Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Appendix I

Health impact assessment

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Technical working paper: Health impact assessment

December 2020

Prepared for

Transport for NSW

Prepared by

Environmental Risk Sciences Pty Ltd

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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	*Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016)
CTAMP	Construction Traffic Management and Access Plan
DAWE	Australian Government Department of Agriculture, Water and the Environment
dB(A)	Decibels (A-weighted)

Term	Definition
DE	Diesel exhaust
DECCW	The former (NSW) Department of Environment, Climate Change and Water (now part of DPIE (EES) or NSW EPA)
DEFRA	(UK) Department for Environment, Food & Rural Affairs
DEH	The *former* Australian Government Department of Environment and Heritage (now part of DAWE)
Detection limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
DIRD	The former Australian Government Department of Infrastructure and Regional Development (now part of DITRDC)
Do minimum	Air quality, noise and traffic modelling scenario with WestConnex but without the project, Western Harbour Tunnel and Warringah Freeway Upgrade, Sydney Gateway and the M6 Motorway
Do something	Air quality, noise and traffic modelling scenario with WestConnex and with the project and Warringah Freeway Upgrade but without the Western Harbour Tunnel, Sydney Gateway and the M6 Motorway
Do something cumulative	Air quality, noise and traffic modelling scenario with WestConnex, the project, the Western Harbour Tunnel and Warringah Freeway Upgrade, Sydney Gateway and the M6 Motorway
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	NSW Department of Planning, Industry and Environment
DPIE (EES)	NSW Department of Planning, Industry and Environment (Environment, Energy and Science)
DPM	Diesel particulate matter
DSI	Detailed site investigation
DTRDC	Australian Government Department of Infrastructure, Transport, Regional Development and Communications
EC	European Commission
ED	Emergency department
EMF	Electromagnetic field
EP&A Act	*Environmental Planning and Assessment Act 1979* (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.

Term	Definition
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
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.
HI	Hazard Index
IARC	International Agency for Research on Cancer
ICNG	*Interim Construction Noise Guideline* (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].
L_{A1}	A-weighted sound level exceeded for one per cent of the measurement period
L_{A10}	A-weighted sound level exceeded for 10 per cent of the measurement period
L_{A90}	A-weighted sound level exceeded for 90 per cent of the measurement period
L_{Aeq}	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

Term	Definition
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
OEH	The former (NSW) Office of Environment and Heritage (now part of the DPIE (EES))
OEHHA	Office of Environmental Health Hazard Assessment, California Environment Protection Agency (Cal EPA)
OLS	Obstacle limitation surface
PAH	Polycyclic aromatic hydrocarbon
PFAS	Per- and polyfluoroalkyl substances
PIARC	Permanent International Association of Road Congresses
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	Beaches Link and Gore Hill Freeway Connection
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	*NSW Road Noise Policy* (DECCW, 2011)
Roads and Maritime	The former (NSW) Roads and Maritime Services (now part of Transport for NSW)
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
Transport for NSW	The proponent
Toxicity	The degree of danger posed by a substance to human, animal or plant life.

Term	Definition
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 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
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
$\mu g/m^3$	Micrograms per cubic metre

Executive summary

E.1 The project

Transport for NSW is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Beaches Link and Gore Hill Freeway Connection project, which would comprise two components:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights, and an upgrade of the Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

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 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 now, 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 surface motorways and their potential effects on people who live or work around them. It uses this information to predict the potential impacts of the project on community health.

In this case, this report includes a detailed review of potential impacts which 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 2012a, 2017; Harris 2007), which has involved the following:

- Review of predicted impacts associated with air quality, noise and vibration, public safety, contamination and social change 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

- Undertaking a more detailed assessment of potential risks of changes in nitrogen dioxide and particulates, including fine particulate matter or $PM_{2.5}$ (particulate matter of aerodynamic diameter 2.5 microns (μm) and less) and coarse particulate matter or PM_{10} (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 particulate matter based on the NSW Environment Protection Authority (NSW EPA) methodology
- Assessment of noise and vibration impacts on health including:
  - Reviewing the potential impacts that are predicted from the construction and operation of the project. Potential impacts associated with construction noise and vibration are assessed using typical and worst case works scenarios
  - 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 potential 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 well-being. 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 undertaken.

E.4 Conclusions

E.4.1 Air Quality

In relation to air quality impacts the following conclusion are made:

- Impacts associated with dust generated from construction activities require management to ensure impacts to community health are minimised. Measures required to be implemented to minimise dust impacts are to be detailed in construction environmental management documentation, as detailed in Appendix H (Technical working paper: Air quality) of the environmental impact statement
- Odour generated from the handling of dredged material unsuitable for sea disposal onshore would unlikely be detectable at the nearest sensitive receptor
- Impacts in the community outside the tunnel: the project is expected to result in 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

- For future buildings that may be constructed with heights over 30 metres and within 300 metres of the ventilation outlets, planning controls (that include more detailed assessment of pollutants) should be developed to ensure impacts to health are addressed and minimised
- Impacts within the tunnel: while 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:
  - Concentrations of nitrogen dioxide and carbon monoxide within the tunnel are expected to be below the current health based guidelines and in-tunnel air criteria under all plausible tunnel operating scenarios, including significant congestion. Levels inside vehicles are expected to be even lower. Placing ventilation on recirculation is expected to minimise exposure of vehicle occupants to particulates during travel through the tunnels
  - For motorcyclists, where there is no opportunity to minimise exposure through the use of ventilation, there is the potential for higher levels of exposure to air pollutants nitrogen dioxide. 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 permissible lane filtering, limiting the duration of exposure and the potential for adverse health effects.

