent outcomes, the calculated relative risk estimates for these studies do vary. Figure 10-1, Figure 10-2 and Figure 10-3 show the variability in the relative risk estimates calculated in published studies for the US (and Canadian) population that are relevant to the primary health endpoints considered in this assessment (USEPA 2012). A similar variability is observed where additional studies from Europe, Asia and Australia/New Zealand are considered.

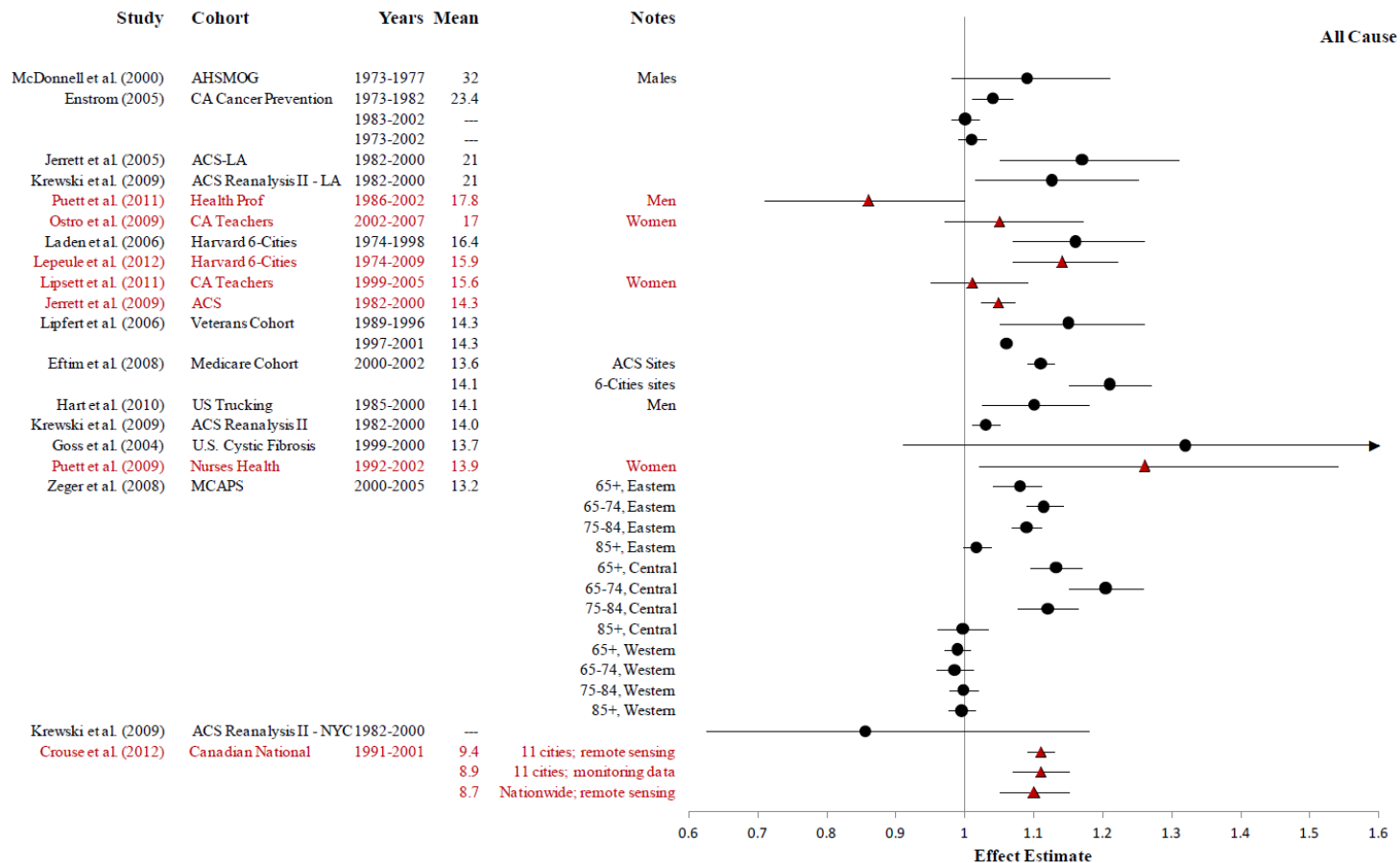


Figure 10-1 All-cause mortality relative risk estimates for long term exposure to PM_{2.5} (USEPA 2012). Note studies in red are those completed since 2009

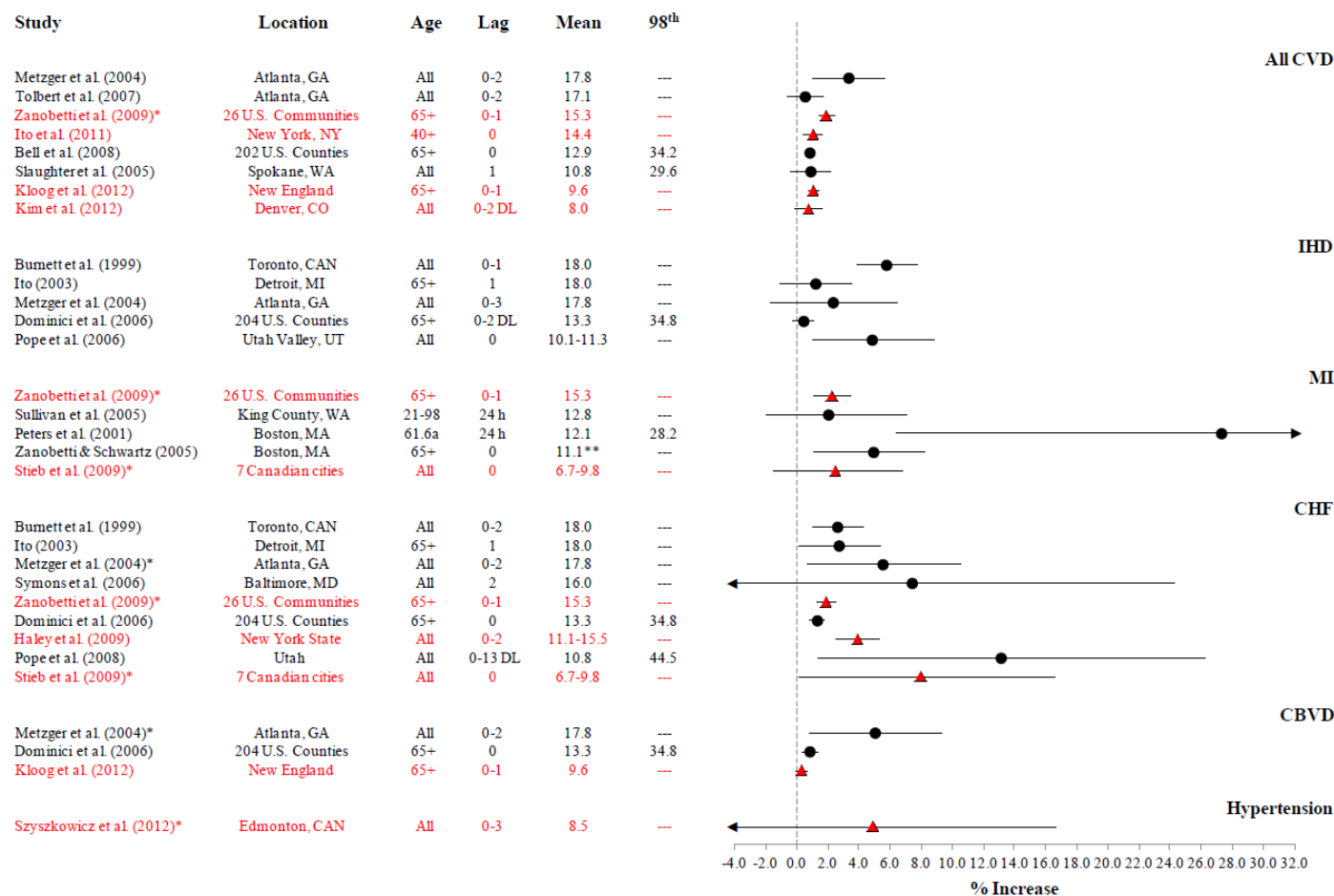


Figure 10-2 Per cent increase in cardiovascular-related hospital admissions for a 10 µg/m³ increase in short term (24 hour average) exposure to PM_{2.5} (USEPA, 2012). Note studies in red are those completed since 2009

(Note: CVD = cardiovascular disease; IHD = ischemic heart disease; MI = myocardial infarction; CHF = congestive heart failure; CBVD = cerebrovascular disease)

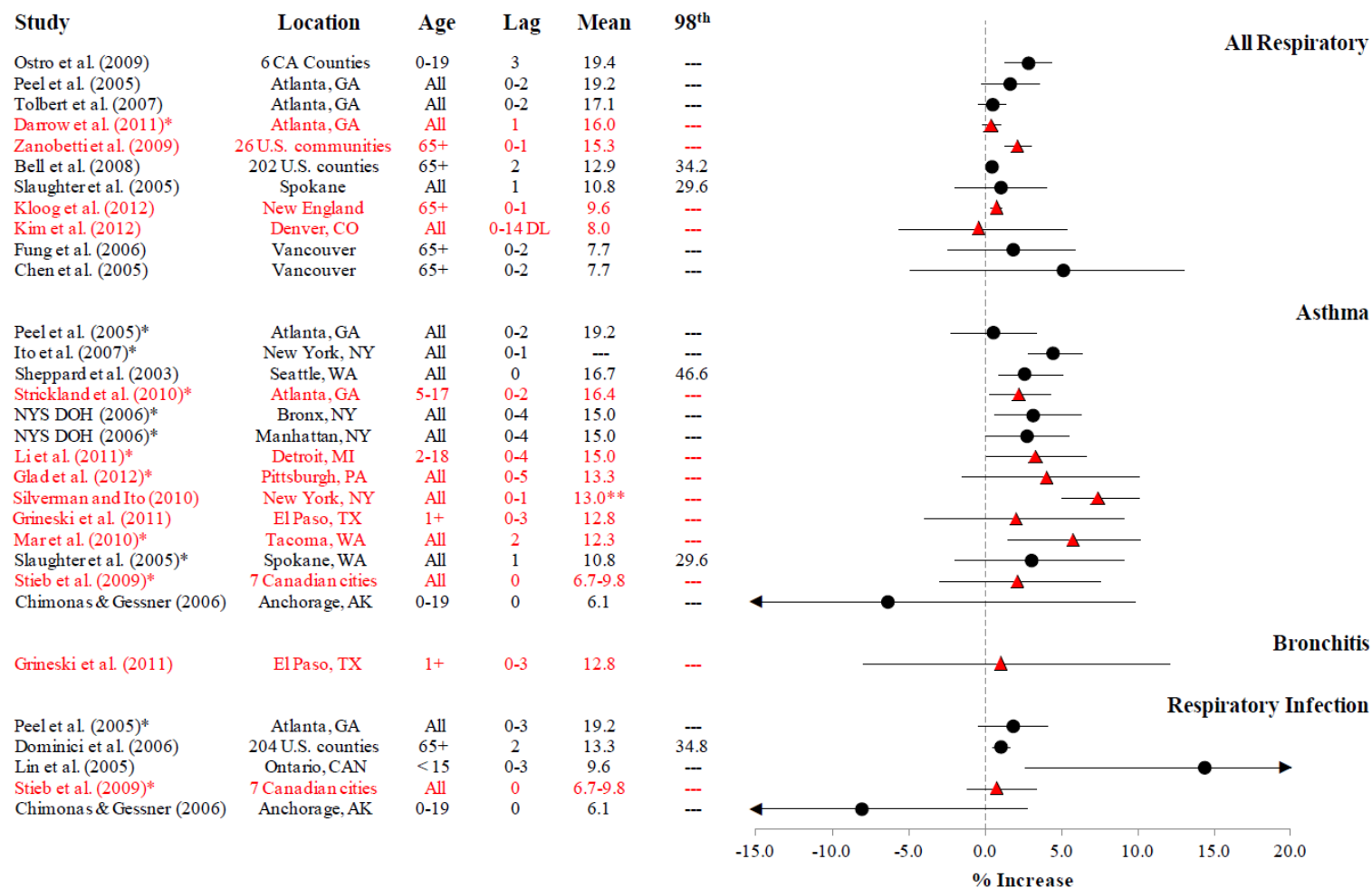


Figure 10-3 Per cent increase in respiratory-related hospital admissions for a 10 µg/m³ increase in short term (24 hour average) exposure to PM_{2.5} (USEPA, 2012). Note studies in red are those completed since 2009

These figures illustrate the variability inherent in the studies used to estimate exposure-response functions. The variability is expected to reflect the local and regional variability in the characteristics of particulate matter to which the population is exposed.

Based on the available data, and the detailed reviews carried out by organisations such as the USEPA (USEPA 2010, 2012) and WHO (WHO 2003, 2006b, 2006a) and previous discussions with NSW Health, the adopted exposure-response estimates are considered to be current, robust and relevant to the characterisation of impacts from PM_{2.5}.

10.4.3 Shape of exposure-response function

The shape of the exposure-response function and whether there is a threshold for some of the effects endpoints remains an uncertainty. Reviews of the currently available data (that includes studies that show effects at low concentrations) have not shown evidence of a threshold. However, as these conclusions are based on epidemiological studies, discerning the characteristics of the particulates responsible for these effects and the observed shape of the dose-response relationship is complex. For example, it is not possible to determine if the observed no threshold response is relevant to exposure to particulates from all sources, or whether it relates to particulates from combustion sources only.

Most studies have demonstrated that there is a linear relationship between relative risk and ambient concentration however for long term exposure-related mortality a log-linear relationship is more plausible and should be considered where there is the potential for exposure to very high concentrations of pollution. In this assessment, the impact considered is a localised impact with low level incremental increases in concentration. At low levels, the assumption of a linear relationship is considered appropriate.

10.5 Diesel particulate matter evaluation

The assessment of exposure to diesel particulate matter has assumed that 100 per cent of the PM_{2.5} associated with the project is derived from diesel sources. This is a conservative assumption.

The health hazard conclusions associated with exposure to diesel particulate matter are based on studies that are dominated by exhaust emissions from diesel engines built prior to the mid-1990s. With current engine use including some new and many older engines (engines typically stay in service for a long time), the health hazard conclusions, in general, are likely to be applicable to engines currently in use.

However as new and cleaner diesel engines, together with different diesel fuels, replace a substantial number of existing engines; the general applicability of the health hazard conclusions may require further evaluation. The NEPC (NEPC 2009) has established a program to reduce diesel emissions from the Australian heavy vehicle fleet. This is expected to lower the potential for all diesel emissions over time

10.6 Co-pollutants

For the assessment of NO₂, particulates and noise, the exposure-response relationships used in this assessment are based on large epidemiology studies where exposures have occurred in urban areas. These exposures do not relate to only one pollutant or exposure (noise) but a mix of these, and others including occupational and smoking. While many of the studies have endeavoured to correct for other pollutants and exposures, no study can fully correct for these and there would always be some level of influence from other exposures on the relationships adopted.

In relation to air quality, many of the pollutants evaluated come from a common source (eg fuel combustion) so the use of only particulate matter (or NO₂) as an index for the mix of pollutants that is in urban air at the time of exposure is reasonable but conservative.

In relation to the assessment of cardiovascular effects from road traffic noise, these effects are also associated with (and occur together with) increased exposures to vehicle emissions, specifically particulate exposures.

For this reason, it is important the health risks and incidence evaluations presented for exposure to NO₂, particulates and noise should not be added together as these effects are not necessarily additive as the relationships already include co-exposures to all these aspects (and others).

10.7 Selected health outcomes

The assessment of risk has utilised exposure-response functions and relative risk values that relate to the more significant health endpoints where the most significant and robust positive associations have been identified. The approach does not include all possible subsets of effects that have been considered in various published studies. However, the assessment carried out has considered the health endpoints/outcomes that incorporate many of the subsets, and has utilised the most current and robust relationships.

10.8 Exposure time/duration

The assessment of potential exposure and risk to changes in air quality and noise levels associated with the project has assumed that all areas evaluated are residential and people may be at home for 24 hours of the day for 365 days of the year, for a lifetime. This is a conservative assumption to ensure that all members of the public are adequately addressed in the assessment of health impacts, including the elderly and those with disabilities who may not leave the home very often. As a result, the quantification of risk and health incidence is expected to be an overestimation.

10.9 Changing population size and demographics

The assessment presented has utilised information on the size of the population and distribution of the population in relevant ages from the ABS Census data from 2016. As discussed in Section 3 the population in the study area is projected to increase significantly by 2036. In addition, many of the LGAs are expecting a significant increase in the proportion of the population aged 65 years and over.

The increase in population size and distribution does not affect the calculation of an individual risk. The key aspect that does affect this calculation is the baseline incidence of the health effects within the population. Based on statistics from NSW Health the baseline incidence of the health effects evaluated in this assessment have been relatively stable or decreasing over time (with improvements in health care). Hence changes in the population over time are not expected to result in any increase in the calculated individual risk.

For the calculation of the change in incidence in the community the size and distribution of the population is important. However, as the project is associated with an overall improvement (ie decrease in incidence) in the health endpoints evaluated, and increase in population would not change this outcome.

It is noted that population growth has been included in the forecast of traffic volumes predicted for the project and hence these changes have, by default, be incorporated into all subsequent impact assessment, including assessments associated with changes in air quality, noise and vibration.

10.10 Application of exposure-response functions to small populations

The exposure-response functions have been developed on the basis of epidemiological studies from large urban populations where associations have been determined between health effects (health endpoints) and changes in ambient (regional) particulate levels. Typically, these exposure-response functions are applied to large populations for the purpose of establishing/reviewing air guidelines or reviewing potential impacts of regional air quality issues on large populations. When applied to small populations (less than larger urban centres such as the whole of Greater Sydney) the uncertainty increases.

In addition, it is noted that the exposure-response functions relate changes in health endpoints with changes in regional air quality measurements. They do not relate to specific local sources (which occur within a regional airshed), or daily variability in exposure that may occur as a result of various different activities that may occur in any one day.

10.11 Overall evaluation of uncertainty

Overall the assessment of potential health impacts presented in this report has incorporated a range of assumptions and models that will have resulted in an overestimation of impacts, including the use of traffic demand models. The most significant factors that result in the assessment providing conservative outcomes are as follows:

- Modelling of potential air quality impacts – this has included a range of conservative assumptions about the type of vehicles and the emissions to air that may come from these vehicles over time. The assessment has also utilised a model to predict ground level concentrations (ie concentrations in the community) that are expected to be conservative. Overall the air modelling may have overestimated air concentrations in the community by a factor of two fold
- Potential community exposures – there are a number of assumptions adopted in the characterisation of exposure that will have overestimated exposure:
 - It is assumed that the maximum changes in air quality, regardless of where this may occur (eg industrial area, in a roadway, open space area or residential area), affects a resident
 - All exposures to changes in air quality and noise that occur, in all areas, assume that all residents are at home all day, every day for a lifetime
- Potential exposure-response – the relationships utilised in this assessment are based on the most current, robust studies that relate to health effects from exposure to changes in NO₂ and particulates. The relationships adopted come from large epidemiology studies that include a number of co-pollutants (ie exposure occurs to a wide range of factors not just the pollutant being evaluated) and confounding factors that can result in more conservative relationships being developed. In addition, it is assumed the relationships adopted are linear and apply to small changes in air quality, at levels that would not be measurable with air monitoring equipment.

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Annexures

Annexure A – Approach to risk assessment using exposure-response relationships

Mortality and morbidity health endpoints

A quantitative assessment of risk for these endpoints uses a mathematical relationship between an exposure concentration (ie concentration in air) and a response (namely a health effect). This relationship is termed an exposure-response relationship and is relevant to the range of health effects (or endpoints) identified as relevant (to the nature of the emissions assessed) and robust (as identified in the main document). An exposure-response relationship can have a threshold, where there is a safe level of exposure, below which there are no adverse effects; or the relationship can have no threshold (and is regarded as linear) where there is some potential for adverse effects at any level of exposure.

In relation to the health effects associated with exposure to NO₂ and particulate matter, no threshold has been identified. Non-threshold exposure-response relationships have been identified for the health endpoints considered in this assessment.

The assessment of potential risks associated with exposure to particulate matter involves the calculation of a relative risk (RR). For the purpose of this assessment the shape of the exposure-response function used to calculate the relative risk is assumed to be linear¹⁴. The calculation of a relative risk based on the change in relative risk exposure concentration from baseline/existing (ie based on incremental impacts from the project) can be calculated on the basis of the following equation (Ostro 2004):

Equation 1 $RR = \exp[\beta(X-X_0)]$

Where:

$X-X_0$ = the change in particulate matter concentration to which the population is exposed ($\mu\text{g}/\text{m}^3$)

β = regression/slope coefficient, or the slope of the exposure-response function which can also be expressed as the per cent change in response per 1 $\mu\text{g}/\text{m}^3$ increase in particulate matter exposure.

Based on this equation, where the published studies have derived relative risk values that are associated with a 10 $\mu\text{g}/\text{m}^3$ increase in exposure, the β coefficient can be calculated using the following equation:

Equation 2
$$\beta = \frac{\ln(RR)}{10}$$

Where:

RR = relative risk for the relevant health endpoint as published ($\mu\text{g}/\text{m}^3$)

10 = increase in particulate matter concentration associated with the RR (where the RR is associated with a 10 $\mu\text{g}/\text{m}^3$ increase in concentration).

¹⁴ Some reviews have identified that a log-linear exposure-response function may be more relevant for some of the health endpoints considered in this assessment. Review of outcomes where a log-linear exposure-response function has been adopted (Ostro 2004) for PM_{2.5} identified that the log-linear relationship calculated slightly higher relative risks compared with the linear relationship within the range 10–30 $\mu\text{g}/\text{m}^3$, (relevant for evaluating potential impacts associated with air quality goals or guidelines) but lower relative risks below and above this range. For this assessment (where impacts from a particular project are being evaluated) the impacts assessed relate to concentrations of PM_{2.5} that are well below 10 $\mu\text{g}/\text{m}^3$ and hence use of the linear relationship is expected to provide a more conservative estimate of relative risk.

Quantification of impact and risk

The assessment of health impacts for a particular population associated with exposure to particulate matter has been carried out utilising the methodology presented by the WHO (Ostro 2004)¹⁵ where the exposure-response relationships identified have been directly considered on the basis of the approach outlined below.

The calculation of changes in health endpoints associated with exposure to NO₂ and particulate matter as outlined by the WHO (Ostro 2004) has considered the following four elements:

- Estimates of the changes in particulate matter exposure levels (ie incremental impacts) due to the project for the relevant modelled scenarios
- Estimates of the number of people exposed to particulate matter at a given location
- Baseline incidence of the key health endpoints that are relevant to the population exposed
- Exposure-response relationships expressed as a percentage change in health endpoint per microgram per cubic metre change in NO₂ or particulate matter exposure, where a relative risk (RR) is determined (refer to Equation 1).

From the above, the increased incidence of a health endpoint corresponding to a particular change in particulate matter concentrations can be calculated using the following approach:

The attributable fraction/portion (AF) of health effects from air pollution, or impact factor, can be calculated from the relative risk (calculated for the incremental change in concentration considered as per Equation 1) as:

Equation 3 $AF = \frac{RR-1}{RR}$

The total number of cases attributable to exposure to particulate matter (where a linear dose-response is assumed) can be calculated as:

Equation 4 $E = AF \times B \times P$

Where:

B = baseline incidence of a given health effect (eg mortality rate per person per year)

P = relevant exposed population

The above approach (while presented slightly differently) is consistent with that presented in Australia (Burgers & Walsh 2002), US (OEHHA 2002; USEPA 2005b, 2010) and Europe (Martuzzi et al. 2002; Sjoberg et al. 2009).

The calculation of an increased incidence (ie number of cases) of a particular health endpoint is not relevant to a specific individual, rather this is relevant to a statistically relevant population. This calculation has been carried out for populations within the suburbs surrounding the proposed project. When considering the potential impact of the project on the population, the calculation has been carried out using the following:

¹⁵ For regional guidance, such as that provided for Europe by the WHO (WHO 2006a), Health risks or particulate matter from long-range transboundary air pollution regional background incidence data for relevant health endpoints are combined with exposure-response functions to present an impact function, which is expressed as the number/change in incidence/new cases per 100,000 population exposed per microgram per cubic metre change in particulate matter exposure. These impact functions are simpler to use than the approach adopted in this assessment, however in utilising this approach it is assumed that the baseline incidence of the health effects is consistent throughout the whole population (as used in the studies) and is specifically applicable to the sub-population group being evaluated. For the assessment of exposures in the areas evaluated surrounding the project it is more relevant to utilise local data in relation to baseline incidence rather than assume that the population is similar to that in Europe (where these relationships are derived).

- Equation 1 has been used to calculate a relative risk. The relative risk has been calculated for a population weighted annual average incremental increase in concentrations. The population weighted average has been calculated on the basis of the smallest statistical division provided by the Australian Bureau of Statistics within a suburb (ie mesh blocks – which are small blocks that cover an area of about 30 urban residences). For each mesh block in a suburb the average incremental increase in concentration has been calculated and multiplied by the population living in the mesh block (data available from the ABS for the 2011 census year). The weighted average has been calculated by summing these calculations for each mesh block in a suburb and dividing by the total population in the suburb (ie in all the mesh block)
- Equation 3 has been used to calculate an attributable fraction
- Equation 4 has been used to calculate the increased number of cases associated with the incremental impact evaluated. The calculation is carried out utilising the baseline incidence data relevant for the endpoint considered and the population (for the relevant age groups) present in the suburb.

The above approach can be simplified (mathematically, where the incremental change in particulate concentration is low, less than 1 $\mu\text{g}/\text{m}^3$) as follows:

Equation 5 $E = \beta \times B \times \sum_{\text{mesh}} (\Delta X_{\text{mesh}} \times P_{\text{mesh}})$

Where:

β = slope coefficient relevant to the per cent change in response to a 1 $\mu\text{g}/\text{m}^3$ change in exposure concentration

B = baseline incidence of a given health effect per person (eg annual mortality rate)

ΔX_{mesh} = change (increment) in exposure concentration in $\mu\text{g}/\text{m}^3$ as an average within a small area defined as a mesh block (from the ABS – where many mesh blocks make up a suburb)

P_{mesh} = population (residential – based on data from the ABS) within each small mesh block

An additional risk can then be calculated as:

Equation 6 $\text{Risk} = \beta \times \Delta X \times B$

Where:

β = slope coefficient relevant to the per cent change in response to a 1 $\mu\text{g}/\text{m}^3$ change in exposure

ΔX = change (increment) in exposure concentration in $\mu\text{g}/\text{m}^3$ relevant to the project at the point of exposure

B = baseline incidence of a given health effect per person (eg annual mortality rate)

This calculation provides an annual risk for individuals exposed to changes in air quality from the project at specific locations (such as the maximum, or at specific sensitive receptor locations). The calculated risk does not take into account the duration of exposure at any one location and hence is considered to be representative of a population risk.

Quantification of short and long term effects

The concentration-response functions adopted for the assessment of exposure are derived from long and short term studies and relate to short or long term effects endpoints (eg change in incidence from daily changes in NO_2 or particulate matter, or chronic incidence from long term exposures to particulate matter).

Long term or chronic effects are assessed on the basis of the identified exposure-response function and annual average concentrations. These then allow the calculation of a chronic incidence of the assessed health endpoint.

Short term effects are also assessed on the basis of an exposure-response function that is expressed as a percentage change in endpoint per microgram per cubic metre change in concentration. For short term effects, the calculations relate to daily changes in NO_2 and particulate matter exposures to calculate changes in daily effects endpoints. While it may be possible to measure daily incidence of the evaluated health endpoints in a large population study specifically designed to include such data,

it is not common to collect such data in hospitals nor are effects measurable in smaller communities. Instead these calculations relate to a parameter that is measurable, such as annual incidence of hospitalisations, mortality or lung cancer risks. The calculation of an annual incidence or additional risk can be carried out using two approaches (Ostro 2004; USEPA 2010):

- Calculate the daily incidence or risk at each receptor location over every 24 hour period of the year (based on the modelled incremental 24 hour average concentration for each day of the year and daily baseline incidence data) and then sum the daily incidence/risk to get the annual risk
- Calculate the annual incidence/risk based on the incremental annual average concentration at each receptor (and using annual baseline incidence data).

In the absence of a threshold, and assuming a linear concentration-response function (as is the case in this assessment), these two approaches result in the same outcome mathematically (calculated incidence or risk). Given that it is much simpler computationally to calculate the incidence (for each receptor) based on the incremental annual average, compared with calculating effects on each day of the year and then summing, this is the preferred calculation method. It is the recommended method outlined by the WHO (Ostro 2004).

The use of the simpler approach, based on annual average concentrations should not be taken as implying or suggesting that the calculation is quantifying the effects of long term exposure.

Hence for the calculations presented in this technical working paper that relate to the expected use of the project tunnel, for both long term and short term effects, annual average concentrations of NO₂ and particulate matter have been utilised.

Where short term worst case exposures are assessed (such as those related to a breakdown in the tunnel) short term, daily, calculations have been carried out to assessed short term health endpoints. This has been carried out as the exposure being assessed relates to an infrequent short duration event. It would not occur each day of the year and hence it is not appropriate to assess on the basis of an annual average.

Annexure B – Approach to assessment of cancer risk

Diesel exhaust (DE) is emitted from 'on-road' diesel engines (vehicle engines) and can be formed from the gaseous compounds emitted by diesel engines (secondary particulate matter). After emission from the exhaust pipe, diesel exhaust undergoes dilution and chemical and physical transformations in the atmosphere, as well as dispersion and transport in the atmosphere. The atmospheric lifetime for some compounds present in diesel exhaust ranges from hours to days.

Data from the USEPA (USEPA 2002b) indicates that diesel exhaust as measured as diesel particulate matter made up about six per cent of the total ambient/urban air PM_{2.5}. In this project, emissions to air from the operation of the tunnel include a significant proportion of diesel powered vehicles. Available evidence indicates that there are human health hazards associated with exposure to diesel particulate matter. The hazards include acute exposure-related symptoms, chronic exposure related non-cancer respiratory effects, and lung cancer.

In relation to non-carcinogenic effects, acute or short term (eg episodic) exposure to diesel particulate matter can cause acute irritation (eg eye, throat, bronchial), neurophysiological symptoms (eg light-headedness, nausea), and respiratory symptoms (cough, phlegm). There also is evidence for an immunologic effect-exacerbation of allergenic responses to known allergens and asthma-like symptoms. Chronic effects include respiratory effects. The review of these effects (USEPA 2002b) identified a threshold concentration for the assessment of chronic non-carcinogenic effects. The review conducted by the USEPA also concluded that exposures to diesel particulate matter also consider PM_{2.5} goals (as these also address the presence of diesel particulate matter in urban air environments). The review found that the diesel particulate matter chronic guideline would also be met if the PM_{2.5} guideline was met.

Review of exposures to diesel particulate matter (USEPA 2002b) identified that such exposures are 'likely to be carcinogenic to humans by inhalation'. A more recent review by IARC (Attfield et al. 2012; IARC 2012; Silverman et al. 2012) classified diesel engine exhaust as carcinogenic to humans (Group 1) based on sufficient evidence that exposure is associated with an increased risk for lung cancer. In addition, outdoor air pollution and particulate matter (that includes diesel particulate matter) have been classified by IARC as carcinogenic to humans based on sufficient evidence of lung cancer.

Many of the organic compounds present in diesel exhaust are known to have mutagenic and carcinogenic properties and hence it is appropriate that a non-threshold approach is considered for the quantification of lung-cancer endpoints.

In relation to quantifying carcinogenic risks associated with exposure to diesel exhaust, the USEPA (USEPA 2002b) has not established a non-threshold value (due to uncertainties identified in the available data).

WHO has used data from studies in rats to estimate unit risk values for cancer (WHO 1996). Using four different studies where lung cancer was the cancer endpoint, WHO calculated a range of 1.6×10^{-5} to 7.1×10^{-5} per microgram per cubic metres (mean value of 3.4×10^{-5} per microgram per cubic metres). This would suggest that an increase in lifetime exposure to diesel particulate matter between 0.14 and 0.625 $\mu\text{g}/\text{m}^3$ could result in a one in one hundred thousand excess risk of cancer.

The California Environmental Protection Agency has proposed a unit lifetime cancer risk of 3.0×10^{-4} per microgram per cubic metres diesel particulate matter (OEHHA 1998). This was derived from data on exposed workers and based on evidence that suggested unit risks between 1.5×10^{-4} and 15×10^{-4} per microgram per cubic metres. This would suggest that an increase in lifetime exposure to diesel particulate matter of 0.033 $\mu\text{g}/\text{m}^3$ could result in a one in one hundred thousand excess risk of cancer. This estimate has been widely criticised as overestimating the risk and hence has not been considered in this assessment.

On the basis of the above, the WHO cancer unit risk value (mean value of 3.4×10^{-5} per microgram per cubic metres) has been used to evaluate potential excess lifetime risks associated with incremental impacts from diesel particulate matter exposures. Diesel particulate matter has not been specifically modelled in Technical working paper: Air quality; rather diesel particulate matter is part of the PM_{2.5} assessment. For the purpose of this assessment it has been conservatively assumed that 100 per cent of the incremental PM_{2.5} (from the project only) is derived from diesel sources. This is conservative as not all the vehicles using the tunnel (and emitting PM_{2.5}) would be diesel powered (as currently there is a mix of petrol, diesel, LPG and hybrid-electric powered vehicles with the proportion of alternative fuels rising in the future).

For the assessment of potential lung cancer risks associated with exposure to diesel particulate matter, a non-threshold cancer risk is calculated. Non-threshold carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential non-threshold carcinogen. The numerical estimate of excess lifetime cancer risk is calculated as follows for inhalation exposures (USEPA 2009b):

Equation 7 Carcinogenic Risk (inhalation) = Concentration in Air x Inhalation Unit Risk x AF

Exposure adjustment factor (AF):

The above calculation assumes the receptor is exposed at the same location for 24 hours of the day, every day, for a lifetime (which is assumed to be 70 years). This assumption is overly conservative for residents and workers in the community surrounding the project. Residents do not live in the one home for a lifetime. Guidance from enHealth indicates that an appropriate assumption for the time living in the one home is 35 years (enHealth 2012a). For residents, it is assumed that they may be at home for 20 hours per day for 365 days of the year, for 35 years. This results in an adjustment factor of 0.4 (20/24 hours x 35 years/70 years). This factor has been adopted for the assessment of all exposures regardless of whether these are residential areas, schools, recreational areas or workplaces.

Annexure C – Acceptable risk levels

General

The acceptability of an additional population risk is the subject of some discussion as there are currently no guidelines available in Australia, or internationally, in relation to an acceptable level of population risk associated with exposure to particulate matter. More specifically there are no guidelines available that relate to an acceptable level of risk for a small population (associated with impacts from a specific activity or project) compared with risks that are relevant to whole urban populations (that are considered when deriving guidelines). The following provides additional discussion in relation to evaluating calculated risk levels.

'The solution to developing better criteria for environmental contaminants is not to adopt arbitrary thresholds of 'acceptable risk' in an attempt to manage the public's perception of risk, or develop oversimplified tools for enforcement or risk assessment. Rather, the solution is to standardize the process by which risks are assessed, and to undertake efforts to narrow the gap between the public's understanding of actual vs. perceived risk. A more educated public with regard to the actual sources of known risks to health, environmental or otherwise, will greatly facilitate the regulatory agencies' ability to prioritize their efforts and standards to reduce overall risks to public health.' (Kelly 1991).

Most human activities that have contributed to economic progress present also some disadvantages, including risks of different kinds that adversely affect human health. These risks include air or water pollution due to industrial activities (coal power generation, chemical plants, and transportation), food contaminants (pesticide residues, additives), and soil contamination (hazardous waste). Despite all possible efforts to reduce these threats, it is clear that the zero risk objective is unobtainable or simply not necessary for human and environmental protection and that a certain level of risk in a given situation is deemed 'acceptable' as the effects are so small as to be negligible or undetectable. Risk managers need to cope with some residual risks and thus must adopt some measure of an acceptable risk.

Much has been written about how to determine the acceptability of risk. The general consensus in the literature is that 'acceptability' of a risk is a judgment decision properly made by those exposed to the hazard or their designated health officials. It is not a scientifically derived value or a decision made by outsiders to the process. Acceptability is based on many factors, such as the number of people exposed, the consequences of the risk, the degree of control over exposure, and many other factors.

The USEPA (Hoffman 1988) 'surveyed a range of health risks that our society faces' and reviewed acceptable-risk standards of government and independent institutions. The survey found that 'No fixed level of risk could be identified as acceptable in all cases and under all regulatory programs...', and that: '...the acceptability of risk is a relative concept and involves consideration of different factors'. Considerations may include:

- The certainty and severity of the risk
- The reversibility of the health effect
- The knowledge or familiarity of the risk
- Whether the risk is voluntarily accepted or involuntarily imposed
- Whether individuals are compensated for their exposure to the risk
- The advantages of the activity
- The risks and advantages for any alternatives.

To regulate a technology in a logically defensible way, one must consider all its consequences, ie both risks and benefits.

10⁻⁶ as an ‘acceptable’ risk level?

The concept of 1x10⁻⁶ (10⁻⁶) was originally an arbitrary number, finalised by the US Food and Drug Administration (FDA) in 1977 as a screening level of ‘essentially zero’ or de minimus risk. The term de minimus is an abbreviation of the legal concept, ‘de minimus non curat lex: the law does not concern itself with trifles.’ In other words, 10⁻⁶ was developed as a level of risk below which risk was considered a ‘trifle’ and not of concern in a legal case.

This concept was traced back to a 1961 proposal by two scientists from the National Cancer Institute regarding methods to determine ‘safety’ levels in carcinogenicity testing. The FDA applied the concept in risk assessment in its efforts to deal with diethylstilboestrol as a growth promoter in cattle. The threshold of one in a million risk of developing cancer was established as a screening level to determine what carcinogenic animal drug residues merited further regulatory consideration. In the FDA legislation, the regulators specifically stated that this level of ‘essentially zero’ was not to be interpreted as equal to an acceptable level of residues in meat products. Since then, the use of risk assessment and 10⁻⁶ (or variations thereof) have been greatly expanded to almost all areas of chemical regulation, to the point where today one-in-a-million (10⁻⁶) risk means different things to different regulatory agencies in different countries. What the FDA intended to be a lower regulatory level of ‘zero risk’ below which no consideration would be given as to risk to human health, for many regulators it somehow came to be considered a maximum or target level of ‘acceptable’ risk (Kelly 1991).

When evaluating human health risks, the quantification of risk can involve the calculation of an increased lifetime chance of cancer (as is calculated for diesel particulate matter in this assessment) or an increased probability of some adverse health effect (or disease) occurring, over and above the baseline incidence of that health effect/disease in the community (as is calculated for exposure to particulate matter).

In the context of human health risks, 10⁻⁶ is a shorthand description for an increased chance of 0.000001 in one (one chance in a million) of developing a specific adverse health effect due to exposure (over a lifetime or a shorter duration as relevant for particulate matter) to a substance. The number 10⁻⁵ represents one chance in 100,000, and so on.

Where cancer may be considered, lifetime exposure to a substance associated with a cancer risk of 1x10⁻⁶ would increase an individual’s current chances of developing cancer from all causes (which is 40 per cent, or 0.4 – the background incidence of cancer in a lifetime) from 0.4 to 0.400001, an increase of 0.00025 per cent.

For other health indicators considered in this assessment, such as cardiovascular hospitalisations for people aged 65 years and older (for example), an increased risk of 10⁻⁶ (one chance in a million) would increase an individual’s (aged 65 years and older) chance of hospitalisation for cardiovascular disease (above the baseline incidence of 23 per cent, or 0.23) from 0.23 to 0.230001, an increase of 0.00043 per cent.

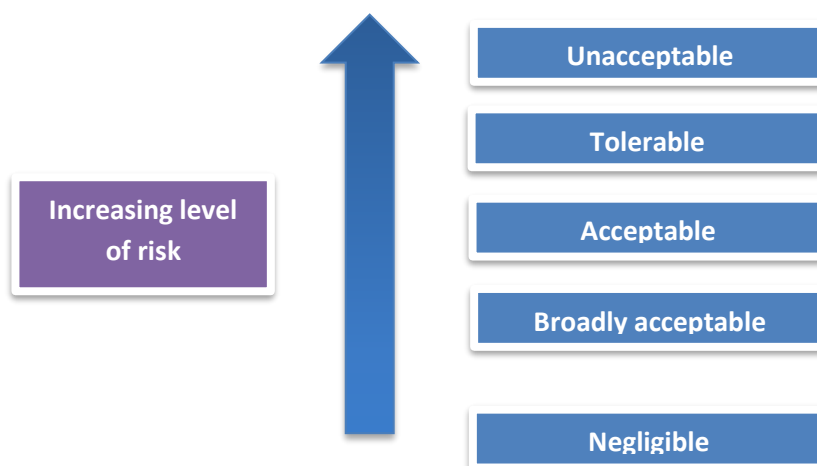
To provide more context in relation to the concept of a one in a million risk, the following presents a range of everyday life occurrences. The activity and the time spent carrying out the activity that is associated with reaching a risk of one in a million for mortality are listed below (Higson 1989; NSW Planning 2011):

- Motor vehicle accident – 2.5 days spent driving a motor vehicle to reach one in a million chance of having an accident that causes mortality (death)
- Home accidents – 3.3 days spent within a residence to reach a one in a million chance of having an accident at home that causes mortality
- Pedestrian accident (being struck by vehicles) – 10 days spent walking along roads to reach a one in a million chance of being struck by a vehicle that causes mortality
- Train accident – 12 days spent travelling on a train to reach a one in a million chance of being involved in an accident that causes mortality

- Falling down stairs [1] – 66 days spent requiring the use of stairs in day-to-day activities to reach a one in a million chance of being involved in a fall that causes mortality
- Falling objects – 121 days spent in day-to-day activities to reach a one in a million chance of being hit by a falling object that causes mortality.

This risk level should also be considered in the context that everyone has a cumulative risk of death that ultimately must equal one and the annual risk of death for most of one's life is about one in 1000.

While various terms have been applied, it is clear that the two ends of what is a spectrum of risk are the 'negligible' level and the 'unacceptable' level. Risk levels intermediate between these are frequently adopted by regulators with varying terms often used to describe the levels. When considering a risk derived for an environmental impact it is important to consider that the level of risk that may be considered acceptable would lie somewhere between what is negligible and unacceptable, as illustrated below.



The calculated individual lifetime risk of death or illness due to an exposure to a range of different environmental hazards covers many orders of magnitude, ranging from well less than 10^{-6} to levels of 10^{-3} and higher (in some situations). However, most figures for an acceptable or a tolerable risk range between 10^{-6} to 10^{-4} , used for either one year of exposure or a whole life exposure. It is noteworthy that 10^{-6} as a criterion for 'acceptable risk' has not been applied to all sources of exposure or all agents that pose risk to public health.

A review of the evolution of 10^{-6} reveals that perception of risk is a major determinant of the circumstances under which this criterion is used. The risk level 10^{-6} is not consistently applied to all environmental legislation. Rather, it seems to be applied according to the general perception of the risk associated with the source being regulated and where the risk is being regulated (with different levels selected in different countries for the same sources).

⁽¹⁾ Mortality risks as presented by: <http://www.riskcomm.com/visualaids/riskscale/datasources.php>.

A review of acceptable risk levels at the USEPA (Schoeny 2008) points out that risk assessors can identify risks and possibly calculate their value but cannot determine what is acceptable. Acceptability is a value judgment that varies with type of risk, culture, voluntariness and many other factors. Acceptability may be set by convention or law. The review also states that the USEPA aims for risk levels between 10^{-6} and 10^{-4} for risks calculated to be linear at low dose, while for other endpoints, not thought to be linear at low dose, the risk is compared to Reference Dose/Concentrations or guideline levels. The USEPA typically uses a target reference risk range of 10^{-4} to 10^{-6} for carcinogens in drinking water, which is in line with World Health Organization (WHO) guidelines for drinking water quality which, where practical, base guideline values for genotoxic carcinogens on the upper bound estimate of an excess lifetime cancer risk of 10^{-5} .

There are many different ways to define acceptable risk and each way gives different weight to the views of different stakeholders in the debate. No definition of 'acceptable' would be acceptable to all stakeholders. Resolving such issues, therefore, becomes a political (in the widest sense) rather than a strictly health process.

The following is a list of standpoints that could be used as a basis for determining when a risk is acceptable or, perhaps, tolerable. The WHO (Fewtrell & Bartram 2001) address standards related to water quality. They offer the following guidelines for determining acceptable risk. A risk is acceptable when:

- It falls below an arbitrary defined probability
- It falls below some level that is already tolerated
- It falls below an arbitrary defined attributable fraction of total disease burden in the community
- The cost of reducing the risk would exceed the costs saved
- The cost of reducing the risk would exceed the costs saved when the 'costs of suffering' are also factored in
- The opportunity costs would be better spent on other, more pressing, public health problems
- Public health professionals say it is acceptable
- The general public say it is acceptable (or more likely, do not say it is not)
- Politicians say it is acceptable.

In everyday life individual risks are rarely considered in isolation. It could be argued that a sensible approach would be to consider health risks in terms of the total disease burden of a community and to define acceptability in terms of it falling below an arbitrary defined level. A problem with this approach is that the current burden of disease attributable to a single factor, such as air pollution, may not be a good indicator of the potential reductions available from improving other environmental health factors. For diseases such as cardiovascular disease where causes are multifactorial, reducing the disease burden by one route may have little impact on the overall burden of disease.

Overall

It is not possible to provide a rigid definition of acceptable risk due to the complex and context driven nature of the challenge. It is possible to propose some general guidelines as to what might be an acceptable risk for specific development projects.

If the level of 10^{-6} (one chance in a million) were retained as a level of increased risk that would be considered as a negligible risk in the community, then the level of risk that could be considered to be tolerable would lie between this level and an upper level that is considered to be unacceptable.

While there is no guidance available on what level of risk is considered to be unacceptable in the community, a level of 10^{-4} for increased risk (one chance in 10,000) has been generally adopted by health authorities as a point where risk is considered to be unacceptable in the development of drinking water guidelines (that impact on whole populations) (for exposure to carcinogens as well as for annual risks of disease (Fewtrell & Bartram 2001)) and in the evaluation of exposures from pollutants in air (NSW DEC 2005).

Between an increased risk level considered negligible (10^{-6}) and unacceptable (10^{-4}) lie risks that may be considered to be tolerable or even acceptable. Tolerable risks are those that can be tolerated (and

where the best available, and most appropriate, technology has been implemented to minimise exposure) in order to realise some benefit.