E.4.2 Noise and Vibration

In relation to noise and vibration the following conclusions are made:

Construction

- Potential exceedances of noise management levels during construction have been predicted at a number of receptor buildings, including impacts greater than 15 dB(A). These exceedances have been modelled using typical and worst case work scenarios. To mitigate this potential impact, additional mitigation measures are to be implemented to minimise impacts to health impacts on 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 four per cent of receptor buildings experiencing increases greater than 2 dB(A) due to the project.
- Additional mitigation for road traffic noise would be considered for a large number of receiver buildings. For of these buildings it is existing road traffic noise, rather than increases due to the project, that trigger the need for additional mitigation. 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 undertaken. 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, potential air and 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.

1 Introduction

This section provides an overview of the Beaches Link and Gore Hill Freeway Connection (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), 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 Middle 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 which 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 the Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of the 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 areas 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 existing harbour crossings.

1.2 The project

Transport for NSW is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Beaches Link and Gore Hill Freeway Connection project, which would comprise two components:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights, and an upgrade of the Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

A detailed description of these two components is provided in Section 1.5.

1.3 Project location

The project would be located within the North Sydney, Willoughby, Mosman and Northern Beaches local government areas, connecting Cammeray in the south with Killarney Heights, Frenchs Forest and Balgowlah in the north. The project would also connect to both the Gore Hill Freeway and Reserve Road in Artarmon in the west.

Commencing at the Warringah Freeway at Cammeray, the mainline tunnels would pass under Naremburn and Northbridge, then cross Middle Harbour between Northbridge and Seaforth. The mainline tunnels would then split under Seaforth into two ramp tunnels and continue north to the Wakehurst Parkway at Killarney Heights and north-east to Balgowlah, linking directly to the Burnt Bridge Creek Deviation to the south of the existing Kitchener Street bridge.

The mainline tunnels would also have on and off ramps from under Northbridge connecting to the Gore Hill Freeway and Reserve Road east of the existing Lane Cove Tunnel. Surface works would also be carried out at the Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation at Balgowlah and along the Wakehurst Parkway between Seaforth and Frenchs Forest to connect the project to the existing arterial and local road networks.

1.4 Key features of the project

Key features of the Beaches Link component of the project are shown in Figure 1-1 and would include:

- Twin mainline tunnels about 5.6 kilometres long and each accommodating three lanes of traffic in each direction, together with entry and exit ramp tunnels to connections at the surface. The crossing of Middle Harbour between Northbridge and Seaforth would involve three lane, twin immersed tube tunnels
- Connection to the stub tunnels constructed at Cammeray as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project
- Twin two lane ramp tunnels:
  - Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at the Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length)
  - Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at the Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length)
  - Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway and Reserve Road, Artarmon (about 2.1 kilometres in length).
- An access road connection at Balgowlah between the Burnt Bridge Creek Deviation and Sydney Road including the modification of the intersection at Maretimo Street and Sydney Road, Balgowlah
- Upgrade and integration works along the Wakehurst Parkway, at Seaforth, Killarney Heights and Frenchs Forest, through to Frenchs Forest Road East
- New open space and recreation facilities at Balgowlah
- New and upgraded pedestrian and cyclist infrastructure
- Ventilation outlets and motorway facilities at the Warringah Freeway in Cammeray, the Gore Hill Freeway in Artarmon, the Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway in Killarney Heights
- Operational facilities, including a motorway control centre at the Gore Hill Freeway in Artarmon, and tunnel support facilities at the Gore Hill Freeway in Artarmon and the Wakehurst Parkway in Frenchs Forest
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, surface drainage, signage, tolling infrastructure, fire and life safety systems, roadside furniture, lighting, emergency evacuation and emergency smoke extraction infrastructure, Closed Circuit Television (CCTV) and other traffic management systems.

Key features of the Gore Hill Freeway Connection component of the project are shown in Figure 1-2 and would include:

- Upgrade and reconfiguration of the Gore Hill Freeway between the T1 North Shore and Western Line and T9 Northern Line and the Pacific Highway
- Modifications to the Reserve Road and Hampden Road bridges
- Widening of Reserve Road between the Gore Hill Freeway and Dickson Avenue
- Modification of the Dickson Avenue and Reserve Road intersection to allow for the Beaches Link off ramp
- Upgrades to existing roads around the Gore Hill Freeway to integrate the project with the surrounding road network
- Upgrade of the Dickson Avenue and Pacific Highway intersection
- New and upgraded pedestrian and cyclist infrastructure
- Other operational infrastructure, including surface drainage and utility infrastructure, signage and lighting, CCTV and other traffic management systems.

A detailed description of the project is provided in Chapter 5 (Project description) of the environmental impact statement.

Subject to obtaining planning approval, construction of the project is anticipated to commence in 2023 and is expected to take around five to six years to complete.