In a societal context, risks are inevitable and any new development would be accompanied by risks which are not amenable or economically feasible to reduce below a certain level. It is not good policy to impose an arbitrary risk level to such developments without consideration of the myriad factors that should be brought into play to determine what is 'tolerable'.

When considering the impacts associated with this project, it is important to note that there are a range of benefits associated with the project and the design of the project has incorporated measures to minimise exposures to traffic-related emissions in the local areas. Hence for this project the calculated risks have been considered to be tolerable when in the range of 10^{-6} and 10^{-4} of increased risk and where the increased incidence of the health impacts are considered to be insignificant.

Determination of significance of population impacts

The assessment of potential health impacts associated with emissions to air from the project has not only calculated an increased annual risk, relevant to the health endpoints considered, but also a change in the incidence, ie the additional (or saving of) number of cases, of the adverse effects occurring within the population potentially exposed. The calculated change in incidence need to be considered in terms of what may be significant.

In relation to the calculated change in incidence of an adverse health effect occurring in a population, the following is noted for the primary health indicators (based on statistics available from NSW Health):

- In relation to mortality (all causes), the health statistics available show that for the year 2011/2012 the variability in all admissions data reported (based on the 95 per cent confidence interval for data reported in Sydney) is around ± 2.5 per cent. This is the variability in the data reported in one year. Each year the mortality rate also varies with around one per cent variability reported in the mortality rate (number reported for all causes) between 2010/11 and 2011/12. Based on the population considered in this assessment and the baseline incidence, a one per cent variability results in ± 10 cases per year. Changes in mortality within this range would not be detected (above normal variability) in the health statistics
- In relation to cardiovascular disease hospitalisations, the health statistics available show that for the year 2013/2014 the variability in all admissions data reported (based on the 95 per cent confidence interval for data reported in Sydney) is around \pm two per cent. This is the variability in the data reported in one year. Each year the rate of hospitalisations (all ages) also varies with around two to three per cent variability reported in the number of hospitalisations for people aged 65 years and older in each year between 2010/11 and 2013/14. Based on the baseline incidence of cardiovascular hospitalisations considered in this assessment for individuals aged 65 years and the population considered in this assessment a variability of two per cent equates to ± 40 cases per year. Changes in cardiovascular hospitalisations in the population aged 65 years and older within this range would not be detected (above normal variability) in the health statistics
- In relation to respiratory disease hospitalisations, the health statistics available show that for the year 2013/2014 the variability in all admissions data reported (based on the 95 per cent confidence interval for data reported in Sydney) is around \pm six per cent. This is the variability in the data reported in one year. Each year the rate of hospitalisations (all ages) also varies with around three to four per cent variability reported in the number of hospitalisations (all ages) in each year between 2011 and 2014. Based on the baseline incidence of respiratory hospitalisations considered in this assessment for individuals aged 65 years and older, and the population evaluated in this assessment, a variability of three per cent equates to ± 25 cases per year. Changes in respiratory hospitalisations in the population aged 65 years and older within this range would not be detected (above normal variability) in the health statistics.

Where changes in air quality associated with this project are well below 10 cases per year they are considered to be within the normal variability of health statistics. For evaluating impacts from this project a 10 fold margin of safety has been included to determine what changes in incidence may be considered negligible within the study population. This means that changes in the population incidence of any health effect evaluated that is less than one case per year are considered negligible.

Annexure D Risk calculations: Nitrogen dioxide

Quantification of Effects - NO₂
Western Harbour Tunnel

Air quality indicator:		"Do something 2027"		
		NO ₂	NO ₂	NO ₂
Endpoint:		Mortality - All Causes	Mortality - Respiratory	Asthma - ED Hospital admissions
Effect Exposure Duration:		Short-term	Short-term	Short-term
Age Group:		All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ NO ₂) (as per Table 5-15)		0.00188	0.00426	0.00115
Annual baseline incidence (as per Table 3-5)				
Annual baseline incidence (per 100,000)		428	32.1	1209
Baseline incidence (per person per year)		0.00428	0.000321	0.01209

Air quality indicator:		"Do something cumulative 2027"		
		NO ₂	NO ₂	NO ₂
Endpoint:		Mortality - All Causes	Mortality - Respiratory	Asthma - ED Hospital admissions
Effect Exposure Duration:		Short-term	Short-term	Short-term
Age Group:		All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ NO ₂) (as per Table 5-15)		0.00188	0.00426	0.00115
Annual baseline incidence (as per Table 3-5)				
Annual baseline incidence (per 100,000)		428	32.1	1209
Baseline incidence (per person per year)		0.00428	0.000321	0.01209

Air quality indicator:		"Do something 2027"		
		NO ₂	NO ₂	NO ₂
Endpoint:		Mortality - All Causes	Mortality - Respiratory	Asthma - ED Hospital admissions
Effect Exposure Duration:		Short-term	Short-term	Short-term
Age Group:		All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ NO ₂) (as per Table 5-15)		0.00188	0.00426	0.00115
Annual baseline incidence (as per Table 3-5)				
Annual baseline incidence (per 100,000)		428	32.1	1209
Baseline incidence (per person per year)		0.00428	0.000321	0.01209

Air quality indicator:		"Do something cumulative 2027"		
		NO ₂	NO ₂	NO ₂
Endpoint:		Mortality - All Causes	Mortality - Respiratory	Asthma - ED Hospital admissions
Effect Exposure Duration:		Short-term	Short-term	Short-term
Age Group:		All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ NO ₂) (as per Table 5-15)		0.00188	0.00426	0.00115
Annual baseline incidence (as per Table 3-5)				
Annual baseline incidence (per 100,000)		428	32.1	1209
Baseline incidence (per person per year)		0.00428	0.000321	0.01209

Sensitive Receptors		Change in Annual Average NO ₂ Concentration (µg/m ³)	Risk	Risk	Risk
Impacts from tunnel ventilation outlets					
Grid receptors: maximum regardless of land use		2.70	2E-05	4E-06	4E-05
Grid receptors: maximum residential		2.70	2E-05	4E-06	4E-05
Grid receptors: commercial/industrial		1.26	1E-05	2E-06	2E-05
Grid receptors: maximum childcare		1.91	2E-05	3E-06	3E-05
Grid receptors: maximum school		1.44	1E-05	2E-06	2E-05
Grid receptors: maximum aged care		0.60	5E-06	8E-07	8E-06
Grid receptors: maximum hospital and medical		0.50	4E-06	7E-07	7E-06
Grid receptors: open space		1.20	1E-05	2E-06	2E-05
Community Receptors					
University of Notre Dame, Broadway	University	-0.180	-1E-06	-2E-07	-2E-06
Laverty Pathology, Annandale	Medical centre	-0.197	-2E-06	-3E-07	-3E-06
St Basil's, Annandale	Aged care	0.558	4E-06	8E-07	8E-06
The Jimmy Little Community Centre	Community centre	0.446	4E-06	6E-07	6E-06
Rozella Public School	Primary School	-0.408	-3E-06	-6E-07	-6E-06
St Aloysius College	High School	-1.563	-1E-05	-2E-06	-2E-05
Channon Dingo Family Day Care	Child care	-0.633	-3E-06	-6E-07	-6E-06
Werrona School	Primary School	-1.725	-1E-05	-2E-06	-2E-05
Mater Hospital	Hospital	-0.120	-1E-06	-2E-07	-2E-06
Neutral Bay Public School	Primary School	-0.221	-2E-06	-3E-07	-3E-06
Neutral Bay Medical Centre	Medical Centre	0.042	3E-07	6E-08	6E-07
Puddleducka Child Care Centre	Childcare	-0.335	-3E-06	-5E-07	-5E-06
Mosman Public School	Primary School	0.198	2E-06	3E-07	3E-06
Garrison & Killamey Retirement Centre	Aged care	0.848	7E-06	1E-06	1E-05
Beauty Point Public School	Primary School	0.011	9E-08	2E-08	2E-07
Anzac Park Public School	Primary School	0.006	2E-06	3E-07	3E-06
Ku Cammeray Preschool	Preschool	0.425	3E-06	6E-07	6E-06
Cammeray Public School	Primary School	0.167	1E-06	2E-07	2E-06
Nicholson Preschool	Preschool	0.261	2E-06	4E-07	4E-06
Berry Cottage Childcare	Child care	-0.311	-3E-06	-4E-07	-4E-06
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.108	9E-07	1E-07	1E-06
SBS Child Care	Child care	0.159	1E-06	2E-07	2E-06
Butterflies Early Learning Childcare Centre	Child care	1.080	9E-06	1E-06	2E-05
Artarmon Public School	Primary School	-0.214	-2E-06	-3E-07	-3E-06
Sue's Childcare, Castlereagh	Child care	0.279	2E-06	4E-07	4E-06
Northside Baptist Preschool	Preschool	-0.527	-4E-06	-7E-07	-7E-06
Willoughby Public School	Primary School	-0.108	-9E-07	-1E-07	-2E-06
Peek A Boo College	Child care	2.456	2E-05	3E-06	3E-05
St Cecilia's Catholic Primary School	Primary School	-0.228	-2E-06	-3E-07	-3E-06
Sealforth Public School	Primary School	0.388	3E-06	5E-07	5E-06

Change in Annual Average NO ₂ Concentration (µg/m ³)	Risk	Risk	Risk
2.31	2E-05	3E-06	3E-05
2.31	2E-05	3E-06	3E-05
2.31	2E-05	3E-06	3E-05
1.97	2E-05	3E-06	3E-05
1.22	1E-05	2E-06	2E-05
0.55	4E-06	8E-07	8E-06
0.91	7E-06	1E-06	1E-05
1.77	1E-05	2E-06	2E-05
-0.706	-6E-06	-1E-06	-1E-05
0.381	3E-06	5E-07	5E-06
0.258	2E-06	4E-07	4E-06
-0.134	-1E-06	-2E-07	-2E-06
-0.445	-4E-06	-6E-07	-6E-06
-1.455	-1E-05	-2E-06	-2E-05
-0.335	-3E-06	-6E-07	-6E-06
-1.819	-1E-05	-2E-06	-2E-05
0.149	1E-06	2E-07	2E-06
-0.581	-6E-06	-8E-07	-8E-06
-1.289	-1E-05	-2E-06	-2E-05
-0.873	-7E-06	-1E-06	-1E-05
-0.117	-9E-07	-2E-07	-2E-06
-2.025	-2E-05	-3E-06	-3E-05
-0.803	-6E-06	-1E-06	-1E-05
0.200	2E-06	3E-07	3E-06
0.048	4E-07	7E-08	7E-07
0.107	9E-07	1E-07	1E-06
-0.439	-4E-06	-6E-07	-6E-06
-0.193	-2E-06	-3E-07	-3E-06
0.136	1E-06	2E-07	2E-06
0.581	5E-06	8E-07	8E-06
0.023	2E-07	3E-08	3E-07
0.012	1E-07	2E-08	2E-07
-0.753	-6E-06	-1E-06	-1E-05
-0.831	-7E-06	-1E-06	-1E-05
-0.222	-2E-06	-3E-07	-3E-06
-0.052	-2E-06	-4E-06	-4E-05
-0.349	-3E-06	-5E-07	-5E-06
0.003	3E-08	5E-09	5E-08

Change in Annual Average NO ₂ Concentration (µg/m ³)	Risk	Risk	Risk
2.57	2E-05	4E-06	4E-05
2.27	2E-05	4E-06	4E-05
1.87	2E-05	3E-06	3E-05
1.41	1E-05	2E-06	2E-05
1.04	8E-06	1E-06	1E-05
0.65	5E-06	9E-07	9E-06
1.24	1E-05	2E-06	2E-05
1.53	1E-05	2E-06	2E-05
-0.633	-5E-06	-9E-07	-9E-06
0.751	6E-06	1E-06	1E-05
0.528	4E-06	7E-07	7E-06
-0.212	-2E-06	-3E-07	-3E-06
0.369	3E-06	5E-07	5E-06
-1.313	-1E-05	-2E-06	-2E-05
-0.189	-3E-06	-6E-07	-6E-06
-1.092	-9E-06	-1E-06	-2E-05
0.181	1E-06	2E-07	3E-06
-0.916	-7E-06	-1E-06	-1E-05
0.113	9E-07	2E-07	2E-06
0.480	4E-06	7E-07	7E-06
0.092	7E-07	1E-07	1E-06
0.119	1E-06	2E-07	2E-06
0.172	1E-06	2E-07	2E-06
0.815	8E-06	8E-07	8E-06
0.234	2E-06	3E-07	3E-06
0.584	5E-06	8E-07	8E-06
-0.625	-6E-06	-9E-07	-9E-06
-0.689	-6E-06	-9E-07	-1E-05
0.198	2E-06	3E-07	3E-06
0.170	1E-06	2E-07	2E-06
0.472	4E-06	6E-07	7E-06
0.080	6E-07	1E-07	1E-06
1.085	9E-06	1E-06	2E-05
-0.118	-1E-06	-2E-07	-2E-06
0.162	1E-06	2E-07	2E-06
1.214	1E-05	2E-06	2E-05
0.032	3E-07	4E-08	4E-07
-0.706	-6E-06	-1E-06	-1E-05

Change in Annual Average NO ₂ Concentration (µg/m ³)	Risk	Risk	Risk
2.88	2E-05	4E-06	4E-05
2.06	2E-05	3E-06	3E-05
2.88	2E-05	4E-06	4E-05
1.16	2E-06	2E-06	2E-05
0.87	7E-06	1E-06	1E-05
0.88	7E-06	1E-06	1E-05
0.96	8E-06	1E-06	1E-05
2.07	2E-05	3E-06	3E-05
-0.945	-8E-06	-1E-06	-1E-05
0.516	4E-06	7E-07	7E-06
0.335	7E-06	1E-06	1E-05
0.317	3E-06	4E-07	4E-06
0.158	1E-06	2E-07	2E-06
-0.560	-5E-06	-8E-07	-8E-06
0.184	1E-06	3E-07	3E-06
-0.463	-4E-06	-6E-07	-6E-06
-0.009	-8E-08	-1E-08	-1E-07
-1.116	-9E-06	-2E-06	-2E-05
-1.093	-9E-06	-1E-06	-2E-05
-0.369	-3E-06	-5E-07	-5E-06
-0.082	-7E-07	-1E-07	-1E-06
-1.627	-1E-05	-2E-06	-2E-05
-0.089	-7E-07	-1E-07	-1E-06
0.204	2E-06	3E-07	3E-06
0.124	1E-06	2E-07	2E-06
0.494	4E-06	7E-07	7E-06
-0.157	-1E-06	-2E-07	-2E-06
-0.107	-9E-07	-1E-07	-1E-06
0.750	6E-06	1E-06	1E-05
0.752	6E-06	1E-06	1E-05
0.998	8E-06	1E-06	1E-05
0.219	2E-06	3E-07	3E-06
0.297	2E-06	4E-07	4E-06
-0.927	-8E-06	-1E-06	-1E-05
0.018	1E-07	2E-08	2E-07
1.008	8E-06	1E-06	1E-05
0.020	2E-07	3E-08	3E-07
-0.269	-2E-06	-4E-07	-4E-06

Annexure E – Population incidence calculations: Nitrogen dioxide

Assessment of Increased Incidence - NO₂

Western Harbour Tunnel: 2027

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Canada Bay LGA			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-111.20	-111.20	-111.20
Population weighted Δx (µg/m ³):	-0.04764353	-0.04764353	-0.04764353
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999910	0.999797	0.999945
Attributable fraction (AF):	-9.0E-05	-2.0E-04	-5.5E-05
Increased number of cases in population:	-0.00084	-0.00015	-0.00023
Risk:	-3.6E-07	-6.5E-08	-6.6E-07
Individual subrubs within LGA			
Drummoyne - Rodd Pt			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-111.20	-111.20	-111.20
Population weighted Δx (µg/m ³):	-0.04764353	-0.04764353	-0.04764353
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999910	0.999797	0.999945
Attributable fraction (AF):	-9.0E-05	-2.0E-04	-5.5E-05
Increased number of cases in population:	-0.0008	-0.00015	-0.000230
Risk:	-3.6E-07	-6.5E-08	-6.6E-07
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-14264	-14264	-14264
Population weighted Δx (µg/m ³):	-0.15150453	-0.15150453	-0.15150453
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999715	0.999355	0.999826
Attributable fraction (AF):	-2.8E-04	-6.5E-04	-1.7E-04
Increased number of cases in population:	-0.1063	-0.01951	-0.02757
Risk:	-1.1E-06	-2.1E-07	-2.1E-06
Individual subrubs within LGA			
Cremorne - Cammeray			
Total Population in study area:	19045	19045	19045
% population in assessment age-group:	100%	100%	13.9%
total change	315.3	315.3	315.3
Population weighted Δx (µg/m ³):	0.01655553	0.01655553	0.01655553
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000031	1.000071	1.000019
Attributable fraction (AF):	3.1E-05	7.1E-05	1.9E-05
Increased number of cases in population:	0.0023	0.0004	0.0006
Risk:	1.2E-07	2.3E-08	2.3E-07
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	2994.6	2994.6	2994.6
Population weighted Δx (µg/m ³):	0.16578641	0.16578641	0.16578641
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000312	1.000706	1.000191
Attributable fraction (AF):	3.1E-04	7.1E-04	1.9E-04
Increased number of cases in population:	0.0223	0.0041	0.0058
Risk:	1.2E-06	2.3E-07	2.3E-06
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-286.4	-286.4	-286.4
Population weighted Δx (µg/m ³):	-0.01006254	-0.01006254	-0.01006254
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999981	0.999957	0.999988
Attributable fraction (AF):	-1.9E-05	-4.3E-05	-1.2E-05
Increased number of cases in population:	-0.0021	-0.0004	-0.0006
Risk:	-7.5E-08	-1.4E-08	-1.4E-07
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-13164	-13164	-13164
Population weighted Δx (µg/m ³):	-0.73546008	-0.73546008	-0.73546008
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998618	0.996872	0.999155
Attributable fraction (AF):	-1.4E-03	-3.1E-03	-8.5E-04
Increased number of cases in population:	-0.0982	-0.0180	-0.0255
Risk:	-5.5E-06	-1.0E-06	-1.0E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-4123.5	-4123.5	-4123.5
Population weighted Δx (µg/m ³):	-0.38609551	-0.38609551	-0.38609551
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999274	0.998357	0.999556
Attributable fraction (AF):	-7.3E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.0307	-0.0056	-0.0080
Risk:	-2.9E-06	-5.3E-07	-5.4E-06
Sydney Inner West LGA			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	-596	-596	-596
Population weighted Δx (µg/m³):	-0.01233878	-0.01233878	-0.01233878
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999977	0.999947	0.999986
Attributable fraction (AF):	-2.3E-05	-5.3E-05	-1.4E-05
Increased number of cases in population:	-0.006	-0.00082	-0.0012
Risk:	-1.2E-07	-1.7E-08	-1.7E-07
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	-602.3	-602.3	-602.3
Population weighted Δx (µg/m³):	-0.03838017	-0.03838017	-0.03838017
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999928	0.999837	0.999956
Attributable fraction (AF):	-7.2E-05	-1.6E-04	-4.4E-05
Increased number of cases in population:	-0.0060	-0.00082	-0.001181
Risk:	-3.9E-07	-5.2E-08	-5.3E-07
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	939.1	939.1	939.1
Population weighted Δx (µg/m³):	0.05353743	0.05353743	0.05353743
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	1.000101	1.000228	1.000062
Attributable fraction (AF):	1.0E-04	2.3E-04	6.2E-05
Increased number of cases in population:	0.009	0.0013	0.0018
Risk:	5.4E-07	7.3E-08	7.4E-07
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-932.9	-932.9	-932.9
Population weighted Δx (µg/m³):	-0.07434058	-0.07434058	-0.07434058
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999860	0.999683	0.999915
Attributable fraction (AF):	-1.4E-04	-3.2E-04	-8.5E-05
Increased number of cases in population:	-0.009	-0.00128	-0.0018
Risk:	-7.5E-07	-1.0E-07	-1.0E-06
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-105.9	-105.9	-105.9
Population weighted Δx (µg/m³):	-0.04202381	-0.04202381	-0.04202381
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999921	0.999821	0.999952
Attributable fraction (AF):	-7.9E-05	-1.8E-04	-4.8E-05
Increased number of cases in population:	-0.0011	-0.00014	-0.00021
Risk:	-4.2E-07	-5.7E-08	-5.8E-07
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-55914.0	-55914	-55914
Population weighted Δx (µg/m³):	-0.42380602	-0.42380602	-0.42380602
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999204	0.998196	0.999513
Attributable fraction (AF):	-8.0E-04	-1.8E-03	-4.9E-04
Increased number of cases in population:	-0.5342	-0.07653	-0.04588
Risk:	-4.0E-06	-5.8E-07	-5.9E-06
Individual subrubs within LGA			
Darlinghurst			
Total Population in study area:	11354	11354	11354
% population in assessment age-group:	100%	100%	5.9%
total change	-4297.6	-4297.6	-4297.6
Population weighted Δx (µg/m³):	-0.37850978	-0.37850978	-0.37850978
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999289	0.998389	0.999565
Attributable fraction (AF):	-7.1E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.041	-0.0059	-0.00353
Risk:	-3.6E-06	-5.2E-07	-5.3E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593
% population in assessment age-group:	100%	100%	5.9%
total change	-3179.4	-3179.4	-3179.4

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.16227224	-0.16227224	-0.16227224
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999695	0.999309	0.999813
Attributable fraction (AF):	-3.1E-04	-6.9E-04	-1.9E-04
Increased number of cases in population:	-0.030	-0.0043	-0.00261
Risk:	-1.5E-06	-2.2E-07	-2.3E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-1685.6	-1685.6	-1685.6
Population weighted Δx (µg/m³):	-0.32704695	-0.32704695	-0.32704695
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999385	0.998608	0.999624
Attributable fraction (AF):	-6.2E-04	-1.4E-03	-3.8E-04
Increased number of cases in population:	-0.01610	-0.002307	-0.001383
Risk:	-3.1E-06	-4.5E-07	-4.5E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-22304.5	-22304.5	-22304.5
Population weighted Δx (µg/m³):	-1.05209906	-1.05209906	-1.05209906
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.998024	0.995528	0.998791
Attributable fraction (AF):	-2.0E-03	-4.5E-03	-1.2E-03
Increased number of cases in population:	-0.213	-0.031	-0.0183
Risk:	-1.0E-05	-1.4E-06	-1.5E-05
Pymont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-9878.5	-9878.5	-9878.5
Population weighted Δx (µg/m³):	-0.45596584	-0.45596584	-0.45596584
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999143	0.998059	0.999476
Attributable fraction (AF):	-8.6E-04	-1.9E-03	-5.2E-04
Increased number of cases in population:	-0.094	-0.0135	-0.0081
Risk:	-4.4E-06	-6.2E-07	-6.3E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	-1018.3	-1018.3	-1018.3
Population weighted Δx (µg/m³):	-0.10326539	-0.10326539	-0.10326539
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999806	0.999560	0.999881
Attributable fraction (AF):	-1.9E-04	-4.4E-04	-1.2E-04
Increased number of cases in population:	-0.00973	-0.001393	-0.000835
Risk:	-9.9E-07	-1.4E-07	-1.4E-06
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-5251.3	-5251.3	-5251.3
Population weighted Δx (µg/m³):	-0.33449901	-0.33449901	-0.33449901
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999371	0.998576	0.999615
Attributable fraction (AF):	-6.3E-04	-1.4E-03	-3.8E-04
Increased number of cases in population:	-0.050	-0.0072	-0.00431
Risk:	-3.2E-06	-4.6E-07	-4.7E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-8298.6	-8298.6	-8298.6
Population weighted Δx (µg/m³):	-0.30279126	-0.30279126	-0.30279126
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999431	0.998711	0.999652
Attributable fraction (AF):	-5.7E-04	-1.3E-03	-3.5E-04
Increased number of cases in population:	-0.0793	-0.0114	-0.00681
Risk:	-2.9E-06	-4.1E-07	-4.2E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	3892.20	3892.2	3892.2
Population weighted Δx (µg/m³):	0.03765856	0.03765856	0.03765856
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000071	1.000160	1.000043
Attributable fraction (AF):	7.1E-05	1.6E-04	4.3E-05
Increased number of cases in population:	0.025	0.00532	0.0093
Risk:	2.4E-07	5.1E-08	5.2E-07
Individual suburbs within LGA			
Chatswood East - Artarmon			
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	559.1	559.1	559.1

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 $\mu\text{g}/\text{m}^3$ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.01952778	0.01952778	0.01952778
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000037	1.000083	1.000022
Attributable fraction (AF):	3.7E-05	8.3E-05	2.2E-05
Increased number of cases in population:	0.0035	0.0008	0.0013
Risk:	1.2E-07	2.7E-08	2.7E-07
Chatswood West - Lane Cove North			
Total Population in study area:	18393	18393	18393
% population in assessment age-group:	100%	100%	17.1%
total change	-553.5	-553.5	-553.5
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	-0.03009297	-0.03009297	-0.03009297
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999943	0.999872	0.999965
Attributable fraction (AF):	-5.7E-05	-1.3E-04	-3.5E-05
Increased number of cases in population:	-0.0035	-0.0008	-0.0013
Risk:	-1.9E-07	-4.1E-08	-4.2E-07
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	589	589	589
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.02887113	0.02887113	0.02887113
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000054	1.000123	1.000033
Attributable fraction (AF):	5.4E-05	1.2E-04	3.3E-05
Increased number of cases in population:	0.0037	0.0008	0.0014
Risk:	1.8E-07	3.9E-08	4.0E-07
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	1363	1363	1363
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.13008208	0.13008208	0.13008208
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000245	1.000554	1.000150
Attributable fraction (AF):	2.4E-04	5.5E-04	1.5E-04
Increased number of cases in population:	0.0086	0.0019	0.0032
Risk:	8.2E-07	1.8E-07	1.8E-06
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	1934.5	1934.5	1934.5
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.07600581	0.07600581	0.07600581
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000143	1.000324	1.000087
Attributable fraction (AF):	1.4E-04	3.2E-04	8.7E-05
Increased number of cases in population:	0.0122	0.0026	0.0046
Risk:	4.8E-07	1.0E-07	1.1E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	2.8	2.75	2.75
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.00121789	0.00121789	0.00121789
Baseline Incidence (per 100,000) (as per Table 3-5)	502	32	1209
Baseline Incidence (per person)	0.00502	0.00032	0.01209
Relative Risk:	1.000002	1.000005	1.000001
Attributable fraction (AF):	2.3E-06	5.2E-06	1.4E-06
Increased number of cases in population:	0.000026	0.000004	0.000007
Risk:	1.1E-08	1.7E-09	1.7E-08
Individual suburbs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	2.75	2.75	2.75
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	0.00121789	0.00121789	0.00121789
Baseline Incidence (per 100,000) (as per Table 3-5)	502	32	1209
Baseline Incidence (per person)	0.00502	0.00032	0.01209
Relative Risk:	1.000002	1.000005	1.000001
Attributable fraction (AF):	2.3E-06	5.2E-06	1.4E-06
Increased number of cases in population:	0.000026	0.0000038	0.000007
Risk:	1.1E-08	1.7E-09	1.7E-08
Woollara LGA (Easterns Suburbs - North)			
Total Population in study area:	71841	71841	71841
% population in assessment age-group:	100%	100%	14.5%
total change	-3138.6	-3138.6	-3138.6
Population weighted Δx ($\mu\text{g}/\text{m}^3$):	-0.04368814	-0.04368814	-0.04368814
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999918	0.999814	0.999950
Attributable fraction (AF):	-8.2E-05	-1.9E-04	-5.0E-05
Increased number of cases in population:	-0.023	-0.0043	-0.0063
Risk:	-3.3E-07	-6.0E-08	-6.1E-07
Individual suburbs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
% population in assessment age-group:	100%	100%	14.5%
total change	22.4	22.4	22.4
Population weighted Δx (µg/m³):	0.01025641	0.01025641	0.01025641
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000019	1.000044	1.000012
Attributable fraction (AF):	1.9E-05	4.4E-05	1.2E-05
Increased number of cases in population:	0.00017	0.000031	0.00005
Risk:	7.6E-08	1.4E-08	1.4E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-419.1	-419.1	-419.1
Population weighted Δx (µg/m³):	-0.03545985	-0.03545985	-0.03545985
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999933	0.999849	0.999959
Attributable fraction (AF):	-6.7E-05	-1.5E-04	-4.1E-05
Increased number of cases in population:	-0.0031	-0.0006	-0.00084
Risk:	-2.6E-07	-4.8E-08	-4.9E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	-8.22	-8.22	-8.22
Population weighted Δx (µg/m³):	-0.00431950	-0.00431950	-0.00431950
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999992	0.999982	0.999995
Attributable fraction (AF):	-8.1E-06	-1.8E-05	-5.0E-06
Increased number of cases in population:	-0.000061	-0.000011	-0.00002
Risk:	-3.2E-08	-5.9E-09	-6.0E-08
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-573.3	-573.3	-573.3
Population weighted Δx (µg/m³):	-0.02311880	-0.02311880	-0.02311880
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999957	0.999902	0.999973
Attributable fraction (AF):	-4.3E-05	-9.8E-05	-2.7E-05
Increased number of cases in population:	-0.0043	-0.00078	-0.00116
Risk:	-1.7E-07	-3.2E-08	-3.2E-07
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-60.1	-60.1	-60.1
Population weighted Δx (µg/m³):	-0.01890532	-0.01890532	-0.01890532
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999964	0.999919	0.999978
Attributable fraction (AF):	-3.6E-05	-8.1E-05	-2.2E-05
Increased number of cases in population:	-0.0004	-0.000082	-0.00012
Risk:	-1.4E-07	-2.6E-08	-2.6E-07
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-1780.3	-1780.3	-1780.3
Population weighted Δx (µg/m³):	-0.13374653	-0.13374653	-0.13374653
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999749	0.999430	0.999846
Attributable fraction (AF):	-2.5E-04	-5.7E-04	-1.5E-04
Increased number of cases in population:	-0.01326	-0.00244	-0.003589
Risk:	-1.0E-06	-1.8E-07	-1.9E-06
Rose Bay - Vaucluse - Watsons Bay			
Total Population in study area:	6984	6984	6984
% population in assessment age-group:	100%	100%	14.5%
total change	-617.8	-617.8	-617.8
Population weighted Δx (µg/m³):	-0.08845934	-0.08845934	-0.08845934
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999834	0.999623	0.999898
Attributable fraction (AF):	-1.7E-04	-3.8E-04	-1.0E-04
Increased number of cases in population:	-0.00460	-0.00084	-0.001246
Risk:	-6.6E-07	-1.2E-07	-1.2E-06
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	298	298	298
Population weighted Δx (µg/m³):	0.03888816	0.03888816	0.03888816
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000073	1.000166	1.000045
Attributable fraction (AF):	7.3E-05	1.7E-04	4.5E-05
Increased number of cases in population:	0.00222	0.00041	0.000601
Risk:	2.9E-07	5.3E-08	5.4E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	1407.4	1407.4	1407.4

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	0.01623411	0.01623411	0.01623411
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000031	1.000069	1.000019
Attributable fraction (AF):	3.1E-05	6.9E-05	1.9E-05
Increased number of cases in population:	0.012232	0.001924	0.00364
Risk:	1.4E-07	2.2E-08	2.3E-07
Individual suburbs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	495.2	495.2	495.2
Population weighted Δx (µg/m³):	0.02449787	0.02449787	0.02449787
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000046	1.000104	1.000028
Attributable fraction (AF):	4.6E-05	1.0E-04	2.8E-05
Increased number of cases in population:	0.0043	0.0007	0.00128
Risk:	2.1E-07	3.3E-08	3.4E-07
Beacon Hill - Narrabeena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	191.5	191.5	191.5
Population weighted Δx (µg/m³):	0.01501137	0.01501137	0.01501137
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000028	1.000064	1.000017
Attributable fraction (AF):	2.8E-05	6.4E-05	1.7E-05
Increased number of cases in population:	0.0017	0.0003	0.00050
Risk:	1.3E-07	2.1E-08	2.1E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	-110	-110	-110
Population weighted Δx (µg/m³):	-0.48245614	-0.48245614	-0.48245614
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999093	0.997947	0.999445
Attributable fraction (AF):	-9.1E-04	-2.1E-03	-5.5E-04
Increased number of cases in population:	-0.0010	-0.000151	-0.00028
Risk:	-4.2E-06	-6.6E-07	-6.7E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	384.6	384.6	384.6
Population weighted Δx (µg/m³):	0.03001639	0.03001639	0.03001639
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000056	1.000128	1.000035
Attributable fraction (AF):	5.6E-05	1.3E-04	3.5E-05
Increased number of cases in population:	0.0033	0.0005	0.00099
Risk:	2.6E-07	4.1E-08	4.2E-07
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	19%
total change	134.1	134.1	134.1
Population weighted Δx (µg/m³):	0.01320012	0.01320012	0.01320012
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000025	1.000056	1.000015
Attributable fraction (AF):	2.5E-05	5.6E-05	1.5E-05
Increased number of cases in population:	0.0012	0.0002	0.00035
Risk:	1.1E-07	1.8E-08	1.8E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	127.5	127.5	127.5
Population weighted Δx (µg/m³):	0.01584441	0.01584441	0.01584441
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000030	1.000067	1.000018
Attributable fraction (AF):	3.0E-05	6.7E-05	1.8E-05
Increased number of cases in population:	0.0011	0.0002	0.00033
Risk:	1.4E-07	2.2E-08	2.2E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	283.7	283.7	283.7
Population weighted Δx (µg/m³):	0.05087877	0.05087877	0.05087877
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000096	1.000217	1.000059
Attributable fraction (AF):	9.6E-05	2.2E-04	5.9E-05
Increased number of cases in population:	0.0025	0.0004	0.00073
Risk:	4.4E-07	7.0E-08	7.1E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	-99.4	-99.4	-99.4
Population weighted Δx (µg/m³):	-0.00588166	-0.00588166	-0.00588166

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999989	0.999975	0.999993
Attributable fraction (AF):	-1.1E-05	-2.5E-05	-6.8E-06
Increased number of cases in population:	-0.0009	-0.00014	-0.00026
Risk:	-5.1E-08	-8.0E-09	-8.2E-08
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-13.3	-13.3	-13.3
Population weighted Δx (µg/m³):	-0.00041313	-0.00041313	-0.00041313
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999999	0.999998	1.000000
Attributable fraction (AF):	-7.8E-07	-1.8E-06	-4.8E-07
Increased number of cases in population:	-0.00009	-0.00002	-0.00004
Risk:	-2.8E-09	-5.6E-10	-5.7E-09
Individual suburbs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	197.4	197.4	197.4
Population weighted Δx (µg/m³):	0.02012027	0.02012027	0.02012027
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	1.000038	1.000086	1.000023
Attributable fraction (AF):	3.8E-05	8.6E-05	2.3E-05
Increased number of cases in population:	0.0014	0.0003	0.00053
Risk:	1.4E-07	2.8E-08	2.8E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-156.6	-156.6	-156.6
Population weighted Δx (µg/m³):	-0.00733730	-0.00733730	-0.00733730
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999986	0.999969	0.999992
Attributable fraction (AF):	-1.4E-05	-3.1E-05	-8.4E-06
Increased number of cases in population:	-0.0011	-0.0002	-0.00042
Risk:	-5.0E-08	-1.0E-08	-1.0E-07
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-54	-54	-54
Population weighted Δx (µg/m³):	-0.05197305	-0.05197305	-0.05197305
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999902	0.999779	0.999940
Attributable fraction (AF):	-9.8E-05	-2.2E-04	-6.0E-05
Increased number of cases in population:	-0.0004	-0.000074	-0.00015
Risk:	-3.6E-07	-7.1E-08	-7.2E-07
Total population incidence - All Suburbs	-0.63	-0.094	-0.07

Assessment of Increased Incidence - NO₂

Western Harbour Tunnel: 2037

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Canada Bay LGA			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-402.40	-402.40	-402.40
Population weighted Δx (µg/m ³):	-0.17240788	-0.17240788	-0.17240788
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999676	0.999266	0.999802
Attributable fraction (AF):	-3.2E-04	-7.3E-04	-2.0E-04
Increased number of cases in population:	-0.003052	-0.0005505	-0.00083370
Risk:	-1.3E-06	-2.4E-07	-2.4E-06
Individual subrubs within LGA			
Drummoyne - Rodd Pt			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-402.40	-402.40	-402.40
Population weighted Δx (µg/m ³):	-0.17240788	-0.17240788	-0.17240788
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999676	0.999266	0.999802
Attributable fraction (AF):	-3.2E-04	-7.3E-04	-2.0E-04
Increased number of cases in population:	-0.0031	-0.00055	-0.000834
Risk:	-1.3E-06	-2.4E-07	-2.4E-06
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-17687	-17687	-17687
Population weighted Δx (µg/m ³):	-0.18786179	-0.18786179	-0.18786179
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999647	0.999200	0.999784
Attributable fraction (AF):	-3.5E-04	-8.0E-04	-2.2E-04
Increased number of cases in population:	-0.1318	-0.02420	-0.03419
Risk:	-1.4E-06	-2.6E-07	-2.6E-06
Individual subrubs within LGA			
Cremorne - Cammeray			
Total Population in study area:	19045	19045	19045
% population in assessment age-group:	100%	100%	13.9%
total change	579.2	579.2	579.2
Population weighted Δx (µg/m ³):	0.03041218	0.03041218	0.03041218
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000057	1.000130	1.000035
Attributable fraction (AF):	5.7E-05	1.3E-04	3.5E-05
Increased number of cases in population:	0.0043	0.0008	0.0011
Risk:	2.3E-07	4.2E-08	4.2E-07
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	3259.7	3259.7	3259.7
Population weighted Δx (µg/m ³):	0.18046282	0.18046282	0.18046282
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000339	1.000769	1.000208
Attributable fraction (AF):	3.4E-04	7.7E-04	2.1E-04
Increased number of cases in population:	0.0243	0.0045	0.0063
Risk:	1.3E-06	2.5E-07	2.5E-06
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-1071.1	-1071.1	-1071.1
Population weighted Δx (µg/m ³):	-0.03763263	-0.03763263	-0.03763263
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999929	0.999840	0.999957
Attributable fraction (AF):	-7.1E-05	-1.6E-04	-4.3E-05
Increased number of cases in population:	-0.0080	-0.0015	-0.0021
Risk:	-2.8E-07	-5.1E-08	-5.2E-07
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-14120	-14120	-14120
Population weighted Δx (µg/m ³):	-0.78887089	-0.78887089	-0.78887089
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998518	0.996645	0.999093
Attributable fraction (AF):	-1.5E-03	-3.4E-03	-9.1E-04
Increased number of cases in population:	-0.1053	-0.0193	-0.0273
Risk:	-5.9E-06	-1.1E-06	-1.1E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-6334.9	-6334.9	-6334.9
Population weighted Δx (µg/m ³):	-0.59315543	-0.59315543	-0.59315543
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per person):	0.00396	0.00032	0.01209
Relative Risk:	0.99885	0.997476	0.999318
Attributable fraction (AF):	-1.1E-03	-2.5E-03	-6.8E-04
Increased number of cases in population:	-0.0472	-0.0087	-0.0122
Risk:	-4.4E-06	-8.1E-07	-8.2E-06
Sydney Inner West LGA			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	-2560.6	-2560.6	-2560.6
Population weighted Δx (µg/m³):	-0.05301120	-0.05301120	-0.05301120
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999900	0.999774	0.999939
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.1E-05
Increased number of cases in population:	-0.026	-0.0035	-0.0050
Risk:	-5.3E-07	-7.2E-08	-7.4E-07
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	-2589.3	-2589.3	-2589.3
Population weighted Δx (µg/m³):	-0.16499713	-0.16499713	-0.16499713
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999690	0.999297	0.999810
Attributable fraction (AF):	-3.1E-04	-7.0E-04	-1.9E-04
Increased number of cases in population:	-0.0260	-0.00354	-0.005077
Risk:	-1.7E-06	-2.3E-07	-2.3E-06
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	785.7	785.7	785.7
Population weighted Δx (µg/m³):	0.04479220	0.04479220	0.04479220
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	1.000084	1.000191	1.000052
Attributable fraction (AF):	8.4E-05	1.9E-04	5.2E-05
Increased number of cases in population:	0.008	0.0011	0.0015
Risk:	4.5E-07	6.1E-08	6.2E-07
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-757	-757	-757
Population weighted Δx (µg/m³):	-0.06032353	-0.06032353	-0.06032353
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999887	0.999743	0.999931
Attributable fraction (AF):	-1.1E-04	-2.6E-04	-6.9E-05
Increased number of cases in population:	-0.008	-0.00104	-0.0015
Risk:	-6.1E-07	-8.2E-08	-8.4E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-50.5	-50.5	-50.5
Population weighted Δx (µg/m³):	-0.02003968	-0.02003968	-0.02003968
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999962	0.999915	0.999977
Attributable fraction (AF):	-3.8E-05	-8.5E-05	-2.3E-05
Increased number of cases in population:	-0.0005	-0.00007	-0.00010
Risk:	-2.0E-07	-2.7E-08	-2.8E-07
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-31739.0	-31739	-31739
Population weighted Δx (µg/m³):	-0.24056908	-0.24056908	-0.24056908
Baseline Incidence (per 100,000) (as per Table 3-5):	508	32	1209
Baseline Incidence (per person):	0.00508	0.00032	0.01209
Relative Risk:	0.999548	0.998976	0.999723
Attributable fraction (AF):	-4.5E-04	-1.0E-03	-2.8E-04
Increased number of cases in population:	-0.30	-0.043	-0.026
Risk:	-2.3E-06	-3.3E-07	-3.3E-06
Individual subrubs within LGA			
Darlinghurst			
Total Population in study area:	11354	11354	11354
% population in assessment age-group:	100%	100%	5.9%
total change	-1419.3	-1419.3	-1419.3
Population weighted Δx (µg/m³):	-0.12500440	-0.12500440	-0.12500440
Baseline Incidence (per 100,000) (as per Table 3-5):	508	32	1209
Baseline Incidence (per person):	0.00508	0.00032	0.01209
Relative Risk:	0.999765	0.999468	0.999856
Attributable fraction (AF):	-2.4E-04	-5.3E-04	-1.4E-04
Increased number of cases in population:	-0.014	-0.0019	-0.00116
Risk:	-1.2E-06	-1.7E-07	-1.7E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593
% population in assessment age-group:	100%	100%	5.9%
total change	-3341.8	-3341.8	-3341.8

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.17056091	-0.17056091	-0.17056091
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999679	0.999274	0.999804
Attributable fraction (AF):	-3.2E-04	-7.3E-04	-2.0E-04
Increased number of cases in population:	-0.032	-0.0046	-0.00274
Risk:	-1.6E-06	-2.3E-07	-2.4E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-840.5	-840.5	-840.5
Population weighted Δx (µg/m³):	-0.16307722	-0.16307722	-0.16307722
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999693	0.999306	0.999812
Attributable fraction (AF):	-3.1E-04	-6.9E-04	-1.9E-04
Increased number of cases in population:	-0.00803	-0.001150	-0.000690
Risk:	-1.6E-06	-2.2E-07	-2.3E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-4279.9	-4279.9	-4279.9
Population weighted Δx (µg/m³):	-0.20188208	-0.20188208	-0.20188208
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999621	0.999140	0.999768
Attributable fraction (AF):	-3.8E-04	-8.6E-04	-2.3E-04
Increased number of cases in population:	-0.041	-0.006	-0.0035
Risk:	-1.9E-06	-2.8E-07	-2.8E-06
Pymont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-9474.2	-9474.2	-9474.2
Population weighted Δx (µg/m³):	-0.43730441	-0.43730441	-0.43730441
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999178	0.998139	0.999497
Attributable fraction (AF):	-8.2E-04	-1.9E-03	-5.0E-04
Increased number of cases in population:	-0.091	-0.0130	-0.0078
Risk:	-4.2E-06	-6.0E-07	-6.1E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	551.5	551.5	551.5
Population weighted Δx (µg/m³):	0.05592739	0.05592739	0.05592739
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	1.000105	1.000238	1.000064
Attributable fraction (AF):	1.1E-04	2.4E-04	6.4E-05
Increased number of cases in population:	0.00527	0.000754	0.000452
Risk:	5.3E-07	7.6E-08	7.8E-07
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-2291.9	-2291.9	-2291.9
Population weighted Δx (µg/m³):	-0.14599019	-0.14599019	-0.14599019
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999726	0.999378	0.999832
Attributable fraction (AF):	-2.7E-04	-6.2E-04	-1.7E-04
Increased number of cases in population:	-0.022	-0.0031	-0.00188
Risk:	-1.4E-06	-2.0E-07	-2.0E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-10646	-10646	-10646
Population weighted Δx (µg/m³):	-0.38844091	-0.38844091	-0.38844091
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999270	0.998347	0.999553
Attributable fraction (AF):	-7.3E-04	-1.7E-03	-4.5E-04
Increased number of cases in population:	-0.1017	-0.0146	-0.00873
Risk:	-3.7E-06	-5.3E-07	-5.4E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	5370.00	5370	5370
Population weighted Δx (µg/m³):	0.05195685	0.05195685	0.05195685
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000098	1.000221	1.000060
Attributable fraction (AF):	9.8E-05	2.2E-04	6.0E-05
Increased number of cases in population:	0.034	0.0073	0.0128
Risk:	3.3E-07	7.1E-08	7.2E-07
Individual suburbs within LGA			
Chatswood East - Artarmon			
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	475.7	475.7	475.7