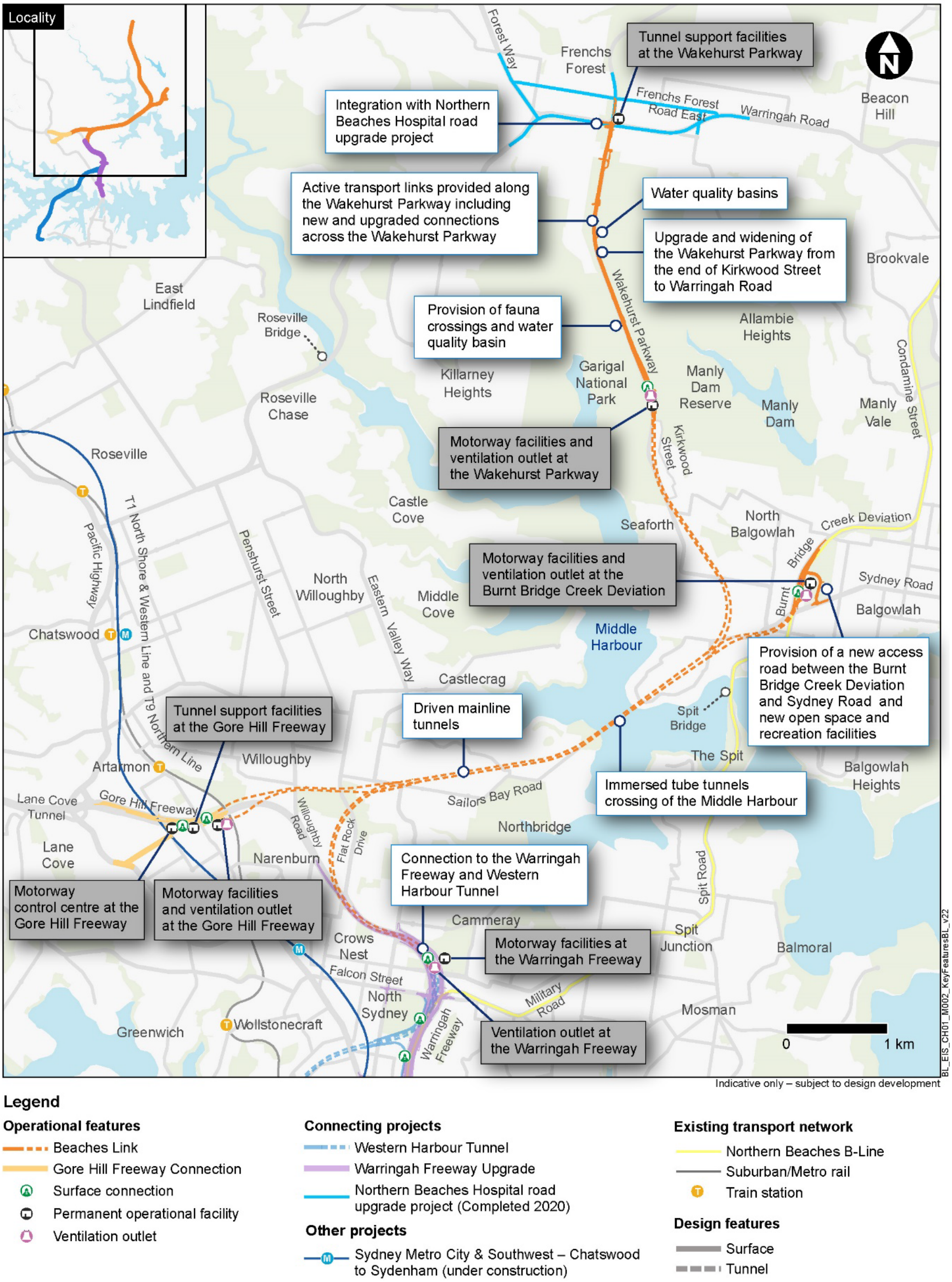
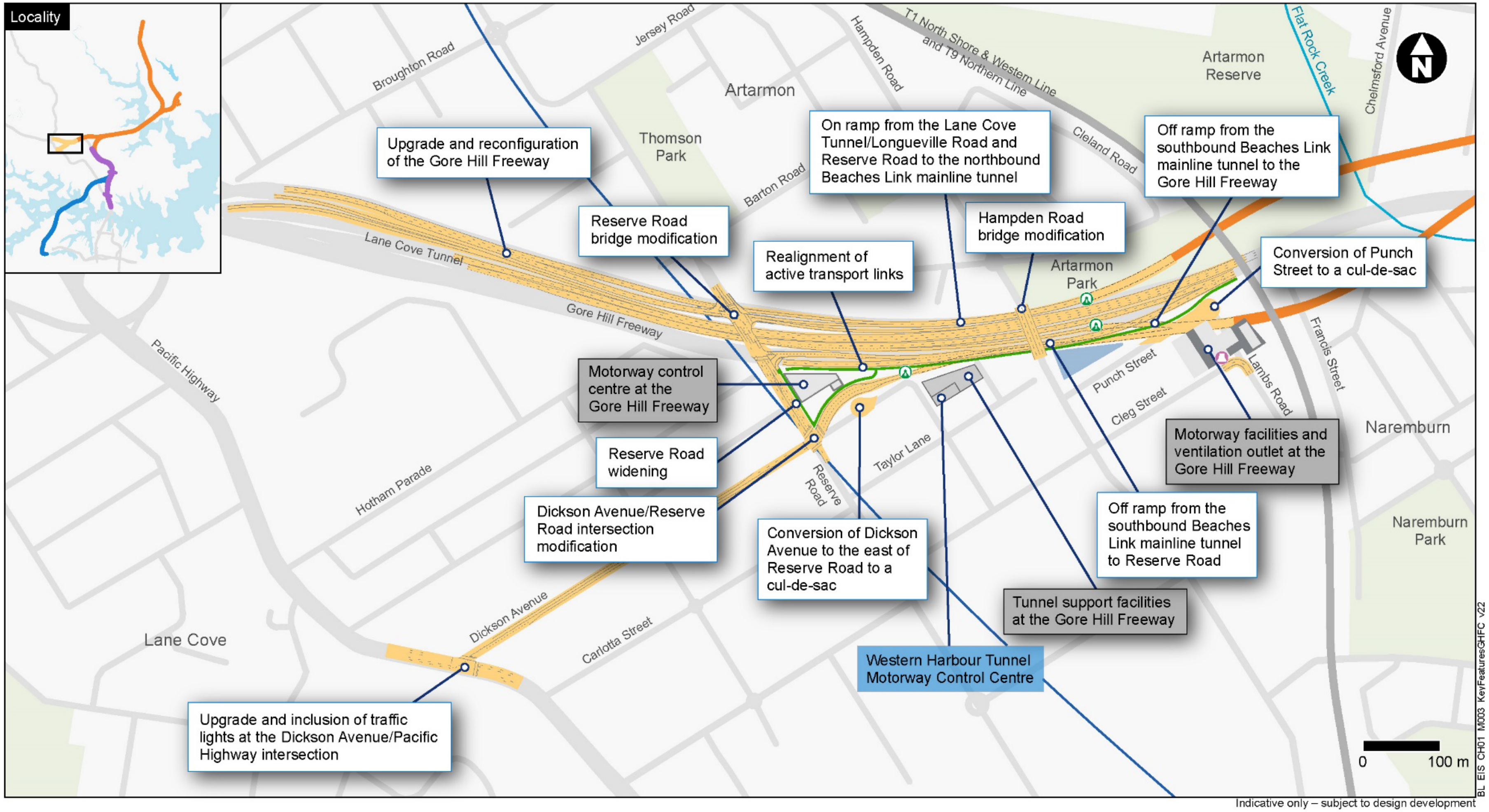