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	0.01661486	0.01661486	0.01661486
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	1.000031	1.000071	1.000019
Attributable fraction (AF):	3.1E-05	7.1E-05	1.9E-05
Increased number of cases in population:	0.0030	0.0007	0.0011
Risk:	1.0E-07	2.3E-08	2.3E-07
Chatswood West - Lane Cove North			
Total Population in study area:	18393	18393	18393
% population in assessment age-group:	100%	100%	17.1%
total change	-356.8	-356.8	-356.8
Population weighted Δx (µg/m³):	-0.01939868	-0.01939868	-0.01939868
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	0.999964	0.999917	0.999978
Attributable fraction (AF):	-3.6E-05	-8.3E-05	-2.2E-05
Increased number of cases in population:	-0.0022	-0.0005	-0.0008
Risk:	-1.2E-07	-2.7E-08	-2.7E-07
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	-121.6	-121.6	-121.6
Population weighted Δx (µg/m³):	-0.00596049	-0.00596049	-0.00596049
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	0.999989	0.999975	0.999993
Attributable fraction (AF):	-1.1E-05	-2.5E-05	-6.9E-06
Increased number of cases in population:	-0.0008	-0.0002	-0.0003
Risk:	-3.8E-08	-8.2E-09	-8.3E-08
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	3432.3	3432.3	3432.3
Population weighted Δx (µg/m³):	0.32757206	0.32757206	0.32757206
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	1.000616	1.001396	1.000377
Attributable fraction (AF):	6.2E-04	1.4E-03	3.8E-04
Increased number of cases in population:	0.0216	0.0047	0.0082
Risk:	2.1E-06	4.5E-07	4.6E-06
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	1940.9	1940.9	1940.9
Population weighted Δx (µg/m³):	0.07625727	0.07625727	0.07625727
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	1.000143	1.000325	1.000088
Attributable fraction (AF):	1.4E-04	3.2E-04	8.8E-05
Increased number of cases in population:	0.0122	0.0027	0.0046
Risk:	4.8E-07	1.0E-07	1.1E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	124.5	124.5	124.5
Population weighted Δx (µg/m³):	0.05513729	0.05513729	0.05513729
Baseline Incidence (per 100,000) (as per Table 3-5):	502	32	1209
Baseline Incidence (per person):	0.00502	0.00032	0.01209
Relative Risk:	1.000104	1.000235	1.000063
Attributable fraction (AF):	1.0E-04	2.3E-04	6.3E-05
Increased number of cases in population:	0.001174	0.000170	0.000313
Risk:	5.2E-07	7.5E-08	7.7E-07
Individual subbrbs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	124.5	124.5	124.5
Population weighted Δx (µg/m³):	0.05513729	0.05513729	0.05513729
Baseline Incidence (per 100,000) (as per Table 3-5):	502	32	1209
Baseline Incidence (per person):	0.00502	0.00032	0.01209
Relative Risk:	1.000104	1.000235	1.000063
Attributable fraction (AF):	1.0E-04	2.3E-04	6.3E-05
Increased number of cases in population:	0.0012	0.00017	0.0003
Risk:	5.2E-07	7.5E-08	7.7E-07
Woollara LGA (Easterns Suburbs - North)			
Total Population in study area:	71841	71841	71841
% population in assessment age-group:	100%	100%	14.5%
total change	-1383.3	-1383.3	-1383.3
Population weighted Δx (µg/m³):	-0.01925502	-0.01925502	-0.01925502
Baseline Incidence (per 100,000) (as per Table 3-5):	396	32	1209
Baseline Incidence (per person):	0.00396	0.00032	0.01209
Relative Risk:	0.999964	0.999918	0.999978
Attributable fraction (AF):	-3.6E-05	-8.2E-05	-2.2E-05
Increased number of cases in population:	-0.010	-0.0019	-0.0028
Risk:	-1.4E-07	-2.6E-08	-2.7E-07
Individual subbrbs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
% population in assessment age-group:	100%	100%	14.5%
total change	101.9	101.9	101.9
Population weighted Δx (µg/m³):	0.04665751	0.04665751	0.04665751
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000088	1.000199	1.000054
Attributable fraction (AF):	8.8E-05	2.0E-04	5.4E-05
Increased number of cases in population:	0.0008	0.00014	0.00021
Risk:	3.5E-07	6.4E-08	6.5E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-218.1	-218.1	-218.1
Population weighted Δx (µg/m³):	-0.01845334	-0.01845334	-0.01845334
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999965	0.999921	0.999979
Attributable fraction (AF):	-3.5E-05	-7.9E-05	-2.1E-05
Increased number of cases in population:	-0.0016	-0.0003	-0.00044
Risk:	-1.4E-07	-2.5E-08	-2.6E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	0.064	0.064	0.064
Population weighted Δx (µg/m³):	0.00003363	0.00003363	0.00003363
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000000	1.000000	1.000000
Attributable fraction (AF):	6.3E-08	1.4E-07	3.9E-08
Increased number of cases in population:	0.00000048	0.00000009	0.00000013
Risk:	2.5E-10	4.6E-11	4.7E-10
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-630.3	-630.3	-630.3
Population weighted Δx (µg/m³):	-0.02541737	-0.02541737	-0.02541737
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999952	0.999892	0.999971
Attributable fraction (AF):	-4.8E-05	-1.1E-04	-2.9E-05
Increased number of cases in population:	-0.0047	-0.00086	-0.00127
Risk:	-1.9E-07	-3.5E-08	-3.5E-07
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-4.99	-4.99	-4.99
Population weighted Δx (µg/m³):	-0.00156968	-0.00156968	-0.00156968
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999997	0.999993	0.999998
Attributable fraction (AF):	-3.0E-06	-6.7E-06	-1.8E-06
Increased number of cases in population:	-0.000037	-0.000007	-0.000010
Risk:	-1.2E-08	-2.1E-09	-2.2E-08
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-305.3	-305.3	-305.3
Population weighted Δx (µg/m³):	-0.02293592	-0.02293592	-0.02293592
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999957	0.999902	0.999974
Attributable fraction (AF):	-4.3E-05	-9.8E-05	-2.6E-05
Increased number of cases in population:	-0.00227	-0.00042	-0.000615
Risk:	-1.7E-07	-3.1E-08	-3.2E-07
Rose Bay - Vaucluse - Watsons Bay			
Total Population in study area:	6984	6984	6984
% population in assessment age-group:	100%	100%	14.5%
total change	-398.7	-398.7	-398.7
Population weighted Δx (µg/m³):	-0.05708763	-0.05708763	-0.05708763
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999893	0.999757	0.999934
Attributable fraction (AF):	-1.1E-04	-2.4E-04	-6.6E-05
Increased number of cases in population:	-0.00297	-0.00055	-0.000804
Risk:	-4.3E-07	-7.8E-08	-7.9E-07
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	70.5	70.5	70.5
Population weighted Δx (µg/m³):	0.00920005	0.00920005	0.00920005
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000017	1.000039	1.000011
Attributable fraction (AF):	1.7E-05	3.9E-05	1.1E-05
Increased number of cases in population:	0.00052	0.00010	0.000142
Risk:	6.8E-08	1.3E-08	1.3E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	-33.2	-33.2	-33.2

Western Harbour Tunnel and Warringah Freeway Upgrade

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Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.00038296	-0.00038296	-0.00038296
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999999	0.999998	1.000000
Attributable fraction (AF):	-0.000001	-0.000002	0.000000
Increased number of cases in population:	-0.000289	-0.000045	-0.000086
Risk:	-3.3E-09	-5.2E-10	-5.3E-09
Individual suburbs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	-103.7	-103.7	-103.7
Population weighted Δx (µg/m³):	-0.00513011	-0.00513011	-0.00513011
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999990	0.999978	0.999994
Attributable fraction (AF):	-9.6E-06	-2.2E-05	-5.9E-06
Increased number of cases in population:	-0.0009	-0.00014	-0.00027
Risk:	-4.5E-08	-7.0E-09	-7.1E-08
Beacon Hill - Narrabeena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	501.9	501.9	501.9
Population weighted Δx (µg/m³):	0.03934311	0.03934311	0.03934311
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000074	1.000168	1.000045
Attributable fraction (AF):	7.4E-05	1.7E-04	4.5E-05
Increased number of cases in population:	0.0044	0.0007	0.00130
Risk:	3.4E-07	5.4E-08	5.5E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	13.6	13.6	13.6
Population weighted Δx (µg/m³):	0.05964912	0.05964912	0.05964912
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000112	1.000254	1.000069
Attributable fraction (AF):	1.1E-04	2.5E-04	6.9E-05
Increased number of cases in population:	0.00012	0.000019	0.00004
Risk:	5.2E-07	8.2E-08	8.3E-07
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	371.4	371.4	371.4
Population weighted Δx (µg/m³):	0.02898619	0.02898619	0.02898619
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000054	1.000123	1.000033
Attributable fraction (AF):	5.4E-05	1.2E-04	3.3E-05
Increased number of cases in population:	0.0032	0.00051	0.00096
Risk:	2.5E-07	4.0E-08	4.0E-07
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	19%
total change	11.3	11.3	11.3
Population weighted Δx (µg/m³):	0.00111231	0.00111231	0.00111231
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000002	1.000005	1.000001
Attributable fraction (AF):	2.1E-06	4.7E-06	1.3E-06
Increased number of cases in population:	0.00010	0.000015	0.00003
Risk:	9.7E-09	1.5E-09	1.5E-08
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	-472.9	-472.9	-472.9
Population weighted Δx (µg/m³):	-0.05876724	-0.05876724	-0.05876724
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999890	0.999750	0.999932
Attributable fraction (AF):	-1.1E-04	-2.5E-04	-6.8E-05
Increased number of cases in population:	-0.0041	-0.0006	-0.00122
Risk:	-5.1E-07	-8.0E-08	-8.2E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	-47	-47	-47
Population weighted Δx (µg/m³):	-0.00842898	-0.00842898	-0.00842898
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999984	0.999964	0.999990
Attributable fraction (AF):	-1.6E-05	-3.6E-05	-9.7E-06
Increased number of cases in population:	-0.0004	-0.000064	-0.00012
Risk:	-7.3E-08	-1.2E-08	-1.2E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	-307.7	-307.7	-307.7
Population weighted Δx (µg/m³):	-0.01820710	-0.01820710	-0.01820710

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999966	0.999922	0.999979
Attributable fraction (AF):	-3.4E-05	-7.8E-05	-2.1E-05
Increased number of cases in population:	-0.0027	-0.00042	-0.00080
Risk:	-1.6E-07	-2.5E-08	-2.5E-07
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-389.9	-389.9	-389.9
Population weighted Δx (µg/m³):	-0.01211133	-0.01211133	-0.01211133
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999977	0.999948	0.999986
Attributable fraction (AF):	-2.3E-05	-5.2E-05	-1.4E-05
Increased number of cases in population:	-0.00267	-0.00053	-0.0011
Risk:	-8.3E-08	-1.7E-08	-1.7E-07
Individual suburbs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	-175.9	-175.9	-175.9
Population weighted Δx (µg/m³):	-0.01792886	-0.01792886	-0.01792886
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999966	0.999924	0.999979
Attributable fraction (AF):	-3.4E-05	-7.6E-05	-2.1E-05
Increased number of cases in population:	-0.0012	-0.0002	-0.00047
Risk:	-1.2E-07	-2.5E-08	-2.5E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-162.1	-162.1	-162.1
Population weighted Δx (µg/m³):	-0.00759500	-0.00759500	-0.00759500
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999986	0.999968	0.999991
Attributable fraction (AF):	-1.4E-05	-3.2E-05	-8.7E-06
Increased number of cases in population:	-0.0011	-0.0002	-0.00044
Risk:	-5.2E-08	-1.0E-08	-1.1E-07
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-51.8	-51.8	-51.8
Population weighted Δx (µg/m³):	-0.04985563	-0.04985563	-0.04985563
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999906	0.999788	0.999943
Attributable fraction (AF):	-9.4E-05	-2.1E-04	-5.7E-05
Increased number of cases in population:	-0.0004	-0.000071	-0.00014
Risk:	-3.4E-07	-6.8E-08	-6.9E-07
Total population incidence - All Suburbs			
	-0.44	-0.067	-0.057

Assessment of Increased Incidence - NO₂

Western Harbour Tunnel: 2027 Cumulative

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Canada Bay LGA			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	52.80	52.80	52.80
Population weighted Δx (µg/m ³):	0.02262211	0.02262211	0.02262211
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	1.000043	1.000096	1.000026
Attributable fraction (AF):	4.3E-05	9.6E-05	2.6E-05
Increased number of cases in population:	0.000400	0.0000722	0.00010938
Risk:	1.7E-07	3.1E-08	3.1E-07
Individual subbrs within LGA			
Drummoyne - Rodd Pt			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	52.80	52.80	52.80
Population weighted Δx (µg/m ³):	0.02262211	0.02262211	0.02262211
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	1.000043	1.000096	1.000026
Attributable fraction (AF):	4.3E-05	9.6E-05	2.6E-05
Increased number of cases in population:	0.0004	0.00007	0.000109
Risk:	1.7E-07	3.1E-08	3.1E-07
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-41602	-41602	-41602
Population weighted Δx (µg/m ³):	-0.44187405	-0.44187405	-0.44187405
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999170	0.998119	0.999492
Attributable fraction (AF):	-8.3E-04	-1.9E-03	-5.1E-04
Increased number of cases in population:	-0.3102	-0.05694	-0.08042
Risk:	-3.3E-06	-6.0E-07	-6.1E-06
Individual subbrs within LGA			
Cremorne - Cammeray			
Total Population in study area:	19045	19045	19045
% population in assessment age-group:	100%	100%	13.9%
total change	-7034.5	-7034.5	-7034.5
Population weighted Δx (µg/m ³):	-0.36936204	-0.36936204	-0.36936204
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999306	0.998428	0.999575
Attributable fraction (AF):	-6.9E-04	-1.6E-03	-4.2E-04
Increased number of cases in population:	-0.0524	-0.0096	-0.0136
Risk:	-2.8E-06	-5.1E-07	-5.1E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	286.4	286.4	286.4
Population weighted Δx (µg/m ³):	0.01585562	0.01585562	0.01585562
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000030	1.000068	1.000018
Attributable fraction (AF):	3.0E-05	6.8E-05	1.8E-05
Increased number of cases in population:	0.0021	0.0004	0.0006
Risk:	1.2E-07	2.2E-08	2.2E-07
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-10906	-10906	-10906
Population weighted Δx (µg/m ³):	-0.38317757	-0.38317757	-0.38317757
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999280	0.998369	0.999559
Attributable fraction (AF):	-7.2E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.0813	-0.0149	-0.0211
Risk:	-2.9E-06	-5.2E-07	-5.3E-06
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-18734	-18734	-18734
Population weighted Δx (µg/m ³):	-1.04665065	-1.04665065	-1.04665065
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998034	0.995551	0.998797
Attributable fraction (AF):	-2.0E-03	-4.5E-03	-1.2E-03
Increased number of cases in population:	-0.1397	-0.0257	-0.0362
Risk:	-7.8E-06	-1.4E-06	-1.5E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-5214	-5214	-5214
Population weighted Δx (µg/m ³):	-0.48820225	-0.48820225	-0.48820225
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per person):	0.00396	0.00032	0.01209
Relative Risk:	0.999083	0.997922	0.999439
Attributable fraction (AF):	-9.2E-04	-2.1E-03	-5.6E-04
Increased number of cases in population:	-0.0389	-0.0071	-0.0101
Risk:	-3.6E-06	-6.7E-07	-6.8E-06
Sydney Inner West LGA			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	1137.5	1137.5	1137.5
Population weighted Δx (µg/m³):	0.02354926	0.02354926	0.02354926
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	1.000044	1.000100	1.000027
Attributable fraction (AF):	4.4E-05	1.0E-04	2.7E-05
Increased number of cases in population:	0.01142	0.00156	0.00223
Risk:	2.4E-07	3.2E-08	3.3E-07
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	-849	-849	-849
Population weighted Δx (µg/m³):	-0.05410055	-0.05410055	-0.05410055
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999898	0.999770	0.999938
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.2E-05
Increased number of cases in population:	-0.0085	-0.00116	-0.001664
Risk:	-5.4E-07	-7.4E-08	-7.5E-07
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	2474.7	2474.7	2474.7
Population weighted Δx (µg/m³):	0.14108090	0.14108090	0.14108090
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	1.000265	1.000601	1.000162
Attributable fraction (AF):	2.7E-04	6.0E-04	1.6E-04
Increased number of cases in population:	0.025	0.003	0.0049
Risk:	1.4E-06	1.9E-07	2.0E-06
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-488.1	-488.1	-488.1
Population weighted Δx (µg/m³):	-0.03889553	-0.03889553	-0.03889553
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	0.999927	0.999834	0.999955
Attributable fraction (AF):	-7.3E-05	-1.7E-04	-4.5E-05
Increased number of cases in population:	-0.005	-0.00067	-0.0010
Risk:	-3.9E-07	-5.3E-08	-5.4E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	137.4	137.4	137.4
Population weighted Δx (µg/m³):	0.05452381	0.05452381	0.05452381
Baseline Incidence (per 100,000) (as per Table 3-5):	534	32	1209
Baseline Incidence (per person):	0.00534	0.00032	0.01209
Relative Risk:	1.000103	1.000232	1.000063
Attributable fraction (AF):	1.0E-04	2.3E-04	6.3E-05
Increased number of cases in population:	0.0014	0.00019	0.00027
Risk:	5.5E-07	7.5E-08	7.6E-07
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-67430.0	-67430	-67430
Population weighted Δx (µg/m³):	-0.51109275	-0.51109275	-0.51109275
Baseline Incidence (per 100,000) (as per Table 3-5):	508	32	1209
Baseline Incidence (per person):	0.00508	0.00032	0.01209
Relative Risk:	0.999040	0.997825	0.999412
Attributable fraction (AF):	-9.6E-04	-2.2E-03	-5.9E-04
Increased number of cases in population:	-0.6443	-0.09231	-0.05533
Risk:	-4.9E-06	-7.0E-07	-7.1E-06
Individual subrubs within LGA			
Darlinghurst			
Total Population in study area:	11354	11354	11354
% population in assessment age-group:	100%	100%	5.9%
total change	-5674.8	-5674.8	-5674.8
Population weighted Δx (µg/m³):	-0.49980624	-0.49980624	-0.49980624
Baseline Incidence (per 100,000) (as per Table 3-5):	508	32	1209
Baseline Incidence (per person):	0.00508	0.00032	0.01209
Relative Risk:	0.999061	0.997873	0.999425
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.7E-04
Increased number of cases in population:	-0.054	-0.0078	-0.00466
Risk:	-4.8E-06	-6.8E-07	-6.9E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593
% population in assessment age-group:	100%	100%	5.9%
total change	-3822.3	-3822.3	-3822.3

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.19508498	-0.19508498	-0.19508498
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999633	0.999169	0.999776
Attributable fraction (AF):	-3.7E-04	-8.3E-04	-2.2E-04
Increased number of cases in population:	-0.037	-0.0052	-0.00314
Risk:	-1.9E-06	-2.7E-07	-2.7E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-1299.5	-1299.5	-1299.5
Population weighted Δx (µg/m³):	-0.25213426	-0.25213426	-0.25213426
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999526	0.998926	0.999710
Attributable fraction (AF):	-4.7E-04	-1.1E-03	-2.9E-04
Increased number of cases in population:	-0.01241	-0.001778	-0.001066
Risk:	-2.4E-06	-3.4E-07	-3.5E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-27160	-27160	-27160
Population weighted Δx (µg/m³):	-1.28113208	-1.28113208	-1.28113208
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.997594	0.994557	0.998528
Attributable fraction (AF):	-2.4E-03	-5.5E-03	-1.5E-03
Increased number of cases in population:	-0.260	-0.037	-0.0223
Risk:	-1.2E-05	-1.8E-06	-1.8E-05
Pymont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-10173	-10173	-10173
Population weighted Δx (µg/m³):	-0.46955920	-0.46955920	-0.46955920
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999118	0.998002	0.999460
Attributable fraction (AF):	-8.8E-04	-2.0E-03	-5.4E-04
Increased number of cases in population:	-0.097	-0.0139	-0.0083
Risk:	-4.5E-06	-6.4E-07	-6.5E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	-1666.8	-1666.8	-1666.8
Population weighted Δx (µg/m³):	-0.16902951	-0.16902951	-0.16902951
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999682	0.999280	0.999806
Attributable fraction (AF):	-3.2E-04	-7.2E-04	-1.9E-04
Increased number of cases in population:	-0.01592	-0.002280	-0.001367
Risk:	-1.6E-06	-2.3E-07	-2.4E-06
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-7123	-7123	-7123
Population weighted Δx (µg/m³):	-0.45372317	-0.45372317	-0.45372317
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999147	0.998069	0.999478
Attributable fraction (AF):	-8.5E-04	-1.9E-03	-5.2E-04
Increased number of cases in population:	-0.068	-0.0097	-0.00584
Risk:	-4.3E-06	-6.2E-07	-6.3E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-10499	-10499	-10499
Population weighted Δx (µg/m³):	-0.38307732	-0.38307732	-0.38307732
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999280	0.998369	0.999560
Attributable fraction (AF):	-7.2E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.1003	-0.0144	-0.00861
Risk:	-3.7E-06	-5.2E-07	-5.3E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-15752.00	-15752	-15752
Population weighted Δx (µg/m³):	-0.15240675	-0.15240675	-0.15240675
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999714	0.999351	0.999825
Attributable fraction (AF):	-2.9E-04	-6.5E-04	-1.8E-04
Increased number of cases in population:	-0.099	-0.022	-0.0375
Risk:	-9.6E-07	-2.1E-07	-2.1E-06
Individual suburbs within LGA			
Chatswood East - Artarmon			
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	6997.7	6997.7	6997.7

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	0.24440991	0.24440991	0.24440991
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	1.000460	1.001042	1.000281
Attributable fraction (AF):	4.6E-04	1.0E-03	2.8E-04
Increased number of cases in population:	0.0441	0.0096	0.0166
Risk:	1.5E-06	3.3E-07	3.4E-06
Chatswood West - Lane Cove North			
Total Population in study area:	18393	18393	18393
% population in assessment age-group:	100%	100%	17.1%
total change	-3220.3	-3220.3	-3220.3
Population weighted Δx (µg/m³):	-0.17508291	-0.17508291	-0.17508291
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999671	0.999254	0.999799
Attributable fraction (AF):	-3.3E-04	-7.5E-04	-2.0E-04
Increased number of cases in population:	-0.0203	-0.0044	-0.0077
Risk:	-1.1E-06	-2.4E-07	-2.4E-06
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	-23.5	-23.5	-23.5
Population weighted Δx (µg/m³):	-0.00115190	-0.00115190	-0.00115190
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999998	0.999995	0.999999
Attributable fraction (AF):	-2.2E-06	-4.9E-06	-1.3E-06
Increased number of cases in population:	-0.00015	-0.000032	-0.00006
Risk:	-7.3E-09	-1.6E-09	-1.6E-08
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-928.4	-928.4	-928.4
Population weighted Δx (µg/m³):	-0.08860470	-0.08860470	-0.08860470
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999833	0.999623	0.999898
Attributable fraction (AF):	-1.7E-04	-3.8E-04	-1.0E-04
Increased number of cases in population:	-0.0058	-0.0013	-0.0022
Risk:	-5.6E-07	-1.2E-07	-1.2E-06
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-4582.9	-4582.9	-4582.9
Population weighted Δx (µg/m³):	-0.18006051	-0.18006051	-0.18006051
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999662	0.999233	0.999793
Attributable fraction (AF):	-3.4E-04	-7.7E-04	-2.1E-04
Increased number of cases in population:	-0.0289	-0.0063	-0.0109
Risk:	-1.1E-06	-2.5E-07	-2.5E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	-99.0	-99	-99
Population weighted Δx (µg/m³):	-0.04384411	-0.04384411	-0.04384411
Baseline Incidence (per 100,000) (as per Table 3-5)	502	32	1209
Baseline Incidence (per person)	0.00502	0.00032	0.01209
Relative Risk:	0.999918	0.999813	0.999950
Attributable fraction (AF):	-8.2E-05	-1.9E-04	-5.0E-05
Increased number of cases in population:	-0.001	0.000	-0.0002
Risk:	-4.1E-07	-6.0E-08	-6.1E-07
Individual subbrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	99	99	99
Population weighted Δx (µg/m³):	0.04384411	0.04384411	0.04384411
Baseline Incidence (per 100,000) (as per Table 3-5)	502	32	1209
Baseline Incidence (per person)	0.00502	0.00032	0.01209
Relative Risk:	1.000082	1.000187	1.000050
Attributable fraction (AF):	8.2E-05	1.9E-04	5.0E-05
Increased number of cases in population:	0.0009	0.00014	0.0002
Risk:	4.1E-07	6.0E-08	6.1E-07
Woollara LGA (Easterns Suburbs - North)			
Total Population in study area:	71841	71841	71841
% population in assessment age-group:	100%	100%	14.5%
total change	-4298.0	-4298	-4298
Population weighted Δx (µg/m³):	-0.05982656	-0.05982656	-0.05982656
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999888	0.999745	0.999931
Attributable fraction (AF):	-1.1E-04	-2.5E-04	-6.9E-05
Increased number of cases in population:	-0.032000	-0.005878	-0.008665
Risk:	-4.5E-07	-8.2E-08	-8.3E-07
Individual subbrubs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
% population in assessment age-group:	100%	100%	14.5%
total change	-62.7	-62.7	-62.7
Population weighted Δx (µg/m³):	-0.02870879	-0.02870879	-0.02870879
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999946	0.999878	0.999967
Attributable fraction (AF):	-5.4E-05	-1.2E-04	-3.3E-05
Increased number of cases in population:	-0.0005	-0.0001	-0.00013
Risk:	-2.1E-07	-3.9E-08	-4.0E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-159	-159	-159
Population weighted Δx (µg/m³):	-0.01345291	-0.01345291	-0.01345291
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999975	0.999943	0.999985
Attributable fraction (AF):	-2.5E-05	-5.7E-05	-1.5E-05
Increased number of cases in population:	-0.0012	-0.0002	-0.00032
Risk:	-1.0E-07	-1.8E-08	-1.9E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	10.7	10.7	10.7
Population weighted Δx (µg/m³):	0.00562270	0.00562270	0.00562270
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000011	1.000024	1.000006
Attributable fraction (AF):	1.1E-05	2.4E-05	6.5E-06
Increased number of cases in population:	0.00008	0.000015	0.00002
Risk:	4.2E-08	7.7E-09	7.8E-08
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-1543.6	-1543.6	-1543.6
Population weighted Δx (µg/m³):	-0.06224696	-0.06224696	-0.06224696
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999883	0.999735	0.999928
Attributable fraction (AF):	-1.2E-04	-2.7E-04	-7.2E-05
Increased number of cases in population:	-0.0115	-0.00211	-0.00311
Risk:	-4.6E-07	-8.5E-08	-8.7E-07
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-85.5	-85.5	-85.5
Population weighted Δx (µg/m³):	-0.02689525	-0.02689525	-0.02689525
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999949	0.999885	0.999969
Attributable fraction (AF):	-5.1E-05	-1.1E-04	-3.1E-05
Increased number of cases in population:	-0.0006	-0.000117	-0.00017
Risk:	-2.0E-07	-3.7E-08	-3.7E-07
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-1968.6	-1968.6	-1968.6
Population weighted Δx (µg/m³):	-0.14789272	-0.14789272	-0.14789272
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999722	0.999370	0.999830
Attributable fraction (AF):	-2.8E-04	-6.3E-04	-1.7E-04
Increased number of cases in population:	-0.01466	-0.00269	-0.003969
Risk:	-1.1E-06	-2.0E-07	-2.1E-06
Rose Bay - Vaucluse - Watsons Bay			
Total Population in study area:	6984	6984	6984
% population in assessment age-group:	100%	100%	14.5%
total change	-472.6	-472.6	-472.6
Population weighted Δx (µg/m³):	-0.06766896	-0.06766896	-0.06766896
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999873	0.999712	0.999922
Attributable fraction (AF):	-1.3E-04	-2.9E-04	-7.8E-05
Increased number of cases in population:	-0.00352	-0.00065	-0.000953
Risk:	-5.0E-07	-9.3E-08	-9.4E-07
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-16.5	-16.5	-16.5
Population weighted Δx (µg/m³):	-0.00215320	-0.00215320	-0.00215320
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999996	0.999991	0.999998
Attributable fraction (AF):	-4.0E-06	-9.2E-06	-2.5E-06
Increased number of cases in population:	-0.00012	-0.00002	-0.000033
Risk:	-1.6E-08	-2.9E-09	-3.0E-08
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	1673.0	1673	1673

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	0.01929776	0.01929776	0.01929776
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000036	1.000082	1.000022
Attributable fraction (AF):	3.6E-05	8.2E-05	2.2E-05
Increased number of cases in population:	0.015	0.0023	0.0043
Risk:	1.7E-07	2.6E-08	2.7E-07
Individual suburbs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	709.2	709.2	709.2
Population weighted Δx (µg/m³):	0.03508459	0.03508459	0.03508459
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000066	1.000149	1.000040
Attributable fraction (AF):	6.6E-05	1.5E-04	4.0E-05
Increased number of cases in population:	0.0062	0.0010	0.00183
Risk:	3.0E-07	4.8E-08	4.9E-07
Beacon Hill - Narrabeena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	-408.8	-408.8	-408.8
Population weighted Δx (µg/m³):	-0.03204515	-0.03204515	-0.03204515
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999940	0.999863	0.999963
Attributable fraction (AF):	-6.0E-05	-1.4E-04	-3.7E-05
Increased number of cases in population:	-0.0036	-0.0006	-0.00106
Risk:	-2.8E-07	-4.4E-08	-4.5E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	-102.8	-102.8	-102.8
Population weighted Δx (µg/m³):	-0.45087719	-0.45087719	-0.45087719
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999153	0.998081	0.999482
Attributable fraction (AF):	-8.5E-04	-1.9E-03	-5.2E-04
Increased number of cases in population:	-0.0009	-0.000141	-0.00027
Risk:	-3.9E-06	-6.2E-07	-6.3E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	-4244	-4244	-4244
Population weighted Δx (µg/m³):	-0.33122610	-0.33122610	-0.33122610
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999377	0.998590	0.999619
Attributable fraction (AF):	-6.2E-04	-1.4E-03	-3.8E-04
Increased number of cases in population:	-0.0369	-0.0058	-0.01098
Risk:	-2.9E-06	-4.5E-07	-4.6E-06
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	19%
total change	-202.6	-202.6	-202.6
Population weighted Δx (µg/m³):	-0.01994291	-0.01994291	-0.01994291
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	0.999963	0.999915	0.999977
Attributable fraction (AF):	-3.7E-05	-8.5E-05	-2.3E-05
Increased number of cases in population:	-0.0018	-0.0003	-0.00052
Risk:	-1.7E-07	-2.7E-08	-2.8E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	790.4	790.4	790.4
Population weighted Δx (µg/m³):	0.09822294	0.09822294	0.09822294
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000185	1.000419	1.000113
Attributable fraction (AF):	1.8E-04	4.2E-04	1.1E-04
Increased number of cases in population:	0.0069	0.0011	0.00204
Risk:	8.5E-07	1.3E-07	1.4E-06
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	301.4	301.4	301.4
Population weighted Δx (µg/m³):	0.05405308	0.05405308	0.05405308
Baseline Incidence (per 100,000) (as per Table 3-5):	462	32	1209
Baseline Incidence (per person):	0.00462	0.00032	0.01209
Relative Risk:	1.000102	1.000230	1.000062
Attributable fraction (AF):	1.0E-04	2.3E-04	6.2E-05
Increased number of cases in population:	0.0026	0.0004	0.00078
Risk:	4.7E-07	7.4E-08	7.5E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	4830.1	4830.1	4830.1
Population weighted Δx (µg/m³):	0.28580473	0.28580473	0.28580473

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	1.000537	1.001218	1.000329
Attributable fraction (AF):	5.4E-04	1.2E-03	3.3E-04
Increased number of cases in population:	0.0420	0.00660	0.01249
Risk:	2.5E-06	3.9E-07	4.0E-06
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-3641.9	-3641.9	-3641.9
Population weighted Δx (µg/m ³):	-0.11312708	-0.11312708	-0.11312708
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999787	0.999518	0.999870
Attributable fraction (AF):	-2.1E-04	-4.8E-04	-1.3E-04
Increased number of cases in population:	-0.025	-0.0050	-0.0098
Risk:	-7.8E-07	-1.5E-07	-1.6E-06
Individual suburbs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	-47.8	-47.8	-47.8
Population weighted Δx (µg/m ³):	-0.00487208	-0.00487208	-0.00487208
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999991	0.999979	0.999994
Attributable fraction (AF):	-9.2E-06	-2.1E-05	-5.6E-06
Increased number of cases in population:	-0.0003	-0.00007	-0.00013
Risk:	-3.3E-08	-6.7E-09	-6.8E-08
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-3547	-3547	-3547
Population weighted Δx (µg/m ³):	-0.16619032	-0.16619032	-0.16619032
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999688	0.999292	0.999809
Attributable fraction (AF):	-3.1E-04	-7.1E-04	-1.9E-04
Increased number of cases in population:	-0.0243	-0.0049	-0.00957
Risk:	-1.1E-06	-2.3E-07	-2.3E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-47	-47	-47
Population weighted Δx (µg/m ³):	-0.04523580	-0.04523580	-0.04523580
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999915	0.999807	0.999948
Attributable fraction (AF):	-8.5E-05	-1.9E-04	-5.2E-05
Increased number of cases in population:	-0.0003	-0.000064	-0.00013
Risk:	-3.1E-07	-6.2E-08	-6.3E-07
Total population incidence - All Suburbs	-1.09	-0.178	-0.19

Assessment of Increased Incidence - NO₂

Western Harbour Tunnel: 2037 Cumulative

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Canada Bay LGA			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-199.10	-199.10	-199.10
Population weighted Δx (µg/m ³):	-0.08530420	-0.08530420	-0.08530420
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999840	0.999637	0.999902
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.8E-05
Increased number of cases in population:	-0.001510	-0.0002723	-0.00041248
Risk:	-6.5E-07	-1.2E-07	-1.2E-06
Individual subrubs within LGA			
Drummoyne - Rodd Pt			
Total Population in study area:	2334	2334	2334
% population in assessment age-group:	100%	100%	14.9%
total change	-199.10	-199.10	-199.10
Population weighted Δx (µg/m ³):	-0.08530420	-0.08530420	-0.08530420
Baseline Incidence (per 100,000) (as per Table 3-5)	403	32	1209
Baseline Incidence (per person)	0.00403	0.00032	0.01209
Relative Risk:	0.999840	0.999637	0.999902
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.8E-05
Increased number of cases in population:	-0.0015	-0.00027	-0.000412
Risk:	-6.5E-07	-1.2E-07	-1.2E-06
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-48205	-48205	-48205
Population weighted Δx (µg/m ³):	-0.51200756	-0.51200756	-0.51200756
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999038	0.997821	0.999411
Attributable fraction (AF):	-9.6E-04	-2.2E-03	-5.9E-04
Increased number of cases in population:	-0.3594	-0.06599	-0.09319
Risk:	-3.8E-06	-7.0E-07	-7.1E-06
Individual subrubs within LGA			
Cremorne - Cammeray			
Total Population in study area:	19045	19045	19045
% population in assessment age-group:	100%	100%	13.9%
total change	-8348.1	-8348.1	-8348.1
Population weighted Δx (µg/m ³):	-0.43833552	-0.43833552	-0.43833552
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999176	0.998134	0.999496
Attributable fraction (AF):	-8.2E-04	-1.9E-03	-5.0E-04
Increased number of cases in population:	-0.0622	-0.0114	-0.0161
Risk:	-3.3E-06	-6.0E-07	-6.1E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	443.3	443.3	443.3
Population weighted Δx (µg/m ³):	0.02454188	0.02454188	0.02454188
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	1.000046	1.000105	1.000028
Attributable fraction (AF):	4.6E-05	1.0E-04	2.8E-05
Increased number of cases in population:	0.0033	0.0006	0.0009
Risk:	1.8E-07	3.4E-08	3.4E-07
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-14293	-14293	-14293
Population weighted Δx (µg/m ³):	-0.50217834	-0.50217834	-0.50217834
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999056	0.997863	0.999423
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.8E-04
Increased number of cases in population:	-0.1066	-0.0196	-0.0276
Risk:	-3.7E-06	-6.9E-07	-7.0E-06
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-19380	-19380	-19380
Population weighted Δx (µg/m ³):	-1.08274205	-1.08274205	-1.08274205
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.997967	0.995398	0.998756
Attributable fraction (AF):	-2.0E-03	-4.6E-03	-1.2E-03
Increased number of cases in population:	-0.1446	-0.0266	-0.0375
Risk:	-8.1E-06	-1.5E-06	-1.5E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-6626.8	-6626.8	-6626.8
Population weighted Δx (µg/m ³):	-0.62048689	-0.62048689	-0.62048689
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998834	0.997360	0.999287
Attributable fraction (AF):	-1.2E-03	-2.6E-03	-7.1E-04
Increased number of cases in population:	-0.0494	-0.0091	-0.0128
Risk:	-4.6E-06	-8.5E-07	-8.6E-06
Sydney Inner West LGA			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	-614.8	-614.8	-614.8
Population weighted Δx (µg/m³):	-0.01272799	-0.01272799	-0.01272799
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999976	0.999946	0.999985
Attributable fraction (AF):	-2.4E-05	-5.4E-05	-1.5E-05
Increased number of cases in population:	-0.006	-0.00084	-0.0012
Risk:	-1.3E-07	-1.7E-08	-1.8E-07
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	-1623.8	-1623.8	-1623.8
Population weighted Δx (µg/m³):	-0.10347289	-0.10347289	-0.10347289
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999805	0.999559	0.999881
Attributable fraction (AF):	-1.9E-04	-4.4E-04	-1.2E-04
Increased number of cases in population:	-0.0163	-0.00222	-0.003183
Risk:	-1.0E-06	-1.4E-07	-1.4E-06
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	1503.9	1503.9	1503.9
Population weighted Δx (µg/m³):	0.08573628	0.08573628	0.08573628
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	1.000161	1.000365	1.000099
Attributable fraction (AF):	1.6E-04	3.7E-04	9.9E-05
Increased number of cases in population:	0.015	0.002	0.0029
Risk:	8.6E-07	1.2E-07	1.2E-06
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-494.9	-494.9	-494.9
Population weighted Δx (µg/m³):	-0.03943741	-0.03943741	-0.03943741
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999926	0.999832	0.999955
Attributable fraction (AF):	-7.4E-05	-1.7E-04	-4.5E-05
Increased number of cases in population:	-0.005	-0.00068	-0.0010
Risk:	-4.0E-07	-5.4E-08	-5.5E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-247.6	-247.6	-247.6
Population weighted Δx (µg/m³):	-0.09825397	-0.09825397	-0.09825397
Baseline Incidence (per 100,000) (as per Table 3-5)	534	32	1209
Baseline Incidence (per person)	0.00534	0.00032	0.01209
Relative Risk:	0.999815	0.999582	0.999887
Attributable fraction (AF):	-1.8E-04	-4.2E-04	-1.1E-04
Increased number of cases in population:	-0.0025	-0.00034	-0.00049
Risk:	-9.9E-07	-1.3E-07	-1.4E-06
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-48734.0	-48734	-48734
Population weighted Δx (µg/m³):	-0.36938446	-0.36938446	-0.36938446
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999306	0.998428	0.999575
Attributable fraction (AF):	-6.9E-04	-1.6E-03	-4.2E-04
Increased number of cases in population:	-0.4656	-0.06669	-0.03999
Risk:	-3.5E-06	-5.1E-07	-5.1E-06
Individual subrubs within LGA			
Darlinghurst			
Total Population in study area:	11354	11354	11354
% population in assessment age-group:	100%	100%	5.9%
total change	-3400.9	-3400.9	-3400.9
Population weighted Δx (µg/m³):	-0.29953320	-0.29953320	-0.29953320
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999437	0.998725	0.999656
Attributable fraction (AF):	-5.6E-04	-1.3E-03	-3.4E-04
Increased number of cases in population:	-0.032	-0.0047	-0.00279
Risk:	-2.9E-06	-4.1E-07	-4.2E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593
% population in assessment age-group:	100%	100%	5.9%
total change	-4380.5	-4380.5	-4380.5

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.22357475	-0.22357475	-0.22357475
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999580	0.999048	0.999743
Attributable fraction (AF):	-4.2E-04	-9.5E-04	-2.6E-04
Increased number of cases in population:	-0.042	-0.0060	-0.00359
Risk:	-2.1E-06	-3.1E-07	-3.1E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-52.7	-52.7	-52.7
Population weighted Δx (µg/m³):	-0.01022507	-0.01022507	-0.01022507
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999981	0.999956	0.999988
Attributable fraction (AF):	-1.9E-05	-4.4E-05	-1.2E-05
Increased number of cases in population:	-0.00050	-0.000072	-0.000043
Risk:	-9.8E-08	-1.4E-08	-1.4E-07
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-10109	-10109	-10109
Population weighted Δx (µg/m³):	-0.47683962	-0.47683962	-0.47683962
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999104	0.997971	0.999452
Attributable fraction (AF):	-9.0E-04	-2.0E-03	-5.5E-04
Increased number of cases in population:	-0.097	-0.014	-0.0083
Risk:	-4.6E-06	-6.5E-07	-6.6E-06
Pymont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-11171	-11171	-11171
Population weighted Δx (µg/m³):	-0.51562428	-0.51562428	-0.51562428
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999031	0.997806	0.999407
Attributable fraction (AF):	-9.7E-04	-2.2E-03	-5.9E-04
Increased number of cases in population:	-0.107	-0.0153	-0.0092
Risk:	-4.9E-06	-7.1E-07	-7.2E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	-1772.9	-1772.9	-1772.9
Population weighted Δx (µg/m³):	-0.17978907	-0.17978907	-0.17978907
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999662	0.999234	0.999793
Attributable fraction (AF):	-3.4E-04	-7.7E-04	-2.1E-04
Increased number of cases in population:	-0.01693	-0.002425	-0.001454
Risk:	-1.7E-06	-2.5E-07	-2.5E-06
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-4723.4	-4723.4	-4723.4
Population weighted Δx (µg/m³):	-0.30087267	-0.30087267	-0.30087267
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999435	0.998719	0.999654
Attributable fraction (AF):	-5.7E-04	-1.3E-03	-3.5E-04
Increased number of cases in population:	-0.045	-0.0065	-0.00388
Risk:	-2.9E-06	-4.1E-07	-4.2E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-13123	-13123	-13123
Population weighted Δx (µg/m³):	-0.47881928	-0.47881928	-0.47881928
Baseline Incidence (per 100,000) (as per Table 3-5)	508	32	1209
Baseline Incidence (per person)	0.00508	0.00032	0.01209
Relative Risk:	0.999100	0.997962	0.999450
Attributable fraction (AF):	-9.0E-04	-2.0E-03	-5.5E-04
Increased number of cases in population:	-0.1254	-0.0180	-0.01077
Risk:	-4.6E-06	-6.5E-07	-6.7E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-13973.00	-13973	-13973
Population weighted Δx (µg/m³):	-0.13519423	-0.13519423	-0.13519423
Baseline Incidence (per 100,000) (as per Table 3-5)	335	32	1209
Baseline Incidence (per person)	0.00335	0.00032	0.01209
Relative Risk:	0.999746	0.999424	0.999845
Attributable fraction (AF):	-2.5E-04	-5.8E-04	-1.6E-04
Increased number of cases in population:	-0.088	-0.019	-0.0332
Risk:	-8.5E-07	-1.8E-07	-1.9E-06
Individual subrubs within LGA			
Chatswood East - Artarmon			
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	6200.4	6200.4	6200.4

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	0.21656247	0.21656247	0.21656247
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	1.000407	1.000923	1.000249
Attributable fraction (AF):	4.1E-04	9.2E-04	2.5E-04
Increased number of cases in population:	0.0390	0.0085	0.0147
Risk:	1.4E-06	3.0E-07	3.0E-06
Chatswood West - Lane Cove North			
Total Population in study area:	18393	18393	18393
% population in assessment age-group:	100%	100%	17.1%
total change	-2821.3	-2821.3	-2821.3
Population weighted Δx (µg/m³):	-0.15338988	-0.15338988	-0.15338988
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	0.999712	0.999347	0.999824
Attributable fraction (AF):	-2.9E-04	-6.5E-04	-1.8E-04
Increased number of cases in population:	-0.0178	-0.0039	-0.0067
Risk:	-9.7E-07	-2.1E-07	-2.1E-06
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	229.2	229.2	229.2
Population weighted Δx (µg/m³):	0.01123474	0.01123474	0.01123474
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	1.000021	1.000048	1.000013
Attributable fraction (AF):	2.1E-05	4.8E-05	1.3E-05
Increased number of cases in population:	0.0014	0.0003	0.0005
Risk:	7.1E-08	1.5E-08	1.6E-07
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-708.3	-708.3	-708.3
Population weighted Δx (µg/m³):	-0.06759878	-0.06759878	-0.06759878
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	0.999873	0.999712	0.999922
Attributable fraction (AF):	-1.3E-04	-2.9E-04	-7.8E-05
Increased number of cases in population:	-0.0045	-0.0010	-0.0017
Risk:	-4.3E-07	-9.2E-08	-9.4E-07
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-4472.9	-4472.9	-4472.9
Population weighted Δx (µg/m³):	-0.17573865	-0.17573865	-0.17573865
Baseline Incidence (per 100,000) (as per Table 3-5):	335	32	1209
Baseline Incidence (per person):	0.00335	0.00032	0.01209
Relative Risk:	0.999670	0.999252	0.999798
Attributable fraction (AF):	-3.3E-04	-7.5E-04	-2.0E-04
Increased number of cases in population:	-0.0282	-0.0061	-0.0106
Risk:	-1.1E-06	-2.4E-07	-2.4E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	80.4	80.4	80.4
Population weighted Δx (µg/m³):	0.03560673	0.03560673	0.03560673
Baseline Incidence (per 100,000) (as per Table 3-5):	502	32	1209
Baseline Incidence (per person):	0.00502	0.00032	0.01209
Relative Risk:	1.000067	1.000152	1.000041
Attributable fraction (AF):	6.7E-05	1.5E-04	4.1E-05
Increased number of cases in population:	0.00076	0.00011	0.00020
Risk:	3.4E-07	4.9E-08	5.0E-07
Individual subbrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	80.4	80.4	80.4
Population weighted Δx (µg/m³):	0.03560673	0.03560673	0.03560673
Baseline Incidence (per 100,000) (as per Table 3-5):	502	32	1209
Baseline Incidence (per person):	0.00502	0.00032	0.01209
Relative Risk:	1.000067	1.000152	1.000041
Attributable fraction (AF):	6.7E-05	1.5E-04	4.1E-05
Increased number of cases in population:	0.0008	0.00011	0.0002
Risk:	3.4E-07	4.9E-08	5.0E-07
Woollara LGA (Easterns Suburbs - North)			
Total Population in study area:	71841	71841	71841
% population in assessment age-group:	100%	100%	14.5%
total change	-3635.2	-3635.2	-3635.2
Population weighted Δx (µg/m³):	-0.05060063	-0.05060063	-0.05060063
Baseline Incidence (per 100,000) (as per Table 3-5):	396	32	1209
Baseline Incidence (per person):	0.00396	0.00032	0.01209
Relative Risk:	0.999905	0.999784	0.999942
Attributable fraction (AF):	-9.5E-05	-2.2E-04	-5.8E-05
Increased number of cases in population:	-0.027	-0.0050	-0.0073
Risk:	-3.8E-07	-6.9E-08	-7.0E-07
Individual subbrubs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
% population in assessment age-group:	100%	100%	14.5%
total change	-136.5	-136.5	-136.5
Population weighted Δx (µg/m³):	-0.06250000	-0.06250000	-0.06250000
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999883	0.999734	0.999928
Attributable fraction (AF):	-1.2E-04	-2.7E-04	-7.2E-05
Increased number of cases in population:	-0.0010	-0.0002	-0.00028
Risk:	-4.7E-07	-8.5E-08	-8.7E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-260.5	-260.5	-260.5
Population weighted Δx (µg/m³):	-0.02204078	-0.02204078	-0.02204078
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999959	0.999906	0.999975
Attributable fraction (AF):	-4.1E-05	-9.4E-05	-2.5E-05
Increased number of cases in population:	-0.0019	-0.0004	-0.00053
Risk:	-1.6E-07	-3.0E-08	-3.1E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	-44.6	-44.6	-44.6
Population weighted Δx (µg/m³):	-0.02343668	-0.02343668	-0.02343668
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999956	0.999900	0.999973
Attributable fraction (AF):	-4.4E-05	-1.0E-04	-2.7E-05
Increased number of cases in population:	-0.0003	-0.00006	-0.00009
Risk:	-1.7E-07	-3.2E-08	-3.3E-07
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-1136.2	-1136.2	-1136.2
Population weighted Δx (µg/m³):	-0.04581821	-0.04581821	-0.04581821
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999914	0.999805	0.999947
Attributable fraction (AF):	-8.6E-05	-2.0E-04	-5.3E-05
Increased number of cases in population:	-0.0085	-0.00155	-0.00229
Risk:	-3.4E-07	-6.3E-08	-6.4E-07
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-53.3	-53.3	-53.3
Population weighted Δx (µg/m³):	-0.01676628	-0.01676628	-0.01676628
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999968	0.999929	0.999981
Attributable fraction (AF):	-3.2E-05	-7.1E-05	-1.9E-05
Increased number of cases in population:	-0.0004	-0.000073	-0.00011
Risk:	-1.2E-07	-2.3E-08	-2.3E-07
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-1390.1	-1390.1	-1390.1
Population weighted Δx (µg/m³):	-0.10443242	-0.10443242	-0.10443242
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999804	0.999555	0.999880
Attributable fraction (AF):	-2.0E-04	-4.4E-04	-1.2E-04
Increased number of cases in population:	-0.01035	-0.00190	-0.002803
Risk:	-7.8E-07	-1.4E-07	-1.5E-06
Rose Bay - Vaucluse - Watsons Bay			
Total Population in study area:	6984	6984	6984
% population in assessment age-group:	100%	100%	14.5%
total change	-392.7	-392.7	-392.7
Population weighted Δx (µg/m³):	-0.05622852	-0.05622852	-0.05622852
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999894	0.999760	0.999935
Attributable fraction (AF):	-1.1E-04	-2.4E-04	-6.5E-05
Increased number of cases in population:	-0.00292	-0.00054	-0.000792
Risk:	-4.2E-07	-7.7E-08	-7.8E-07
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-220.9	-220.9	-220.9
Population weighted Δx (µg/m³):	-0.02882683	-0.02882683	-0.02882683
Baseline Incidence (per 100,000) (as per Table 3-5)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999946	0.999877	0.999967
Attributable fraction (AF):	-5.4E-05	-1.2E-04	-3.3E-05
Increased number of cases in population:	-0.00164	-0.00030	-0.000445
Risk:	-2.1E-07	-3.9E-08	-4.0E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	18.6%
total change	-3978.2	-3978.2	-3978.2