Figure 1-1 Key features of the Beaches Link component of the project



Indicative only – subject to design development

Legend

Operational features

- Gore Hill Freeway Connection
- Beaches Link
- Permanent operational facility
- Surface connection
- Ventilation outlet
- Pedestrian / active transport links
- Permanent water quality basin

Existing rail network

- Suburban/Metro rail

Other projects

- Sydney Metro City & Southwest – Chatswood to Sydenham (under construction)

Figure 1-2 Key features of the Gore Hill Freeway component of the project

1.5 Key construction activities

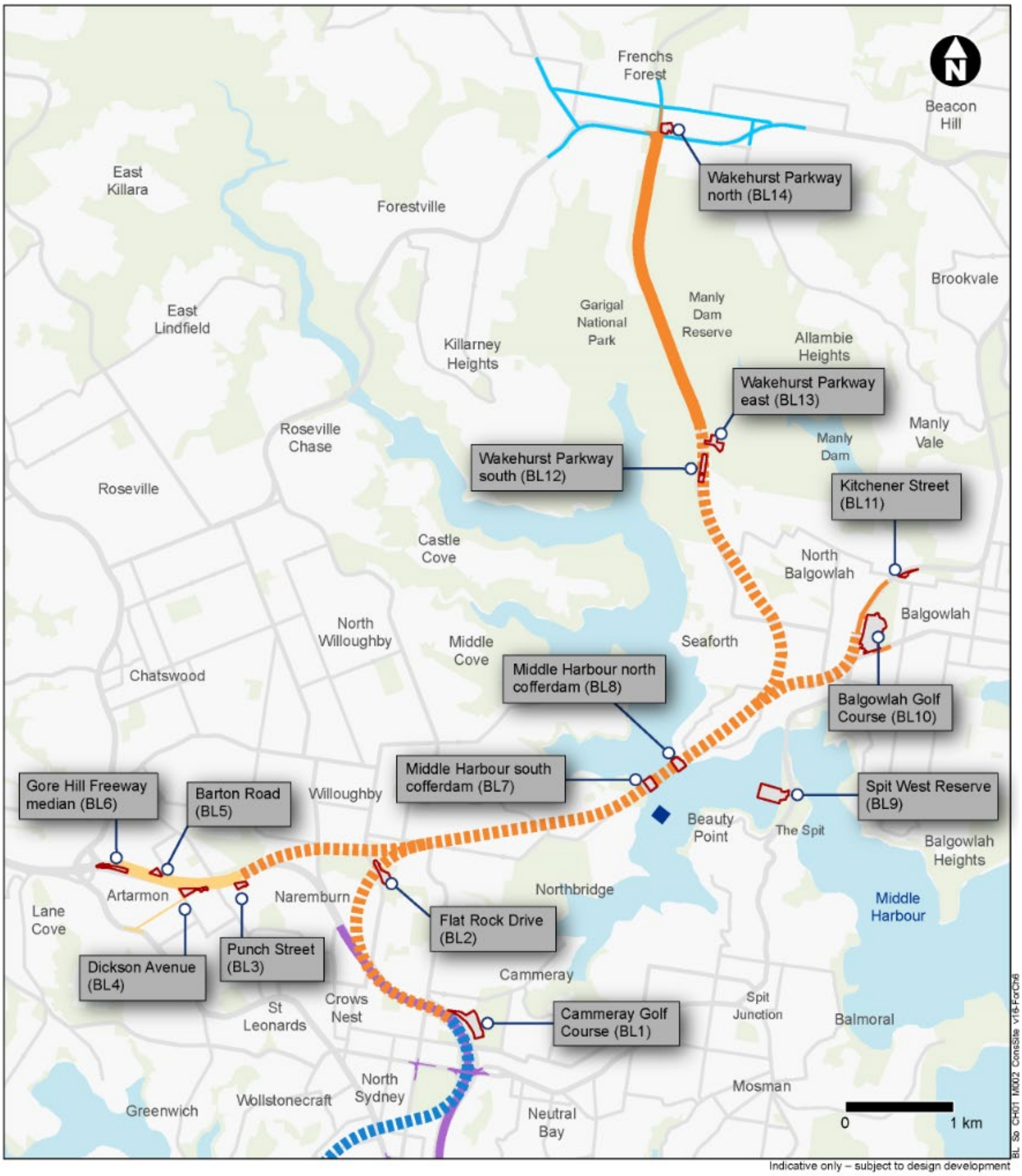
The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline and ramp tunnels. However, surface areas would also be required to support tunnelling activities and to construct the tunnel connections, tunnel portals, surface road upgrades and operational 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), traffic management controls, vegetation clearing, earthworks, demolition of structures, building 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 and/or provision of alternative facilities (mooring or marina berth) within Middle Harbour
- Construction of the Beaches Link, with typical activities being excavation of tunnel construction access declines, construction of driven tunnels, cut and cover and trough structures, construction of surface upgrade works, construction of cofferdams, dredging and immersed tube tunnel piled support 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:
  - A motorway control centre at the Gore Hill Freeway in Artarmon
  - Tunnel support facilities at the Gore Hill Freeway in Artarmon and at the Wakehurst Parkway in Frenchs Forest
  - Motorway facilities and ventilation outlets at the Warringah Freeway in Cammeray (fitout only of the Beaches Link ventilation outlet at the Warringah Freeway (being constructed by the Western Harbour Tunnel and Warringah Freeway Upgrade project), the Gore Hill Freeway in Artarmon, the Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway in Killarney Heights
  - A wastewater treatment plant at the Gore Hill Freeway in Artarmon
  - Installation of motorway tolling infrastructure
- Staged construction of the Gore Hill Freeway Connection at Artarmon and upgrade and integration works at Balgowlah and along the Wakehurst Parkway with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of roadside 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 would include:
  - Cammeray Golf Course (BL1)
  - Flat Rock Drive (BL2)
  - Punch Street (BL3)
  - Dickson Avenue (BL4)
  - Barton Road (BL5)
  - Gore Hill Freeway median (BL6)
  - Middle Harbour south cofferdam (BL7)
  - Middle Harbour north cofferdam (BL8)
  - Spit West Reserve (BL9)
  - Balgowlah Golf Course (BL10)

- Kitchener Street (BL11)
- Wakehurst Parkway south (BL12)
- Wakehurst Parkway east (BL13)
- Wakehurst Parkway north (BL14).

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



Legend

Construction features

- Beaches Link
- Gore Hill Freeway Connection
- Construction support site
- Temporary mooring facility for completed immersed tube tunnel units

Connecting projects

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Northern Beaches Hospital road upgrade project (completed 2020)

Figure 1-3 Overview of the construction support sites

1.6 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 ('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 requirements. The report has been prepared in accordance with the relevant guidelines as outlined in Section 2.2.1.

1.7 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.	Section 5 to 9
2. The assessment must:	
(a) describe the current known health status of the potentially affected population	Section 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	Section 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	Section 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)
(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

Secretary's environmental assessment requirements	Where addressed
(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 An assessment of bushfire risks relating to construction and operation of the project and the handling, transport and use of dangerous goods is detailed in Chapter 23 (Hazards and risks) of the environmental impact statement. An assessment of potential ground movement associated with the project is provided in Chapter 16 (Geology, soils and groundwater) of the environmental impact statement. Pedestrian safety is discussed in Chapter 8 (Construction traffic and transport) of the environmental impact statement.
(g) assess the opportunities for health improvement	Section 5 to 9
(h) assess the distribution of the health risks and benefits	Section 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	Section 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 utilised. 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 Beaches Link and Gore Hill Freeway Connection as well as WestConnex plus Sydney Gateway, Western Harbour Tunnel and Warringah Freeway Upgrade and M6 Motorway 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 undertake 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.

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 2012a)
- 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 2013c))

- National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure, 2003 (NEPC 1998 amended 2016)
- *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 2009a)).

More specifically, in relation to the assessment of health impacts associated with exposure to nitrogen dioxide (NO_2) and particulate matter (PM), guidelines available from the NEPC ((Burgers & Walsh 2002; NEPC 1998, 1998 amended 2016, 2002, 2009, 2010)), World Health Organization (WHO) (Ostro 2004; WHO 2003, 2006b, 2006a, 2013b) and the USEPA (USEPA 2005b, 2009b) 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* (NSW Health, 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)
- Changes in 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 and 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 NO_2 and PM emissions within the surrounding community from the operation of the project. Other pollutants that have also been considered include volatile organic compounds, 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 NO_2 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 NO_2 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 NO_2 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 volatile organic carbon (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 project design, and all aspects of the technical studies relied on for the conduct of 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 systematic tool 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) in the local community and hence 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:

- Refinement to the Cammeray Golf Course construction support site layout and permanent motorway facilities to ensure a functional golf course can be reinstated
- Selection of the preferred Flat Rock Drive construction support site (BL2) to reduce the potential interaction with putrescible waste within the former landfill, to reduce construction impacts on receptors located to the south of the Flat Rock Baseball Diamond, Naremburn, and to avoid disruption to the baseball diamond
- Refinement to the Spit West Reserve construction support site (BL9) to minimise the impact to public open space, car parking, moorings and Mosman Rowers
- Investigation of disposing suitable dredged material at sea, which would avoid unnecessary disposal of spoil to landfill, and would reduce the impacts of construction vehicle movements on the local road network
- Use of the Balgowlah Golf Course for a construction support site (BL10) and for permanent infrastructure to reduce impacts on residences, Burnt Bridge Creek, Seaforth Public School, traffic and buses. The preferred designs of the access road and motorway facilities at this location have been made to achieve a balance of potential visual impacts on various nearby residential properties. Engagement with Northern Beaches Council has identified potential for the residual land associated with Balgowlah Golf Course and properties acquired in Dudley Street to be

developed for new and improved open space and recreation facilities. Use of the residual land for such facilities would align with the *Northern Beaches Sportsground Strategy* (Northern Beaches Council 2017) and address the current under supply of sporting grounds available for public use in the local area. A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council would take place to give the community an opportunity to provide input to the final layout of the new open space and recreation facilities at Balgowlah. An indicative layout of the new and improved open space and recreation facilities at Balgowlah is provided in Chapter 5 (Project description) of the environmental impact statement

- Staging of the project works and works to create new and improved open space and recreation facilities at Balgowlah allowing for earlier access for the community
- Inclusion of concrete batching plants at Balgowlah and Frenchs Forest to reduce heavy vehicle haulage to/from existing plants at Artarmon and Brookvale
- Provision of new or upgraded active transport links at Balgowlah and along the Wakehurst Parkway
- Use of Transport for NSW owned land at Frenchs Forest for operational tunnel support facilities.

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 ventilation rate minimises local air quality impacts.

Noise mitigation measures (road pavement treatments, noise barriers and/or at-property treatments where necessary) have also been identified to address potential 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement (ERM, 2020). The defined area (study area), illustrated in Figure 3-1, identifies the area over which impacts to 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 local government areas (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 Greater Sydney and/or NSW.

3.2 Surrounding area and population

The population considered in this assessment include 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 Beaches Link and Gore Hill Freeway Connection as well as the Western Harbour Tunnel and Warringah Freeway Upgrade and WestConnex.

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.