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Population weighted Δx (µg/m³):	-0.04588784	-0.04588784	-0.04588784
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999914	0.999805	0.999947
Attributable fraction (AF):	-8.6E-05	-2.0E-04	-5.3E-05
Increased number of cases in population:	-0.035	-0.0054	-0.0103
Risk:	-4.0E-07	-6.3E-08	-6.4E-07
Individual suburbs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	18.6%
total change	-1884.5	-1884.5	-1884.5
Population weighted Δx (µg/m³):	-0.09322747	-0.09322747	-0.09322747
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999825	0.999603	0.999893
Attributable fraction (AF):	-1.8E-04	-4.0E-04	-1.1E-04
Increased number of cases in population:	-0.0164	-0.0026	-0.00487
Risk:	-8.1E-07	-1.3E-07	-1.3E-06
Beacon Hill - Narrabeena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	18.6%
total change	-725.6	-725.6	-725.6
Population weighted Δx (µg/m³):	-0.05687858	-0.05687858	-0.05687858
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999893	0.999758	0.999935
Attributable fraction (AF):	-1.1E-04	-2.4E-04	-6.5E-05
Increased number of cases in population:	-0.0063	-0.0010	-0.00188
Risk:	-4.9E-07	-7.8E-08	-7.9E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	18.6%
total change	41.1	41.1	41.1
Population weighted Δx (µg/m³):	0.18026316	0.18026316	0.18026316
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	1.000339	1.000768	1.000207
Attributable fraction (AF):	3.4E-04	7.7E-04	2.1E-04
Increased number of cases in population:	0.0004	0.000056	0.00011
Risk:	1.6E-06	2.5E-07	2.5E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	18.6%
total change	-4373.4	-4373.4	-4373.4
Population weighted Δx (µg/m³):	-0.34132522	-0.34132522	-0.34132522
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999359	0.998547	0.999608
Attributable fraction (AF):	-6.4E-04	-1.5E-03	-3.9E-04
Increased number of cases in population:	-0.0380	-0.0060	-0.01131
Risk:	-3.0E-06	-4.7E-07	-4.7E-06
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	18.6%
total change	-290.4	-290.4	-290.4
Population weighted Δx (µg/m³):	-0.02858549	-0.02858549	-0.02858549
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999946	0.999878	0.999967
Attributable fraction (AF):	-5.4E-05	-1.2E-04	-3.3E-05
Increased number of cases in population:	-0.0025	-0.0004	-0.00075
Risk:	-2.5E-07	-3.9E-08	-4.0E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	18.6%
total change	-155	-155	-155
Population weighted Δx (µg/m³):	-0.01926184	-0.01926184	-0.01926184
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999964	0.999918	0.999978
Attributable fraction (AF):	-3.6E-05	-8.2E-05	-2.2E-05
Increased number of cases in population:	-0.0013	-0.0002	-0.00040
Risk:	-1.7E-07	-2.6E-08	-2.7E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	18.6%
total change	-267.6	-267.6	-267.6
Population weighted Δx (µg/m³):	-0.04799139	-0.04799139	-0.04799139
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	0.999910	0.999796	0.999945
Attributable fraction (AF):	-9.0E-05	-2.0E-04	-5.5E-05
Increased number of cases in population:	-0.0023	-0.0004	-0.00069
Risk:	-4.2E-07	-6.6E-08	-6.7E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	18.6%
total change	36677.3	36677.3	36677.3
Population weighted Δx (µg/m³):	2.17025444	2.17025444	2.17025444

Health Endpoint:	Mortality - All Causes, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions, Short-term
Age Group:	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.00188	0.00426	0.00115
Baseline Incidence (per 100,000) (as per Table 3-5)	462	32	1209
Baseline Incidence (per person)	0.00462	0.00032	0.01209
Relative Risk:	1.004088	1.009288	1.002499
Attributable fraction (AF):	4.1E-03	9.2E-03	2.5E-03
Increased number of cases in population:	0.3181	0.04992	0.09473
Risk:	1.9E-05	3.0E-06	3.0E-05
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19.4%
total change	-3746.0	-3746	-3746
Population weighted Δx (µg/m³):	-0.11636070	-0.11636070	-0.11636070
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999781	0.999504	0.999866
Attributable fraction (AF):	-2.2E-04	-5.0E-04	-1.3E-04
Increased number of cases in population:	-0.026	-0.0051	-0.0101
Risk:	-8.0E-07	-1.6E-07	-1.6E-06
Individual suburbs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19.4%
total change	-155.3	-155.3	-155.3
Population weighted Δx (µg/m³):	-0.01582917	-0.01582917	-0.01582917
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999970	0.999933	0.999982
Attributable fraction (AF):	-3.0E-05	-6.7E-05	-1.8E-05
Increased number of cases in population:	-0.0011	-0.0002	-0.00042
Risk:	-1.1E-07	-2.2E-08	-2.2E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19.4%
total change	-3534.3	-3534.3	-3534.3
Population weighted Δx (µg/m³):	-0.16559528	-0.16559528	-0.16559528
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999689	0.999295	0.999810
Attributable fraction (AF):	-3.1E-04	-7.1E-04	-1.9E-04
Increased number of cases in population:	-0.0242	-0.0048	-0.00953
Risk:	-1.1E-06	-2.3E-07	-2.3E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19.4%
total change	-56.3	-56.3	-56.3
Population weighted Δx (µg/m³):	-0.05418672	-0.05418672	-0.05418672
Baseline Incidence (per 100,000) (as per Table 3-5)	365	32	1209
Baseline Incidence (per person)	0.00365	0.00032	0.01209
Relative Risk:	0.999898	0.999769	0.999938
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.2E-05
Increased number of cases in population:	-0.0004	-0.000077	-0.00015
Risk:	-3.7E-07	-7.4E-08	-7.5E-07
Total population incidence - All Suburbs	-1.01	-0.168	-0.20

Annexure F – Risk calculations: Particulate matter

Quantification of Effects - PM_{2.5} and PM₁₀
Western Harbour Tunnel: 2027

Air quality indicator:				PM _{2.5}	PM _{2.5}	PM _{2.5}	PM ₁₀	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	DPM
Endpoint:				Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	Morbidity - Asthma ED Admissions	Increased risk - lung cancer
Effect Exposure Duration:				Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	Short-Term	Based on WHO
Age Group:				≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	1-14 years	inhalation unit risk
β (change in effect per 1 µg/m ³) (as per Table 5-22)				0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	0.00148	3.40E-05
Annual Baseline Incidence (as per Table 3-5)													(ug/m3)-1
Annual baseline incidence (per 100,000)				1026	9235	3978	428	428	412	132	32.1	1209	
Baseline Incidence (per person per year)				0.01026	0.09235	0.03978	0.00428	0.00428	0.00412	0.00132	0.000321	0.01209	

Sensitive Receptors		Change in Annual Average PM ₁₀ Concentration (µg/m ³)	Change in Annual Average PM _{2.5} Concentration (µg/m ³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
Impacts from project (ventilation outlets and roads)												
Grid receptors: maximum regardless of land use		1.01	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05
Grid receptors: maximum residential		1.01	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05
Grid receptors: maximum childcare		0.30	0.16	9E-06	1E-05	3E-06	8E-07	6E-07	8E-06	2E-07	9E-08	3E-06
Grid receptors: maximum school		0.17	0.19	1E-05	1E-05	3E-06	4E-07	8E-07	1E-05	2E-07	1E-07	3E-06
Grid receptors: maximum aged care		0.36	0.10	6E-06	7E-06	2E-06	9E-07	4E-07	5E-06	1E-07	6E-08	2E-06
Grid receptors: maximum hospital and medical		0.16	0.14	8E-06	1E-05	2E-06	4E-07	6E-07	7E-06	2E-07	9E-08	3E-06
Grid receptors: commercial/industrial		0.46	0.31	2E-05	2E-05	5E-06	1E-06	1E-06	2E-05	4E-07	2E-07	6E-06
Grid receptors: open space		0.43	0.20	1E-05	1E-05	3E-06	1E-06	8E-07	1E-05	3E-07	1E-07	4E-06
Community Receptors												
University of Notre Dame, Broadway	University	0.0520	0.0398	2E-06	3E-06	6E-07	1E-07	2E-07	2E-06	5E-08	2E-08	7E-07
Laverly Pathology, Annandale	Medical centre	-0.0253	-0.0493	-3E-06	-4E-06	-8E-07	-7E-08	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07
St Basil's, Annandale	Aged care	0.1040	0.0609	4E-06	5E-06	1E-06	3E-07	2E-07	3E-06	8E-08	4E-08	1E-06
The Jimmy Little Community Centre	Community centre	0.2608	-0.0283	-2E-06	-2E-06	-5E-07	7E-07	-1E-07	-2E-06	-4E-08	-2E-08	-5E-07
Rozelle Public School	Primary School	0.1145	0.0066	4E-07	5E-07	1E-07	3E-07	3E-08	4E-07	8E-09	4E-09	1E-07
St Aloysius College	High School	-0.2138	-0.2164	-1E-05	-2E-05	-4E-06	-5E-07	-9E-07	-1E-05	-3E-07	-1E-07	-4E-06
Dancing Dingo Family Day Care	Child care	-0.0002	-0.0391	-2E-06	-3E-06	-6E-07	-6E-10	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07
Wenona School	Primary School	-0.1896	-0.1188	-7E-06	-9E-06	-2E-06	-5E-07	-5E-07	-6E-06	-2E-07	-7E-08	-2E-06
Mater Hospital	Hospital	0.1073	-0.0046	-3E-07	-3E-07	-7E-08	3E-07	-2E-08	-2E-07	-6E-09	-3E-09	-8E-08
Neutral Bay Public School	Primary School	-0.1143	-0.0998	-6E-06	-7E-06	-2E-06	-3E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06
Neutral Bay Medical Centre	Medical Centre	-0.0106	-0.0614	-4E-06	-5E-06	-1E-06	-3E-08	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06
Puddleducks Child Care Centre	Childcare	0.1091	-0.0004	-2E-08	-3E-08	-6E-09	3E-07	-2E-09	-2E-08	-5E-10	-2E-10	-7E-09
Mosman Public School	Primary School	0.0146	-0.0404	-2E-06	-3E-06	-7E-07	4E-08	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07
Garrison & Killarney Retirement Centre	Aged care	0.3357	0.1028	6E-06	8E-06	2E-06	9E-07	4E-07	6E-06	1E-07	6E-08	2E-06
Beauty Point Public School	Primary School	0.0322	0.0409	2E-06	3E-06	7E-07	8E-08	2E-07	2E-06	5E-08	2E-08	7E-07
Anzac Park Public School	Primary School	0.1648	0.0046	3E-07	3E-07	7E-08	4E-07	2E-08	2E-07	6E-09	3E-09	8E-08
Ku Cammeray Preschool	Preschool	0.0574	-0.0036	-2E-07	-3E-07	-6E-08	1E-07	-1E-08	-2E-07	-5E-09	-2E-09	-6E-08
Cammeray Public School	Primary School	0.0293	0.0317	2E-06	2E-06	5E-07	8E-08	1E-07	2E-06	4E-08	2E-08	6E-07
Atchison Preschool	Preschool	-0.1980	0.0120	7E-07	9E-07	2E-07	-5E-07	5E-08	6E-07	2E-08	7E-09	2E-07
Berry Cottage Childcare	Child care	0.0309	0.0979	6E-06	7E-06	2E-06	8E-08	4E-07	5E-06	1E-07	6E-08	2E-06
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.0420	0.0426	3E-06	3E-06	7E-07	1E-07	2E-07	2E-06	5E-08	3E-08	8E-07
SBS Child Care	Child care	-0.1299	0.0758	5E-06	6E-06	1E-06	-3E-07	3E-07	4E-06	1E-07	5E-08	1E-06
Butterflies Early Learning Childcare Centre	Child care	0.2073	0.0810	5E-06	6E-06	1E-06	5E-07	3E-07	4E-06	1E-07	5E-08	1E-06
Artarmon Public School	Primary School	-0.0928	-0.0123	-7E-07	-9E-07	-2E-07	-2E-07	-5E-08	-7E-07	-2E-08	-8E-09	-2E-07
Sue's Childcare, Castlevale	Child care	0.1613	0.1334	8E-06	1E-05	2E-06	4E-07	5E-07	7E-06	2E-07	8E-08	2E-06
Northside Baptist Preschool	Preschool	-0.0043	0.0588	3E-06	4E-06	1E-06	-1E-08	2E-07	3E-06	8E-08	4E-08	1E-06
Willoughby Public School	Primary School	-0.0507	-0.0075	-4E-07	-6E-07	-1E-07	-1E-07	-3E-08	-4E-07	-1E-08	-5E-09	-1E-07
Peek A Boo Cottage	Child care	0.1891	-0.0074	-4E-07	-5E-07	-1E-07	5E-07	-3E-08	-4E-07	-9E-09	-5E-09	-1E-07
St Cecilia's Catholic Primary School	Primary School	0.0264	0.0059	3E-07	4E-07	1E-07	7E-08	2E-08	3E-07	8E-09	4E-09	1E-07
Seaforth Public School	Primary School	-0.0589	-0.0878	-5E-06	-6E-06	-1E-06	-2E-07	-4E-07	-5E-06	-1E-07	-5E-08	-2E-06

Quantification of Effects - PM_{2.5} and PM₁₀
Western Harbour Tunnel: 2027 Cumulative

Air quality indicator:				PM _{2.5}	PM _{2.5}	PM _{2.5}	PM ₁₀	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	DPM
Endpoint:				Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	Morbidity - Asthma ED Admissions	Increased risk - lung cancer
Effect Exposure Duration:				Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	Short-Term	Based on WHO
Age Group:				≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	1-14 years	inhalation unit risk
β (change in effect per 1 µg/m ³) (as per Table 5-22)				0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	0.00148	3.40E-05
Annual Baseline Incidence (as per Table 3-5)													(ug/m3)-1
Annual baseline incidence (per 100,000)				1026	9235	3978	428	428	412	132	32.1	1209	
Baseline Incidence (per person per year)				0.01026	0.09235	0.03978	0.00428	0.00428	0.00412	0.00132	0.000321	0.01209	

		Change in Annual Average PM ₁₀ Concentration (µg/m ³)	Change in Annual Average PM _{2.5} Concentration (µg/m ³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
Impacts from project (ventilation outlets and roads)												
Grid receptors: maximum regardless of land use		0.61	0.51	3E-05	4E-05	8E-06	2E-06	2E-06	3E-05	7E-07	3E-07	9E-06
Grid receptors: maximum residential		0.61	0.51	3E-05	4E-05	8E-06	2E-06	2E-06	3E-05	7E-07	3E-07	9E-06
Grid receptors: maximum childcare		0.25	0.27	2E-05	2E-05	4E-06	6E-07	1E-06	1E-05	3E-07	2E-07	5E-06
Grid receptors: maximum school		0.35	0.33	2E-05	2E-05	5E-06	9E-07	1E-06	2E-05	4E-07	2E-07	6E-06
Grid receptors: maximum aged care		0.29	0.13	8E-06	1E-05	2E-06	7E-07	5E-07	7E-06	2E-07	8E-08	2E-06
Grid receptors: maximum hospital and medical		0.19	0.21	1E-05	2E-05	3E-06	5E-07	8E-07	1E-05	3E-07	1E-07	4E-06
Grid receptors: commercial/industrial		0.61	0.40	2E-05	3E-05	7E-06	2E-06	2E-06	2E-05	5E-07	2E-07	7E-06
Grid receptors: open space		0.46	0.28	2E-05	2E-05	5E-06	1E-06	1E-06	1E-05	4E-07	2E-07	5E-06
Community Receptors												
University of Notre Dame, Broadway	University	0.1214	-0.1591	-9E-06	-1E-05	-3E-06	3E-07	-6E-07	-9E-06	-2E-07	-1E-07	-3E-06
Laverly Pathology, Annandale	Medical centre	0.0244	-0.0595	-4E-06	-4E-06	-1E-06	6E-08	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06
St Basil's, Annandale	Aged care	0.0780	0.0312	2E-06	2E-06	5E-07	2E-07	1E-07	2E-06	4E-08	2E-08	6E-07
The Jimmy Little Community Centre	Community centre	-0.0505	-0.0337	-2E-06	-2E-06	-5E-07	-1E-07	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07
Rozelle Public School	Primary School	0.0275	-0.0363	-2E-06	-3E-06	-6E-07	7E-08	-1E-07	-2E-06	-5E-08	-2E-08	-6E-07
St Aloysius College	High School	-0.1577	-0.2419	-1E-05	-2E-05	-4E-06	-4E-07	-1E-06	-1E-05	-3E-07	-1E-07	-4E-06
Dancing Dingo Family Day Care	Child care	0.0619	0.0349	2E-06	3E-06	6E-07	2E-07	1E-07	2E-06	4E-08	2E-08	6E-07
Wenona School	Primary School	-0.2231	-0.1301	-8E-06	-1E-05	-2E-06	-6E-07	-5E-07	-7E-06	-2E-07	-8E-08	-2E-06
Mater Hospital	Hospital	0.0586	-0.0488	-3E-06	-4E-06	-8E-07	2E-07	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07
Neutral Bay Public School	Primary School	-0.3411	-0.0704	-4E-06	-5E-06	-1E-06	-9E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06
Neutral Bay Medical Centre	Medical Centre	-0.4334	-0.3098	-2E-05	-2E-05	-5E-06	-1E-06	-1E-06	-2E-05	-4E-07	-2E-07	-6E-06
Puddleducks Child Care Centre	Childcare	-0.0867	-0.0772	-5E-06	-6E-06	-1E-06	-2E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Mosman Public School	Primary School	-0.0437	-0.0383	-2E-06	-3E-06	-6E-07	-1E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07
Garrison & Killarney Retirement Centre	Aged care	-0.6241	-0.3526	-2E-05	-3E-05	-6E-06	-2E-06	-1E-06	-2E-05	-5E-07	-2E-07	-6E-06
Beauty Point Public School	Primary School	-0.1080	-0.0164	-1E-06	-1E-06	-3E-07	-3E-07	-7E-08	-9E-07	-2E-08	-1E-08	-3E-07
Anzac Park Public School	Primary School	0.1941	-0.0330	-2E-06	-2E-06	-5E-07	5E-07	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07
Ku Cammeray Preschool	Preschool	0.1129	0.0076	5E-07	6E-07	1E-07	3E-07	3E-08	4E-07	1E-08	5E-09	1E-07
Cammeray Public School	Primary School	-0.0395	0.0041	2E-07	3E-07	7E-08	-1E-07	2E-08	2E-07	5E-09	3E-09	7E-08
Atchison Preschool	Preschool	-0.1388	-0.0331	-2E-06	-2E-06	-5E-07	-4E-07	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07
Berry Cottage Childcare	Child care	0.0632	-0.0257	-2E-06	-2E-06	-4E-07	2E-07	-1E-07	-1E-06	-3E-08	-2E-08	-5E-07
Explore & Develop Artarmon - Early Learning Centre	Preschool	-0.0096	0.0920	5E-06	7E-06	2E-06	-2E-08	4E-07	5E-06	1E-07	6E-08	2E-06
SBS Child Care	Child care	-0.0144	0.0854	5E-06	6E-06	1E-06	-4E-08	3E-07	5E-06	1E-07	5E-08	2E-06
Butterflies Early Learning Childcare Centre	Child care	0.2885	0.0889	5E-06	7E-06	1E-06	7E-07	4E-07	5E-06	1E-07	5E-08	2E-06
Artarmon Public School	Primary School	-0.0877	-0.0574	-3E-06	-4E-06	-9E-07	-2E-07	-2E-07	-3E-06	-7E-08	-4E-08	-1E-06
Sue's Childcare, Castlevale	Child care	0.0056	-0.0401	-2E-06	-3E-06	-7E-07	1E-08	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07
Northside Baptist Preschool	Preschool	-0.1908	-0.0812	-5E-06	-6E-06	-1E-06	-5E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Willoughby Public School	Primary School	-0.0734	-0.0153	-9E-07	-1E-06	-3E-07	-2E-07	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07
Peek A Boo Cottage	Child care	-1.4426	-0.9189	-5E-05	-7E-05	-1E-05	-4E-06	-4E-06	-5E-05	-1E-06	-6E-07	-2E-05
St Cecilia's Catholic Primary School	Primary School	-0.0270	-0.0247	-1E-06	-2E-06	-4E-07	-7E-08	-1E-07	-1E-06	-3E-08	-2E-08	-4E-07
Seaforth Public School	Primary School	0.0111	-0.0112	-7E-07	-8E-07	-2E-07	3E-08	-5E-08	-6E-07	-1E-08	-7E-09	-2E-07

Quantification of Effects - PM_{2.5} and PM₁₀
Western Harbour Tunnel: 2037

Air quality indicator:				PM _{2.5}	PM _{2.5}	PM _{2.5}	PM ₁₀	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	DPM
Endpoint:				Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	Morbidity - Asthma ED Admissions	Increased risk - lung cancer
Effect Exposure Duration:				Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	Short-Term	Based on WHO
Age Group:				≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	1-14 years	inhalation unit risk
β (change in effect per 1 µg/m ³) (as per Table 5-22)				0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	0.00148	3.40E-05
Annual Baseline Incidence (as per Table 3-5)													(ug/m3)-1
Annual baseline incidence (per 100,000)				1026	9235	3978	428	428	412	132	32.1	1209	
Baseline Incidence (per person per year)				0.01026	0.09235	0.03978	0.00428	0.00428	0.00412	0.00132	0.000321	0.01209	

Sensitive Receptors		Change in Annual Average PM ₁₀ Concentration (µg/m ³)	Change in Annual Average PM _{2.5} Concentration (µg/m ³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	
Impacts from project (ventilation outlets and roads)													
Grid receptors: maximum regardless of land use		1.34	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05	2E-05
Grid receptors: maximum residential		1.34	0.64	4E-05	5E-05	1E-05	3E-06	3E-06	3E-05	8E-07	4E-07	1E-05	2E-05
Grid receptors: maximum childcare		0.29	0.22	1E-05	2E-05	4E-06	7E-07	9E-07	1E-05	3E-07	1E-07	4E-06	7E-06
Grid receptors: maximum school		0.29	0.15	9E-06	1E-05	2E-06	7E-07	6E-07	8E-06	2E-07	9E-08	3E-06	5E-06
Grid receptors: maximum aged care		0.11	0.10	6E-06	7E-06	2E-06	3E-07	4E-07	5E-06	1E-07	6E-08	2E-06	3E-06
Grid receptors: maximum hospital and medical		0.21	0.11	7E-06	8E-06	2E-06	8E-07	4E-07	6E-06	1E-07	7E-08	2E-06	4E-06
Grid receptors: commercial/industrial		0.47	0.35	2E-05	3E-05	6E-06	1E-06	1E-06	2E-05	4E-07	2E-07	6E-06	1E-05
Grid receptors: open space		0.51	0.24	1E-05	2E-05	4E-06	1E-06	1E-06	1E-05	3E-07	1E-07	4E-06	8E-06
Community Receptors													
University of Notre Dame, Broadway	University	0.1256	-0.1298	-8E-06	-1E-05	-2E-06	3E-07	-5E-07	-7E-06	-2E-07	-8E-08	-2E-06	-4E-06
Laverly Pathology, Annandale	Medical centre	0.0412	-0.1945	-1E-05	-1E-05	-3E-06	1E-07	-8E-07	-1E-05	-2E-07	-1E-07	-3E-06	-7E-06
St Basil's, Annandale	Aged care	0.1923	0.1669	1E-05	1E-05	3E-06	5E-07	7E-07	9E-06	2E-07	1E-07	3E-06	6E-06
The Jimmy Little Community Centre	Community centre	-0.1016	-0.1507	-9E-06	-1E-05	-2E-06	-3E-07	-6E-07	-8E-06	-2E-07	-9E-08	-3E-06	-5E-06
Rozelle Public School	Primary School	0.0287	-0.0558	-3E-06	-4E-06	-9E-07	7E-08	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	-2E-06
St Aloysius College	High School	-0.5076	-0.4257	-3E-05	-3E-05	-7E-06	-1E-06	-2E-06	-3E-05	-5E-07	-3E-07	-8E-06	-1E-05
Dancing Dingo Family Day Care	Child care	-0.0274	-0.0520	-3E-06	-4E-06	-8E-07	-7E-08	-2E-07	-3E-06	-7E-08	-3E-08	-9E-07	-2E-06
Wenona School	Primary School	-0.1178	-0.0976	-6E-06	-7E-06	-2E-06	-3E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06	-3E-06
Mater Hospital	Hospital	0.1626	-0.0065	-4E-07	-5E-07	-1E-07	4E-07	-3E-08	-3E-07	-8E-09	-4E-09	-1E-07	-2E-07
Neutral Bay Public School	Primary School	0.0621	-0.0147	-9E-07	-1E-06	-2E-07	2E-07	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	-5E-07
Neutral Bay Medical Centre	Medical Centre	0.1543	-0.0407	-2E-06	-3E-06	-7E-07	4E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	-1E-06
Puddleducks Child Care Centre	Childcare	-0.0529	0.0893	5E-06	7E-06	1E-06	-1E-07	4E-07	5E-06	1E-07	5E-08	2E-06	3E-06
Mosman Public School	Primary School	-0.0764	0.0080	5E-07	6E-07	1E-07	-2E-07	3E-08	4E-07	1E-08	5E-09	1E-07	3E-07
Garrison & Killarney Retirement Centre	Aged care	-0.1240	-0.0591	-4E-06	-4E-06	-1E-06	-3E-07	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06	-2E-06
Beauty Point Public School	Primary School	-0.0307	0.0229	1E-06	2E-06	4E-07	-8E-08	9E-08	1E-06	3E-08	1E-08	4E-07	8E-07
Anzac Park Public School	Primary School	0.2657	0.1882	1E-05	1E-05	3E-06	7E-07	8E-07	1E-05	2E-07	1E-07	3E-06	6E-06
Ku Cammeray Preschool	Preschool	-0.0708	0.0794	5E-06	6E-06	1E-06	-2E-07	3E-07	4E-06	1E-07	5E-08	1E-06	3E-06
Cammeray Public School	Primary School	0.0817	0.0252	1E-06	2E-06	4E-07	2E-07	1E-07	1E-06	3E-08	2E-08	5E-07	9E-07
Atchison Preschool	Preschool	-0.0059	-0.0703	-4E-06	-5E-06	-1E-06	-2E-08	-3E-07	-4E-06	-8E-08	-4E-08	-1E-06	-2E-06
Berry Cottage Childcare	Child care	0.2979	-0.0019	-1E-07	-1E-07	-3E-08	8E-07	-8E-09	-1E-07	-2E-09	-1E-09	-3E-08	-7E-08
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.1560	-0.0538	-3E-06	-4E-06	-9E-07	4E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	-2E-06
SBS Child Care	Child care	-0.0154	0.0633	4E-06	5E-06	1E-06	-4E-08	3E-07	3E-06	8E-08	4E-08	1E-06	2E-06
Butterflies Early Learning Childcare Centre	Child care	-0.0294	0.0415	2E-06	3E-06	7E-07	-8E-08	2E-07	2E-06	5E-08	3E-08	7E-07	1E-06
Artarmon Public School	Primary School	0.0731	-0.0209	-1E-06	-2E-06	-3E-07	2E-07	-8E-08	-1E-06	-3E-08	-1E-08	-4E-07	-7E-07
Sue's Childcare, Castlevale	Child care	0.2142	0.1539	9E-06	1E-05	3E-06	5E-07	6E-07	8E-06	2E-07	9E-08	3E-06	5E-06
Northside Baptist Preschool	Preschool	0.0269	-0.0252	-1E-06	-2E-06	-4E-07	7E-08	-1E-07	-1E-06	-3E-08	-2E-08	-5E-07	-9E-07
Willoughby Public School	Primary School	0.0070	-0.0342	-2E-06	-3E-06	-6E-07	2E-08	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07	-1E-06
Peek A Boo Cottage	Child care	0.4511	0.1889	1E-05	1E-05	3E-06	1E-06	8E-07	1E-05	2E-07	1E-07	3E-06	6E-06
St Cecilia's Catholic Primary School	Primary School	0.0053	0.0239	1E-06	2E-06	4E-07	1E-08	1E-07	1E-06	3E-08	1E-08	4E-07	8E-07
Seaforth Public School	Primary School	0.0514	-0.1333	-8E-06	-1E-05	-2E-06	1E-07	-5E-07	-7E-06	-2E-07	-8E-08	-2E-06	-5E-06

Quantification of Effects - PM_{2.5} and PM₁₀
Western Harbour Tunnel: 2037 Cumulative

Air quality indicator:				PM _{2.5}	PM _{2.5}	PM _{2.5}	PM ₁₀	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	DPM
Endpoint:				Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	Morbidity - Asthma ED Admissions	Increased risk - lung cancer
Effect Exposure Duration:				Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	Short-Term	Based on WHO
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Annual baseline incidence (per 100,000)				1026	9235	3978	428	428	412	132	32.1	1209	
Baseline Incidence (per person per year)				0.01026	0.09235	0.03978	0.00428	0.00428	0.00412	0.00132	0.000321	0.01209	

Sensitive Receptors		Change in Annual Average PM ₁₀ Concentration (µg/m ³)	Change in Annual Average PM _{2.5} Concentration (µg/m ³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
Impacts from project (ventilation outlets and roads)												
Grid receptors: maximum regardless of land use		1.11	0.57	3E-05	4E-05	9E-06	3E-06	2E-06	3E-05	7E-07	3E-07	1E-05
Grid receptors: maximum residential		1.11	0.57	3E-05	4E-05	9E-06	3E-06	2E-06	3E-05	7E-07	3E-07	1E-05
Grid receptors: maximum childcare		0.25	0.13	7E-06	9E-06	2E-06	6E-07	5E-07	7E-06	2E-07	8E-08	2E-06
Grid receptors: maximum school		0.31	0.43	3E-05	3E-05	7E-06	8E-07	2E-06	2E-05	6E-07	3E-07	8E-06
Grid receptors: maximum aged care		0.12	0.10	6E-06	7E-06	2E-06	3E-07	4E-07	5E-06	1E-07	6E-08	2E-06
Grid receptors: maximum hospital and medical		0.31	0.19	1E-05	1E-05	3E-06	8E-07	7E-07	1E-05	2E-07	1E-07	3E-06
Grid receptors: commercial/industrial		0.83	0.47	3E-05	3E-05	8E-06	2E-06	2E-06	3E-05	6E-07	3E-07	8E-06
Grid receptors: open space		0.60	0.29	2E-05	2E-05	5E-06	2E-06	1E-06	2E-05	4E-07	2E-07	5E-06
Community Receptors												
University of Notre Dame, Broadway	University	-0.3604	-0.0056	-3E-07	-4E-07	-9E-08	-9E-07	-2E-08	-3E-07	-7E-09	-3E-09	-1E-07
Laverly Pathology, Annandale	Medical centre	0.0752	-0.1687	-1E-05	-1E-05	-3E-06	2E-07	-7E-07	-9E-06	-2E-07	-1E-07	-3E-06
St Basil's, Annandale	Aged care	0.1559	0.1801	1E-05	1E-05	3E-06	4E-07	7E-07	1E-05	2E-07	1E-07	3E-06
The Jimmy Little Community Centre	Community centre	-0.0697	-0.1328	-8E-06	-1E-05	-2E-06	-2E-07	-5E-07	-7E-06	-2E-07	-8E-08	-2E-06
Rozelle Public School	Primary School	0.0001	-0.0663	-4E-06	-5E-06	-1E-06	3E-10	-3E-07	-4E-06	-8E-08	-4E-08	-1E-06
St Aloysius College	High School	-0.5342	-0.2552	-2E-05	-2E-05	-4E-06	-1E-06	-1E-06	-1E-05	-3E-07	-2E-07	-5E-06
Dancing Dingo Family Day Care	Child care	0.0428	-0.0232	-1E-06	-2E-06	-4E-07	1E-07	-9E-08	-1E-06	-3E-08	-1E-08	-4E-07
Wenona School	Primary School	-0.0258	-0.0765	-5E-06	-6E-06	-1E-06	-7E-08	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Mater Hospital	Hospital	0.1417	0.0807	5E-06	6E-06	1E-06	4E-07	3E-07	4E-06	1E-07	5E-08	1E-06
Neutral Bay Public School	Primary School	-0.0559	-0.1372	-8E-06	-1E-05	-2E-06	-1E-07	-6E-07	-7E-06	-2E-07	-8E-08	-2E-06
Neutral Bay Medical Centre	Medical Centre	-0.3411	-0.2330	-1E-05	-2E-05	-4E-06	-9E-07	-9E-07	-1E-05	-3E-07	-1E-07	-4E-06
Puddleducks Child Care Centre	Childcare	-0.2216	-0.0760	-5E-06	-6E-06	-1E-06	-6E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Mosman Public School	Primary School	-0.1022	-0.0466	-3E-06	-3E-06	-8E-07	-3E-07	-2E-07	-2E-06	-6E-08	-3E-08	-8E-07
Garrison & Killarney Retirement Centre	Aged care	-0.6229	-0.5317	-3E-05	-4E-05	-9E-06	-2E-06	-2E-06	-3E-05	-7E-07	-3E-07	-1E-05
Beauty Point Public School	Primary School	-0.1361	-0.0821	-5E-06	-6E-06	-1E-06	-3E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Anzac Park Public School	Primary School	0.1291	0.0637	4E-06	5E-06	1E-06	3E-07	3E-07	3E-06	8E-08	4E-08	1E-06
Ku Cammeray Preschool	Preschool	-0.0506	0.0046	3E-07	3E-07	7E-08	-1E-07	2E-08	3E-07	6E-09	3E-09	8E-08
Cammeray Public School	Primary School	0.1180	0.0283	2E-06	2E-06	5E-07	3E-07	1E-07	2E-06	4E-08	2E-08	5E-07
Atchison Preschool	Preschool	-0.1465	-0.0539	-3E-06	-4E-06	-9E-07	-4E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06
Berry Cottage Childcare	Child care	0.0828	0.0249	1E-06	2E-06	4E-07	2E-07	1E-07	1E-06	3E-08	2E-08	4E-07
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.2831	0.0102	6E-07	8E-07	2E-07	7E-07	4E-08	5E-07	1E-08	6E-09	2E-07
SBS Child Care	Child care	0.0469	0.1218	7E-06	9E-06	2E-06	1E-07	5E-07	7E-06	2E-07	7E-08	2E-06
Butterflies Early Learning Childcare Centre	Child care	-0.1931	0.0848	5E-06	6E-06	1E-06	-5E-07	3E-07	5E-06	1E-07	5E-08	2E-06
Artarmon Public School	Primary School	-0.1284	-0.0341	-2E-06	-3E-06	-6E-07	3E-07	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07
Sue's Childcare, Castlevale	Child care	-0.0450	-0.0065	-4E-07	-5E-07	-1E-07	-1E-07	-3E-08	-3E-07	-8E-09	-4E-09	-1E-07
Northside Baptist Preschool	Preschool	-0.0953	-0.1376	-8E-06	-1E-05	-2E-06	-2E-07	-6E-07	-7E-06	-2E-07	-8E-08	-2E-06
Willoughby Public School	Primary School	-0.0375	-0.0777	-5E-06	-6E-06	-1E-06	-1E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06
Peek A Boo Cottage	Child care	-1.3433	-0.9581	-6E-05	-7E-05	-2E-05	-3E-06	-4E-06	-5E-05	-1E-06	-6E-07	-2E-05
St Cecilia's Catholic Primary School	Primary School	-0.0332	-0.0057	-3E-07	-4E-07	-9E-08	-9E-08	-2E-08	-3E-07	-7E-09	-3E-09	-1E-07
Seaforth Public School	Primary School	0.0974	-0.0571	-3E-06	-4E-06	-9E-07	3E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06

Annexure G – Population incidence calculations: Particulate matter

Assessment of Increased Incidence - PM_{2.5}
Western Harbour Tunnel: 2027

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Canada Bay LGA								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Population weighted Δx (µg/m ³):	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000049	1.000007	1.000003	1.000008	1.000110	1.000008	1.000016	1.000013
Attributable fraction (AF):	4.9E-05	6.8E-06	3.5E-06	8.0E-06	1.1E-04	8.2E-06	1.6E-05	1.3E-05
Increased number of cases in population:	0.00074	0.00022	0.00047	0.00075	0.00067	0.00022	0.00019	0.00053
Risk:	5.0E-07	6.3E-07	1.4E-07	3.2E-08	4.5E-07	9.3E-09	8.0E-09	1.5E-07
Individual subrubs within LGA								
Drummoyle - Rodd Pt								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	19.80	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Population weighted Δx (µg/m ³):	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329	0.00848329
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000049	1.000007	1.000003	1.000008	1.000110	1.000008	1.000016	1.000013
Attributable fraction (AF):	4.9E-05	6.8E-06	3.5E-06	8.0E-06	1.1E-04	8.2E-06	1.6E-05	1.3E-05
Increased number of cases in population:	0.00074	0.00022	0.00047	0.00075	0.00067	0.00022	0.00019	0.00053
Risk:	5.0E-07	6.3E-07	1.4E-07	3.2E-08	4.5E-07	9.3E-09	8.0E-09	1.5E-07
North Sydney - Mosman								
Total Population in study area:	94149	94149	94149	94149	94149	94149	94149	94149
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-2626.1	-2626.1	-2626.1	-2626.1	-2626.1	-2626.1	-2626.1	-2626.1
Population weighted Δx (µg/m ³):	-0.02789302	-0.02789302	-0.02789302	-0.02789302	-0.02789302	-0.02789302	-0.02789302	-0.02789302
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999838	0.999978	0.999989	0.999974	0.999637	0.999973	0.999947	0.999959
Attributable fraction (AF):	-1.6E-04	-2.2E-05	-1.1E-05	-2.6E-05	-3.6E-04	-2.7E-05	-5.3E-05	-4.1E-05
Increased number of cases in population:	-0.10	-0.037	-0.0082	-0.0083	-0.094	-0.0025	-0.0025	-0.0078
Risk:	-1.7E-06	-2.1E-06	-4.5E-07	-8.8E-08	-1.5E-06	-2.7E-08	-2.6E-08	-5.0E-07
Individual subrubs within LGA								
Cremorne - Cammeray								
Total Population in study area:	19045	19045	19045	19045	19045	19045	19045	19045
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7
Population weighted Δx (µg/m ³):	0.00423733	0.00423733	0.00423733	0.00423733	0.00423733	0.00423733	0.00423733	0.00423733
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000025	1.000003	1.000002	1.000004	1.000055	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.5E-05	3.4E-06	1.7E-06	4.0E-06	5.5E-05	4.1E-06	8.1E-06	6.3E-06
Increased number of cases in population:	0.0032	0.0011	0.0003	0.0003	0.0029	0.00008	0.00008	0.0002
Risk:	2.5E-07	3.1E-07	6.9E-08	1.3E-08	2.3E-07	4.1E-09	4.0E-09	7.6E-08
Crows Nest - Waverton								
Total Population in study area:	18063	18063	18063	18063	18063	18063	18063	18063
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	367.1	367.1	367.1	367.1	367.1	367.1	367.1	367.1
Population weighted Δx (µg/m ³):	0.02032331	0.02032331	0.02032331	0.02032331	0.02032331	0.02032331	0.02032331	0.02032331
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000118	1.000016	1.000008	1.000019	1.000264	1.000020	1.000039	1.000030
Attributable fraction (AF):	1.2E-04	1.6E-05	8.3E-06	1.9E-05	2.6E-04	2.0E-05	3.9E-05	3.0E-05
Increased number of cases in population:	0.0149	0.0039	0.0009	0.0012	0.0134	0.0004	0.0003	0.0007
Risk:	1.2E-06	1.5E-06	3.3E-07	6.4E-08	1.1E-06	1.9E-08	1.9E-08	3.6E-07
Mosman								
Total Population in study area:	28462	28462	28462	28462	28462	28462	28462	28462
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-3.56	-3.56	-3.56	-3.56	-3.56	-3.56	-3.56	-3.56
Population weighted Δx (µg/m ³):	-0.00012508	-0.00012508	-0.00012508	-0.00012508	-0.00012508	-0.00012508	-0.00012508	-0.00012508
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999999	1.000000	1.000000	1.000000	0.999998	1.000000	1.000000	1.000000
Attributable fraction (AF):	-7.3E-07	-1.0E-07	-5.1E-08	-1.2E-07	-1.6E-06	-1.2E-07	-2.4E-07	-1.9E-07
Increased number of cases in population:	-0.000142	-0.000050	-0.000011	-0.000011	-0.000128	-0.000003	-0.000003	-0.000011
Risk:	-7.4E-09	-9.2E-09	-2.0E-09	-3.9E-10	-6.7E-09	-1.2E-10	-1.2E-10	-2.2E-09
Neutral Bay - Kirribilli								
Total Population in study area:	17899	17899	17899	17899	17899	17899	17899	17899
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-2217.6	-2217.6	-2217.6	-2217.6	-2217.6	-2217.6	-2217.6	-2217.6
Population weighted Δx (µg/m ³):	-0.12389519	-0.12389519	-0.12389519	-0.12389519	-0.12389519	-0.12389519	-0.12389519	-0.12389519
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999282	0.999901	0.999949	0.999884	0.998391	0.999884	0.999765	0.999817
Attributable fraction (AF):	-7.2E-04	-9.9E-05	-5.1E-05	-1.2E-04	-1.6E-03	-1.2E-04	-2.4E-04	-1.8E-04
Increased number of cases in population:	-0.0903	-0.0236	-0.0052	-0.0070	-0.0813	-0.0021	-0.0021	-0.0044
Risk:	-7.4E-06	-9.2E-06	-2.0E-06	-3.9E-07	-6.6E-06	-1.2E-07	-1.2E-07	-2.2E-06
North Sydney - Lavender Bay								
Total Population in study area:	10680	10680	10680	10680	10680	10680	10680	10680
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-852.8	-852.8	-852.8	-852.8	-852.8	-852.8	-852.8	-852.8
Population weighted Δx (µg/m ³):	-0.07985019	-0.07985019	-0.07985019	-0.07985019	-0.07985019	-0.07985019	-0.07985019	-0.07985019
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999537	0.999936	0.999967	0.999925	0.998962	0.999923	0.999848	0.999882

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Attributable fraction (AF):	-4.6E-04	-6.4E-05	-3.3E-05	-7.5E-05	-1.0E-03	-7.7E-05	-1.5E-04	-1.2E-04
Increased number of cases in population:	-0.0347	-0.0091	-0.0020	-0.0313	-0.0008	-0.0008	-0.0008	-0.0017
Risk:	-4.8E-06	-5.9E-06	-1.3E-06	-2.5E-07	-4.3E-06	-7.6E-08	-7.5E-08	-1.4E-06
Sydney Inner West LGA								
Total Population in study area:	48303	48303	48303	48303	48303	48303	48303	48303
% population in assessment age-group:	64%	12%	12%	64%	64%	100%	100%	14%
total change	447.8	447.8	447.8	447.8	447.8	447.8	447.8	447.8
Population weighted Δx (µg/m³):	0.00927065	0.00927065	0.00927065	0.00927065	0.00927065	0.00927065	0.00927065	0.00927065
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000054	1.000007	1.000004	1.000009	1.000121	1.000009	1.000018	1.000014
Attributable fraction (AF):	5.4E-05	7.4E-06	3.8E-06	8.7E-06	1.2E-04	9.0E-06	1.8E-05	1.4E-05
Increased number of cases in population:	0.017	0.0040	0.00089	0.0022	0.015	0.00064	0.00042	0.0011
Risk:	5.5E-07	6.8E-07	1.5E-07	4.7E-08	5.0E-07	1.3E-08	8.7E-09	1.7E-07
Individual subrubs within LGA								
Balmain								
Total Population in study area:	15693	15693	15693	15693	15693	15693	15693	15693
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7
Population weighted Δx (µg/m³):	-0.00157395	-0.00157395	-0.00157395	-0.00157395	-0.00157395	-0.00157395	-0.00157395	-0.00157395
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	0.999991	0.999999	0.999999	0.999999	0.999980	0.999998	0.999997	0.999998
Attributable fraction (AF):	-9.1E-06	-1.3E-06	-6.5E-07	-1.5E-06	-2.0E-05	-1.5E-06	-3.0E-06	-2.3E-06
Increased number of cases in population:	-0.0009	-0.00022	-0.000049	-0.00012	-0.0008	-0.000035	-0.000023	-0.000062
Risk:	-9.4E-08	-1.2E-07	-2.6E-08	-7.9E-09	-8.4E-08	-2.2E-09	-1.5E-09	-2.8E-08
Leichhardt - Annandale								
Total Population in study area:	17541	17541	17541	17541	17541	17541	17541	17541
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	319.3	319.3	319.3	319.3	319.3	319.3	319.3	319.3
Population weighted Δx (µg/m³):	0.01820307	0.01820307	0.01820307	0.01820307	0.01820307	0.01820307	0.01820307	0.01820307
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000106	1.000015	1.000007	1.000017	1.000237	1.000018	1.000035	1.000027
Attributable fraction (AF):	1.1E-04	1.5E-05	7.5E-06	1.7E-05	2.4E-04	1.8E-05	3.5E-05	2.7E-05
Increased number of cases in population:	0.012	0.003	0.0006	0.002	0.011	0.0005	0.0003	0.0008
Risk:	1.1E-06	1.3E-06	3.0E-07	9.1E-08	9.7E-07	2.6E-08	1.7E-08	3.3E-07
Lilyfield - Rozelle								
Total Population in study area:	12549	12549	12549	12549	12549	12549	12549	12549
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	153.2	153.2	153.2	153.2	153.2	153.2	153.2	153.2
Population weighted Δx (µg/m³):	0.01220814	0.01220814	0.01220814	0.01220814	0.01220814	0.01220814	0.01220814	0.01220814
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000071	1.000010	1.000005	1.000011	1.000159	1.000012	1.000023	1.000018
Attributable fraction (AF):	7.1E-05	9.8E-06	5.0E-06	1.1E-05	1.6E-04	1.2E-05	2.3E-05	1.8E-05
Increased number of cases in population:	0.006	0.0014	0.0003	0.0008	0.005	0.0002	0.00014	0.0004
Risk:	7.3E-07	9.0E-07	2.0E-07	6.1E-08	6.5E-07	1.7E-08	1.1E-08	2.2E-07
Petersham - Stanmore								
Total Population in study area:	2520	2520	2520	2520	2520	2520	2520	2520
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	3.98	3.98	3.98	3.98	3.98	3.98	3.98	3.98
Population weighted Δx (µg/m³):	0.00157937	0.00157937	0.00157937	0.00157937	0.00157937	0.00157937	0.00157937	0.00157937
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000009	1.000001	1.000001	1.000001	1.000021	1.000002	1.000003	1.000002
Attributable fraction (AF):	9.2E-06	1.3E-06	6.5E-07	1.5E-06	2.1E-05	1.5E-06	3.0E-06	2.3E-06
Increased number of cases in population:	0.000151	0.000036	0.000008	0.000020	0.000136	0.000006	0.000004	0.000010
Risk:	9.4E-08	1.2E-07	2.6E-08	7.9E-09	8.5E-08	2.2E-09	1.5E-09	2.8E-08
Sydney LGA								
Total Population in study area:	131933	131933	131933	131933	131933	131933	131933	131933
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1188.1	-1188.1	-1188.1	-1188.1	-1188.1	-1188.1	-1188.1	-1188.1
Population weighted Δx (µg/m³):	-0.00900533	-0.00900533	-0.00900533	-0.00900533	-0.00900533	-0.00900533	-0.00900533	-0.00900533
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999948	0.999933	0.999996	0.999992	0.999883	0.999991	0.999983	0.999987
Attributable fraction (AF):	-5.2E-05	-7.2E-06	-3.7E-06	-8.5E-06	-1.2E-04	-8.7E-06	-1.7E-05	-1.3E-05
Increased number of cases in population:	-0.041	-0.0072	-0.0016	-0.0057	-0.037	-0.0016	-0.0011	-0.0013
Risk:	-5.4E-07	-6.7E-07	-1.5E-07	-4.3E-08	-4.8E-07	-1.2E-08	-8.5E-09	-1.6E-07
Individual subrubs within LGA								
Darlinghurst								
Total Population in study area:	11354	11354	11354	11354	11354	11354	11354	11354
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-712.1	-712.1	-712.1	-712.1	-712.1	-712.1	-712.1	-712.1
Population weighted Δx (µg/m³):	-0.06271798	-0.06271798	-0.06271798	-0.06271798	-0.06271798	-0.06271798	-0.06271798	-0.06271798
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999636	0.999950	0.999974	0.999941	0.999185	0.999939	0.999981	0.999907
Attributable fraction (AF):	-3.6E-04	-5.0E-05	-2.6E-05	-5.9E-05	-8.2E-04	-6.1E-05	-1.2E-04	-9.3E-05
Increased number of cases in population:	-0.024	-0.0043	-0.00095	-0.0034	-0.022	-0.00096	-0.00067	-0.00075
Risk:	-3.7E-06	-4.6E-06	-1.0E-06	-3.0E-07	-3.4E-06	-8.5E-08	-5.9E-08	-1.1E-06
Glebe - Forest Lodge								
Total Population in study area:	19593	19593	19593	19593	19593	19593	19593	19593
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-810.5	-810.5	-810.5	-810.5	-810.5	-810.5	-810.5	-810.5
Population weighted Δx (µg/m³):	-0.04136681	-0.04136681	-0.04136681	-0.04136681	-0.04136681	-0.04136681	-0.04136681	-0.04136681
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999760	0.999967	0.999983	0.999961	0.999462	0.999960	0.999921	0.999939
Attributable fraction (AF):	-2.4E-04	-3.3E-05	-1.7E-05	-3.9E-05	-5.4E-04	-4.0E-05	-7.9E-05	-6.1E-05

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Increased number of cases in population:	-0.028	-0.0049	-0.00108	-0.0039	-0.025	-0.00109	-0.00076	-0.00086
Risk:	-2.5E-06	-3.1E-06	-6.7E-07	-2.0E-07	-2.2E-06	-5.6E-08	-3.9E-08	-7.4E-07
Newtown - Camperdown - Darlington								
Total Population in study area:	5154	5154	5154	5154	5154	5154	5154	5154
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-154.2	-154.2	-154.2	-154.2	-154.2	-154.2	-154.2	-154.2
Population weighted Δx (µg/m³):	-0.02991851	-0.02991851	-0.02991851	-0.02991851	-0.02991851	-0.02991851	-0.02991851	-0.02991851
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999826	0.999976	0.999988	0.999972	0.999611	0.999971	0.999943	0.999956
Attributable fraction (AF):	-1.7E-04	-2.4E-05	-1.2E-05	-2.8E-05	-3.9E-04	-2.9E-05	-5.7E-05	-4.4E-05
Increased number of cases in population:	-0.005	-0.0009	-0.0002	-0.0007	-0.005	-0.0002	-0.00014	-0.00016
Risk:	-1.8E-06	-2.2E-06	-4.9E-07	-1.4E-07	-1.6E-06	-4.0E-08	-2.8E-08	-5.4E-07
Potts Point - Woolloomooloo								
Total Population in study area:	21200	21200	21200	21200	21200	21200	21200	21200
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-4979.4	-4979.4	-4979.4	-4979.4	-4979.4	-4979.4	-4979.4	-4979.4
Population weighted Δx (µg/m³):	-0.23487736	-0.23487736	-0.23487736	-0.23487736	-0.23487736	-0.23487736	-0.23487736	-0.23487736
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.998639	0.999812	0.999904	0.999779	0.996951	0.999772	0.999554	0.999652
Attributable fraction (AF):	-1.4E-03	-1.9E-04	-9.6E-05	-2.2E-04	-3.1E-03	-2.3E-04	-4.5E-04	-3.5E-04
Increased number of cases in population:	-0.171	-0.030	-0.0067	-0.024	-0.154	-0.0067	-0.0047	-0.0053
Risk:	-1.4E-05	-1.7E-05	-3.8E-06	-1.1E-06	-1.3E-05	-3.2E-07	-2.2E-07	-4.2E-06
Pyrmont - Ultimo								
Total Population in study area:	21665	21665	21665	21665	21665	21665	21665	21665
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1512.2	-1512.2	-1512.2	-1512.2	-1512.2	-1512.2	-1512.2	-1512.2
Population weighted Δx (µg/m³):	-0.06979922	-0.06979922	-0.06979922	-0.06979922	-0.06979922	-0.06979922	-0.06979922	-0.06979922
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999595	0.999944	0.999971	0.999934	0.999093	0.999972	0.999867	0.999897
Attributable fraction (AF):	-4.0E-04	-5.6E-05	-2.9E-05	-6.6E-05	-9.1E-04	-6.8E-05	-1.3E-04	-1.0E-04
Increased number of cases in population:	-0.052	-0.0092	-0.0020	-0.0072	-0.047	-0.0020	-0.00142	-0.00160
Risk:	-4.2E-06	-5.2E-06	-1.1E-06	-3.3E-07	-3.7E-06	-9.4E-08	-6.6E-08	-1.2E-06
Redfern - Chippendale								
Total Population in study area:	9861	9861	9861	9861	9861	9861	9861	9861
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-275.3	-275.3	-275.3	-275.3	-275.3	-275.3	-275.3	-275.3
Population weighted Δx (µg/m³):	-0.02791806	-0.02791806	-0.02791806	-0.02791806	-0.02791806	-0.02791806	-0.02791806	-0.02791806
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999838	0.999978	0.999989	0.999974	0.999637	0.999973	0.999947	0.999959
Attributable fraction (AF):	-1.6E-04	-2.2E-05	-1.1E-05	-2.6E-05	-3.6E-04	-2.7E-05	-5.3E-05	-4.1E-05
Increased number of cases in population:	-0.00944	-0.00168	-0.000368	-0.001315	-0.00849	-0.000371	-0.000258	-0.000291
Risk:	-1.7E-06	-2.1E-06	-4.6E-07	-1.3E-07	-1.5E-06	-3.8E-08	-2.6E-08	-5.0E-07
Surry Hills								
Total Population in study area:	15699	15699	15699	15699	15699	15699	15699	15699
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1029	-1029	-1029	-1029	-1029	-1029	-1029	-1029
Population weighted Δx (µg/m³):	-0.06554558	-0.06554558	-0.06554558	-0.06554558	-0.06554558	-0.06554558	-0.06554558	-0.06554558
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999620	0.999948	0.999973	0.999938	0.999148	0.999936	0.999875	0.999903
Attributable fraction (AF):	-3.8E-04	-5.2E-05	-2.7E-05	-6.2E-05	-8.5E-04	-6.4E-05	-1.2E-04	-9.7E-05
Increased number of cases in population:	-0.035	-0.0062	-0.00138	-0.0049	-0.032	-0.00139	-0.00097	-0.00109
Risk:	-3.9E-06	-4.8E-06	-1.1E-06	-3.1E-07	-3.5E-06	-8.8E-08	-6.2E-08	-1.2E-06
Sydney - Haymarket - The Rocks								
Total Population in study area:	27407	27407	27407	27407	27407	27407	27407	27407
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-2410.1	-2410.1	-2410.1	-2410.1	-2410.1	-2410.1	-2410.1	-2410.1
Population weighted Δx (µg/m³):	-0.08793739	-0.08793739	-0.08793739	-0.08793739	-0.08793739	-0.08793739	-0.08793739	-0.08793739
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999490	0.999930	0.999964	0.999977	0.998857	0.999915	0.999833	0.999870
Attributable fraction (AF):	-5.1E-04	-7.0E-05	-3.6E-05	-8.3E-05	-1.1E-03	-8.5E-05	-1.3E-04	-1.3E-04
Increased number of cases in population:	-0.0826	-0.0146	-0.00322	-0.0115	-0.0744	-0.00325	-0.00226	-0.00254
Risk:	-5.2E-06	-6.5E-06	-1.4E-06	-4.2E-07	-4.7E-06	-1.2E-07	-8.3E-08	-1.6E-06
Lane Cove - Chatswood LGA								
Total Population in study area:	103355	103355	103355	103355	103355	103355	103355	103355
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	204.50	204.5	204.5	204.5	204.5	204.5	204.5	204.5
Population weighted Δx (µg/m³):	0.00197862	0.00197862	0.00197862	0.00197862	0.00197862	0.00197862	0.00197862	0.00197862
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000011	1.000002	1.000001	1.000002	1.000026	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.1E-05	1.6E-06	8.1E-07	1.9E-06	2.6E-05	1.9E-06	3.8E-06	2.9E-06
Increased number of cases in population:	0.0076	0.00021	0.00046	0.00077	0.0068	0.00022	0.00019	0.00063
Risk:	1.2E-07	1.5E-07	3.2E-08	7.5E-09	1.1E-07	2.2E-09	1.9E-09	3.5E-08
Individual subrubs within LGA								
Chatswood East - Artarmon								
Total Population in study area:	28631	28631	28631	28631	28631	28631	28631	28631
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-77.1	-77.1	-77.1	-77.1	-77.1	-77.1	-77.1	-77.1
Population weighted Δx (µg/m³):	-0.00269289	-0.00269289	-0.00269289	-0.00269289	-0.00269289	-0.00269289	-0.00269289	-0.00269289
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999984	0.999998	0.999999	0.999997	0.999965	0.999997	0.999995	0.999996
Attributable fraction (AF):	-1.6E-05	-2.2E-06	-1.1E-06	-2.5E-06	-3.5E-05	-2.6E-06	-5.1E-06	-4.0E-06
Increased number of cases in population:	-0.0029	-0.0008	-0.0002	-0.0003	-0.0026	-0.00008	-0.00007	-0.0002
Risk:	-1.6E-07	-2.0E-07	-4.4E-08	-1.0E-08	-1.4E-07	-3.0E-09	-2.5E-09	-4.8E-08
Chatswood West - Lane Cove North								

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Total Population in study area:	18393	18393	18393	18393	18393	18393	18393	18393
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-31.4	-31.4	-31.4	-31.4	-31.4	-31.4	-31.4	-31.4
Population weighted Δx (µg/m³):	-0.00170717	-0.00170717	-0.00170717	-0.00170717	-0.00170717	-0.00170717	-0.00170717	-0.00170717
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999990	0.999999	0.999999	0.999998	0.999978	0.999998	0.999997	0.999997
Attributable fraction (AF):	-9.9E-06	-1.4E-06	-7.0E-07	-1.6E-06	-2.2E-05	-1.7E-06	-3.2E-06	-2.5E-06
Increased number of cases in population:	-0.0012	-0.0003	-0.00007	-0.00012	-0.0011	-0.000035	-0.000029	-0.0001
Risk:	-1.0E-07	-1.3E-07	-2.8E-08	-6.4E-09	-9.1E-08	-1.9E-09	-1.6E-09	-3.1E-08
Lane Cove - Greenwich								
Total Population in study area:	20401	20401	20401	20401	20401	20401	20401	20401
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-41.7	-41.7	-41.7	-41.7	-41.7	-41.7	-41.7	-41.7
Population weighted Δx (µg/m³):	-0.00204402	-0.00204402	-0.00204402	-0.00204402	-0.00204402	-0.00204402	-0.00204402	-0.00204402
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999988	0.999998	0.999999	0.999998	0.999973	0.999998	0.999996	0.999997
Attributable fraction (AF):	-1.2E-05	-1.6E-06	-8.4E-07	-1.9E-06	-2.7E-05	-2.0E-06	-3.9E-06	-3.0E-06
Increased number of cases in population:	-0.0016	-0.0004	-0.00009	-0.0002	-0.0014	-0.00005	-0.00004	-0.00013
Risk:	-1.2E-07	-1.5E-07	-3.3E-08	-7.7E-09	-1.1E-07	-2.2E-09	-1.9E-09	-3.7E-08
St Leonards - Naremburn								
Total Population in study area:	10478	10478	10478	10478	10478	10478	10478	10478
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	188.1	188.1	188.1	188.1	188.1	188.1	188.1	188.1
Population weighted Δx (µg/m³):	0.01795190	0.01795190	0.01795190	0.01795190	0.01795190	0.01795190	0.01795190	0.01795190
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000104	1.000014	1.000007	1.000017	1.000233	1.000017	1.000034	1.000027
Attributable fraction (AF):	1.0E-04	1.4E-05	7.4E-06	1.7E-05	2.3E-04	1.7E-05	3.4E-05	2.7E-05
Increased number of cases in population:	0.0070	0.0019	0.00042	0.00071	0.0063	0.00021	0.00018	0.00058
Risk:	1.1E-06	1.3E-06	2.9E-07	6.8E-08	9.6E-07	2.0E-08	1.7E-08	3.2E-07
Willoughby - Castle Cove - Northbridge								
Total Population in study area:	25452	25452	25452	25452	25452	25452	25452	25452
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	166.7	166.7	166.7	166.7	166.7	166.7	166.7	166.7
Population weighted Δx (µg/m³):	0.00654958	0.00654958	0.00654958	0.00654958	0.00654958	0.00654958	0.00654958	0.00654958
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000038	1.000005	1.000003	1.000006	1.000085	1.000006	1.000012	1.000010
Attributable fraction (AF):	3.8E-05	5.2E-06	2.7E-06	6.2E-06	8.5E-05	6.4E-06	1.2E-05	9.7E-06
Increased number of cases in population:	0.0062	0.0017	0.0004	0.0006	0.0056	0.0002	0.0002	0.0005
Risk:	3.9E-07	4.8E-07	1.1E-07	2.5E-08	3.5E-07	7.2E-09	6.1E-09	1.2E-07
Hunters Hill LGA								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Population weighted Δx (µg/m³):	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	1.000052	1.000007	1.000004	1.000008	1.000116	1.000009	1.000017	1.000013
Attributable fraction (AF):	5.2E-05	7.1E-06	3.6E-06	8.4E-06	1.2E-04	8.6E-06	1.7E-05	1.3E-05
Increased number of cases in population:	0.00077	0.00032	0.000071	0.000095	0.00069	0.000026	0.000019	0.000065
Risk:	5.3E-07	6.6E-07	1.5E-07	4.2E-08	4.8E-07	1.2E-08	8.4E-09	1.6E-07
Individual subbrs within LGA								
Hunters Hill - Woolwich								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
Population weighted Δx (µg/m³):	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168	0.00890168
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	1.000052	1.000007	1.000004	1.000008	1.000116	1.000009	1.000017	1.000013
Attributable fraction (AF):	5.2E-05	7.1E-06	3.6E-06	8.4E-06	1.2E-04	8.6E-06	1.7E-05	1.3E-05
Increased number of cases in population:	0.00077	0.00032	0.00007	0.00009	0.00069	0.00003	0.00002	0.00007
Risk:	5.3E-07	6.6E-07	1.5E-07	4.2E-08	4.8E-07	1.2E-08	8.4E-09	1.6E-07
Woollara LGA (Easterns Suburbs - North)								
Total Population in study area:	71841	71841	71841	71841	71841	71841	71841	71841
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-512.5	-512.5	-512.5	-512.5	-512.5	-512.5	-512.5	-512.5
Population weighted Δx (µg/m³):	-0.00713381	-0.00713381	-0.00713381	-0.00713381	-0.00713381	-0.00713381	-0.00713381	-0.00713381
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999959	0.999994	0.999997	0.999993	0.999902	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.1E-05	-5.7E-06	-2.9E-06	-6.7E-06	-9.3E-05	-8.9E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.020	-0.0070	-0.0016	-0.0019	-0.018	-0.00055	-0.00048	-0.0013
Risk:	-4.2E-07	-5.3E-07	-1.2E-07	-2.7E-08	-3.8E-07	-7.6E-09	-6.7E-09	-1.3E-07
Individual subbrs within LGA								
Bondi - Tamarama - Bronte								
Total Population in study area:	2184	2184	2184	2184	2184	2184	2184	2184
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	26	26	26	26	26	26	26	26
Population weighted Δx (µg/m³):	0.01190476	0.01190476	0.01190476	0.01190476	0.01190476	0.01190476	0.01190476	0.01190476
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000069	1.000010	1.000005	1.000011	1.000155	1.000012	1.000023	1.000018
Attributable fraction (AF):	6.9E-05	9.5E-06	4.9E-06	1.1E-05	1.5E-04	1.2E-05	2.3E-05	1.8E-05
Increased number of cases in population:	0.0010	0.00036	0.00008	0.00010	0.0009	0.000028	0.000024	0.00007
Risk:	7.1E-07	8.8E-07	1.9E-07	4.4E-08	6.4E-07	1.3E-08	1.1E-08	2.1E-07
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-61.6	-61.6	-61.6	-61.6	-61.6	-61.6	-61.6	-61.6
Population weighted Δx (µg/m³):	-0.00521195	-0.00521195	-0.00521195	-0.00521195	-0.00521195	-0.00521195	-0.00521195	-0.00521195
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999970	0.999996	0.999998	0.999995	0.999932	0.999995	0.999990	0.999992
Attributable fraction (AF):	-3.0E-05	-4.2E-06	-2.1E-06	-4.9E-06	-6.8E-05	-5.1E-06	-9.9E-06	-7.7E-06
Increased number of cases in population:	-0.0024	-0.0008	-0.00019	-0.00023	-0.00022	-0.000066	-0.000058	-0.00016
Risk:	-3.1E-07	-3.9E-07	-8.5E-08	-1.9E-08	-2.8E-07	-5.6E-09	-4.9E-09	-9.3E-08
Bondi Junction - Waverly								
Total Population in study area:	1903	1903	1903	1903	1903	1903	1903	1903
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	51	51	51	51	51	51	51	51
Population weighted Δx (µg/m³):	0.02679979	0.02679979	0.02679979	0.02679979	0.02679979	0.02679979	0.02679979	0.02679979
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000155	1.000021	1.000011	1.000025	1.000348	1.000026	1.000051	1.000040
Attributable fraction (AF):	1.6E-04	2.1E-05	1.1E-05	2.5E-05	3.5E-04	2.6E-05	5.1E-05	4.0E-05
Increased number of cases in population:	0.0020	0.00070	0.00015	0.00019	0.0018	0.000055	0.000048	0.00013
Risk:	1.6E-06	2.0E-06	4.4E-07	1.0E-07	1.4E-06	2.9E-08	2.5E-08	4.8E-07
Double Bay - Bellevue Hill								
Total Population in study area:	24798	24798	24798	24798	24798	24798	24798	24798
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-127.5	-127.5	-127.5	-127.5	-127.5	-127.5	-127.5	-127.5
Population weighted Δx (µg/m³):	-0.00514154	-0.00514154	-0.00514154	-0.00514154	-0.00514154	-0.00514154	-0.00514154	-0.00514154
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999970	0.999996	0.999998	0.999995	0.999932	0.999995	0.999990	0.999992
Attributable fraction (AF):	-3.0E-05	-4.1E-06	-2.1E-06	-4.8E-06	-6.7E-05	-5.0E-06	-9.8E-06	-7.6E-06
Increased number of cases in population:	-0.0050	-0.00175	-0.00039	-0.00047	-0.0045	-0.000137	-0.000120	-0.000331
Risk:	-3.1E-07	-3.8E-07	-8.4E-08	-1.9E-08	-2.8E-07	-5.5E-09	-4.8E-09	-9.2E-08
Dover Heights								
Total Population in study area:	3179	3179	3179	3179	3179	3179	3179	3179
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-9.06	-9.06	-9.06	-9.06	-9.06	-9.06	-9.06	-9.06
Population weighted Δx (µg/m³):	-0.00284995	-0.00284995	-0.00284995	-0.00284995	-0.00284995	-0.00284995	-0.00284995	-0.00284995
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999983	0.999998	0.999999	0.999997	0.999963	0.999997	0.999995	0.999996
Attributable fraction (AF):	-1.7E-05	-2.3E-06	-1.2E-06	-2.7E-06	-3.7E-05	-2.8E-06	-5.4E-06	-4.2E-06
Increased number of cases in population:	-0.0004	-0.00012	-0.00003	-0.00003	-0.00003	-0.000010	-0.000009	-0.00002
Risk:	-1.7E-07	-2.1E-07	-4.6E-08	-1.1E-08	-1.5E-07	-3.1E-09	-2.7E-09	-5.1E-08
Paddington - Moore Park								
Total Population in study area:	13311	13311	13311	13311	13311	13311	13311	13311
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-271.3	-271.3	-271.3	-271.3	-271.3	-271.3	-271.3	-271.3
Population weighted Δx (µg/m³):	-0.02038164	-0.02038164	-0.02038164	-0.02038164	-0.02038164	-0.02038164	-0.02038164	-0.02038164
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999882	0.999984	0.999992	0.999981	0.999735	0.999980	0.999961	0.999970
Attributable fraction (AF):	-1.2E-04	-1.6E-05	-8.4E-06	-1.9E-05	-2.6E-04	-2.0E-05	-3.9E-05	-3.0E-05
Increased number of cases in population:	-0.01059	-0.00373	-0.000823	-0.001010	-0.00953	-0.000291	-0.000255	-0.000704
Risk:	-1.2E-06	-1.5E-06	-3.3E-07	-7.6E-08	-1.1E-06	-2.2E-08	-1.9E-08	-3.6E-07
Rose Bay - Vaucluse - Watsons Bay								
Total Population in study area:	6984	6984	6984	6984	6984	6984	6984	6984
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-69.4	-69.4	-69.4	-69.4	-69.4	-69.4	-69.4	-69.4
Population weighted Δx (µg/m³):	-0.00993700	-0.00993700	-0.00993700	-0.00993700	-0.00993700	-0.00993700	-0.00993700	-0.00993700
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999942	0.999992	0.999996	0.999991	0.999871	0.999990	0.999981	0.999985
Attributable fraction (AF):	-5.8E-05	-7.9E-06	-4.1E-06	-9.3E-06	-1.3E-04	-9.6E-06	-1.9E-05	-1.5E-05
Increased number of cases in population:	-0.00271	-0.00095	-0.000211	-0.000258	-0.00244	-0.000074	-0.000065	-0.000180
Risk:	-5.9E-07	-7.3E-07	-1.6E-07	-3.7E-08	-5.3E-07	-1.1E-08	-9.3E-09	-1.8E-07
Woollahra								
Total Population in study area:	7663	7663	7663	7663	7663	7663	7663	7663
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6	-50.6
Population weighted Δx (µg/m³):	-0.00660316	-0.00660316	-0.00660316	-0.00660316	-0.00660316	-0.00660316	-0.00660316	-0.00660316
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999962	0.999995	0.999997	0.999994	0.999914	0.999994	0.999987	0.999990
Attributable fraction (AF):	-3.8E-05	-5.3E-06	-2.7E-06	-6.2E-06	-8.6E-05	-6.4E-06	-1.3E-05	-9.8E-06
Increased number of cases in population:	-0.00198	-0.00070	-0.000154	-0.000188	-0.00178	-0.000054	-0.000047	-0.000131
Risk:	-3.9E-07	-4.9E-07	-1.1E-07	-2.5E-08	-3.5E-07	-7.1E-09	-6.2E-09	-1.2E-07
Northern Beaches LGA								
Total Population in study area:	86694	86694	86694	86694	86694	86694	86694	86694
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Population weighted Δx (µg/m³):	0.00091586	0.00091586	0.00091586	0.00091586	0.00091586	0.00091586	0.00091586	0.00091586
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000005	1.000001	1.000000	1.000001	1.000012	1.000002	1.000002	1.000001
Attributable fraction (AF):	5.3E-06	7.3E-07	3.8E-07	8.6E-07	1.2E-05	8.9E-07	1.7E-06	1.4E-06
Increased number of cases in population:	0.0030	0.00099	0.00022	0.00035	0.0027	0.000098	0.000075	0.00026
Risk:	5.5E-08	6.8E-08	1.5E-08	4.0E-09	4.9E-08	1.1E-09	8.6E-10	1.6E-08
Individual subrubs within LGA								
Balgowlah - Clontarf - Seaford								
Total Population in study area:	20214	20214	20214	20214	20214	20214	20214	20214
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-7.95	-7.95	-7.95	-7.95	-7.95	-7.95	-7.95	-7.95

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Population weighted Δx (µg/m³):	-0.00039329	-0.00039329	-0.00039329	-0.00039329	-0.00039329	-0.00039329	-0.00039329	-0.00039329
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999998	1.000000	1.000000	1.000000	0.999995	1.000000	0.999999	0.999999
Attributable fraction (AF):	-2.3E-06	-3.1E-07	-1.6E-07	-3.7E-07	-5.1E-06	-3.8E-07	-7.5E-07	-5.8E-07
Increased number of cases in population:	-0.0003	-0.0001	-0.00002	-0.00003	-0.0003	-0.00001	-0.00001	-0.00003
Risk:	-2.3E-08	-2.9E-08	-6.4E-09	-1.7E-09	-2.1E-08	-4.9E-10	-3.7E-10	-7.0E-09
Beacon Hill - Narraweena								
Total Population in study area:	12757	12757	12757	12757	12757	12757	12757	12757
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8
Population weighted Δx (µg/m³):	0.00758799	0.00758799	0.00758799	0.00758799	0.00758799	0.00758799	0.00758799	0.00758799
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000044	1.000006	1.000003	1.000007	1.000099	1.000027	1.000014	1.000011
Attributable fraction (AF):	4.4E-05	6.1E-06	3.1E-06	7.1E-06	9.9E-05	7.4E-06	1.4E-05	1.1E-05
Increased number of cases in population:	0.0037	0.0012	0.00027	0.00042	0.0033	0.00012	0.00009	0.00032
Risk:	4.5E-07	5.6E-07	1.2E-07	3.3E-08	4.1E-07	9.4E-09	7.1E-09	1.4E-07
Dee Why - North Curl Curl								
Total Population in study area:	228	228	228	228	228	228	228	228
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
Population weighted Δx (µg/m³):	0.01263158	0.01263158	0.01263158	0.01263158	0.01263158	0.01263158	0.01263158	0.01263158
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000073	1.000010	1.000005	1.000012	1.000164	1.000012	1.000024	1.000019
Attributable fraction (AF):	7.3E-05	1.0E-05	5.2E-06	1.2E-05	1.6E-04	1.2E-05	2.4E-05	1.9E-05
Increased number of cases in population:	0.000110	0.000036	0.000008	0.000013	0.000099	0.000004	0.000003	0.000010
Risk:	7.5E-07	9.3E-07	2.1E-07	5.5E-08	6.8E-07	1.6E-08	1.2E-08	2.3E-07
Forrestville - Killarney Heights								
Total Population in study area:	12813	12813	12813	12813	12813	12813	12813	12813
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
Population weighted Δx (µg/m³):	0.00224772	0.00224772	0.00224772	0.00224772	0.00224772	0.00224772	0.00224772	0.00224772
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000013	1.000002	1.000001	1.000002	1.000029	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.3E-05	1.8E-06	9.2E-07	2.1E-06	2.9E-05	2.2E-06	4.3E-06	3.3E-06
Increased number of cases in population:	0.0011	0.0004	0.00008	0.00013	0.0010	0.00004	0.00003	0.00010
Risk:	1.3E-07	1.7E-07	3.7E-08	9.8E-09	1.2E-07	2.8E-09	2.1E-09	4.0E-08
Frenchs Forrest - Belrose								
Total Population in study area:	10159	10159	10159	10159	10159	10159	10159	10159
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	82.1	82.1	82.1	82.1	82.1	82.1	82.1	82.1
Population weighted Δx (µg/m³):	0.00808150	0.00808150	0.00808150	0.00808150	0.00808150	0.00808150	0.00808150	0.00808150
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000047	1.000006	1.000003	1.000008	1.000105	1.000008	1.000015	1.000012
Attributable fraction (AF):	4.7E-05	6.5E-06	3.3E-06	7.6E-06	1.1E-04	7.8E-06	1.5E-05	1.2E-05
Increased number of cases in population:	0.0031	0.0010	0.00022	0.00036	0.0028	0.00010	0.00008	0.00027
Risk:	4.8E-07	6.0E-07	1.3E-07	3.5E-08	4.3E-07	1.0E-08	7.6E-09	1.4E-07
Freshwater - Brookvale								
Total Population in study area:	8047	8047	8047	8047	8047	8047	8047	8047
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-20.5	-20.5	-20.5	-20.5	-20.5	-20.5	-20.5	-20.5
Population weighted Δx (µg/m³):	-0.00254753	-0.00254753	-0.00254753	-0.00254753	-0.00254753	-0.00254753	-0.00254753	-0.00254753
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999985	0.999998	0.999999	0.999999	0.999967	0.999998	0.999995	0.999996
Attributable fraction (AF):	-1.5E-05	-2.0E-06	-1.0E-06	-2.4E-06	-3.3E-05	-2.5E-06	-4.8E-06	-3.8E-06
Increased number of cases in population:	-0.0008	-0.0003	-0.00006	-0.00009	-0.0007	-0.00003	-0.00002	-0.00007
Risk:	-1.5E-07	-1.9E-07	-4.2E-08	-1.1E-08	-1.4E-07	-3.1E-09	-2.4E-09	-4.6E-08
Manly - Fairlight								
Total Population in study area:	5576	5576	5576	5576	5576	5576	5576	5576
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-21.4	-21.4	-21.4	-21.4	-21.4	-21.4	-21.4	-21.4
Population weighted Δx (µg/m³):	-0.00383788	-0.00383788	-0.00383788	-0.00383788	-0.00383788	-0.00383788	-0.00383788	-0.00383788
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999978	0.999997	0.999998	0.999996	0.999950	0.999996	0.999993	0.999994
Attributable fraction (AF):	-2.2E-05	-3.1E-06	-1.6E-06	-3.6E-06	-5.0E-05	-3.7E-06	-7.3E-06	-5.7E-06
Increased number of cases in population:	-0.000819	-0.000266	-0.000059	-0.000093	-0.000737	-0.000026	-0.000020	-0.000071
Risk:	-2.3E-07	-2.8E-07	-6.3E-08	-1.7E-08	-2.1E-07	-4.7E-09	-3.6E-09	-6.9E-08
Manly Vale - Allambie Heights								
Total Population in study area:	16900	16900	16900	16900	16900	16900	16900	16900
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-81.3	-81.3	-81.3	-81.3	-81.3	-81.3	-81.3	-81.3
Population weighted Δx (µg/m³):	-0.00481065	-0.00481065	-0.00481065	-0.00481065	-0.00481065	-0.00481065	-0.00481065	-0.00481065
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999972	0.999996	0.999998	0.999995	0.999937	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.8E-05	-3.8E-06	-2.0E-06	-4.5E-06	-6.3E-05	-4.7E-06	-9.1E-06	-7.1E-06
Increased number of cases in population:	-0.0031	-0.0010	-0.00022	-0.00035	-0.0028	-0.00010	-0.00008	-0.00027
Risk:	-2.9E-07	-3.6E-07	-7.8E-08	-2.1E-08	-2.6E-07	-5.9E-09	-4.5E-09	-8.6E-08
Ku-ring-gai LGA								
Total Population in study area:	32193	32193	32193	32193	32193	32193	32193	32193
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-5.1	-5.08	-5.08	-5.08	-5.08	-5.08	-5.08	-5.08
Population weighted Δx (µg/m³):	-0.00015780	-0.00015780	-0.00015780	-0.00015780	-0.00015780	-0.00015780	-0.00015780	-0.00015780
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Relative Risk:	0.999999	1.000000	1.000000	1.000000	0.999998	1.000000	1.000000	1.000000
Attributable fraction (AF):	-9.2E-07	-1.3E-07	-6.5E-08	-1.5E-07	-2.1E-06	-1.5E-07	-3.0E-07	-2.3E-07
Increased number of cases in population:	-0.00019	-0.000068	-0.000015	-0.000017	-0.00017	-0.0000053	-0.0000048	-0.000018
Risk:	-9.4E-09	-1.2E-08	-2.6E-09	-5.4E-10	-8.5E-09	-1.6E-10	-1.5E-10	-2.8E-09
Individual subrubs within LGA								
Gordon-Killara								
Total Population in study area:	9811	9811	9811	9811	9811	9811	9811	9811
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-36.2	-36.2	-36.2	-36.2	-36.2	-36.2	-36.2	-36.2
Population weighted Δx (µg/m³):	-0.00368974	-0.00368974	-0.00368974	-0.00368974	-0.00368974	-0.00368974	-0.00368974	-0.00368974
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999979	0.999997	0.999998	0.999997	0.999952	0.999996	0.999993	0.999995
Attributable fraction (AF):	-2.1E-05	-3.0E-06	-1.5E-06	-3.5E-06	-4.8E-05	-3.6E-06	-7.0E-06	-5.5E-06
Increased number of cases in population:	-0.0013	-0.0005	-0.00011	-0.00012	-0.0012	-0.00004	-0.00003	-0.00013
Risk:	-2.2E-07	-2.7E-07	-6.0E-08	-1.3E-08	-2.0E-07	-3.9E-09	-3.5E-09	-6.6E-08
Lindfield - Roseville								
Total Population in study area:	21343	21343	21343	21343	21343	21343	21343	21343
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
Population weighted Δx (µg/m³):	0.00163051	0.00163051	0.00163051	0.00163051	0.00163051	0.00163051	0.00163051	0.00163051
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	1.000009	1.000001	1.000001	1.000002	1.000021	1.000002	1.000003	1.000002
Attributable fraction (AF):	9.5E-06	1.3E-06	6.7E-07	1.5E-06	2.1E-05	1.6E-06	3.1E-06	2.4E-06
Increased number of cases in population:	0.0013	0.0005	0.00010	0.00012	0.0012	0.00004	0.00003	0.00012
Risk:	9.7E-08	1.2E-07	2.7E-08	5.6E-09	8.7E-08	1.7E-09	1.5E-09	2.9E-08
St Ives								
Total Population in study area:	1039	1039	1039	1039	1039	1039	1039	1039
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68
Population weighted Δx (µg/m³):	-0.00354187	-0.00354187	-0.00354187	-0.00354187	-0.00354187	-0.00354187	-0.00354187	-0.00354187
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999979	0.999997	0.999998	0.999997	0.999954	0.999997	0.999993	0.999995
Attributable fraction (AF):	-2.1E-05	-2.8E-06	-1.5E-06	-3.3E-06	-4.6E-05	-3.4E-06	-6.7E-06	-5.2E-06
Increased number of cases in population:	-0.000137	-0.000049	-0.000011	-0.000013	-0.000123	-0.000004	-0.000003	-0.000013
Risk:	-2.1E-07	-2.6E-07	-5.8E-08	-1.2E-08	-1.9E-07	-3.7E-09	-3.3E-09	-6.3E-08
Total population incidence - All Suburbs								
	-0.14	-0.044	-0.010	-0.012	-0.12	-0.0037	-0.0033	-0.0083

Assessment of Increased Incidence - PM_{2.5}
Western Harbour Tunnel: 2037

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Canada Bay LGA								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09
Population weighted Δx (µg/m ³):	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000060	1.000008	1.000004	1.000010	1.000134	1.000010	1.000020	1.000015
Attributable fraction (AF):	6.0E-05	8.3E-06	4.2E-06	9.7E-06	1.3E-04	1.0E-05	2.0E-05	1.5E-05
Increased number of cases in population:	0.00090	0.00026	0.000058	0.000091	0.00081	0.000026	0.000023	0.000064
Risk:	6.1E-07	7.6E-07	1.7E-07	3.9E-08	5.5E-07	1.1E-08	9.7E-09	1.8E-07
Individual subrubs within LGA								
Drummoyne - Rodd Pt								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09
Population weighted Δx (µg/m ³):	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134	0.01032134
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000060	1.000008	1.000004	1.000010	1.000134	1.000010	1.000020	1.000015
Attributable fraction (AF):	6.0E-05	8.3E-06	4.2E-06	9.7E-06	1.3E-04	1.0E-05	2.0E-05	1.5E-05
Increased number of cases in population:	0.0009	0.00026	0.000058	0.00009	0.0008	0.000026	0.000023	0.00006
Risk:	6.1E-07	7.6E-07	1.7E-07	3.9E-08	5.5E-07	1.1E-08	9.7E-09	1.8E-07
North Sydney - Mosman								
Total Population in study area:	94149	94149	94149	94149	94149	94149	94149	94149
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-2877.8	-2877.8	-2877.8	-2877.8	-2877.8	-2877.8	-2877.8	-2877.8
Population weighted Δx (µg/m ³):	-0.03056644	-0.03056644	-0.03056644	-0.03056644	-0.03056644	-0.03056644	-0.03056644	-0.03056644
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999823	0.999976	0.999987	0.999971	0.999603	0.999970	0.999942	0.999955
Attributable fraction (AF):	-1.8E-04	-2.4E-05	-1.3E-05	-2.9E-05	-4.0E-04	-3.0E-05	-5.8E-05	-4.5E-05
Increased number of cases in population:	-0.11	-0.041	-0.0090	-0.0091	-0.10	-0.0028	-0.0027	-0.0085
Risk:	-1.8E-06	-2.3E-06	-5.0E-07	-9.6E-08	-1.6E-06	-2.9E-08	-2.9E-08	-5.5E-07
Individual subrubs within LGA								
Cremorne - Cammeray								
Total Population in study area:	19045	19045	19045	19045	19045	19045	19045	19045
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9
Population weighted Δx (µg/m ³):	0.00372276	0.00372276	0.00372276	0.00372276	0.00372276	0.00372276	0.00372276	0.00372276
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000022	1.000003	1.000002	1.000003	1.000048	1.000004	1.000007	1.000006
Attributable fraction (AF):	2.2E-05	3.0E-06	1.5E-06	3.5E-06	4.8E-05	3.6E-06	7.1E-06	5.5E-06
Increased number of cases in population:	0.00283	0.00100	0.00022	0.00022	0.00255	0.00007	0.00007	0.00021
Risk:	2.2E-07	2.8E-07	6.1E-08	1.2E-08	2.0E-07	3.6E-09	3.5E-09	6.7E-08
Crows Nest - Waverton								
Total Population in study area:	18063	18063	18063	18063	18063	18063	18063	18063
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	362.8	362.8	362.8	362.8	362.8	362.8	362.8	362.8
Population weighted Δx (µg/m ³):	0.02008526	0.02008526	0.02008526	0.02008526	0.02008526	0.02008526	0.02008526	0.02008526
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000117	1.000016	1.000008	1.000019	1.000261	1.000019	1.000038	1.000030
Attributable fraction (AF):	1.2E-04	1.6E-05	8.2E-06	1.9E-05	2.6E-04	1.9E-05	3.8E-05	3.0E-05
Increased number of cases in population:	0.0148	0.0039	0.0009	0.0011	0.0133	0.0003	0.0003	0.0007
Risk:	1.2E-06	1.5E-06	3.3E-07	6.3E-08	1.1E-06	1.9E-08	1.9E-08	3.6E-07
Mosman								
Total Population in study area:	28462	28462	28462	28462	28462	28462	28462	28462
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
Population weighted Δx (µg/m ³):	0.00055513	0.00055513	0.00055513	0.00055513	0.00055513	0.00055513	0.00055513	0.00055513
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000003	1.000000	1.000000	1.000001	1.000007	1.000001	1.000001	1.000001
Attributable fraction (AF):	3.2E-06	4.4E-07	2.3E-07	5.2E-07	7.2E-06	5.4E-07	1.1E-06	8.2E-07
Increased number of cases in population:	0.000631	0.000223	0.000049	0.000050	0.000568	0.000015	0.000015	0.000047
Risk:	3.3E-08	4.1E-08	9.1E-09	1.7E-09	3.0E-08	5.3E-10	5.2E-10	9.9E-09
Neutral Bay - Kirribilli								
Total Population in study area:	17899	17899	17899	17899	17899	17899	17899	17899
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-2273.4	-2273.4	-2273.4	-2273.4	-2273.4	-2273.4	-2273.4	-2273.4
Population weighted Δx (µg/m ³):	-0.12701268	-0.12701268	-0.12701268	-0.12701268	-0.12701268	-0.12701268	-0.12701268	-0.12701268
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999264	0.999898	0.999948	0.999881	0.998350	0.999877	0.999759	0.999812
Attributable fraction (AF):	-7.4E-04	-1.0E-04	-5.2E-05	-1.2E-04	-1.7E-03	-1.2E-04	-2.4E-04	-1.9E-04
Increased number of cases in population:	-0.0926	-0.0242	-0.0053	-0.0072	-0.0834	-0.0022	-0.0021	-0.0046
Risk:	-7.6E-06	-9.4E-06	-2.1E-06	-4.0E-07	-6.8E-06	-1.2E-07	-1.2E-07	-2.3E-06
North Sydney - Lavender Bay								
Total Population in study area:	10680	10680	10680	10680	10680	10680	10680	10680
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-1054	-1054	-1054	-1054	-1054	-1054	-1054	-1054
Population weighted Δx (µg/m ³):	-0.09868914	-0.09868914	-0.09868914	-0.09868914	-0.09868914	-0.09868914	-0.09868914	-0.09868914
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999428	0.999921	0.999960	0.999907	0.998718	0.999904	0.999813	0.999854