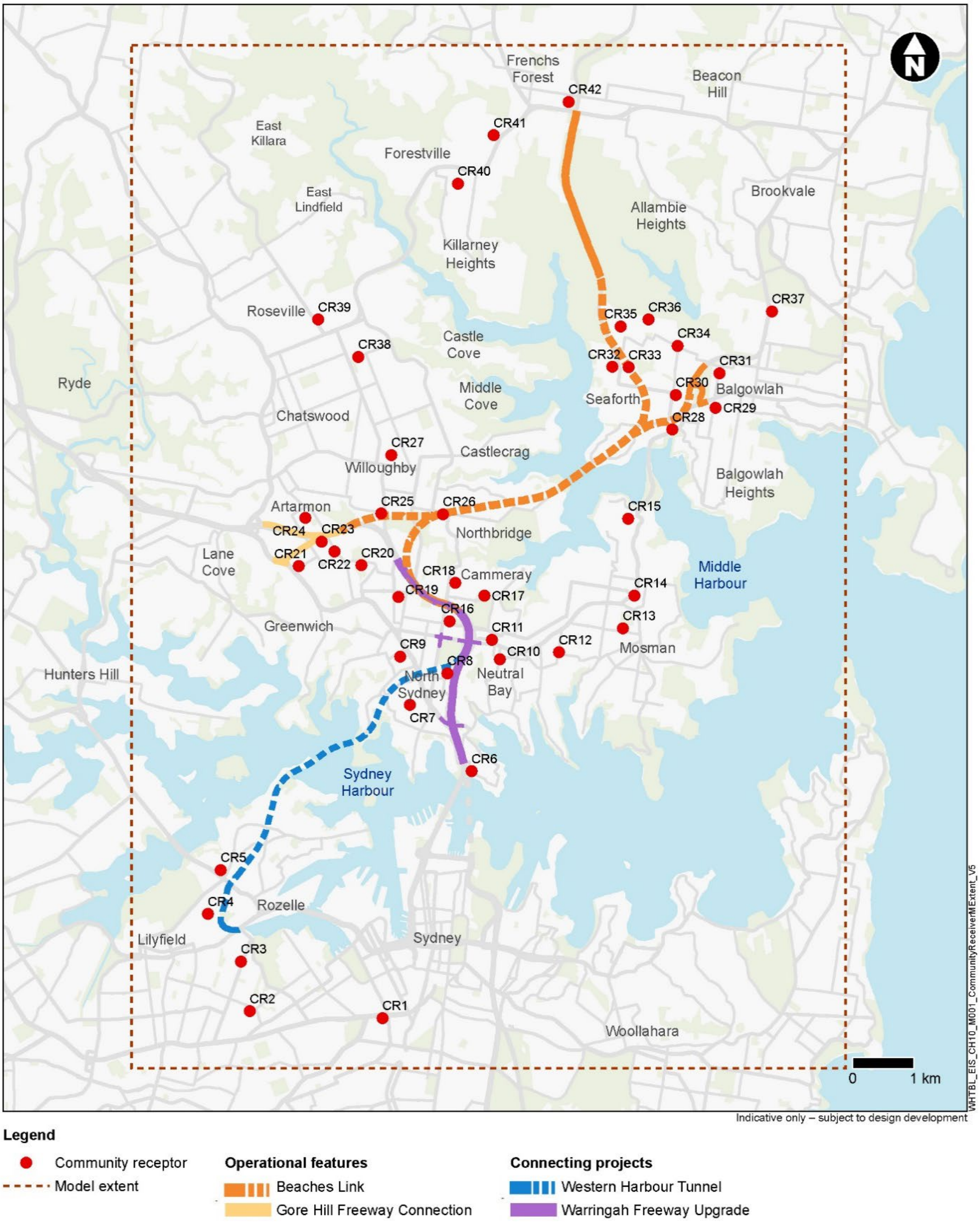


Figure 3-1 Health impact assessment study area

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 project. Community receptors are representative of locations 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 receptors include hospitals, child care facilities, schools and aged care homes/facilities. Section 8.4.1 of in Appendix H (Technical working paper: Air quality) of the environmental impact statement provides further details on how community receptors were selected.

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 in Figure 3-2.