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Attributable fraction (AF):	-5.7E-04	-7.9E-05	-4.0E-05	-9.3E-05	-1.3E-03	-9.6E-05	-1.9E-04	-1.5E-04
Increased number of cases in population:	-0.0429	-0.0112	-0.0025	-0.0386	-0.0010	-0.0010	-0.0010	-0.0021
Risk:	-5.9E-06	-7.3E-06	-1.6E-06	-3.1E-07	-5.3E-06	-9.4E-08	-9.3E-08	-1.8E-06
Sydney Inner West LGA								
Total Population in study area:	48303	48303	48303	48303	48303	48303	48303	48303
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	420.2	420.2	420.2	420.2	420.2	420.2	420.2	420.2
Population weighted Δx (µg/m³):	0.00869925	0.00869925	0.00869925	0.00869925	0.00869925	0.00869925	0.00869925	0.00869925
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000050	1.000007	1.000004	1.000008	1.000113	1.000008	1.000017	1.000013
Attributable fraction (AF):	5.0E-05	7.0E-06	3.6E-06	8.2E-06	1.1E-04	8.4E-06	1.7E-05	1.3E-05
Increased number of cases in population:	0.016	0.0038	0.00084	0.0021	0.014	0.00060	0.00039	0.0011
Risk:	5.2E-07	6.4E-07	1.4E-07	4.4E-08	4.7E-07	1.2E-08	8.2E-09	1.6E-07
Individual subrubs within LGA								
Balmain								
Total Population in study area:	15693	15693	15693	15693	15693	15693	15693	15693
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	-35	-35	-35	-35	-35	-35	-35	-35
Population weighted Δx (µg/m³):	-0.00223029	-0.00223029	-0.00223029	-0.00223029	-0.00223029	-0.00223029	-0.00223029	-0.00223029
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	0.999987	0.999998	0.999999	0.999998	0.999971	0.999998	0.999998	0.999997
Attributable fraction (AF):	-1.3E-05	-1.8E-06	-9.1E-07	-2.1E-06	-2.9E-05	-2.2E-06	-4.2E-06	-3.3E-06
Increased number of cases in population:	-0.0013	-0.00032	-0.000070	-0.00018	-0.0012	-0.000050	-0.000033	-0.000088
Risk:	-1.3E-07	-1.6E-07	-3.6E-08	-1.1E-08	-1.2E-07	-3.2E-09	-2.1E-09	-4.0E-08
Leichhardt - Annandale								
Total Population in study area:	17541	17541	17541	17541	17541	17541	17541	17541
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	403	403	403	403	403	403	403	403
Population weighted Δx (µg/m³):	0.02297474	0.02297474	0.02297474	0.02297474	0.02297474	0.02297474	0.02297474	0.02297474
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000133	1.000018	1.000009	1.000022	1.000299	1.000022	1.000044	1.000034
Attributable fraction (AF):	1.3E-04	1.8E-05	9.4E-06	2.2E-05	3.0E-04	2.2E-05	4.4E-05	3.4E-05
Increased number of cases in population:	0.015	0.004	0.0008	0.002	0.014	0.0006	0.0004	0.0010
Risk:	1.4E-06	1.7E-06	3.7E-07	1.2E-07	1.2E-06	3.3E-08	2.2E-08	4.1E-07
Lilyfield - Rozelle								
Total Population in study area:	12549	12549	12549	12549	12549	12549	12549	12549
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	52.1	52.1	52.1	52.1	52.1	52.1	52.1	52.1
Population weighted Δx (µg/m³):	0.00415173	0.00415173	0.00415173	0.00415173	0.00415173	0.00415173	0.00415173	0.00415173
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000024	1.000003	1.000002	1.000004	1.000054	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.4E-05	3.3E-06	1.7E-06	3.9E-06	5.4E-05	4.0E-06	7.9E-06	6.1E-06
Increased number of cases in population:	0.002	0.00047	0.00010	0.00026	0.00178	0.00007	0.00005	0.00013
Risk:	2.5E-07	3.1E-07	6.8E-08	2.1E-08	2.2E-07	5.9E-09	3.9E-09	7.4E-08
Petersham - Stanmore								
Total Population in study area:	2520	2520	2520	2520	2520	2520	2520	2520
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
Population weighted Δx (µg/m³):	0.00603175	0.00603175	0.00603175	0.00603175	0.00603175	0.00603175	0.00603175	0.00603175
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000035	1.000005	1.000002	1.000006	1.000078	1.000006	1.000011	1.000009
Attributable fraction (AF):	3.5E-05	4.8E-06	2.5E-06	5.7E-06	7.8E-05	5.9E-06	1.1E-05	8.9E-06
Increased number of cases in population:	0.000577	0.000137	0.000030	0.000076	0.000519	0.000022	0.000014	0.000038
Risk:	3.6E-07	4.5E-07	9.8E-08	3.0E-08	3.2E-07	8.6E-09	5.7E-09	1.1E-07
Sydney LGA								
Total Population in study area:	131933	131933	131933	131933	131933	131933	131933	131933
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-6533.4	-6533.4	-6533.4	-6533.4	-6533.4	-6533.4	-6533.4	-6533.4
Population weighted Δx (µg/m³):	-0.04952059	-0.04952059	-0.04952059	-0.04952059	-0.04952059	-0.04952059	-0.04952059	-0.04952059
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999713	0.999960	0.999980	0.999953	0.999356	0.999952	0.999906	0.999927
Attributable fraction (AF):	-2.9E-04	-4.0E-05	-2.0E-05	-4.7E-05	-6.4E-04	-4.8E-05	-9.4E-05	-7.3E-05
Increased number of cases in population:	-0.22	-0.040	-0.0087	-0.031	-0.20	-0.0088	-0.0061	-0.0069
Risk:	-2.9E-06	-3.7E-06	-8.1E-07	-2.4E-07	-2.7E-06	-6.7E-08	-4.6E-08	-8.9E-07
Individual subrubs within LGA								
Darlinghurst								
Total Population in study area:	11354	11354	11354	11354	11354	11354	11354	11354
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-193.8	-193.8	-193.8	-193.8	-193.8	-193.8	-193.8	-193.8
Population weighted Δx (µg/m³):	-0.01706887	-0.01706887	-0.01706887	-0.01706887	-0.01706887	-0.01706887	-0.01706887	-0.01706887
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999901	0.999986	0.999993	0.999984	0.999778	0.999983	0.999968	0.999975
Attributable fraction (AF):	-9.9E-05	-1.4E-05	-7.0E-06	-1.6E-05	-2.2E-04	-1.7E-05	-3.2E-05	-2.5E-05
Increased number of cases in population:	-0.007	-0.0012	-0.00026	-0.0009	-0.006	-0.00026	-0.00018	-0.00020
Risk:	-1.0E-06	-1.3E-06	-2.8E-07	-8.2E-08	-9.1E-07	-2.3E-08	-1.6E-08	-3.1E-07
Glebe - Forest Lodge								
Total Population in study area:	19593	19593	19593	19593	19593	19593	19593	19593
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-520.3	-520.3	-520.3	-520.3	-520.3	-520.3	-520.3	-520.3
Population weighted Δx (µg/m³):	-0.02655540	-0.02655540	-0.02655540	-0.02655540	-0.02655540	-0.02655540	-0.02655540	-0.02655540
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999846	0.999979	0.999989	0.999975	0.999655	0.999974	0.999950	0.999961
Attributable fraction (AF):	-1.5E-04	-2.1E-05	-1.1E-05	-2.5E-05	-3.5E-04	-2.6E-05	-5.0E-05	-3.9E-05

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Increased number of cases in population:	-0.018	-0.0032	-0.00070	-0.0025	-0.016	-0.00070	-0.00049	-0.00055
Risk:	-1.6E-06	-2.0E-06	-4.3E-07	-1.3E-07	-1.4E-06	-3.6E-08	-2.5E-08	-4.8E-07
Newtown - Camperdown - Darlington								
Total Population in study area:	5154	5154	5154	5154	5154	5154	5154	5154
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-37.9	-37.9	-37.9	-37.9	-37.9	-37.9	-37.9	-37.9
Population weighted Δx (µg/m³):	-0.00735351	-0.00735351	-0.00735351	-0.00735351	-0.00735351	-0.00735351	-0.00735351	-0.00735351
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999957	0.999994	0.999997	0.999993	0.999904	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.3E-05	-5.9E-06	-3.0E-06	-6.9E-06	-9.6E-05	-7.1E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.001	-0.0002	-0.00005	-0.0002	-0.0012	-0.00005	-0.00004	-0.00004
Risk:	-4.4E-07	-5.4E-07	-1.2E-07	-3.5E-08	-3.9E-07	-9.9E-09	-6.9E-09	-1.3E-07
Potts Point - Woolloomooloo								
Total Population in study area:	21200	21200	21200	21200	21200	21200	21200	21200
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1083.1	-1083.1	-1083.1	-1083.1	-1083.1	-1083.1	-1083.1	-1083.1
Population weighted Δx (µg/m³):	-0.05108962	-0.05108962	-0.05108962	-0.05108962	-0.05108962	-0.05108962	-0.05108962	-0.05108962
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999704	0.999959	0.999979	0.999952	0.999336	0.999950	0.999903	0.999924
Attributable fraction (AF):	-3.0E-04	-4.1E-05	-2.1E-05	-4.8E-05	-6.6E-04	-5.0E-05	-9.7E-06	-7.6E-05
Increased number of cases in population:	-0.037	-0.0014	-0.00014	-0.005	-0.033	-0.0015	-0.0010	-0.0011
Risk:	-3.0E-06	-3.8E-06	-8.3E-07	-2.4E-07	-2.7E-06	-6.9E-08	-4.8E-08	-9.1E-07
Pyrmont - Ultimo								
Total Population in study area:	21665	21665	21665	21665	21665	21665	21665	21665
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1905.2	-1905.2	-1905.2	-1905.2	-1905.2	-1905.2	-1905.2	-1905.2
Population weighted Δx (µg/m³):	-0.08793907	-0.08793907	-0.08793907	-0.08793907	-0.08793907	-0.08793907	-0.08793907	-0.08793907
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999490	0.999930	0.999964	0.999971	0.998857	0.999950	0.999833	0.999870
Attributable fraction (AF):	-5.1E-04	-7.0E-05	-3.6E-05	-8.3E-05	-1.1E-03	-8.5E-05	-1.7E-04	-1.3E-04
Increased number of cases in population:	-0.065	-0.0115	-0.0025	-0.0091	-0.059	-0.0026	-0.00179	-0.00201
Risk:	-5.2E-06	-6.5E-06	-1.4E-06	-4.2E-07	-4.7E-06	-1.2E-07	-8.3E-08	-1.6E-06
Redfern - Chippendale								
Total Population in study area:	9861	9861	9861	9861	9861	9861	9861	9861
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-249.7	-249.7	-249.7	-249.7	-249.7	-249.7	-249.7	-249.7
Population weighted Δx (µg/m³):	-0.02532198	-0.02532198	-0.02532198	-0.02532198	-0.02532198	-0.02532198	-0.02532198	-0.02532198
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999853	0.999980	0.999990	0.999976	0.999671	0.999975	0.999952	0.999963
Attributable fraction (AF):	-1.5E-04	-2.0E-05	-1.0E-05	-2.4E-05	-3.3E-04	-2.5E-05	-4.8E-05	-3.7E-05
Increased number of cases in population:	-0.00856	-0.001513	-0.000334	-0.001192	-0.00770	-0.000336	-0.000234	-0.000264
Risk:	-1.5E-06	-1.9E-06	-4.1E-07	-1.2E-07	-1.4E-06	-3.4E-08	-2.4E-08	-4.5E-07
Surry Hills								
Total Population in study area:	15699	15699	15699	15699	15699	15699	15699	15699
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-415.6	-415.6	-415.6	-415.6	-415.6	-415.6	-415.6	-415.6
Population weighted Δx (µg/m³):	-0.02647302	-0.02647302	-0.02647302	-0.02647302	-0.02647302	-0.02647302	-0.02647302	-0.02647302
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999846	0.999979	0.999989	0.999975	0.999656	0.999974	0.999950	0.999961
Attributable fraction (AF):	-1.5E-04	-2.1E-05	-1.1E-05	-2.5E-05	-3.4E-04	-2.6E-05	-5.0E-05	-3.9E-05
Increased number of cases in population:	-0.014	-0.0025	-0.00056	-0.0020	-0.013	-0.00056	-0.00039	-0.00044
Risk:	-1.6E-06	-2.0E-06	-4.3E-07	-1.3E-07	-1.4E-06	-3.6E-08	-2.5E-08	-4.7E-07
Sydney - Haymarket - The Rocks								
Total Population in study area:	27407	27407	27407	27407	27407	27407	27407	27407
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-2127.5	-2127.5	-2127.5	-2127.5	-2127.5	-2127.5	-2127.5	-2127.5
Population weighted Δx (µg/m³):	-0.07762615	-0.07762615	-0.07762615	-0.07762615	-0.07762615	-0.07762615	-0.07762615	-0.07762615
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999550	0.999938	0.999968	0.999972	0.999891	0.999925	0.999853	0.999885
Attributable fraction (AF):	-4.5E-04	-6.2E-05	-3.2E-05	-7.3E-05	-1.0E-03	-7.5E-05	-1.5E-04	-1.1E-04
Increased number of cases in population:	-0.0729	-0.0129	-0.00285	-0.0102	-0.0657	-0.00287	-0.00200	-0.00225
Risk:	-4.6E-06	-5.7E-06	-1.3E-06	-3.7E-07	-4.2E-06	-1.0E-07	-7.3E-08	-1.4E-06
Lane Cove - Chatswood LGA								
Total Population in study area:	103355	103355	103355	103355	103355	103355	103355	103355
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	872.00	872	872	872	872	872	872	872
Population weighted Δx (µg/m³):	0.00843694	0.00843694	0.00843694	0.00843694	0.00843694	0.00843694	0.00843694	0.00843694
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000049	1.000007	1.000003	1.000008	1.000110	1.000008	1.000016	1.000012
Attributable fraction (AF):	4.9E-05	6.7E-06	3.5E-06	7.9E-06	1.1E-04	8.2E-06	1.6E-05	1.2E-05
Increased number of cases in population:	0.032	0.0088	0.0019	0.0033	0.029	0.00096	0.00082	0.00027
Risk:	5.0E-07	6.2E-07	1.4E-07	3.2E-08	4.5E-07	9.3E-09	7.9E-09	1.5E-07
Individual subrubs within LGA								
Chatswood East - Artarmon								
Total Population in study area:	28631	28631	28631	28631	28631	28631	28631	28631
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	184.3	184.3	184.3	184.3	184.3	184.3	184.3	184.3
Population weighted Δx (µg/m³):	0.00643708	0.00643708	0.00643708	0.00643708	0.00643708	0.00643708	0.00643708	0.00643708
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000037	1.000005	1.000003	1.000006	1.000084	1.000006	1.000012	1.000010
Attributable fraction (AF):	3.7E-05	5.1E-06	2.6E-06	6.1E-06	8.4E-05	6.2E-06	1.2E-05	9.5E-06
Increased number of cases in population:	0.0069	0.0019	0.0004	0.0007	0.0062	0.0002	0.0002	0.0006
Risk:	3.8E-07	4.8E-07	1.0E-07	2.4E-08	3.4E-07	7.1E-09	6.0E-09	1.2E-07
Chatswood West - Lane Cove North								

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Total Population in study area:	18393	18393	18393	18393	18393	18393	18393	18393
% population in assessment age-group:	63%	63%	14%	100%	63%	100%	100%	17%
total change	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1
Population weighted Δx (µg/m³):	0.00348502	0.00348502	0.00348502	0.00348502	0.00348502	0.00348502	0.00348502	0.00348502
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000020	1.000003	1.000001	1.000003	1.000045	1.000003	1.000007	1.000005
Attributable fraction (AF):	2.0E-05	2.8E-06	1.4E-06	3.3E-06	4.5E-05	3.4E-06	6.6E-06	5.2E-06
Increased number of cases in population:	0.0024	0.0006	0.0001	0.0002	0.0021	0.0001	0.0001	0.0002
Risk:	2.1E-07	2.6E-07	5.7E-08	1.3E-08	1.9E-07	3.8E-09	3.3E-09	6.2E-08
Lane Cove - Greenwich								
Total Population in study area:	20401	20401	20401	20401	20401	20401	20401	20401
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	84	84	84	84	84	84	84	84
Population weighted Δx (µg/m³):	0.00411745	0.00411745	0.00411745	0.00411745	0.00411745	0.00411745	0.00411745	0.00411745
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000024	1.000003	1.000002	1.000004	1.000054	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.4E-05	3.3E-06	1.7E-06	3.9E-06	5.4E-05	4.0E-06	7.8E-06	6.1E-06
Increased number of cases in population:	0.0031	0.0009	0.0002	0.0003	0.0028	0.0009	0.0008	0.0003
Risk:	2.5E-07	3.0E-07	6.7E-08	1.6E-08	2.2E-07	4.5E-09	3.9E-09	7.4E-08
St Leonards - Naremburn								
Total Population in study area:	10478	10478	10478	10478	10478	10478	10478	10478
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	290.1	290.1	290.1	290.1	290.1	290.1	290.1	290.1
Population weighted Δx (µg/m³):	0.02768658	0.02768658	0.02768658	0.02768658	0.02768658	0.02768658	0.02768658	0.02768658
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000161	1.000022	1.000011	1.000026	1.000360	1.000027	1.000053	1.000041
Attributable fraction (AF):	1.6E-04	2.2E-05	1.1E-05	2.6E-05	3.6E-04	2.7E-05	5.3E-05	4.1E-05
Increased number of cases in population:	0.0108	0.0029	0.00065	0.00110	0.0097	0.00032	0.00027	0.00089
Risk:	1.6E-06	2.0E-06	4.5E-07	1.0E-07	1.5E-06	3.0E-08	2.6E-08	5.0E-07
Willoughby - Castle Cove - Northbridge								
Total Population in study area:	25452	25452	25452	25452	25452	25452	25452	25452
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	249.3	249.3	249.3	249.3	249.3	249.3	249.3	249.3
Population weighted Δx (µg/m³):	0.00979491	0.00979491	0.00979491	0.00979491	0.00979491	0.00979491	0.00979491	0.00979491
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000057	1.000008	1.000004	1.000009	1.000127	1.000010	1.000019	1.000014
Attributable fraction (AF):	5.7E-05	7.8E-06	4.0E-06	9.2E-06	1.3E-04	9.5E-06	1.9E-05	1.4E-05
Increased number of cases in population:	0.0093	0.0025	0.0006	0.0009	0.0083	0.0003	0.0002	0.0008
Risk:	5.8E-07	7.2E-07	1.6E-07	3.7E-08	5.2E-07	1.1E-08	9.2E-09	1.8E-07
Hunters Hill LGA								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	-2.6	-2.55	-2.55	-2.55	-2.55	-2.55	-2.55	-2.55
Population weighted Δx (µg/m³):	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	0.999993	0.999999	1.000000	0.999999	0.999985	0.999999	0.999998	0.999998
Attributable fraction (AF):	-6.6E-06	-9.0E-07	-4.6E-07	-1.1E-06	-1.5E-05	-1.1E-06	-2.1E-06	-1.7E-06
Increased number of cases in population:	-0.000098	-0.000041	-0.0000090	-0.000012	-0.000088	-0.0000033	-0.0000024	-0.0000083
Risk:	-6.7E-08	-8.3E-08	-1.8E-08	-5.3E-09	-6.0E-08	-1.5E-09	-1.1E-09	-2.0E-08
Individual subrubs within LGA								
Hunters Hill - Woolwich								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	-2.55	-2.55	-2.55	-2.55	-2.55	-2.55	-2.55	-2.55
Population weighted Δx (µg/m³):	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932	-0.00112932
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	0.999993	0.999999	1.000000	0.999999	0.999985	0.999999	0.999998	0.999998
Attributable fraction (AF):	-6.6E-06	-9.0E-07	-4.6E-07	-1.1E-06	-1.5E-05	-1.1E-06	-2.1E-06	-1.7E-06
Increased number of cases in population:	-0.00010	-0.00004	-0.000009	-0.000012	-0.00009	-0.0000033	-0.0000024	-0.000008
Risk:	-6.7E-08	-8.3E-08	-1.8E-08	-5.3E-09	-6.0E-08	-1.5E-09	-1.1E-09	-2.0E-08
Woollara LGA (Easterns Suburbs - North)								
Total Population in study area:	71841	71841	71841	71841	71841	71841	71841	71841
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-75.0	-75	-75	-75	-75	-75	-75	-75
Population weighted Δx (µg/m³):	-0.00104397	-0.00104397	-0.00104397	-0.00104397	-0.00104397	-0.00104397	-0.00104397	-0.00104397
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999973	0.999999	1.000000	0.999999	0.999986	0.999999	0.999998	0.999998
Attributable fraction (AF):	-6.1E-06	-8.4E-07	-4.3E-07	-9.8E-07	-1.4E-05	-1.0E-06	-2.0E-06	-1.5E-06
Increased number of cases in population:	-0.0029	-0.0010	-0.00023	-0.00028	-0.0026	-0.000080	-0.000070	-0.00019
Risk:	-6.2E-08	-7.7E-08	-1.7E-08	-3.9E-09	-5.6E-08	-1.1E-09	-9.8E-10	-1.9E-08
Individual subrubs within LGA								
Bondi - Tamarama - Bronte								
Total Population in study area:	2184	2184	2184	2184	2184	2184	2184	2184
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-10.2	-10.2	-10.2	-10.2	-10.2	-10.2	-10.2	-10.2
Population weighted Δx (µg/m³):	-0.00467033	-0.00467033	-0.00467033	-0.00467033	-0.00467033	-0.00467033	-0.00467033	-0.00467033
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999973	0.999999	0.999999	0.999999	0.999939	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.7E-05	-3.7E-06	-1.9E-06	-4.4E-06	-6.1E-05	-4.5E-06	-8.9E-06	-6.9E-06
Increased number of cases in population:	-0.0004	-0.00014	-0.00003	-0.00004	-0.0004	-0.000011	-0.000010	-0.00003
Risk:	-2.8E-07	-3.5E-07	-7.6E-08	-1.7E-08	-2.5E-07	-5.0E-09	-4.4E-09	-8.4E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
Population weighted Δx (µg/m³):	0.00017176	0.00017176	0.00017176	0.00017176	0.00017176	0.00017176	0.00017176	0.00017176
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000001	1.000000	1.000000	1.000000	1.000002	1.000000	1.000000	1.000000
Attributable fraction (AF):	1.0E-06	1.4E-07	7.0E-08	1.6E-07	2.2E-06	1.7E-07	3.3E-07	2.5E-07
Increased number of cases in population:	0.000079	0.000028	0.000006	0.000008	0.000071	0.000002	0.000002	0.000005
Risk:	1.0E-08	1.3E-08	2.8E-09	6.4E-10	9.2E-09	1.8E-10	1.6E-10	3.1E-09
Bondi Junction - Waverly								
Total Population in study area:	1903	1903	1903	1903	1903	1903	1903	1903
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
Population weighted Δx (µg/m³):	0.01713085	0.01713085	0.01713085	0.01713085	0.01713085	0.01713085	0.01713085	0.01713085
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000099	1.000014	1.000007	1.000016	1.000223	1.000017	1.000033	1.000025
Attributable fraction (AF):	9.9E-05	1.4E-05	7.0E-06	1.6E-05	2.2E-04	1.7E-05	3.3E-05	2.5E-05
Increased number of cases in population:	0.0013	0.00045	0.00010	0.00012	0.0011	0.000035	0.000031	0.00008
Risk:	1.0E-06	1.3E-06	2.8E-07	6.4E-08	9.2E-07	1.8E-08	1.6E-08	3.1E-07
Double Bay - Bellevue Hill								
Total Population in study area:	24798	24798	24798	24798	24798	24798	24798	24798
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-37.6	-37.6	-37.6	-37.6	-37.6	-37.6	-37.6	-37.6
Population weighted Δx (µg/m³):	-0.00151625	-0.00151625	-0.00151625	-0.00151625	-0.00151625	-0.00151625	-0.00151625	-0.00151625
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999991	0.999999	0.999999	0.999999	0.999980	0.999999	0.999997	0.999998
Attributable fraction (AF):	-8.8E-06	-1.2E-06	-6.2E-07	-1.4E-06	-2.0E-05	-1.5E-06	-2.9E-06	-2.2E-06
Increased number of cases in population:	-0.0015	-0.00052	-0.00011	-0.00014	-0.0013	-0.000040	-0.000035	-0.000098
Risk:	-9.0E-08	-1.1E-07	-2.5E-08	-5.6E-09	-8.1E-08	-1.6E-09	-1.4E-09	-2.7E-08
Dover Heights								
Total Population in study area:	3179	3179	3179	3179	3179	3179	3179	3179
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-4.35	-4.35	-4.35	-4.35	-4.35	-4.35	-4.35	-4.35
Population weighted Δx (µg/m³):	-0.00136835	-0.00136835	-0.00136835	-0.00136835	-0.00136835	-0.00136835	-0.00136835	-0.00136835
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999992	0.999999	0.999999	0.999999	0.999982	0.999999	0.999997	0.999998
Attributable fraction (AF):	-7.9E-06	-1.1E-06	-5.6E-07	-1.3E-06	-1.8E-05	-1.3E-06	-2.6E-06	-2.0E-06
Increased number of cases in population:	-0.0002	-0.00006	-0.00001	-0.00002	-0.00002	-0.000005	-0.000004	-0.00001
Risk:	-8.1E-08	-1.0E-07	-2.2E-08	-5.1E-09	-7.3E-08	-1.5E-09	-1.3E-09	-2.4E-08
Paddington - Moore Park								
Total Population in study area:	13311	13311	13311	13311	13311	13311	13311	13311
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-17.5	-17.5	-17.5	-17.5	-17.5	-17.5	-17.5	-17.5
Population weighted Δx (µg/m³):	-0.00131470	-0.00131470	-0.00131470	-0.00131470	-0.00131470	-0.00131470	-0.00131470	-0.00131470
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999992	0.999999	0.999999	0.999999	0.999982	0.999999	0.999997	0.999998
Attributable fraction (AF):	-7.6E-06	-1.1E-06	-5.4E-07	-1.2E-06	-1.7E-05	-1.3E-06	-2.5E-06	-1.9E-06
Increased number of cases in population:	-0.00068	-0.00024	-0.000053	-0.000065	-0.00061	-0.000019	-0.000016	-0.000045
Risk:	-7.8E-08	-9.7E-08	-2.1E-08	-4.9E-09	-7.0E-08	-1.4E-09	-1.2E-09	-2.4E-08
Rose Bay - Vaucluse - Watsons Bay								
Total Population in study area:	6984	6984	6984	6984	6984	6984	6984	6984
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-17.3	-17.3	-17.3	-17.3	-17.3	-17.3	-17.3	-17.3
Population weighted Δx (µg/m³):	-0.00247709	-0.00247709	-0.00247709	-0.00247709	-0.00247709	-0.00247709	-0.00247709	-0.00247709
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999986	0.999998	0.999999	0.999998	0.999968	0.999999	0.999995	0.999996
Attributable fraction (AF):	-1.4E-05	-2.0E-06	-1.0E-06	-2.3E-06	-3.2E-05	-2.4E-06	-4.7E-06	-3.7E-06
Increased number of cases in population:	-0.00068	-0.00024	-0.000052	-0.000064	-0.00061	-0.000019	-0.000016	-0.000045
Risk:	-1.5E-07	-1.8E-07	-4.0E-08	-9.2E-09	-1.3E-07	-2.7E-09	-2.3E-09	-4.4E-08
Woollahra								
Total Population in study area:	7663	7663	7663	7663	7663	7663	7663	7663
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5
Population weighted Δx (µg/m³):	-0.00293619	-0.00293619	-0.00293619	-0.00293619	-0.00293619	-0.00293619	-0.00293619	-0.00293619
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999983	0.999998	0.999999	0.999997	0.999962	0.999997	0.999994	0.999996
Attributable fraction (AF):	-1.7E-05	-2.3E-06	-1.2E-06	-2.8E-06	-3.8E-05	-2.8E-06	-5.6E-06	-4.3E-06
Increased number of cases in population:	-0.00088	-0.00031	-0.000068	-0.000084	-0.00079	-0.000024	-0.000021	-0.000058
Risk:	-1.7E-07	-2.2E-07	-4.8E-08	-1.1E-08	-1.6E-07	-3.1E-09	-2.8E-09	-5.3E-08
Northern Beaches LGA								
Total Population in study area:	86694	86694	86694	86694	86694	86694	86694	86694
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-162.6	-162.6	-162.6	-162.6	-162.6	-162.6	-162.6	-162.6
Population weighted Δx (µg/m³):	-0.00187556	-0.00187556	-0.00187556	-0.00187556	-0.00187556	-0.00187556	-0.00187556	-0.00187556
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999989	0.999998	0.999999	0.999998	0.999976	0.999999	0.999996	0.999997
Attributable fraction (AF):	-1.1E-05	-1.5E-06	-7.7E-07	-1.8E-06	-2.4E-05	-1.8E-06	-3.6E-06	-2.8E-06
Increased number of cases in population:	-0.0062	-0.0020	-0.00045	-0.00071	-0.0056	-0.00020	-0.00015	-0.00054
Risk:	-1.1E-07	-1.4E-07	-3.1E-08	-8.2E-09	-1.0E-07	-2.3E-09	-1.8E-09	-3.4E-08
Individual subrubs within LGA								
Balgowlah - Clontarf - Seaforth								
Total Population in study area:	20214	20214	20214	20214	20214	20214	20214	20214
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6	-24.6

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Population weighted Δx (µg/m³):	-0.00121698	-0.00121698	-0.00121698	-0.00121698	-0.00121698	-0.00121698	-0.00121698	-0.00121698
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999993	0.999999	1.000000	0.999999	0.999984	0.999999	0.999998	0.999998
Attributable fraction (AF):	-7.1E-06	-9.7E-07	-5.0E-07	-1.1E-06	-1.6E-05	-1.2E-06	-2.3E-06	-1.8E-06
Increased number of cases in population:	-0.0009	-0.0003	-0.00007	-0.00011	-0.0008	-0.00003	-0.00002	-0.00008
Risk:	-7.2E-08	-9.0E-08	-2.0E-08	-5.3E-09	-6.5E-08	-1.5E-09	-1.1E-09	-2.2E-08
Beacon Hill - Narraweena								
Total Population in study area:	12757	12757	12757	12757	12757	12757	12757	12757
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8
Population weighted Δx (µg/m³):	0.00311986	0.00311986	0.00311986	0.00311986	0.00311986	0.00311986	0.00311986	0.00311986
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000018	1.000002	1.000001	1.000003	1.000041	1.000003	1.000006	1.000005
Attributable fraction (AF):	1.8E-05	2.5E-06	1.3E-06	2.9E-06	4.1E-05	3.0E-06	5.9E-06	4.6E-06
Increased number of cases in population:	0.0015	0.0005	0.00011	0.00017	0.0014	0.00005	0.00004	0.00013
Risk:	1.9E-07	2.3E-07	5.1E-08	1.4E-08	1.7E-07	3.9E-09	2.9E-09	5.6E-08
Dee Why - North Curl Curl								
Total Population in study area:	228	228	228	228	228	228	228	228
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2
Population weighted Δx (µg/m³):	0.07982456	0.07982456	0.07982456	0.07982456	0.07982456	0.07982456	0.07982456	0.07982456
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000463	1.000064	1.000033	1.000075	1.001038	1.000077	1.000152	1.000118
Attributable fraction (AF):	4.6E-04	6.4E-05	3.3E-05	7.5E-05	1.0E-03	7.7E-05	1.5E-04	1.2E-04
Increased number of cases in population:	0.000696	0.000226	0.000050	0.000079	0.000626	0.000022	0.000017	0.000061
Risk:	4.8E-06	5.9E-06	1.3E-06	3.5E-07	4.3E-06	9.9E-08	7.5E-08	1.4E-06
Forrestville - Killarney Heights								
Total Population in study area:	12813	12813	12813	12813	12813	12813	12813	12813
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
Population weighted Δx (µg/m³):	0.00409740	0.00409740	0.00409740	0.00409740	0.00409740	0.00409740	0.00409740	0.00409740
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000024	1.000003	1.000002	1.000004	1.000053	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.4E-05	3.3E-06	1.7E-06	3.9E-06	5.3E-05	4.0E-06	7.8E-06	6.1E-06
Increased number of cases in population:	0.0020	0.0007	0.00014	0.00023	0.0018	0.00006	0.00005	0.00017
Risk:	2.4E-07	3.0E-07	6.7E-08	1.8E-08	2.2E-07	5.1E-09	3.8E-09	7.3E-08
Frenchs Forrest - Belrose								
Total Population in study area:	10159	10159	10159	10159	10159	10159	10159	10159
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-0.44	-0.44	-0.44	-0.44	-0.44	-0.44	-0.44	-0.44
Population weighted Δx (µg/m³):	-0.00004331	-0.00004331	-0.00004331	-0.00004331	-0.00004331	-0.00004331	-0.00004331	-0.00004331
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000000	1.000000	1.000000	1.000000	0.999999	1.000000	1.000000	1.000000
Attributable fraction (AF):	-2.5E-07	-3.5E-08	-1.8E-08	-4.1E-08	-5.6E-07	-4.2E-08	-8.2E-08	-6.4E-08
Increased number of cases in population:	-0.00001684	-0.00000546	-0.00000121	-0.00000191	-0.00001515	-0.00000054	-0.00000041	-0.00000146
Risk:	-2.6E-09	-3.2E-09	-7.1E-10	-1.9E-10	-2.3E-09	-5.4E-11	-4.1E-11	-7.7E-10
Freshwater - Brookvale								
Total Population in study area:	8047	8047	8047	8047	8047	8047	8047	8047
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-93.4	-93.4	-93.4	-93.4	-93.4	-93.4	-93.4	-93.4
Population weighted Δx (µg/m³):	-0.01160681	-0.01160681	-0.01160681	-0.01160681	-0.01160681	-0.01160681	-0.01160681	-0.01160681
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999933	0.999991	0.999995	0.999989	0.999849	0.999989	0.999978	0.999983
Attributable fraction (AF):	-6.7E-05	-9.3E-06	-4.8E-06	-1.1E-05	-1.5E-04	-1.1E-05	-2.2E-05	-1.7E-05
Increased number of cases in population:	-0.0036	-0.0012	-0.00026	-0.00041	-0.0032	-0.00012	-0.00009	-0.00031
Risk:	-6.9E-07	-8.6E-07	-1.9E-07	-5.0E-08	-6.2E-07	-1.4E-08	-1.1E-08	-2.1E-07
Manly - Fairlight								
Total Population in study area:	5576	5576	5576	5576	5576	5576	5576	5576
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8
Population weighted Δx (µg/m³):	-0.00319225	-0.00319225	-0.00319225	-0.00319225	-0.00319225	-0.00319225	-0.00319225	-0.00319225
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999981	0.999997	0.999999	0.999997	0.999959	0.999997	0.999994	0.999995
Attributable fraction (AF):	-1.9E-05	-2.6E-06	-1.3E-06	-3.0E-06	-4.2E-05	-3.1E-06	-6.1E-06	-4.7E-06
Increased number of cases in population:	-0.000681	-0.000221	-0.000049	-0.000077	-0.000613	-0.000022	-0.000017	-0.000059
Risk:	-1.9E-07	-2.4E-07	-5.2E-08	-1.4E-08	-1.7E-07	-3.9E-09	-3.0E-09	-5.7E-08
Manly Vale - Allambie Heights								
Total Population in study area:	16900	16900	16900	16900	16900	16900	16900	16900
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8
Population weighted Δx (µg/m³):	-0.00809467	-0.00809467	-0.00809467	-0.00809467	-0.00809467	-0.00809467	-0.00809467	-0.00809467
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999953	0.999994	0.999997	0.999992	0.999895	0.999992	0.999985	0.999988
Attributable fraction (AF):	-4.7E-05	-6.5E-06	-3.3E-06	-7.6E-06	-1.1E-04	-7.9E-06	-1.5E-05	-1.2E-05
Increased number of cases in population:	-0.0052	-0.0017	-0.00037	-0.00059	-0.0047	-0.00017	-0.00013	-0.00046
Risk:	-4.8E-07	-6.0E-07	-1.3E-07	-3.5E-08	-4.3E-07	-1.0E-08	-7.6E-09	-1.4E-07
Ku-ring-gai LGA								
Total Population in study area:	32193	32193	32193	32193	32193	32193	32193	32193
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-116.7	-116.7	-116.7	-116.7	-116.7	-116.7	-116.7	-116.7
Population weighted Δx (µg/m³):	-0.00362501	-0.00362501	-0.00362501	-0.00362501	-0.00362501	-0.00362501	-0.00362501	-0.00362501
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Relative Risk:	0.999979	0.999997	0.999999	0.999997	0.999953	0.999996	0.999993	0.999995
Attributable fraction (AF):	-2.1E-05	-2.9E-06	-1.5E-06	-3.4E-06	-4.7E-05	-3.5E-06	-6.9E-06	-5.4E-06
Increased number of cases in population:	-0.0043	-0.0016	-0.00035	-0.00040	-0.0039	-0.00012	-0.00011	-0.00041
Risk:	-2.2E-07	-2.7E-07	-5.9E-08	-1.2E-08	-1.9E-07	-3.8E-09	-3.4E-09	-6.5E-08
Individual subrubs within LGA								
Gordon-Killara								
Total Population in study area:	9811	9811	9811	9811	9811	9811	9811	9811
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-42.1	-42.1	-42.1	-42.1	-42.1	-42.1	-42.1	-42.1
Population weighted Δx (µg/m³):	-0.00429110	-0.00429110	-0.00429110	-0.00429110	-0.00429110	-0.00429110	-0.00429110	-0.00429110
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999975	0.999997	0.999998	0.999996	0.999944	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.5E-05	-3.4E-06	-1.8E-06	-4.0E-06	-5.6E-05	-4.2E-06	-8.2E-06	-6.4E-06
Increased number of cases in population:	-0.0016	-0.0006	-0.00012	-0.00014	-0.0014	-0.00004	-0.00004	-0.00015
Risk:	-2.6E-07	-3.2E-07	-7.0E-08	-1.5E-08	-2.3E-07	-4.5E-09	-4.0E-09	-7.7E-08
Lindfield - Roseville								
Total Population in study area:	21343	21343	21343	21343	21343	21343	21343	21343
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-71.9	-71.9	-71.9	-71.9	-71.9	-71.9	-71.9	-71.9
Population weighted Δx (µg/m³):	-0.00336879	-0.00336879	-0.00336879	-0.00336879	-0.00336879	-0.00336879	-0.00336879	-0.00336879
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999980	0.999997	0.999999	0.999997	0.999956	0.999997	0.999994	0.999995
Attributable fraction (AF):	-2.0E-05	-2.7E-06	-1.4E-06	-3.2E-06	-4.4E-05	-3.3E-06	-6.4E-06	-5.0E-06
Increased number of cases in population:	-0.0027	-0.0010	-0.00021	-0.00025	-0.0024	-0.00008	-0.00007	-0.00025
Risk:	-2.0E-07	-2.5E-07	-5.5E-08	-1.2E-08	-1.8E-07	-3.5E-09	-3.2E-09	-6.0E-08
St Ives								
Total Population in study area:	1039	1039	1039	1039	1039	1039	1039	1039
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
Population weighted Δx (µg/m³):	-0.00259865	-0.00259865	-0.00259865	-0.00259865	-0.00259865	-0.00259865	-0.00259865	-0.00259865
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999985	0.999998	0.999999	0.999998	0.999966	0.999997	0.999995	0.999996
Attributable fraction (AF):	-1.5E-05	-2.1E-06	-1.1E-06	-2.4E-06	-3.4E-05	-2.5E-06	-4.9E-06	-3.8E-06
Increased number of cases in population:	-0.000100	-0.000036	-0.000008	-0.000009	-0.000090	-0.000003	-0.000003	-0.000009
Risk:	-1.5E-07	-1.9E-07	-4.2E-08	-8.9E-09	-1.4E-07	-2.7E-09	-2.4E-09	-4.6E-08
Total population incidence - All Suburbs	-0.30	-0.072	-0.016	-0.036	-0.27	-0.010	-0.0079	-0.013

Assessment of Increased Incidence - PM_{2.5}
Western Harbour Tunnel: 2027 Cumulative

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Canada Bay LGA								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	149.36	149.36	149.36	149.36	149.36	149.36	149.36	149.36
Population weighted Δx (µg/m ³):	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000371	1.000051	1.000026	1.000060	1.000832	1.000062	1.000122	1.000095
Attributable fraction (AF):	3.7E-04	5.1E-05	2.6E-05	6.0E-05	8.3E-04	6.2E-05	1.2E-04	9.5E-05
Increased number of cases in population:	0.0056	0.0016	0.00036	0.00057	0.0050	0.00016	0.00014	0.00040
Risk:	3.8E-06	4.7E-06	1.0E-06	2.4E-07	3.4E-06	7.0E-08	6.0E-08	1.1E-06
Individual subrubs within LGA								
Drummoyne - Rodd Pt								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	149.36	149.36	149.36	149.36	149.36	149.36	149.36	149.36
Population weighted Δx (µg/m ³):	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314	0.06399314
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000371	1.000051	1.000026	1.000060	1.000832	1.000062	1.000122	1.000095
Attributable fraction (AF):	3.7E-04	5.1E-05	2.6E-05	6.0E-05	8.3E-04	6.2E-05	1.2E-04	9.5E-05
Increased number of cases in population:	0.0056	0.0016	0.00036	0.00057	0.0050	0.00016	0.00014	0.00040
Risk:	3.8E-06	4.7E-06	1.0E-06	2.4E-07	3.4E-06	7.0E-08	6.0E-08	1.1E-06
North Sydney - Mosman								
Total Population in study area:	94149	94149	94149	94149	94149	94149	94149	94149
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-400.8	-400.8	-400.8	-400.8	-400.8	-400.8	-400.8	-400.8
Population weighted Δx (µg/m ³):	-0.00425708	-0.00425708	-0.00425708	-0.00425708	-0.00425708	-0.00425708	-0.00425708	-0.00425708
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999975	0.999997	0.999998	0.999996	0.999945	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.5E-05	-3.4E-06	-1.7E-06	-4.0E-06	-5.5E-05	-4.1E-06	-8.1E-06	-6.3E-06
Increased number of cases in population:	-0.016	-0.0057	-0.0012	-0.0013	-0.014	-0.00038	-0.00038	-0.0012
Risk:	-2.5E-07	-3.1E-07	-6.9E-08	-1.3E-08	-2.3E-07	-4.1E-09	-4.0E-09	-7.6E-08
Individual subrubs within LGA								
Cremorne - Cammeray								
Total Population in study area:	19045	19045	19045	19045	19045	19045	19045	19045
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	688	688	688	688	688	688	688	688
Population weighted Δx (µg/m ³):	0.03612497	0.03612497	0.03612497	0.03612497	0.03612497	0.03612497	0.03612497	0.03612497
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000210	1.000029	1.000015	1.000034	1.000470	1.000035	1.000069	1.000053
Attributable fraction (AF):	2.1E-04	2.9E-05	1.5E-05	3.4E-05	4.7E-04	3.5E-05	6.9E-05	5.3E-05
Increased number of cases in population:	0.0275	0.0097	0.0021	0.0022	0.0247	0.0007	0.0006	0.0020
Risk:	2.1E-06	2.7E-06	5.9E-07	1.1E-07	1.9E-06	3.5E-08	3.4E-08	6.5E-07
Crows Nest - Waverton								
Total Population in study area:	18063	18063	18063	18063	18063	18063	18063	18063
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	1289.4	1289.4	1289.4	1289.4	1289.4	1289.4	1289.4	1289.4
Population weighted Δx (µg/m ³):	0.07138349	0.07138349	0.07138349	0.07138349	0.07138349	0.07138349	0.07138349	0.07138349
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000414	1.000057	1.000029	1.000067	1.000928	1.000069	1.000136	1.000106
Attributable fraction (AF):	4.1E-04	5.7E-05	2.9E-05	6.7E-05	9.3E-04	6.9E-05	1.4E-04	1.1E-04
Increased number of cases in population:	0.0525	0.0137	0.0030	0.0041	0.0472	0.0012	0.0012	0.0026
Risk:	4.2E-06	5.3E-06	1.2E-06	2.2E-07	3.8E-06	6.8E-08	6.7E-08	1.3E-06
Mosman								
Total Population in study area:	28462	28462	28462	28462	28462	28462	28462	28462
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-76.1	-76.1	-76.1	-76.1	-76.1	-76.1	-76.1	-76.1
Population weighted Δx (µg/m ³):	-0.00267374	-0.00267374	-0.00267374	-0.00267374	-0.00267374	-0.00267374	-0.00267374	-0.00267374
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999984	0.999998	0.999999	0.999997	0.999965	0.999997	0.999995	0.999996
Attributable fraction (AF):	-1.6E-05	-2.1E-06	-1.1E-06	-2.5E-06	-3.5E-05	-2.6E-06	-5.1E-06	-4.0E-06
Increased number of cases in population:	-0.0030	-0.0011	-0.0002	-0.0002	-0.0027	-0.0001	-0.0001	-0.0002
Risk:	-1.6E-07	-2.0E-07	-4.4E-08	-8.4E-09	-1.4E-07	-2.6E-09	-2.5E-09	-4.8E-08
Neutral Bay - Kirribilli								
Total Population in study area:	17899	17899	17899	17899	17899	17899	17899	17899
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-2113.9	-2113.9	-2113.9	-2113.9	-2113.9	-2113.9	-2113.9	-2113.9
Population weighted Δx (µg/m ³):	-0.11810157	-0.11810157	-0.11810157	-0.11810157	-0.11810157	-0.11810157	-0.11810157	-0.11810157
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999315	0.999906	0.999952	0.999889	0.998466	0.999885	0.999776	0.999825
Attributable fraction (AF):	-6.9E-04	-9.4E-05	-4.8E-05	-1.1E-04	-1.5E-03	-1.1E-04	-2.2E-04	-1.7E-04
Increased number of cases in population:	-0.0861	-0.0225	-0.0050	-0.0067	-0.0775	-0.0020	-0.0020	-0.0042
Risk:	-7.0E-06	-8.7E-06	-1.9E-06	-3.7E-07	-6.3E-06	-1.1E-07	-1.1E-07	-2.1E-06
North Sydney - Lavender Bay								
Total Population in study area:	10680	10680	10680	10680	10680	10680	10680	10680
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-228.2	-228.2	-228.2	-228.2	-228.2	-228.2	-228.2	-228.2
Population weighted Δx (µg/m ³):	-0.02136704	-0.02136704	-0.02136704	-0.02136704	-0.02136704	-0.02136704	-0.02136704	-0.02136704
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999876	0.999983	0.999991	0.999980	0.999722	0.999979	0.999959	0.999968