In addition to these community receptors, a maximum of 35,484 individual receptors (residential, workplace and recreational (RWR) receptors also shown in 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	University	Chippendale	Sydney
CR2	Laverty Pathology	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
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

	Receptor name	Type of receptor	Suburb	LGA
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

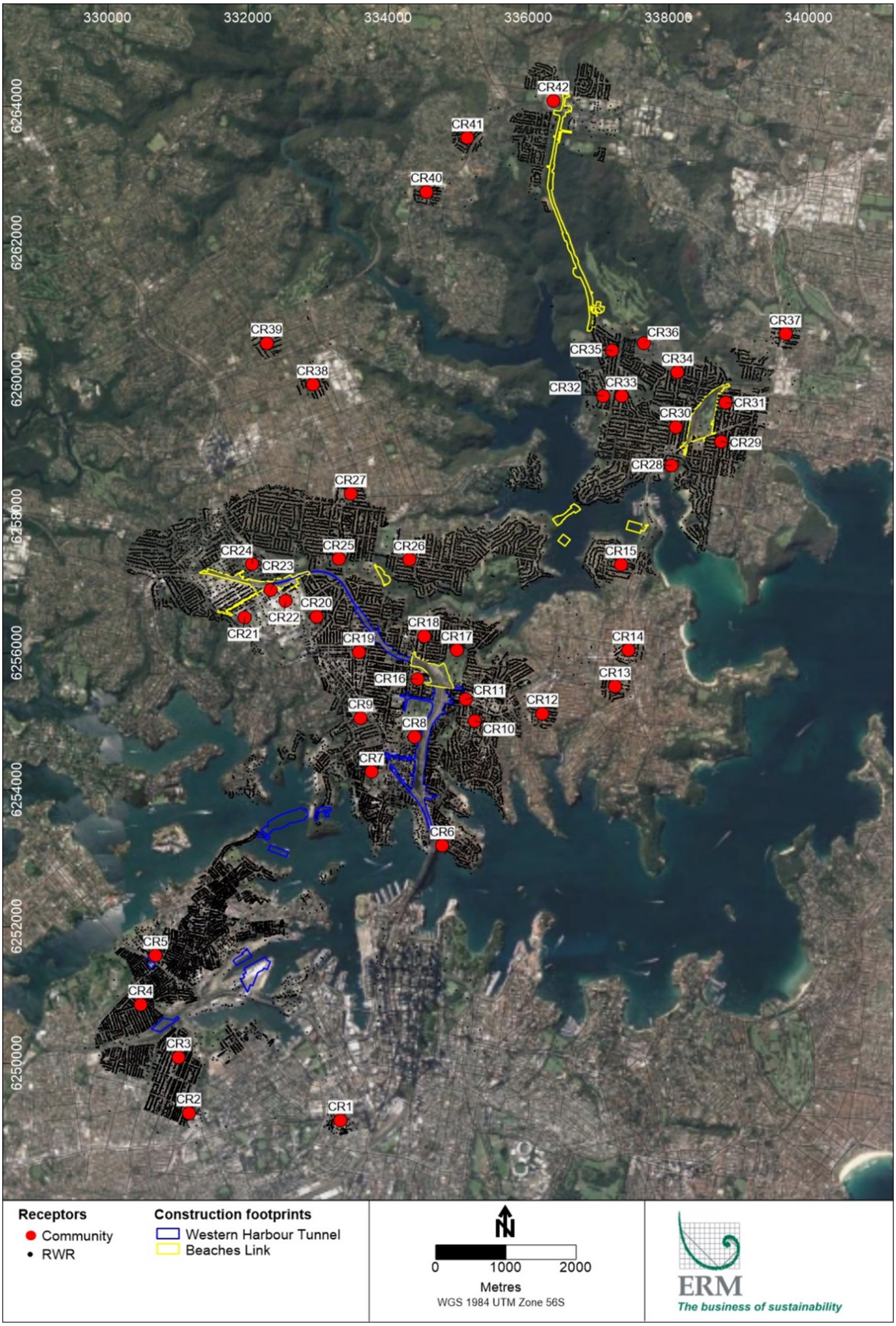


Figure 3-2 Community receptors and RWR receptors evaluated in the health impact assessment