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Attributable fraction (AF):	-1.2E-04	-1.7E-05	-8.8E-06	-2.0E-05	-2.8E-04	-2.1E-05	-4.1E-05	-3.2E-05
Increased number of cases in population:	-0.0093	-0.0024	-0.0005	-0.0007	-0.0084	-0.0002	-0.0002	-0.0005
Risk:	-1.3E-06	-1.6E-06	-3.5E-07	-6.7E-08	-1.1E-06	-2.0E-08	-2.0E-08	-3.8E-07
Sydney Inner West LGA								
Total Population in study area:	48303	48303	48303	48303	48303	48303	48303	48303
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	3663.8	3663.8	3663.8	3663.8	3663.8	3663.8	3663.8	3663.8
Population weighted Δx (µg/m³):	0.07585036	0.07585036	0.07585036	0.07585036	0.07585036	0.07585036	0.07585036	0.07585036
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000440	1.000061	1.000031	1.000071	1.000987	1.000074	1.000144	1.000112
Attributable fraction (AF):	4.4E-04	6.1E-05	3.1E-05	7.1E-05	9.9E-04	7.4E-05	1.4E-04	1.1E-04
Increased number of cases in population:	0.14	0.033	0.0073	0.018	0.13	0.0052	0.0034	0.0092
Risk:	4.5E-06	5.6E-06	1.2E-06	3.8E-07	4.1E-06	1.1E-07	7.1E-08	1.4E-06
Individual subrubs within LGA								
Balmain								
Total Population in study area:	15693	15693	15693	15693	15693	15693	15693	15693
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	821.8	821.8	821.8	821.8	821.8	821.8	821.8	821.8
Population weighted Δx (µg/m³):	0.05236730	0.05236730	0.05236730	0.05236730	0.05236730	0.05236730	0.05236730	0.05236730
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000304	1.000042	1.000021	1.000049	1.000681	1.000051	1.000100	1.000078
Attributable fraction (AF):	3.0E-04	4.2E-05	2.1E-05	4.9E-05	6.8E-04	5.1E-05	9.9E-05	7.8E-05
Increased number of cases in population:	0.0312	0.00741	0.001635	0.00413	0.0281	0.001167	0.000771	0.002073
Risk:	3.1E-06	3.9E-06	8.5E-07	2.6E-07	2.8E-06	7.4E-08	4.9E-08	9.4E-07
Leichhardt - Annandale								
Total Population in study area:	17541	17541	17541	17541	17541	17541	17541	17541
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	1475.7	1475.7	1475.7	1475.7	1475.7	1475.7	1475.7	1475.7
Population weighted Δx (µg/m³):	0.08412861	0.08412861	0.08412861	0.08412861	0.08412861	0.08412861	0.08412861	0.08412861
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000488	1.000067	1.000034	1.000079	1.001094	1.000082	1.000160	1.000125
Attributable fraction (AF):	4.9E-04	6.7E-05	3.4E-05	7.9E-05	1.1E-03	8.2E-05	1.6E-04	1.2E-04
Increased number of cases in population:	0.056	0.013	0.0029	0.007	0.050	0.0021	0.0014	0.0037
Risk:	5.0E-06	6.2E-06	1.4E-06	4.2E-07	4.5E-06	1.2E-07	7.9E-08	1.5E-06
Lilyfield - Rozelle								
Total Population in study area:	12549	12549	12549	12549	12549	12549	12549	12549
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	1366.2	1366.2	1366.2	1366.2	1366.2	1366.2	1366.2	1366.2
Population weighted Δx (µg/m³):	0.10886923	0.10886923	0.10886923	0.10886923	0.10886923	0.10886923	0.10886923	0.10886923
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000632	1.000087	1.000045	1.000102	1.001416	1.000106	1.000207	1.000161
Attributable fraction (AF):	6.3E-04	8.7E-05	4.5E-05	1.0E-04	1.4E-03	1.1E-04	2.1E-04	1.6E-04
Increased number of cases in population:	0.052	0.012	0.0027	0.0069	0.047	0.0019	0.0013	0.0034
Risk:	6.5E-06	8.0E-06	1.8E-06	5.5E-07	5.8E-06	1.5E-07	1.0E-07	1.9E-06
Petersham - Stanmore								
Total Population in study area:	2520	2520	2520	2520	2520	2520	2520	2520
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	67.9	67.9	67.9	67.9	67.9	67.9	67.9	67.9
Population weighted Δx (µg/m³):	0.02694444	0.02694444	0.02694444	0.02694444	0.02694444	0.02694444	0.02694444	0.02694444
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000156	1.000022	1.000011	1.000025	1.000350	1.000026	1.000051	1.000040
Attributable fraction (AF):	1.6E-04	2.2E-05	1.1E-05	2.5E-05	3.5E-04	2.6E-05	5.1E-05	4.0E-05
Increased number of cases in population:	0.002578	0.000612	0.000135	0.000341	0.002320	0.000096	0.000064	0.000171
Risk:	1.6E-06	2.0E-06	4.4E-07	1.4E-07	1.4E-06	3.8E-08	2.5E-08	4.8E-07
Sydney LGA								
Total Population in study area:	131933	131933	131933	131933	131933	131933	131933	131933
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-9643.8	-9643.8	-9643.8	-9643.8	-9643.8	-9643.8	-9643.8	-9643.8
Population weighted Δx (µg/m³):	-0.07309619	-0.07309619	-0.07309619	-0.07309619	-0.07309619	-0.07309619	-0.07309619	-0.07309619
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999576	0.999942	0.999970	0.999931	0.999050	0.999929	0.999861	0.999892
Attributable fraction (AF):	-4.2E-04	-5.8E-05	-3.0E-05	-6.9E-05	-9.5E-04	-7.1E-05	-1.4E-04	-1.1E-04
Increased number of cases in population:	-0.33	-0.058	-0.013	-0.046	-0.30	-0.013	-0.0091	-0.010
Risk:	-4.3E-06	-5.4E-06	-1.2E-06	-3.5E-07	-3.9E-06	-9.8E-08	-6.9E-08	-1.3E-06
Individual subrubs within LGA								
Darlinghurst								
Total Population in study area:	11354	11354	11354	11354	11354	11354	11354	11354
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-549.3	-549.3	-549.3	-549.3	-549.3	-549.3	-549.3	-549.3
Population weighted Δx (µg/m³):	-0.04837943	-0.04837943	-0.04837943	-0.04837943	-0.04837943	-0.04837943	-0.04837943	-0.04837943
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999719	0.999961	0.999980	0.999955	0.999371	0.999953	0.999908	0.999928
Attributable fraction (AF):	-2.8E-04	-3.9E-05	-2.0E-05	-4.5E-05	-6.3E-04	-4.7E-05	-9.2E-05	-7.2E-05
Increased number of cases in population:	-0.019	-0.0033	-0.00073	-0.0026	-0.017	-0.00074	-0.00052	-0.00058
Risk:	-2.9E-06	-3.6E-06	-7.9E-07	-2.3E-07	-2.6E-06	-6.5E-08	-4.5E-08	-8.7E-07
Glebe - Forest Lodge								
Total Population in study area:	19593	19593	19593	19593	19593	19593	19593	19593
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
Population weighted Δx (µg/m³):	0.00139335	0.00139335	0.00139335	0.00139335	0.00139335	0.00139335	0.00139335	0.00139335
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	1.000008	1.000001	1.000001	1.000001	1.000018	1.000001	1.000003	1.000002
Attributable fraction (AF):	8.1E-06	1.1E-06	5.7E-07	1.3E-06	1.8E-05	1.4E-06	2.6E-06	2.1E-06

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Increased number of cases in population:	0.0009	0.0002	0.00004	0.00013	0.0008	0.00004	0.00003	0.00003
Risk:	8.3E-08	1.0E-07	2.3E-08	6.7E-09	7.5E-08	1.9E-09	1.3E-09	2.5E-08
Newtown - Camperdown - Darlington								
Total Population in study area:	5154	5154	5154	5154	5154	5154	5154	5154
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	42	42	42	42	42	42	42	42
Population weighted Δx (µg/m³):	0.00814901	0.00814901	0.00814901	0.00814901	0.00814901	0.00814901	0.00814901	0.00814901
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	1.000047	1.000007	1.000003	1.000008	1.000106	1.000008	1.000015	1.000012
Attributable fraction (AF):	4.7E-05	6.5E-06	3.3E-06	7.7E-06	1.1E-04	7.9E-06	1.5E-05	1.2E-05
Increased number of cases in population:	0.0014	0.0003	0.00006	0.0002	0.0013	0.00006	0.00004	0.00004
Risk:	4.8E-07	6.0E-07	1.3E-07	3.9E-08	4.4E-07	1.1E-08	7.6E-09	1.5E-07
Potts Point - Woolloomooloo								
Total Population in study area:	21200	21200	21200	21200	21200	21200	21200	21200
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-5522.5	-5522.5	-5522.5	-5522.5	-5522.5	-5522.5	-5522.5	-5522.5
Population weighted Δx (µg/m³):	-0.26049528	-0.26049528	-0.26049528	-0.26049528	-0.26049528	-0.26049528	-0.26049528	-0.26049528
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.998490	0.999792	0.999893	0.999755	0.996619	0.999747	0.999505	0.999615
Attributable fraction (AF):	-1.5E-03	-2.1E-04	-1.1E-04	-2.4E-04	-3.4E-03	-2.5E-04	-5.0E-04	-3.9E-04
Increased number of cases in population:	-0.189	-0.033	-0.0074	-0.026	-0.171	-0.0074	-0.0052	-0.0058
Risk:	-1.6E-05	-1.9E-05	-4.2E-06	-1.2E-06	-1.4E-05	-3.5E-07	-2.4E-07	-4.7E-06
Pyrmont - Ultimo								
Total Population in study area:	21665	21665	21665	21665	21665	21665	21665	21665
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-838.2	-838.2	-838.2	-838.2	-838.2	-838.2	-838.2	-838.2
Population weighted Δx (µg/m³):	-0.03868913	-0.03868913	-0.03868913	-0.03868913	-0.03868913	-0.03868913	-0.03868913	-0.03868913
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999776	0.999969	0.999984	0.999962	0.999497	0.999962	0.999926	0.999943
Attributable fraction (AF):	-2.2E-04	-3.1E-05	-1.6E-05	-3.6E-05	-5.0E-04	-3.8E-05	-7.4E-05	-5.7E-05
Increased number of cases in population:	-0.029	-0.0051	-0.0011	-0.0040	-0.026	-0.0011	-0.00079	-0.00088
Risk:	-2.3E-06	-2.9E-06	-6.3E-07	-1.8E-07	-2.1E-06	-5.2E-08	-3.6E-08	-6.9E-07
Redfern - Chippendale								
Total Population in study area:	9861	9861	9861	9861	9861	9861	9861	9861
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-171.7	-171.7	-171.7	-171.7	-171.7	-171.7	-171.7	-171.7
Population weighted Δx (µg/m³):	-0.01741203	-0.01741203	-0.01741203	-0.01741203	-0.01741203	-0.01741203	-0.01741203	-0.01741203
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999899	0.999986	0.999993	0.999984	0.999774	0.999983	0.999967	0.999974
Attributable fraction (AF):	-1.0E-04	-1.4E-05	-7.1E-06	-1.6E-05	-2.3E-04	-1.7E-05	-3.3E-05	-2.6E-05
Increased number of cases in population:	-0.00589	-0.001040	-0.000230	-0.000820	-0.00530	-0.000231	-0.000161	-0.000181
Risk:	-1.0E-06	-1.3E-06	-2.8E-07	-8.3E-08	-9.3E-07	-2.3E-08	-1.6E-08	-3.1E-07
Surry Hills								
Total Population in study area:	15699	15699	15699	15699	15699	15699	15699	15699
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-854.3	-854.3	-854.3	-854.3	-854.3	-854.3	-854.3	-854.3
Population weighted Δx (µg/m³):	-0.05441748	-0.05441748	-0.05441748	-0.05441748	-0.05441748	-0.05441748	-0.05441748	-0.05441748
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999684	0.999956	0.999978	0.999949	0.999293	0.999947	0.999897	0.999919
Attributable fraction (AF):	-3.2E-04	-4.4E-05	-2.2E-05	-5.1E-05	-7.1E-04	-5.3E-05	-1.0E-04	-8.1E-05
Increased number of cases in population:	-0.029	-0.0052	-0.00114	-0.0041	-0.026	-0.00115	-0.00080	-0.00090
Risk:	-3.2E-06	-4.0E-06	-8.9E-07	-2.6E-07	-2.9E-06	-7.3E-08	-5.1E-08	-9.7E-07
Sydney - Haymarket - The Rocks								
Total Population in study area:	27407	27407	27407	27407	27407	27407	27407	27407
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1776.9	-1776.9	-1776.9	-1776.9	-1776.9	-1776.9	-1776.9	-1776.9
Population weighted Δx (µg/m³):	-0.06483380	-0.06483380	-0.06483380	-0.06483380	-0.06483380	-0.06483380	-0.06483380	-0.06483380
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999624	0.999948	0.999973	0.999939	0.999158	0.999937	0.999877	0.999904
Attributable fraction (AF):	-3.8E-04	-5.2E-05	-2.7E-05	-6.1E-05	-8.4E-04	-6.3E-05	-1.2E-04	-9.6E-05
Increased number of cases in population:	-0.0609	-0.0108	-0.00238	-0.0085	-0.0548	-0.00239	-0.00167	-0.00188
Risk:	-3.9E-06	-4.8E-06	-1.1E-06	-3.1E-07	-3.5E-06	-8.7E-08	-6.1E-08	-1.2E-06
Lane Cove - Chatswood LGA								
Total Population in study area:	103355	103355	103355	103355	103355	103355	103355	103355
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	1455.00	1455	1455	1455	1455	1455	1455	1455
Population weighted Δx (µg/m³):	0.01407769	0.01407769	0.01407769	0.01407769	0.01407769	0.01407769	0.01407769	0.01407769
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000082	1.000011	1.000006	1.000013	1.000183	1.000014	1.000027	1.000021
Attributable fraction (AF):	8.2E-05	1.1E-05	5.8E-06	1.3E-05	1.8E-04	1.4E-05	2.7E-05	2.1E-05
Increased number of cases in population:	0.054	0.015	0.0033	0.0055	0.049	0.0016	0.0014	0.0045
Risk:	8.4E-07	1.0E-06	2.3E-07	5.3E-08	7.5E-07	1.5E-08	1.3E-08	2.5E-07
Individual subrubs within LGA								
Chatswood East - Artarmon								
Total Population in study area:	28631	28631	28631	28631	28631	28631	28631	28631
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-96.2	-96.2	-96.2	-96.2	-96.2	-96.2	-96.2	-96.2
Population weighted Δx (µg/m³):	-0.00335999	-0.00335999	-0.00335999	-0.00335999	-0.00335999	-0.00335999	-0.00335999	-0.00335999
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999981	0.999997	0.999999	0.999997	0.999956	0.999997	0.999994	0.999995
Attributable fraction (AF):	-1.9E-05	-2.7E-06	-1.4E-06	-3.2E-06	-4.4E-05	-3.3E-06	-6.4E-06	-5.0E-06
Increased number of cases in population:	-0.0036	-0.0010	-0.0002	-0.0002	-0.0032	-0.0001	-0.0001	-0.0003
Risk:	-2.0E-07	-2.5E-07	-5.5E-08	-1.3E-08	-1.8E-07	-3.7E-09	-3.2E-09	-6.0E-08
Chatswood West - Lane Cove North								

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Total Population in study area:	18393	18393	18393	18393	18393	18393	18393	18393
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Population weighted Δx (µg/m³):	0.00370250	0.00370250	0.00370250	0.00370250	0.00370250	0.00370250	0.00370250	0.00370250
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000021	1.000003	1.000002	1.000003	1.000048	1.000004	1.000007	1.000005
Attributable fraction (AF):	2.1E-05	3.0E-06	1.2E-06	3.5E-06	4.8E-05	3.6E-06	7.0E-06	5.5E-06
Increased number of cases in population:	0.0025	0.0007	0.0002	0.0003	0.0023	0.0001	0.0001	0.0002
Risk:	2.2E-07	2.7E-07	6.0E-08	1.4E-08	2.0E-07	4.1E-09	3.5E-09	6.6E-08
Lane Cove - Greenwich								
Total Population in study area:	20401	20401	20401	20401	20401	20401	20401	20401
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	587.7	587.7	587.7	587.7	587.7	587.7	587.7	587.7
Population weighted Δx (µg/m³):	0.02880741	0.02880741	0.02880741	0.02880741	0.02880741	0.02880741	0.02880741	0.02880741
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000167	1.000023	1.000012	1.000027	1.000375	1.000028	1.000055	1.000043
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.7E-04	2.8E-05	5.5E-05	4.3E-05
Increased number of cases in population:	0.0219	0.0059	0.0013	0.0022	0.0197	0.00065	0.00055	0.0018
Risk:	1.7E-06	2.1E-06	4.7E-07	1.1E-07	1.5E-06	3.2E-08	2.7E-08	5.2E-07
St Leonards - Naremburn								
Total Population in study area:	10478	10478	10478	10478	10478	10478	10478	10478
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	344.1	344.1	344.1	344.1	344.1	344.1	344.1	344.1
Population weighted Δx (µg/m³):	0.03284024	0.03284024	0.03284024	0.03284024	0.03284024	0.03284024	0.03284024	0.03284024
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000190	1.000026	1.000013	1.000031	1.000427	1.000032	1.000062	1.000049
Attributable fraction (AF):	1.9E-04	2.6E-05	1.3E-05	3.1E-05	4.3E-04	3.2E-05	6.2E-05	4.9E-05
Increased number of cases in population:	0.0128	0.0035	0.00077	0.00130	0.0115	0.00038	0.00032	0.00105
Risk:	2.0E-06	2.4E-06	5.4E-07	1.2E-07	1.8E-06	3.6E-08	3.1E-08	5.9E-07
Willoughby - Castle Cove - Northbridge								
Total Population in study area:	25452	25452	25452	25452	25452	25452	25452	25452
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	551.4	551.4	551.4	551.4	551.4	551.4	551.4	551.4
Population weighted Δx (µg/m³):	0.02166431	0.02166431	0.02166431	0.02166431	0.02166431	0.02166431	0.02166431	0.02166431
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	1.000126	1.000017	1.000009	1.000020	1.000282	1.000021	1.000041	1.000032
Attributable fraction (AF):	1.3E-04	1.7E-05	8.9E-06	2.0E-05	2.8E-04	2.1E-05	4.1E-05	3.2E-05
Increased number of cases in population:	0.0205	0.0056	0.0012	0.0021	0.0185	0.0006	0.0005	0.0017
Risk:	1.3E-06	1.6E-06	3.5E-07	8.2E-08	1.2E-06	2.4E-08	2.0E-08	3.9E-07
Hunters Hill LGA								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	113.9	113.9	113.9	113.9	113.9	113.9	113.9	113.9
Population weighted Δx (µg/m³):	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	1.000293	1.000040	1.000021	1.000047	1.000656	1.000049	1.000096	1.000075
Attributable fraction (AF):	2.9E-04	4.0E-05	2.1E-05	4.7E-05	6.6E-04	4.9E-05	9.6E-05	7.5E-05
Increased number of cases in population:	0.0044	0.0018	0.00040	0.00054	0.0039	0.00015	0.00011	0.00037
Risk:	3.0E-06	3.7E-06	8.2E-07	2.4E-07	2.7E-06	6.5E-08	4.7E-08	9.0E-07
Individual subrubs within LGA								
Hunters Hill - Woolwich								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	113.9	113.9	113.9	113.9	113.9	113.9	113.9	113.9
Population weighted Δx (µg/m³):	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287	0.05044287
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	1.000293	1.000040	1.000021	1.000047	1.000656	1.000049	1.000096	1.000075
Attributable fraction (AF):	2.9E-04	4.0E-05	2.1E-05	4.7E-05	6.6E-04	4.9E-05	9.6E-05	7.5E-05
Increased number of cases in population:	0.00436	0.00182	0.00040	0.00054	0.00392	0.00015	0.00011	0.00037
Risk:	3.0E-06	3.7E-06	8.2E-07	2.4E-07	2.7E-06	6.5E-08	4.7E-08	9.0E-07
Woollara LGA (Easterns Suburbs - North)								
Total Population in study area:	71841	71841	71841	71841	71841	71841	71841	71841
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	1015.1	1015.1	1015.1	1015.1	1015.1	1015.1	1015.1	1015.1
Population weighted Δx (µg/m³):	0.01412981	0.01412981	0.01412981	0.01412981	0.01412981	0.01412981	0.01412981	0.01412981
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000082	1.000011	1.000006	1.000031	1.000184	1.000014	1.000027	1.000021
Attributable fraction (AF):	8.2E-05	1.1E-05	5.8E-06	1.3E-05	1.8E-04	1.4E-05	2.7E-05	2.1E-05
Increased number of cases in population:	0.040	0.014	0.0031	0.0038	0.036	0.0011	0.00095	0.0026
Risk:	8.4E-07	1.0E-06	2.3E-07	5.3E-08	7.6E-07	1.5E-08	1.3E-08	2.5E-07
Individual subrubs within LGA								
Bondi - Tamarama - Bronte								
Total Population in study area:	2184	2184	2184	2184	2184	2184	2184	2184
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2
Population weighted Δx (µg/m³):	0.01474359	0.01474359	0.01474359	0.01474359	0.01474359	0.01474359	0.01474359	0.01474359
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000086	1.000012	1.000006	1.000014	1.000192	1.000014	1.000028	1.000022
Attributable fraction (AF):	8.6E-05	1.2E-05	6.0E-06	1.4E-05	1.9E-04	1.4E-05	2.8E-05	2.2E-05
Increased number of cases in population:	0.0013	0.00044	0.00010	0.00012	0.0011	0.000035	0.000030	0.00008
Risk:	8.8E-07	1.1E-06	2.4E-07	5.5E-08	7.9E-07	1.6E-08	1.4E-08	2.6E-07
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	241.5	241.5	241.5	241.5	241.5	241.5	241.5	241.5
Population weighted Δx (µg/m³):	0.02043320	0.02043320	0.02043320	0.02043320	0.02043320	0.02043320	0.02043320	0.02043320
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000119	1.000016	1.000008	1.000019	1.000266	1.000020	1.000039	1.000030
Attributable fraction (AF):	1.2E-04	1.6E-05	8.4E-06	1.9E-05	2.7E-04	2.0E-05	3.9E-05	3.0E-05
Increased number of cases in population:	0.0094	0.0033	0.00073	0.00090	0.0085	0.000259	0.000227	0.00063
Risk:	1.2E-06	1.5E-06	3.3E-07	7.6E-08	1.1E-06	2.2E-08	1.9E-08	3.7E-07
Bondi Junction - Waverly								
Total Population in study area:	1903	1903	1903	1903	1903	1903	1903	1903
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	63.2	63.2	63.2	63.2	63.2	63.2	63.2	63.2
Population weighted Δx (µg/m³):	0.03321072	0.03321072	0.03321072	0.03321072	0.03321072	0.03321072	0.03321072	0.03321072
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000193	1.000027	1.000014	1.000031	1.000432	1.000032	1.000063	1.000049
Attributable fraction (AF):	1.9E-04	2.7E-05	1.4E-05	3.1E-05	4.3E-04	3.2E-05	6.3E-05	4.9E-05
Increased number of cases in population:	0.0025	0.00087	0.00019	0.00024	0.0022	0.000068	0.000059	0.00016
Risk:	2.0E-06	2.5E-06	5.4E-07	1.2E-07	1.8E-06	3.6E-08	3.1E-08	5.9E-07
Double Bay - Bellevue Hill								
Total Population in study area:	24798	24798	24798	24798	24798	24798	24798	24798
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	467.3	467.3	467.3	467.3	467.3	467.3	467.3	467.3
Population weighted Δx (µg/m³):	0.01884426	0.01884426	0.01884426	0.01884426	0.01884426	0.01884426	0.01884426	0.01884426
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000109	1.000015	1.000008	1.000018	1.000245	1.000018	1.000036	1.000028
Attributable fraction (AF):	1.1E-04	1.5E-05	7.7E-06	1.8E-05	2.4E-04	1.8E-05	3.6E-05	2.8E-05
Increased number of cases in population:	0.0182	0.00642	0.00142	0.00174	0.0164	0.000501	0.000439	0.001212
Risk:	1.1E-06	1.4E-06	3.1E-07	7.0E-08	1.0E-06	2.0E-08	1.8E-08	3.4E-07
Dover Heights								
Total Population in study area:	3179	3179	3179	3179	3179	3179	3179	3179
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Population weighted Δx (µg/m³):	0.00361749	0.00361749	0.00361749	0.00361749	0.00361749	0.00361749	0.00361749	0.00361749
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000021	1.000003	1.000001	1.000003	1.000047	1.000004	1.000007	1.000005
Attributable fraction (AF):	2.1E-05	2.9E-06	1.5E-06	3.4E-06	4.7E-05	3.5E-06	6.9E-06	5.4E-06
Increased number of cases in population:	0.0004	0.00016	0.00003	0.00004	0.00004	0.000012	0.000011	0.00003
Risk:	2.2E-07	2.7E-07	5.9E-08	1.3E-08	1.9E-07	3.9E-09	3.4E-09	6.5E-08
Paddington - Moore Park								
Total Population in study area:	13311	13311	13311	13311	13311	13311	13311	13311
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-52.2	-52.2	-52.2	-52.2	-52.2	-52.2	-52.2	-52.2
Population weighted Δx (µg/m³):	-0.00392157	-0.00392157	-0.00392157	-0.00392157	-0.00392157	-0.00392157	-0.00392157	-0.00392157
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999977	0.999997	0.999998	0.999996	0.999949	0.999996	0.999993	0.999994
Attributable fraction (AF):	-2.3E-05	-3.1E-06	-1.6E-06	-3.7E-06	-5.1E-05	-3.8E-06	-7.5E-06	-5.8E-06
Increased number of cases in population:	-0.00204	-0.00072	-0.000158	-0.000194	-0.00183	-0.000056	-0.000049	-0.000135
Risk:	-2.3E-07	-2.9E-07	-6.4E-08	-1.5E-08	-2.1E-07	-4.2E-09	-3.7E-09	-7.0E-08
Rose Bay - Vaucluse - Watsons Bay								
Total Population in study area:	6984	6984	6984	6984	6984	6984	6984	6984
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	127.9	127.9	127.9	127.9	127.9	127.9	127.9	127.9
Population weighted Δx (µg/m³):	0.01831329	0.01831329	0.01831329	0.01831329	0.01831329	0.01831329	0.01831329	0.01831329
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000106	1.000015	1.000008	1.000017	1.000238	1.000018	1.000035	1.000027
Attributable fraction (AF):	1.1E-04	1.5E-05	7.5E-06	1.7E-05	2.4E-04	1.8E-05	3.5E-05	2.7E-05
Increased number of cases in population:	0.00499	0.00176	0.000388	0.000478	0.00449	0.000137	0.000120	0.000332
Risk:	1.1E-06	1.4E-06	3.0E-07	6.8E-08	9.8E-07	2.0E-08	1.7E-08	3.3E-07
Woollahra								
Total Population in study area:	7663	7663	7663	7663	7663	7663	7663	7663
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	123.5	123.5	123.5	123.5	123.5	123.5	123.5	123.5
Population weighted Δx (µg/m³):	0.01611640	0.01611640	0.01611640	0.01611640	0.01611640	0.01611640	0.01611640	0.01611640
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000093	1.000013	1.000007	1.000015	1.000210	1.000016	1.000031	1.000024
Attributable fraction (AF):	9.3E-05	1.3E-05	6.6E-06	1.5E-05	2.1E-04	1.6E-05	3.1E-05	2.4E-05
Increased number of cases in population:	0.00482	0.00170	0.000375	0.000460	0.00434	0.000132	0.000116	0.000320
Risk:	9.6E-07	1.2E-06	2.6E-07	6.0E-08	8.6E-07	1.7E-08	1.5E-08	2.9E-07
Northern Beaches LGA								
Total Population in study area:	86694	86694	86694	86694	86694	86694	86694	86694
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	2784.1	2784.1	2784.1	2784.1	2784.1	2784.1	2784.1	2784.1
Population weighted Δx (µg/m³):	0.03211410	0.03211410	0.03211410	0.03211410	0.03211410	0.03211410	0.03211410	0.03211410
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000186	1.000026	1.000013	1.000030	1.000418	1.000031	1.000061	1.000048
Attributable fraction (AF):	1.9E-04	2.6E-05	1.3E-05	3.0E-05	4.2E-04	3.1E-05	6.1E-05	4.8E-05
Increased number of cases in population:	0.11	0.035	0.0076	0.012	0.096	0.0034	0.0026	0.0093
Risk:	1.9E-06	2.4E-06	5.2E-07	1.4E-07	1.7E-06	4.0E-08	3.0E-08	5.7E-07
Individual subrubs within LGA								
Balgowlah - Clontarf - Seaford								
Total Population in study area:	20214	20214	20214	20214	20214	20214	20214	20214
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	963.2	963.2	963.2	963.2	963.2	963.2	963.2	963.2

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Population weighted Δx (µg/m³):	0.04765014	0.04765014	0.04765014	0.04765014	0.04765014	0.04765014	0.04765014	0.04765014
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000276	1.000038	1.000020	1.000045	1.000620	1.000046	1.000091	1.000071
Attributable fraction (AF):	2.8E-04	3.8E-05	2.0E-05	4.5E-05	6.2E-04	4.6E-05	9.1E-05	7.1E-05
Increased number of cases in population:	0.0369	0.0120	0.00264	0.00419	0.0332	0.00119	0.00090	0.00321
Risk:	2.8E-06	3.5E-06	7.8E-07	2.1E-07	2.6E-06	5.9E-08	4.5E-08	8.5E-07
Beacon Hill - Narraweena								
Total Population in study area:	12757	12757	12757	12757	12757	12757	12757	12757
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	167.5	167.5	167.5	167.5	167.5	167.5	167.5	167.5
Population weighted Δx (µg/m³):	0.01313005	0.01313005	0.01313005	0.01313005	0.01313005	0.01313005	0.01313005	0.01313005
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000076	1.000011	1.000005	1.000012	1.000171	1.000013	1.000025	1.000019
Attributable fraction (AF):	7.6E-05	1.1E-05	5.4E-06	1.2E-05	1.7E-04	1.3E-05	2.5E-05	1.9E-05
Increased number of cases in population:	0.0064	0.0021	0.00046	0.00073	0.0058	0.00021	0.00016	0.00056
Risk:	7.8E-07	9.7E-07	2.1E-07	5.7E-08	7.0E-07	1.6E-08	1.2E-08	2.3E-07
Dee Why - North Curl Curl								
Total Population in study area:	228	228	228	228	228	228	228	228
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-2.63	-2.63	-2.63	-2.63	-2.63	-2.63	-2.63	-2.63
Population weighted Δx (µg/m³):	-0.01153509	-0.01153509	-0.01153509	-0.01153509	-0.01153509	-0.01153509	-0.01153509	-0.01153509
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999933	0.999991	0.999995	0.999989	0.999850	0.999989	0.999978	0.999983
Attributable fraction (AF):	-6.7E-05	-9.2E-06	-4.7E-06	-1.1E-05	-1.5E-04	-1.1E-05	-2.2E-05	-1.7E-05
Increased number of cases in population:	-0.000101	-0.000033	-0.000007	-0.000011	-0.000091	-0.000002	-0.000002	-0.000009
Risk:	-6.9E-07	-8.5E-07	-1.9E-07	-5.0E-08	-6.2E-07	-1.4E-08	-1.1E-08	-2.1E-07
Forrestville - Killarney Heights								
Total Population in study area:	12813	12813	12813	12813	12813	12813	12813	12813
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-196.7	-196.7	-196.7	-196.7	-196.7	-196.7	-196.7	-196.7
Population weighted Δx (µg/m³):	-0.01535160	-0.01535160	-0.01535160	-0.01535160	-0.01535160	-0.01535160	-0.01535160	-0.01535160
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999911	0.999988	0.999994	0.999986	0.999800	0.999985	0.999971	0.999977
Attributable fraction (AF):	-8.9E-05	-1.2E-05	-6.3E-06	-1.4E-05	-2.0E-04	-1.5E-05	-2.9E-05	-2.3E-05
Increased number of cases in population:	-0.0075	-0.0024	-0.00054	-0.00085	-0.0068	-0.00024	-0.00018	-0.00065
Risk:	-9.1E-07	-1.1E-06	-2.5E-07	-6.7E-08	-8.2E-07	-1.9E-08	-1.4E-08	-2.7E-07
Frenchs Forrest - Belrose								
Total Population in study area:	10159	10159	10159	10159	10159	10159	10159	10159
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	184.5	184.5	184.5	184.5	184.5	184.5	184.5	184.5
Population weighted Δx (µg/m³):	0.01816124	0.01816124	0.01816124	0.01816124	0.01816124	0.01816124	0.01816124	0.01816124
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000105	1.000015	1.000007	1.000017	1.000236	1.000018	1.000035	1.000027
Attributable fraction (AF):	1.1E-04	1.5E-05	7.4E-06	1.7E-05	2.4E-04	1.8E-05	3.5E-05	2.7E-05
Increased number of cases in population:	0.0071	0.0023	0.00051	0.00080	0.0064	0.00023	0.00017	0.00061
Risk:	1.1E-06	1.3E-06	3.0E-07	7.9E-08	9.7E-07	2.2E-08	1.7E-08	3.2E-07
Freshwater - Brookvale								
Total Population in study area:	8047	8047	8047	8047	8047	8047	8047	8047
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	200.5	200.5	200.5	200.5	200.5	200.5	200.5	200.5
Population weighted Δx (µg/m³):	0.02491612	0.02491612	0.02491612	0.02491612	0.02491612	0.02491612	0.02491612	0.02491612
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000145	1.000020	1.000010	1.000023	1.000324	1.000024	1.000047	1.000037
Attributable fraction (AF):	1.4E-04	2.0E-05	1.0E-05	2.3E-05	3.2E-04	2.4E-05	4.7E-05	3.7E-05
Increased number of cases in population:	0.0077	0.0025	0.00055	0.00087	0.0069	0.00025	0.00019	0.00067
Risk:	1.5E-06	1.8E-06	4.1E-07	1.1E-07	1.3E-06	3.1E-08	2.3E-08	4.5E-07
Manly - Fairlight								
Total Population in study area:	5576	5576	5576	5576	5576	5576	5576	5576
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	212.1	212.1	212.1	212.1	212.1	212.1	212.1	212.1
Population weighted Δx (µg/m³):	0.03803802	0.03803802	0.03803802	0.03803802	0.03803802	0.03803802	0.03803802	0.03803802
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000221	1.000030	1.000016	1.000036	1.000495	1.000037	1.000072	1.000056
Attributable fraction (AF):	2.2E-04	3.0E-05	1.6E-05	3.6E-05	4.9E-04	3.7E-05	7.2E-05	5.6E-05
Increased number of cases in population:	0.008115	0.002633	0.000581	0.000922	0.007303	0.000262	0.000199	0.000706
Risk:	2.3E-06	2.8E-06	6.2E-07	1.7E-07	2.0E-06	4.7E-08	3.6E-08	6.8E-07
Manly Vale - Allambie Heights								
Total Population in study area:	16900	16900	16900	16900	16900	16900	16900	16900
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	1255.5	1255.5	1255.5	1255.5	1255.5	1255.5	1255.5	1255.5
Population weighted Δx (µg/m³):	0.07428994	0.07428994	0.07428994	0.07428994	0.07428994	0.07428994	0.07428994	0.07428994
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000431	1.000059	1.000030	1.000070	1.000966	1.000072	1.000141	1.000110
Attributable fraction (AF):	4.3E-04	5.9E-05	3.0E-05	7.0E-05	9.7E-04	7.2E-05	1.4E-04	1.1E-04
Increased number of cases in population:	0.0480	0.0156	0.00344	0.00546	0.0432	0.00155	0.00118	0.00418
Risk:	4.4E-06	5.5E-06	1.2E-06	3.2E-07	4.0E-06	9.2E-08	7.0E-08	1.3E-06
Ku-ring-gai LGA								
Total Population in study area:	32193	32193	32193	32193	32193	32193	32193	32193
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	1.4	1.38	1.38	1.38	1.38	1.38	1.38	1.38
Population weighted Δx (µg/m³):	0.00004287	0.00004287	0.00004287	0.00004287	0.00004287	0.00004287	0.00004287	0.00004287
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Relative Risk:	1.000000	1.000000	1.000000	1.000000	1.000001	1.000000	1.000000	1.000000
Attributable fraction (AF):	2.5E-07	3.4E-08	1.8E-08	4.0E-08	5.6E-07	4.2E-08	8.1E-08	6.3E-08
Increased number of cases in population:	0.000051	0.000019	0.0000041	0.0000047	0.000046	0.0000014	0.0000013	0.0000048
Risk:	2.6E-09	3.2E-09	7.0E-10	1.5E-10	2.3E-09	4.5E-11	4.0E-11	7.7E-10
Individual subrubs within LGA								
Gordon-Killara								
Total Population in study area:	9811	9811	9811	9811	9811	9811	9811	9811
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	93.4	93.4	93.4	93.4	93.4	93.4	93.4	93.4
Population weighted Δx (µg/m³):	0.00951993	0.00951993	0.00951993	0.00951993	0.00951993	0.00951993	0.00951993	0.00951993
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	1.000055	1.000008	1.000004	1.000009	1.000124	1.000009	1.000018	1.000014
Attributable fraction (AF):	5.5E-05	7.6E-06	3.9E-06	8.9E-06	1.2E-04	9.2E-06	1.8E-05	1.4E-05
Increased number of cases in population:	0.0035	0.0013	0.00028	0.00032	0.0031	0.00010	0.00009	0.00032
Risk:	5.7E-07	7.0E-07	1.6E-07	3.3E-08	5.1E-07	9.9E-09	8.9E-09	1.7E-07
Lindfield - Roseville								
Total Population in study area:	21343	21343	21343	21343	21343	21343	21343	21343
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5
Population weighted Δx (µg/m³):	-0.00470880	-0.00470880	-0.00470880	-0.00470880	-0.00470880	-0.00470880	-0.00470880	-0.00470880
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999973	0.999996	0.999998	0.999996	0.999939	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.7E-05	-3.8E-06	-1.9E-06	-4.4E-06	-6.1E-05	-4.6E-06	-8.9E-06	-7.0E-06
Increased number of cases in population:	-0.0037	-0.0014	-0.00030	-0.00034	-0.0034	-0.00010	-0.00009	-0.00035
Risk:	-2.8E-07	-3.5E-07	-7.7E-08	-1.6E-08	-2.5E-07	-4.9E-09	-4.4E-09	-8.4E-08
St Ives								
Total Population in study area:	1039	1039	1039	1039	1039	1039	1039	1039
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	8.51	8.51	8.51	8.51	8.51	8.51	8.51	8.51
Population weighted Δx (µg/m³):	0.00819057	0.00819057	0.00819057	0.00819057	0.00819057	0.00819057	0.00819057	0.00819057
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	1.000048	1.000007	1.000003	1.000008	1.000106	1.000008	1.000016	1.000012
Attributable fraction (AF):	4.8E-05	6.6E-06	3.4E-06	7.7E-06	1.1E-04	7.9E-06	1.6E-05	1.2E-05
Increased number of cases in population:	0.000317	0.000114	0.000025	0.000029	0.000285	0.000009	0.000008	0.000030
Risk:	4.9E-07	6.1E-07	1.3E-07	2.8E-08	4.4E-07	8.6E-09	7.7E-09	1.5E-07
Total population incidence - All Suburbs								
	0.0027	0.036	0.0079	-0.0064	0.0023	-0.0017	-0.00081	0.015

Assessment of Increased Incidence - PM_{2.5}
Western Harbour Tunnel: 2037 Cumulative

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m ³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Canada Bay LGA								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58
Population weighted Δx (µg/m ³):	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999924	0.999990	0.999995	0.999988	0.999830	0.999987	0.999975	0.999981
Attributable fraction (AF):	-7.6E-05	-1.0E-05	-5.4E-06	-1.2E-05	-1.7E-04	-1.3E-05	-2.5E-05	-1.9E-05
Increased number of cases in population:	-0.0011	-0.00033	-0.000073	-0.00012	-0.0010	-0.000034	-0.000029	-0.000082
Risk:	-7.8E-07	-9.7E-07	-2.1E-07	-5.0E-08	-7.0E-07	-1.4E-08	-1.2E-08	-2.3E-07
Individual subrubs within LGA								
Drummoyne - Rodd Pt								
Total Population in study area:	2334	2334	2334	2334	2334	2334	2334	2334
% population in assessment age-group:	63%	15%	15%	100%	63%	100%	100%	15%
total change	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58	-30.58
Population weighted Δx (µg/m ³):	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197	-0.01310197
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	403.3	412.0	113.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00403	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999924	0.999990	0.999995	0.999988	0.999830	0.999987	0.999975	0.999981
Attributable fraction (AF):	-7.6E-05	-1.0E-05	-5.4E-06	-1.2E-05	-1.7E-04	-1.3E-05	-2.5E-05	-1.9E-05
Increased number of cases in population:	-0.0011	-0.00033	-0.000073	-0.00012	-0.0010	-0.000034	-0.000029	-0.000082
Risk:	-7.8E-07	-9.7E-07	-2.1E-07	-5.0E-08	-7.0E-07	-1.4E-08	-1.2E-08	-2.3E-07
North Sydney - Mosman								
Total Population in study area:	94149	94149	94149	94149	94149	94149	94149	94149
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-8947.9	-8947.9	-8947.9	-8947.9	-8947.9	-8947.9	-8947.9	-8947.9
Population weighted Δx (µg/m ³):	-0.09503978	-0.09503978	-0.09503978	-0.09503978	-0.09503978	-0.09503978	-0.09503978	-0.09503978
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999449	0.999924	0.999961	0.999911	0.998765	0.999908	0.999819	0.999859
Attributable fraction (AF):	-5.5E-04	-7.6E-05	-3.9E-05	-8.9E-05	-1.2E-03	-9.2E-05	-1.8E-04	-1.4E-04
Increased number of cases in population:	-0.36	-0.13	-0.028	-0.028	-0.32	-0.0086	-0.0084	-0.027
Risk:	-5.7E-06	-7.0E-06	-1.6E-06	-3.0E-07	-5.1E-06	-9.1E-08	-8.9E-08	-1.7E-06
Individual subrubs within LGA								
Cremorne - Cammeray								
Total Population in study area:	19045	19045	19045	19045	19045	19045	19045	19045
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-1272.2	-1272.2	-1272.2	-1272.2	-1272.2	-1272.2	-1272.2	-1272.2
Population weighted Δx (µg/m ³):	-0.06679968	-0.06679968	-0.06679968	-0.06679968	-0.06679968	-0.06679968	-0.06679968	-0.06679968
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999613	0.999947	0.999973	0.999937	0.999132	0.999935	0.999873	0.999901
Attributable fraction (AF):	-3.9E-04	-5.3E-05	-2.7E-05	-6.3E-05	-8.7E-04	-6.5E-05	-1.3E-04	-9.9E-05
Increased number of cases in population:	-0.0508	-0.0180	-0.0040	-0.0040	-0.0457	-0.0012	-0.0012	-0.0038
Risk:	-4.0E-06	-4.9E-06	-1.1E-06	-2.1E-07	-3.6E-06	-6.4E-08	-6.3E-08	-1.2E-06
Crows Nest - Waverton								
Total Population in study area:	18063	18063	18063	18063	18063	18063	18063	18063
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	190.7	190.7	190.7	190.7	190.7	190.7	190.7	190.7
Population weighted Δx (µg/m ³):	0.01055749	0.01055749	0.01055749	0.01055749	0.01055749	0.01055749	0.01055749	0.01055749
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	1.000061	1.000008	1.000004	1.000010	1.000137	1.000010	1.000020	1.000016
Attributable fraction (AF):	6.1E-05	8.4E-06	4.3E-06	9.9E-06	1.4E-04	1.0E-05	2.0E-05	1.6E-05
Increased number of cases in population:	0.0078	0.0020	0.0004	0.0006	0.0070	0.0002	0.0002	0.0004
Risk:	6.3E-07	7.8E-07	1.7E-07	3.3E-08	5.7E-07	1.0E-08	9.9E-09	1.9E-07
Mosman								
Total Population in study area:	28462	28462	28462	28462	28462	28462	28462	28462
% population in assessment age-group:	67%	19%	19%	100%	67%	100%	100%	17%
total change	-2347.5	-2347.5	-2347.5	-2347.5	-2347.5	-2347.5	-2347.5	-2347.5
Population weighted Δx (µg/m ³):	-0.08247839	-0.08247839	-0.08247839	-0.08247839	-0.08247839	-0.08247839	-0.08247839	-0.08247839
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999522	0.999934	0.999966	0.999922	0.998928	0.999920	0.999843	0.999878
Attributable fraction (AF):	-4.8E-04	-6.6E-05	-3.4E-05	-7.8E-05	-1.1E-03	-8.0E-05	-1.6E-04	-1.2E-04
Increased number of cases in population:	-0.0938	-0.0331	-0.0073	-0.0074	-0.0844	-0.0022	-0.0022	-0.0070
Risk:	-4.9E-06	-6.1E-06	-1.3E-06	-2.6E-07	-4.4E-06	-7.9E-08	-7.7E-08	-1.5E-06
Neutral Bay - Kirribilli								
Total Population in study area:	17899	17899	17899	17899	17899	17899	17899	17899
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-4063	-4063	-4063	-4063	-4063	-4063	-4063	-4063
Population weighted Δx (µg/m ³):	-0.22699592	-0.22699592	-0.22699592	-0.22699592	-0.22699592	-0.22699592	-0.22699592	-0.22699592
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.998684	0.999818	0.999907	0.999787	0.997053	0.999780	0.999569	0.999664
Attributable fraction (AF):	-1.3E-03	-1.8E-04	-9.3E-05	-2.1E-04	-3.0E-03	-2.2E-04	-4.3E-04	-3.4E-04
Increased number of cases in population:	-0.1655	-0.0432	-0.0095	-0.0128	-0.1491	-0.0039	-0.0038	-0.0081
Risk:	-1.4E-05	-1.7E-05	-3.7E-06	-7.1E-07	-1.2E-05	-2.2E-07	-2.1E-07	-4.1E-06
North Sydney - Lavender Bay								
Total Population in study area:	10680	10680	10680	10680	10680	10680	10680	10680
% population in assessment age-group:	68%	14%	14%	100%	68%	100%	100%	11%
total change	-1455.7	-1455.7	-1455.7	-1455.7	-1455.7	-1455.7	-1455.7	-1455.7
Population weighted Δx (µg/m ³):	-0.13630150	-0.13630150	-0.13630150	-0.13630150	-0.13630150	-0.13630150	-0.13630150	-0.13630150
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	335.0	412.0	98.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00335	0.00412	0.00099	0.00049	0.01209
Relative Risk:	0.999210	0.999891	0.999944	0.999872	0.998230	0.999868	0.999741	0.999798

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Attributable fraction (AF):	-7.9E-04	-1.1E-04	-5.6E-05	-1.3E-04	-1.8E-03	-1.3E-04	-2.6E-04	-2.0E-04
Increased number of cases in population:	-0.0593	-0.0155	-0.0034	-0.0046	-0.0534	-0.0014	-0.0014	-0.0029
Risk:	-8.1E-06	-1.0E-05	-2.2E-06	-4.3E-07	-7.3E-06	-1.3E-07	-1.3E-07	-2.4E-06
Sydney Inner West LGA								
Total Population in study area:	48303	48303	48303	48303	48303	48303	48303	48303
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	319.4	319.4	319.4	319.4	319.4	319.4	319.4	319.4
Population weighted Δx (µg/m³):	0.00661243	0.00661243	0.00661243	0.00661243	0.00661243	0.00661243	0.00661243	0.00661243
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000038	1.000005	1.000003	1.000006	1.000086	1.000006	1.000013	1.000010
Attributable fraction (AF):	3.8E-05	5.3E-06	2.7E-06	6.2E-06	8.6E-05	6.4E-06	1.3E-05	9.8E-06
Increased number of cases in population:	0.012	0.0029	0.00064	0.0016	0.011	0.00045	0.00030	0.00081
Risk:	3.9E-07	4.9E-07	1.1E-07	3.3E-08	3.5E-07	9.4E-09	6.2E-09	1.2E-07
Individual subrubs within LGA								
Balmain								
Total Population in study area:	15693	15693	15693	15693	15693	15693	15693	15693
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	-303.2	-303.2	-303.2	-303.2	-303.2	-303.2	-303.2	-303.2
Population weighted Δx (µg/m³):	-0.01932072	-0.01932072	-0.01932072	-0.01932072	-0.01932072	-0.01932072	-0.01932072	-0.01932072
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	0.999888	0.999985	0.999992	0.999982	0.999974	0.999981	0.999963	0.999971
Attributable fraction (AF):	-1.1E-04	-1.5E-05	-7.9E-06	-1.8E-05	-2.5E-04	-1.9E-05	-3.7E-05	-2.9E-05
Increased number of cases in population:	-0.0115	-0.00273	-0.000603	-0.00152	-0.0104	-0.000431	-0.000285	-0.000765
Risk:	-1.1E-06	-1.4E-06	-3.2E-07	-9.7E-08	-1.0E-06	-2.7E-08	-1.8E-08	-3.5E-07
Leichhardt - Annandale								
Total Population in study area:	17541	17541	17541	17541	17541	17541	17541	17541
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	416.2	416.2	416.2	416.2	416.2	416.2	416.2	416.2
Population weighted Δx (µg/m³):	0.02372727	0.02372727	0.02372727	0.02372727	0.02372727	0.02372727	0.02372727	0.02372727
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000138	1.000019	1.000010	1.000022	1.000309	1.000023	1.000045	1.000035
Attributable fraction (AF):	1.4E-04	1.9E-05	9.7E-06	2.2E-05	3.1E-04	2.3E-05	4.5E-05	3.5E-05
Increased number of cases in population:	0.016	0.004	0.0008	0.002	0.014	0.0006	0.0004	0.0011
Risk:	1.4E-06	1.8E-06	3.9E-07	1.2E-07	1.3E-06	3.4E-08	2.2E-08	4.2E-07
Lilyfield - Rozelle								
Total Population in study area:	12549	12549	12549	12549	12549	12549	12549	12549
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	206.5	206.5	206.5	206.5	206.5	206.5	206.5	206.5
Population weighted Δx (µg/m³):	0.01645549	0.01645549	0.01645549	0.01645549	0.01645549	0.01645549	0.01645549	0.01645549
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000095	1.000013	1.000007	1.000015	1.000214	1.000016	1.000031	1.000024
Attributable fraction (AF):	9.5E-05	1.3E-05	6.7E-06	1.5E-05	2.1E-04	1.6E-05	3.1E-05	2.4E-05
Increased number of cases in population:	0.008	0.002	0.0004	0.0010	0.007	0.0003	0.0002	0.0005
Risk:	9.8E-07	1.2E-06	2.7E-07	8.3E-08	8.8E-07	2.3E-08	1.5E-08	2.9E-07
Petersham - Stanmore								
Total Population in study area:	2520	2520	2520	2520	2520	2520	2520	2520
% population in assessment age-group:	64%	12%	12%	100%	64%	100%	100%	14%
total change	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Population weighted Δx (µg/m³):	0.00567460	0.00567460	0.00567460	0.00567460	0.00567460	0.00567460	0.00567460	0.00567460
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	534.2	412.0	146.4	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00534	0.00412	0.00146	0.00049	0.01209
Relative Risk:	1.000033	1.000005	1.000002	1.000005	1.000074	1.000006	1.000011	1.000008
Attributable fraction (AF):	3.3E-05	4.5E-06	2.3E-06	5.3E-06	7.4E-05	5.5E-06	1.1E-05	8.4E-06
Increased number of cases in population:	0.000543	0.000129	0.000028	0.000072	0.000489	0.000020	0.000013	0.000036
Risk:	3.4E-07	4.2E-07	9.3E-08	2.8E-08	3.0E-07	8.1E-09	5.3E-09	1.0E-07
Sydney LGA								
Total Population in study area:	131933	131933	131933	131933	131933	131933	131933	131933
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-17547.8	-17547.8	-17547.8	-17547.8	-17547.8	-17547.8	-17547.8	-17547.8
Population weighted Δx (µg/m³):	-0.13300539	-0.13300539	-0.13300539	-0.13300539	-0.13300539	-0.13300539	-0.13300539	-0.13300539
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999229	0.999908	0.999953	0.999892	0.998511	0.999889	0.999782	0.999830
Attributable fraction (AF):	-6.7E-04	-9.2E-05	-4.7E-05	-1.1E-04	-1.5E-03	-1.1E-04	-2.2E-04	-1.7E-04
Increased number of cases in population:	-0.045	-0.0079	-0.00174	-0.0062	-0.040	-0.00175	-0.00122	-0.00137
Risk:	-7.9E-06	-9.8E-06	-2.2E-06	-6.4E-07	-7.1E-06	-1.8E-07	-1.2E-07	-2.4E-06
Individual subrubs within LGA								
Darlinghurst								
Total Population in study area:	11354	11354	11354	11354	11354	11354	11354	11354
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-1301.7	-1301.7	-1301.7	-1301.7	-1301.7	-1301.7	-1301.7	-1301.7
Population weighted Δx (µg/m³):	-0.11464682	-0.11464682	-0.11464682	-0.11464682	-0.11464682	-0.11464682	-0.11464682	-0.11464682
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999335	0.999908	0.999953	0.999892	0.998511	0.999889	0.999782	0.999830
Attributable fraction (AF):	-6.7E-04	-9.2E-05	-4.7E-05	-1.1E-04	-1.5E-03	-1.1E-04	-2.2E-04	-1.7E-04
Increased number of cases in population:	-0.045	-0.0079	-0.00174	-0.0062	-0.040	-0.00175	-0.00122	-0.00137
Risk:	-6.8E-06	-8.5E-06	-1.9E-06	-5.5E-07	-6.1E-06	-1.5E-07	-1.1E-07	-2.1E-06
Glebe - Forest Lodge								
Total Population in study area:	19593	19593	19593	19593	19593	19593	19593	19593
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-663.5	-663.5	-663.5	-663.5	-663.5	-663.5	-663.5	-663.5
Population weighted Δx (µg/m³):	-0.03386414	-0.03386414	-0.03386414	-0.03386414	-0.03386414	-0.03386414	-0.03386414	-0.03386414
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person):	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999804	0.999973	0.999986	0.999968	0.999560	0.999967	0.999936	0.999950
Attributable fraction (AF):	-2.0E-04	-2.7E-05	-1.4E-05	-3.2E-05	-4.4E-04	-3.3E-05	-6.4E-05	-5.0E-05

Western Harbour Tunnel and Warringah Freeway Upgrade

Technical working paper: Health impact assessment

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Increased number of cases in population:	-0.023	-0.0040	-0.00089	-0.0032	-0.020	-0.00089	-0.00062	-0.00070
Risk:	-2.0E-06	-2.5E-06	-5.5E-07	-1.6E-07	-1.8E-06	-4.6E-08	-3.2E-08	-6.1E-07
Newtown - Camperdown - Darlington								
Total Population in study area:	5154	5154	5154	5154	5154	5154	5154	5154
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-90.4	-90.4	-90.4	-90.4	-90.4	-90.4	-90.4	-90.4
Population weighted Δx (µg/m³):	-0.01753977	-0.01753977	-0.01753977	-0.01753977	-0.01753977	-0.01753977	-0.01753977	-0.01753977
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999898	0.999986	0.999993	0.999984	0.999772	0.999983	0.999967	0.999974
Attributable fraction (AF):	-1.0E-04	-1.4E-05	-7.2E-06	-1.6E-05	-2.3E-04	-1.7E-05	-3.3E-05	-2.6E-05
Increased number of cases in population:	-0.003	-0.0005	-0.0001	-0.0004	-0.003	-0.0001	-0.00008	-0.00010
Risk:	-1.0E-06	-1.3E-06	-2.9E-07	-8.4E-08	-9.4E-07	-2.4E-08	-1.6E-08	-3.1E-07
Potts Point - Woolloomooloo								
Total Population in study area:	21200	21200	21200	21200	21200	21200	21200	21200
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-6602.6	-6602.6	-6602.6	-6602.6	-6602.6	-6602.6	-6602.6	-6602.6
Population weighted Δx (µg/m³):	-0.31144340	-0.31144340	-0.31144340	-0.31144340	-0.31144340	-0.31144340	-0.31144340	-0.31144340
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.998195	0.999751	0.999872	0.999707	0.995959	0.999698	0.999408	0.999539
Attributable fraction (AF):	-1.8E-03	-2.5E-04	-1.3E-04	-2.9E-04	-4.1E-03	-3.0E-04	-5.9E-04	-4.6E-04
Increased number of cases in population:	-0.227	-0.040	-0.0088	-0.032	-0.204	-0.0089	-0.0062	-0.0070
Risk:	-1.9E-05	-2.3E-05	-5.1E-06	-1.5E-06	-1.7E-05	-4.2E-07	-2.9E-07	-5.6E-06
Pyrmont - Ultimo								
Total Population in study area:	21665	21665	21665	21665	21665	21665	21665	21665
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-2581.1	-2581.1	-2581.1	-2581.1	-2581.1	-2581.1	-2581.1	-2581.1
Population weighted Δx (µg/m³):	-0.11913686	-0.11913686	-0.11913686	-0.11913686	-0.11913686	-0.11913686	-0.11913686	-0.11913686
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999309	0.999905	0.999951	0.999888	0.998452	0.999698	0.999774	0.999824
Attributable fraction (AF):	-6.9E-04	-9.5E-05	-4.9E-05	-1.1E-04	-1.5E-03	-1.2E-04	-2.3E-04	-1.8E-04
Increased number of cases in population:	-0.089	-0.0156	-0.0035	-0.0123	-0.080	-0.0035	-0.00242	-0.00273
Risk:	-7.1E-06	-8.8E-06	-1.9E-06	-5.7E-07	-6.4E-06	-1.6E-07	-1.1E-07	-2.1E-06
Redfern - Chippendale								
Total Population in study area:	9861	9861	9861	9861	9861	9861	9861	9861
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-303.9	-303.9	-303.9	-303.9	-303.9	-303.9	-303.9	-303.9
Population weighted Δx (µg/m³):	-0.03081838	-0.03081838	-0.03081838	-0.03081838	-0.03081838	-0.03081838	-0.03081838	-0.03081838
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999821	0.999975	0.999987	0.999971	0.999599	0.999970	0.999941	0.999954
Attributable fraction (AF):	-1.8E-04	-2.5E-05	-1.3E-05	-2.9E-05	-4.0E-04	-3.0E-05	-5.9E-05	-4.6E-05
Increased number of cases in population:	-0.01042	-0.001841	-0.000406	-0.001451	-0.00938	-0.000409	-0.000285	-0.000321
Risk:	-1.8E-06	-2.3E-06	-5.0E-07	-1.5E-07	-1.7E-06	-4.2E-08	-2.9E-08	-5.5E-07
Surry Hills								
Total Population in study area:	15699	15699	15699	15699	15699	15699	15699	15699
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-2171.8	-2171.8	-2171.8	-2171.8	-2171.8	-2171.8	-2171.8	-2171.8
Population weighted Δx (µg/m³):	-0.13834002	-0.13834002	-0.13834002	-0.13834002	-0.13834002	-0.13834002	-0.13834002	-0.13834002
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999198	0.999889	0.999943	0.999870	0.998203	0.999866	0.999737	0.999795
Attributable fraction (AF):	-8.0E-04	-1.1E-04	-5.7E-05	-1.3E-04	-1.8E-03	-1.3E-04	-2.6E-04	-2.0E-04
Increased number of cases in population:	-0.074	-0.0132	-0.00290	-0.0104	-0.067	-0.00293	-0.00204	-0.00229
Risk:	-8.2E-06	-1.0E-05	-2.3E-06	-6.6E-07	-7.4E-06	-1.9E-07	-1.3E-07	-2.5E-06
Sydney - Haymarket - The Rocks								
Total Population in study area:	27407	27407	27407	27407	27407	27407	27407	27407
% population in assessment age-group:	58%	8%	8%	100%	58%	100%	100%	6%
total change	-3832.4	-3832.4	-3832.4	-3832.4	-3832.4	-3832.4	-3832.4	-3832.4
Population weighted Δx (µg/m³):	-0.13983289	-0.13983289	-0.13983289	-0.13983289	-0.13983289	-0.13983289	-0.13983289	-0.13983289
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999189	0.999888	0.999943	0.999870	0.998184	0.999866	0.999734	0.999793
Attributable fraction (AF):	-8.1E-04	-1.1E-04	-5.7E-05	-1.3E-04	-1.8E-03	-1.4E-04	-2.7E-04	-2.1E-04
Increased number of cases in population:	-0.1314	-0.0232	-0.00513	-0.0183	-0.1183	-0.00516	-0.00360	-0.00405
Risk:	-8.3E-06	-1.0E-05	-2.3E-06	-6.7E-07	-7.5E-06	-1.9E-07	-1.3E-07	-2.5E-06
Lane Cove - Chatswood LGA								
Total Population in study area:	103355	103355	103355	103355	103355	103355	103355	103355
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-1861.10	-1861.1	-1861.1	-1861.1	-1861.1	-1861.1	-1861.1	-1861.1
Population weighted Δx (µg/m³):	-0.01800687	-0.01800687	-0.01800687	-0.01800687	-0.01800687	-0.01800687	-0.01800687	-0.01800687
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999896	0.999986	0.999993	0.999983	0.999766	0.999983	0.999966	0.999973
Attributable fraction (AF):	-1.0E-04	-1.4E-05	-7.4E-06	-1.7E-05	-2.3E-04	-1.7E-05	-3.4E-05	-2.7E-05
Increased number of cases in population:	-0.069	-0.019	-0.0042	-0.0070	-0.062	-0.0020	-0.0017	-0.0057
Risk:	-1.1E-06	-1.3E-06	-2.9E-07	-6.8E-08	-9.6E-07	-2.0E-08	-1.7E-08	-3.2E-07
Individual subrubs within LGA								
Chatswood East - Artarmon								
Total Population in study area:	28631	28631	28631	28631	28631	28631	28631	28631
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-682.5	-682.5	-682.5	-682.5	-682.5	-682.5	-682.5	-682.5
Population weighted Δx (µg/m³):	-0.02383780	-0.02383780	-0.02383780	-0.02383780	-0.02383780	-0.02383780	-0.02383780	-0.02383780
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999862	0.999981	0.999990	0.999978	0.999690	0.999977	0.999955	0.999965
Attributable fraction (AF):	-1.4E-04	-1.9E-05	-9.8E-06	-2.2E-05	-3.1E-04	-2.3E-05	-4.5E-05	-3.5E-05
Increased number of cases in population:	-0.0254	-0.0069	-0.0015	-0.0026	-0.0229	-0.0008	-0.0002	-0.0021
Risk:	-1.4E-06	-1.8E-06	-3.9E-07	-9.0E-08	-1.3E-06	-2.6E-08	-2.2E-08	-4.3E-07
Chatswood West - Lane Cove North								

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Total Population in study area:	18393	18393	18393	18393	18393	18393	18393	18393
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-428.8	-428.8	-428.8	-428.8	-428.8	-428.8	-428.8	-428.8
Population weighted Δx (µg/m³):	-0.02331322	-0.02331322	-0.02331322	-0.02331322	-0.02331322	-0.02331322	-0.02331322	-0.02331322
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999865	0.999981	0.999990	0.999978	0.999697	0.999977	0.999956	0.999965
Attributable fraction (AF):	-1.4E-04	-1.9E-05	-9.6E-06	-2.2E-05	-3.0E-04	-2.3E-05	-4.4E-05	-3.5E-05
Increased number of cases in population:	-0.0159	-0.0043	-0.0010	-0.0016	-0.0144	-0.0005	-0.0004	-0.0013
Risk:	-1.4E-06	-1.7E-06	-3.8E-07	-8.8E-08	-1.2E-06	-2.6E-08	-2.2E-08	-4.2E-07
Lane Cove - Greenwich								
Total Population in study area:	20401	20401	20401	20401	20401	20401	20401	20401
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-83.8	-83.8	-83.8	-83.8	-83.8	-83.8	-83.8	-83.8
Population weighted Δx (µg/m³):	-0.00410764	-0.00410764	-0.00410764	-0.00410764	-0.00410764	-0.00410764	-0.00410764	-0.00410764
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999976	0.999997	0.999998	0.999996	0.999947	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.4E-05	-3.3E-06	-1.7E-06	-3.9E-06	-5.3E-05	-4.0E-06	-7.8E-06	-6.1E-06
Increased number of cases in population:	-0.0031	-0.0008	-0.0002	-0.0003	-0.0028	-0.0009	-0.0008	-0.0003
Risk:	-2.4E-07	-3.0E-07	-6.7E-08	-1.6E-08	-2.2E-07	-4.5E-09	-3.9E-09	-7.3E-08
St Leonards - Naremburn								
Total Population in study area:	10478	10478	10478	10478	10478	10478	10478	10478
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2	-38.2
Population weighted Δx (µg/m³):	-0.00364573	-0.00364573	-0.00364573	-0.00364573	-0.00364573	-0.00364573	-0.00364573	-0.00364573
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999979	0.999997	0.999999	0.999997	0.999953	0.999996	0.999993	0.999995
Attributable fraction (AF):	-2.1E-05	-2.9E-06	-1.5E-06	-3.4E-06	-4.7E-05	-3.5E-06	-6.9E-06	-5.4E-06
Increased number of cases in population:	-0.0014	-0.0004	-0.00009	-0.00014	-0.0013	-0.00004	-0.00004	-0.00012
Risk:	-2.2E-07	-2.7E-07	-5.9E-08	-1.4E-08	-2.0E-07	-4.0E-09	-3.4E-09	-6.5E-08
Willoughby - Castle Cove - Northbridge								
Total Population in study area:	25452	25452	25452	25452	25452	25452	25452	25452
% population in assessment age-group:	63%	14%	14%	100%	63%	100%	100%	17%
total change	-627.7	-627.7	-627.7	-627.7	-627.7	-627.7	-627.7	-627.7
Population weighted Δx (µg/m³):	-0.02466211	-0.02466211	-0.02466211	-0.02466211	-0.02466211	-0.02466211	-0.02466211	-0.02466211
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	401.6	412.0	113.3	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00402	0.00412	0.00113	0.00049	0.01209
Relative Risk:	0.999857	0.999980	0.999990	0.999977	0.999679	0.999976	0.999953	0.999964
Attributable fraction (AF):	-1.4E-04	-2.0E-05	-1.0E-05	-2.3E-05	-3.2E-04	-2.4E-05	-4.7E-05	-3.7E-05
Increased number of cases in population:	-0.0233	-0.0064	-0.0014	-0.0024	-0.0210	-0.0007	-0.0006	-0.0019
Risk:	-1.5E-06	-1.8E-06	-4.0E-07	-9.3E-08	-1.3E-06	-2.7E-08	-2.3E-08	-4.4E-07
Hunters Hill LGA								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
Population weighted Δx (µg/m³):	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	0.999956	0.999994	0.999997	0.999993	0.999901	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.4E-05	-6.1E-06	-3.1E-06	-7.2E-06	-9.9E-05	-7.4E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.00066	-0.00027	-0.000061	-0.000081	-0.00059	-0.000022	-0.000016	-0.000056
Risk:	-4.5E-07	-5.6E-07	-1.2E-07	-3.6E-08	-4.1E-07	-9.9E-09	-7.1E-09	-1.4E-07
Individual subbrs within LGA								
Hunters Hill - Woolwich								
Total Population in study area:	2258	2258	2258	2258	2258	2258	2258	2258
% population in assessment age-group:	64%	22%	22%	100%	64%	100%	100%	18%
total change	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
Population weighted Δx (µg/m³):	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736	-0.00761736
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	501.7	412.0	133.6	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00502	0.00412	0.00134	0.00049	0.01209
Relative Risk:	0.999956	0.999994	0.999997	0.999993	0.999901	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.4E-05	-6.1E-06	-3.1E-06	-7.2E-06	-9.9E-05	-7.4E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.00066	-0.00027	-0.00006	-0.00008	-0.00059	-0.00002	-0.00002	-0.00006
Risk:	-4.5E-07	-5.6E-07	-1.2E-07	-3.6E-08	-4.1E-07	-9.9E-09	-7.1E-09	-1.4E-07
Woollara LGA (Easterns Suburbs - North)								
Total Population in study area:	71841	71841	71841	71841	71841	71841	71841	71841
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-1007.9	-1007.9	-1007.9	-1007.9	-1007.9	-1007.9	-1007.9	-1007.9
Population weighted Δx (µg/m³):	-0.01402959	-0.01402959	-0.01402959	-0.01402959	-0.01402959	-0.01402959	-0.01402959	-0.01402959
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999919	0.999989	0.999994	0.999987	0.999818	0.999986	0.999973	0.999979
Attributable fraction (AF):	-8.1E-05	-1.1E-05	-5.8E-06	-1.3E-05	-1.8E-04	-1.4E-05	-2.7E-05	-2.1E-05
Increased number of cases in population:	-0.039	-0.014	-0.0031	-0.0038	-0.035	-0.0011	-0.00095	-0.0026
Risk:	-8.3E-07	-1.0E-06	-2.3E-07	-5.2E-08	-7.5E-07	-1.5E-08	-1.3E-08	-2.5E-07
Individual subbrs within LGA								
Bondi - Tamarama - Bronte								
Total Population in study area:	2184	2184	2184	2184	2184	2184	2184	2184
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
Population weighted Δx (µg/m³):	-0.00471612	-0.00471612	-0.00471612	-0.00471612	-0.00471612	-0.00471612	-0.00471612	-0.00471612
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999973	0.999996	0.999998	0.999996	0.999939	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.7E-05	-3.8E-06	-1.9E-06	-4.4E-06	-6.1E-05	-4.6E-06	-9.0E-06	-7.0E-06
Increased number of cases in population:	-0.0004	-0.00014	-0.00003	-0.00004	-0.0004	-0.000011	-0.000010	-0.00003
Risk:	-2.8E-07	-3.5E-07	-7.7E-08	-1.8E-08	-2.5E-07	-5.1E-09	-4.4E-09	-8.4E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-51.4	-51.4	-51.4	-51.4	-51.4	-51.4	-51.4	-51.4
Population weighted Δx (µg/m³):	-0.00434893	-0.00434893	-0.00434893	-0.00434893	-0.00434893	-0.00434893	-0.00434893	-0.00434893
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999975	0.999997	0.999998	0.999996	0.999943	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.5E-05	-3.5E-06	-1.8E-06	-4.1E-06	-5.7E-05	-4.2E-06	-8.3E-06	-6.4E-06
Increased number of cases in population:	-0.0020	-0.0007	-0.00016	-0.00019	-0.0018	-0.000055	-0.000048	-0.00013
Risk:	-2.6E-07	-3.2E-07	-7.1E-08	-1.6E-08	-2.3E-07	-4.7E-09	-4.1E-09	-7.8E-08
Bondi Junction - Waverly								
Total Population in study area:	1903	1903	1903	1903	1903	1903	1903	1903
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Population weighted Δx (µg/m³):	0.00292170	0.00292170	0.00292170	0.00292170	0.00292170	0.00292170	0.00292170	0.00292170
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000017	1.000002	1.000001	1.000003	1.000038	1.000003	1.000006	1.000004
Attributable fraction (AF):	1.7E-05	2.3E-06	1.2E-06	2.7E-06	3.8E-05	2.8E-06	5.6E-06	4.3E-06
Increased number of cases in population:	0.0002	0.00008	0.00002	0.00002	0.0002	0.000006	0.000005	0.00001
Risk:	1.7E-07	2.2E-07	4.8E-08	1.1E-08	1.6E-07	3.1E-09	2.7E-09	5.2E-08
Double Bay - Bellevue Hill								
Total Population in study area:	24798	24798	24798	24798	24798	24798	24798	24798
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-280.2	-280.2	-280.2	-280.2	-280.2	-280.2	-280.2	-280.2
Population weighted Δx (µg/m³):	-0.01129930	-0.01129930	-0.01129930	-0.01129930	-0.01129930	-0.01129930	-0.01129930	-0.01129930
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999934	0.999991	0.999995	0.999989	0.999853	0.999989	0.999979	0.999983
Attributable fraction (AF):	-6.6E-05	-9.0E-06	-4.6E-06	-1.1E-05	-1.5E-04	-1.1E-05	-2.1E-05	-1.7E-05
Increased number of cases in population:	-0.0109	-0.00385	-0.00085	-0.00104	-0.0098	-0.000300	-0.000263	-0.000727
Risk:	-6.7E-07	-8.3E-07	-1.8E-07	-4.2E-08	-6.1E-07	-1.2E-08	-1.1E-08	-2.0E-07
Dover Heights								
Total Population in study area:	3179	3179	3179	3179	3179	3179	3179	3179
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-15.6	-15.6	-15.6	-15.6	-15.6	-15.6	-15.6	-15.6
Population weighted Δx (µg/m³):	-0.00490720	-0.00490720	-0.00490720	-0.00490720	-0.00490720	-0.00490720	-0.00490720	-0.00490720
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999972	0.999996	0.999998	0.999995	0.999936	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.8E-05	-3.9E-06	-2.0E-06	-4.6E-06	-6.4E-05	-4.8E-06	-9.3E-06	-7.3E-06
Increased number of cases in population:	-0.0006	-0.00021	-0.00005	-0.00006	-0.0005	-0.000017	-0.000015	-0.00004
Risk:	-2.9E-07	-3.6E-07	-8.0E-08	-1.8E-08	-2.6E-07	-5.3E-09	-4.6E-09	-8.8E-08
Paddington - Moore Park								
Total Population in study area:	13311	13311	13311	13311	13311	13311	13311	13311
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-510.1	-510.1	-510.1	-510.1	-510.1	-510.1	-510.1	-510.1
Population weighted Δx (µg/m³):	-0.03832169	-0.03832169	-0.03832169	-0.03832169	-0.03832169	-0.03832169	-0.03832169	-0.03832169
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999778	0.999969	0.999984	0.999964	0.999502	0.999963	0.999972	0.999943
Attributable fraction (AF):	-2.2E-04	-3.1E-05	-1.6E-05	-3.6E-05	-5.0E-04	-3.7E-05	-7.3E-05	-5.7E-05
Increased number of cases in population:	-0.01992	-0.00701	-0.001547	-0.001899	-0.01793	-0.000547	-0.000479	-0.001323
Risk:	-2.3E-06	-2.8E-06	-6.3E-07	-1.4E-07	-2.1E-06	-4.1E-08	-3.6E-08	-6.9E-07
Rose Bay - Vaucluse - Watsons Bay								
Total Population in study area:	6984	6984	6984	6984	6984	6984	6984	6984
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-52.8	-52.8	-52.8	-52.8	-52.8	-52.8	-52.8	-52.8
Population weighted Δx (µg/m³):	-0.00756014	-0.00756014	-0.00756014	-0.00756014	-0.00756014	-0.00756014	-0.00756014	-0.00756014
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999956	0.999994	0.999997	0.999993	0.999902	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.4E-05	-6.0E-06	-3.1E-06	-7.1E-06	-9.8E-05	-7.3E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.00206	-0.00073	-0.000160	-0.000197	-0.00186	-0.000057	-0.000050	-0.000137
Risk:	-4.5E-07	-5.6E-07	-1.2E-07	-2.8E-08	-4.0E-07	-8.1E-09	-7.1E-09	-1.4E-07
Woollahra								
Total Population in study area:	7663	7663	7663	7663	7663	7663	7663	7663
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-92.9	-92.9	-92.9	-92.9	-92.9	-92.9	-92.9	-92.9
Population weighted Δx (µg/m³):	-0.01212319	-0.01212319	-0.01212319	-0.01212319	-0.01212319	-0.01212319	-0.01212319	-0.01212319
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	0.999930	0.999990	0.999995	0.999989	0.999842	0.999988	0.999977	0.999982
Attributable fraction (AF):	-7.0E-05	-9.7E-06	-5.0E-06	-1.1E-05	-1.6E-04	-1.2E-05	-2.3E-05	-1.8E-05
Increased number of cases in population:	-0.00363	-0.00128	-0.000282	-0.000346	-0.00326	-0.000100	-0.000087	-0.000241
Risk:	-7.2E-07	-9.0E-07	-2.0E-07	-4.5E-08	-6.5E-07	-1.3E-08	-1.1E-08	-2.2E-07
Northern Beaches LGA								
Total Population in study area:	86694	86694	86694	86694	86694	86694	86694	86694
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-202.9	-202.9	-202.9	-202.9	-202.9	-202.9	-202.9	-202.9
Population weighted Δx (µg/m³):	-0.00234042	-0.00234042	-0.00234042	-0.00234042	-0.00234042	-0.00234042	-0.00234042	-0.00234042
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999986	0.999998	0.999999	0.999998	0.999970	0.999998	0.999996	0.999997
Attributable fraction (AF):	-1.4E-05	-1.9E-06	-9.6E-07	-2.2E-06	-3.0E-05	-2.3E-06	-4.4E-06	-3.5E-06
Increased number of cases in population:	-0.0078	-0.0025	-0.00056	-0.00070	-0.0070	-0.00025	-0.00019	-0.00068
Risk:	-1.4E-07	-1.7E-07	-3.8E-08	-1.0E-08	-1.3E-07	-2.9E-09	-2.2E-09	-4.2E-08
Individual subrubs within LGA								
Balgowlah - Clontarf - Seaford								
Total Population in study area:	20214	20214	20214	20214	20214	20214	20214	20214
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-75.7	-75.7	-75.7	-75.7	-75.7	-75.7	-75.7	-75.7

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Population weighted Δx (µg/m³):	-0.00374493	-0.00374493	-0.00374493	-0.00374493	-0.00374493	-0.00374493	-0.00374493	-0.00374493
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999978	0.999997	0.999998	0.999996	0.999951	0.999996	0.999993	0.999994
Attributable fraction (AF):	-2.2E-05	-3.0E-06	-1.5E-06	-3.5E-06	-4.9E-05	-3.6E-06	-7.1E-06	-5.5E-06
Increased number of cases in population:	-0.0029	-0.0009	-0.00021	-0.00033	-0.0026	-0.00009	-0.00007	-0.00025
Risk:	-2.2E-07	-2.8E-07	-6.1E-08	-1.6E-08	-2.0E-07	-4.6E-09	-3.5E-09	-6.7E-08
Beacon Hill - Narraweena								
Total Population in study area:	12757	12757	12757	12757	12757	12757	12757	12757
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-52.4	-52.4	-52.4	-52.4	-52.4	-52.4	-52.4	-52.4
Population weighted Δx (µg/m³):	-0.00410755	-0.00410755	-0.00410755	-0.00410755	-0.00410755	-0.00410755	-0.00410755	-0.00410755
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999976	0.999997	0.999998	0.999996	0.999947	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.4E-05	-3.3E-06	-1.7E-06	-3.9E-06	-5.3E-05	-4.0E-06	-7.8E-06	-6.1E-06
Increased number of cases in population:	-0.0020	-0.0007	-0.00014	-0.00023	-0.0018	-0.00006	-0.00005	-0.00017
Risk:	-2.4E-07	-3.0E-07	-6.7E-08	-1.8E-08	-2.2E-07	-5.1E-09	-3.9E-09	-7.3E-08
Dee Why - North Curl Curl								
Total Population in study area:	228	228	228	228	228	228	228	228
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-1.93	-1.93	-1.93	-1.93	-1.93	-1.93	-1.93	-1.93
Population weighted Δx (µg/m³):	-0.00846491	-0.00846491	-0.00846491	-0.00846491	-0.00846491	-0.00846491	-0.00846491	-0.00846491
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999951	0.999993	0.999997	0.999992	0.999890	0.999992	0.999984	0.999987
Attributable fraction (AF):	-4.9E-05	-6.8E-06	-3.5E-06	-8.0E-06	-1.1E-04	-8.2E-06	-1.6E-05	-1.3E-05
Increased number of cases in population:	-0.00074	-0.00004	-0.000005	-0.000008	-0.000066	-0.000002	-0.000002	-0.000006
Risk:	-5.0E-07	-6.3E-07	-1.4E-07	-3.7E-08	-4.5E-07	-1.0E-08	-7.9E-09	-1.5E-07
Forrestville - Killarney Heights								
Total Population in study area:	12813	12813	12813	12813	12813	12813	12813	12813
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-487.1	-487.1	-487.1	-487.1	-487.1	-487.1	-487.1	-487.1
Population weighted Δx (µg/m³):	-0.03801608	-0.03801608	-0.03801608	-0.03801608	-0.03801608	-0.03801608	-0.03801608	-0.03801608
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999780	0.999970	0.999984	0.999964	0.999506	0.999963	0.999928	0.999944
Attributable fraction (AF):	-2.2E-04	-3.0E-05	-1.6E-05	-3.6E-05	-4.9E-04	-3.7E-05	-7.2E-05	-5.6E-05
Increased number of cases in population:	-0.0186	-0.0060	-0.00133	-0.00212	-0.0168	-0.00060	-0.00046	-0.00162
Risk:	-2.3E-06	-2.8E-06	-6.2E-07	-1.7E-07	-2.0E-06	-4.7E-08	-3.6E-08	-6.8E-07
Frenchs Forrest - Belrose								
Total Population in study area:	10159	10159	10159	10159	10159	10159	10159	10159
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-34	-34	-34	-34	-34	-34	-34	-34
Population weighted Δx (µg/m³):	-0.00334679	-0.00334679	-0.00334679	-0.00334679	-0.00334679	-0.00334679	-0.00334679	-0.00334679
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999981	0.999997	0.999999	0.999997	0.999956	0.999997	0.999994	0.999995
Attributable fraction (AF):	-1.9E-05	-2.7E-06	-1.4E-06	-3.1E-06	-4.4E-05	-3.2E-06	-6.4E-06	-5.0E-06
Increased number of cases in population:	-0.0013	-0.0004	-0.00009	-0.00015	-0.0012	-0.00004	-0.00003	-0.00011
Risk:	-2.0E-07	-2.5E-07	-5.5E-08	-1.5E-08	-1.8E-07	-4.1E-09	-3.1E-09	-6.0E-08
Freshwater - Brookvale								
Total Population in study area:	8047	8047	8047	8047	8047	8047	8047	8047
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-50.8	-50.8	-50.8	-50.8	-50.8	-50.8	-50.8	-50.8
Population weighted Δx (µg/m³):	-0.00631291	-0.00631291	-0.00631291	-0.00631291	-0.00631291	-0.00631291	-0.00631291	-0.00631291
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999963	0.999995	0.999997	0.999994	0.999918	0.999994	0.999988	0.999991
Attributable fraction (AF):	-3.7E-05	-5.1E-06	-2.6E-06	-5.9E-06	-8.2E-05	-6.1E-06	-1.2E-05	-9.3E-06
Increased number of cases in population:	-0.0019	-0.0006	-0.00014	-0.00022	-0.0017	-0.00006	-0.00005	-0.00017
Risk:	-3.8E-07	-4.7E-07	-1.0E-07	-2.7E-08	-3.4E-07	-7.8E-09	-5.9E-09	-1.1E-07
Manly - Fairlight								
Total Population in study area:	5576	5576	5576	5576	5576	5576	5576	5576
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8
Population weighted Δx (µg/m³):	-0.00175753	-0.00175753	-0.00175753	-0.00175753	-0.00175753	-0.00175753	-0.00175753	-0.00175753
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	0.999990	0.999999	0.999999	0.999998	0.999977	0.999998	0.999997	0.999997
Attributable fraction (AF):	-1.0E-05	-1.4E-06	-7.2E-07	-1.7E-06	-2.3E-05	-1.7E-06	-3.3E-06	-2.6E-06
Increased number of cases in population:	-0.000375	-0.000122	-0.000027	-0.000043	-0.000338	-0.000012	-0.000009	-0.000033
Risk:	-1.0E-07	-1.3E-07	-2.9E-08	-7.6E-09	-9.4E-08	-2.2E-09	-1.6E-09	-3.1E-08
Manly Vale - Allambie Heights								
Total Population in study area:	16900	16900	16900	16900	16900	16900	16900	16900
% population in assessment age-group:	64%	17%	17%	100%	64%	100%	100%	19%
total change	511.2	511.2	511.2	511.2	511.2	511.2	511.2	511.2
Population weighted Δx (µg/m³):	0.03024852	0.03024852	0.03024852	0.03024852	0.03024852	0.03024852	0.03024852	0.03024852
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	127.4	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00462	0.00412	0.00127	0.00049	0.01209
Relative Risk:	1.000175	1.000024	1.000012	1.000028	1.000393	1.000029	1.000057	1.000045
Attributable fraction (AF):	1.8E-04	2.4E-05	1.2E-05	2.8E-05	3.9E-04	2.9E-05	5.7E-05	4.5E-05
Increased number of cases in population:	0.0196	0.0063	0.00140	0.00222	0.0176	0.00063	0.00048	0.00170
Risk:	1.8E-06	2.2E-06	4.9E-07	1.3E-07	1.6E-06	3.7E-08	2.8E-08	5.4E-07
Ku-ring-gai LGA								
Total Population in study area:	32193	32193	32193	32193	32193	32193	32193	32193
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-419.0	-419	-419	-419	-419	-419	-419	-419
Population weighted Δx (µg/m³):	-0.01301525	-0.01301525	-0.01301525	-0.01301525	-0.01301525	-0.01301525	-0.01301525	-0.01301525
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	462.3	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209

Health Endpoint:	Primary Indicators			Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations - Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiopulmonary, Long-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5-22)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Relative Risk:	0.999925	0.999990	0.999995	0.999988	0.999831	0.999987	0.999975	0.999981
Attributable fraction (AF):	-7.5E-05	-1.0E-05	-5.3E-06	-1.2E-05	-1.7E-04	-1.3E-05	-2.5E-05	-1.9E-05
Increased number of cases in population:	-0.016	-0.0056	-0.0012	-0.0014	-0.014	-0.00044	-0.00039	-0.0015
Risk:	-7.7E-07	-9.6E-07	-2.1E-07	-4.5E-08	-7.0E-07	-1.4E-08	-1.2E-08	-2.3E-07
Individual subrubs within LGA								
Gordon-Killara								
Total Population in study area:	9811	9811	9811	9811	9811	9811	9811	9811
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-23.6	-23.6	-23.6	-23.6	-23.6	-23.6	-23.6	-23.6
Population weighted Δx (µg/m³):	-0.00240546	-0.00240546	-0.00240546	-0.00240546	-0.00240546	-0.00240546	-0.00240546	-0.00240546
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999986	0.999998	0.999999	0.999998	0.999969	0.999998	0.999995	0.999996
Attributable fraction (AF):	-1.4E-05	-1.9E-06	-9.9E-07	-2.3E-06	-3.1E-05	-2.3E-06	-4.6E-06	-3.6E-06
Increased number of cases in population:	-0.0009	-0.0003	-0.00007	-0.00008	-0.0008	-0.00002	-0.00002	-0.00008
Risk:	-1.4E-07	-1.8E-07	-3.9E-08	-8.2E-09	-1.3E-07	-2.5E-09	-2.3E-09	-4.3E-08
Lindfield - Roseville								
Total Population in study area:	21343	21343	21343	21343	21343	21343	21343	21343
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	-397.7	-397.7	-397.7	-397.7	-397.7	-397.7	-397.7	-397.7
Population weighted Δx (µg/m³):	-0.01863374	-0.01863374	-0.01863374	-0.01863374	-0.01863374	-0.01863374	-0.01863374	-0.01863374
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	0.999892	0.999985	0.999992	0.999982	0.999758	0.999982	0.999965	0.999972
Attributable fraction (AF):	-1.1E-04	-1.5E-05	-7.6E-06	-1.8E-05	-2.4E-04	-1.8E-05	-3.5E-05	-2.8E-05
Increased number of cases in population:	-0.0148	-0.0053	-0.00118	-0.00136	-0.0133	-0.00042	-0.00037	-0.00138
Risk:	-1.1E-06	-1.4E-06	-3.0E-07	-6.4E-08	-1.0E-06	-1.9E-08	-1.7E-08	-3.3E-07
St Ives								
Total Population in study area:	1039	1039	1039	1039	1039	1039	1039	1039
% population in assessment age-group:	63%	18%	18%	100%	63%	100%	100%	19%
total change	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Population weighted Δx (µg/m³):	0.00219442	0.00219442	0.00219442	0.00219442	0.00219442	0.00219442	0.00219442	0.00219442
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	364.6	412.0	107.7	49.4	1209.0
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00365	0.00412	0.00108	0.00049	0.01209
Relative Risk:	1.000013	1.000002	1.000001	1.000002	1.000029	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.3E-05	1.8E-06	9.0E-07	2.1E-06	2.9E-05	2.1E-06	4.2E-06	3.2E-06
Increased number of cases in population:	0.000085	0.000031	0.000007	0.000008	0.000076	0.000002	0.000002	0.000008
Risk:	1.3E-07	1.6E-07	3.6E-08	7.5E-09	1.2E-07	2.3E-09	2.1E-09	3.9E-08
Total population incidence - All Suburbs								
	-1.1	-0.27	-0.060	-0.12	-0.97	-0.036	-0.028	-0.055

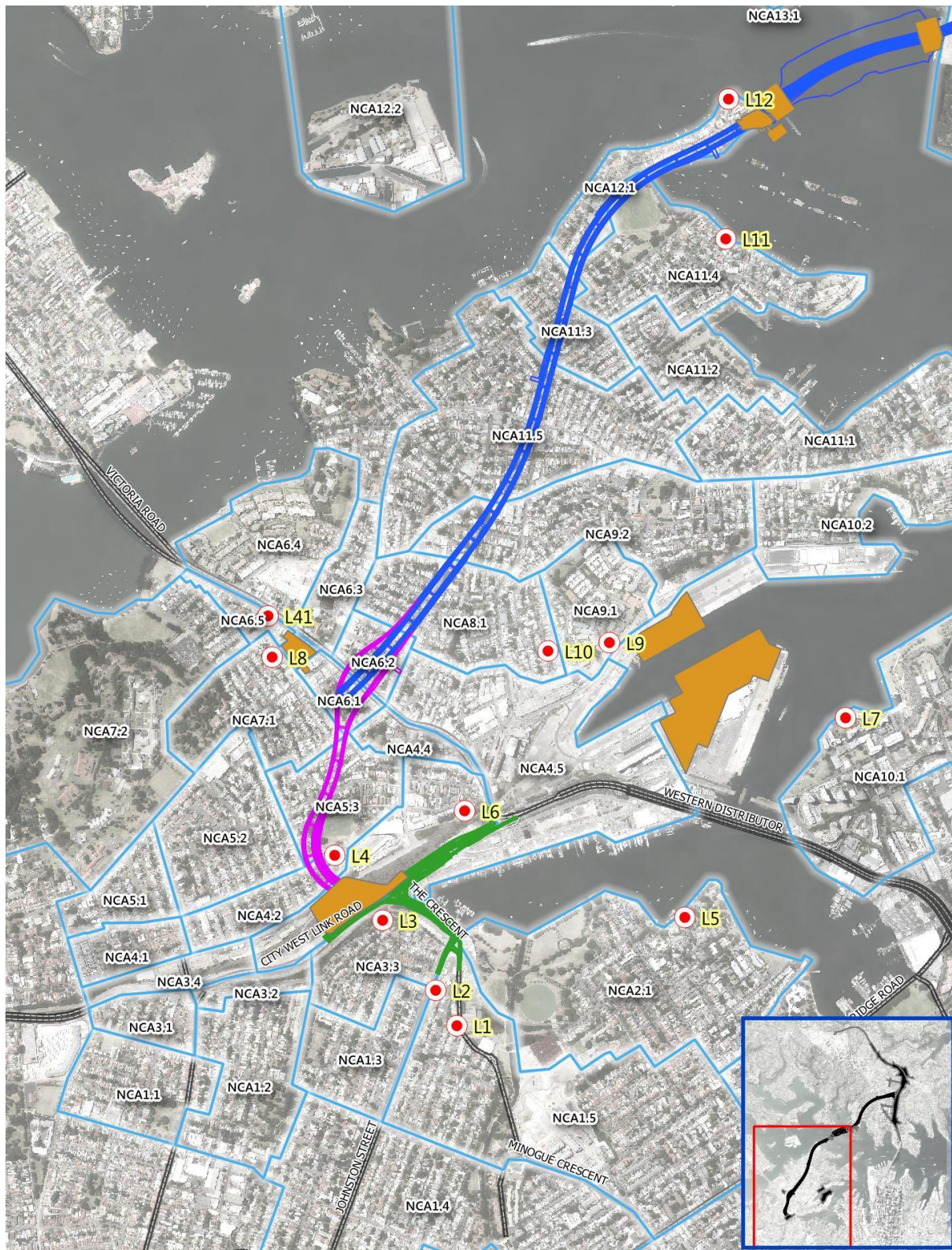
Annexure H – Risk calculations: Particulate matter exposures for elevated receptors

Quantification of Effects - PM_{2.5}
WHTBL: Elevated receptors 2037 Cumulative

Air quality indicator:			PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}	PM _{2.5}
Endpoint:			Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	Morbidity - Asthma ED Admissions
Effect Exposure Duration:			Long-term	Short-term	Short-term	Short-Term	Long-term	Short-Term	Short-Term	Short-Term
Age Group:			≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	1-14 years
β (change in effect per 1 µg/m³) (as per Table 5-22)			0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.00148
Annual Baseline Incidence (as per Table 3-5)										
Annual baseline incidence (per 100,000)			1026	9235	3978	428	412	132	32.1	1209
Baseline Incidence (per person per year)			0.01026	0.09235	0.03978	0.00428	0.00412	0.00132	0.000321	0.01209

Sensitive Receptors		Change in Annual Average PM _{2.5} Concentration (µg/m³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
Impacts from project (ventilation outlets and roads)										
All receptors: maximum at 10m height		0.37	2E-05	3E-05	6E-06	1E-06	2E-05	5E-07	2E-07	7E-06
All receptors: maximum at 20m height		0.24	1E-05	2E-05	4E-06	1E-06	1E-05	3E-07	1E-07	4E-06
All receptors: maximum at 30m height		0.48	3E-05	4E-05	8E-06	2E-06	3E-05	6E-07	3E-07	9E-06
All receptors: maximum at 45m height		2.06	1E-04	2E-04	3E-05	8E-06	1E-04	3E-06	1E-06	4E-05

Annexure I – Noise catchment areas



Legend

- | | | | |
|-------------------------------------|---|-----------------|---------------------------------------|
| — Western Harbour Tunnel | Construction support sites | 0 200 400 600 m | ● Long term noise monitoring location |
| — Connection to Rozelle Interchange | Surface road upgrade construction support sites | | □ Noise catchment boundary |
| — Fitout of the M4-M5 Link tunnels | Surface road upgrade zones | | |