Table 3-2 Summary of RWR receptor types

Receptor type	All receptors ('Do minimum' scenario)		'Do something' scenario		'Do something – cumulative' scenario	
	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	12	0.03%	12	0.03%	12	0.03%
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%	810	2.29%	810	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%	31,993	90.31%	31,982	90.29%
School	135	0.38%	135	0.38%	135	0.38%
Grand Total[(b)]	35,489	100.00%	35,424	100.00%	35,393	99.92%

a) 'Other' includes laboratories, infrastructure, construction sites, wharfs, State Emergency Service (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
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 is noted:

- Sydney – City and Inner South have a lower proportion of children (0 to 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 to 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 have 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: 72.0 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

Location	Median age	Median household income ($/week)	Median mortgage repayment ($/month)	Median rent ($/week)	Average household size (persons)	Unemployment rate (%)
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, NO_2 and PM (namely $PM_{2.5}$ and PM_{10}). 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 study area is located in the Sydney Local Health District and the Northern Sydney Local Health District[1]). 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

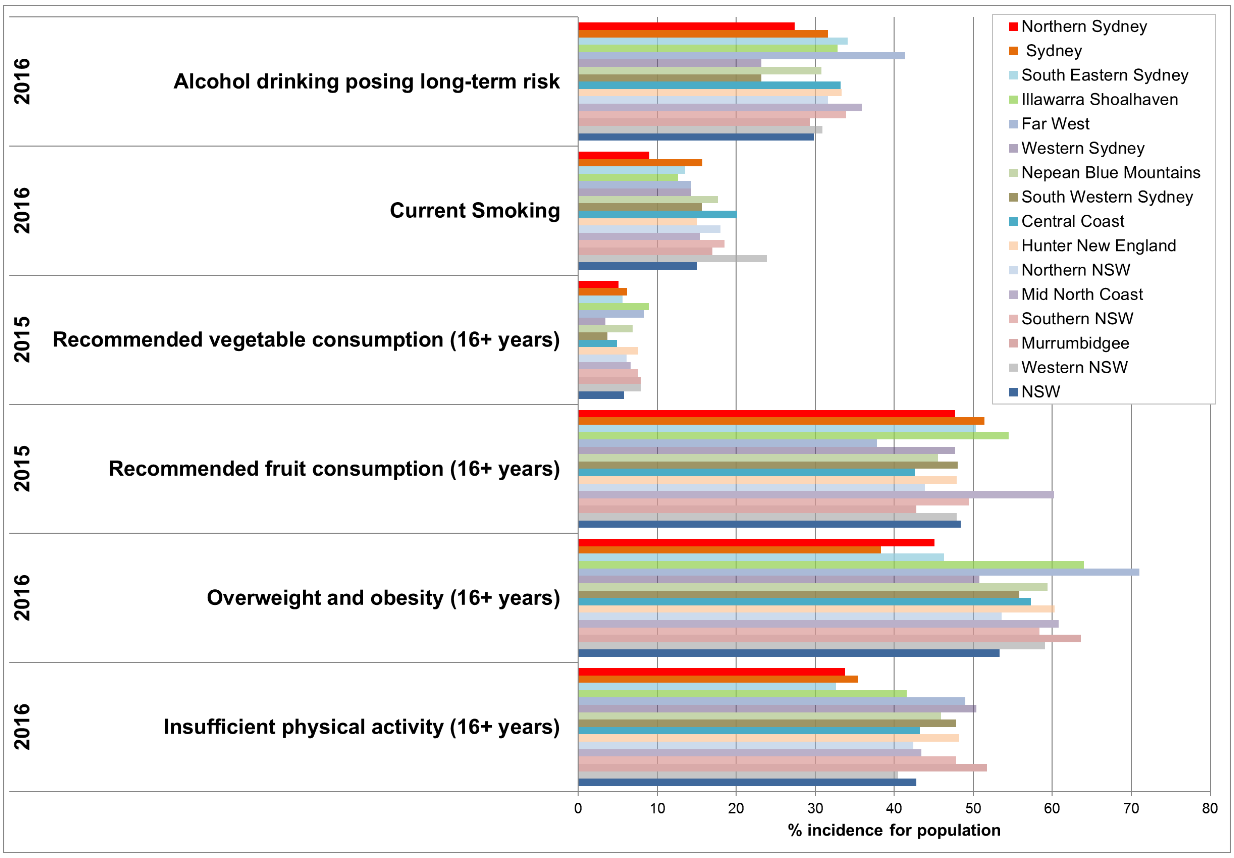


Figure 3-3 Summary of incidence of health-related behaviours (Source: HealthStats NSW, 2018)

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 to 2016 for diabetes, cardiovascular disease, asthma (5 to 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.

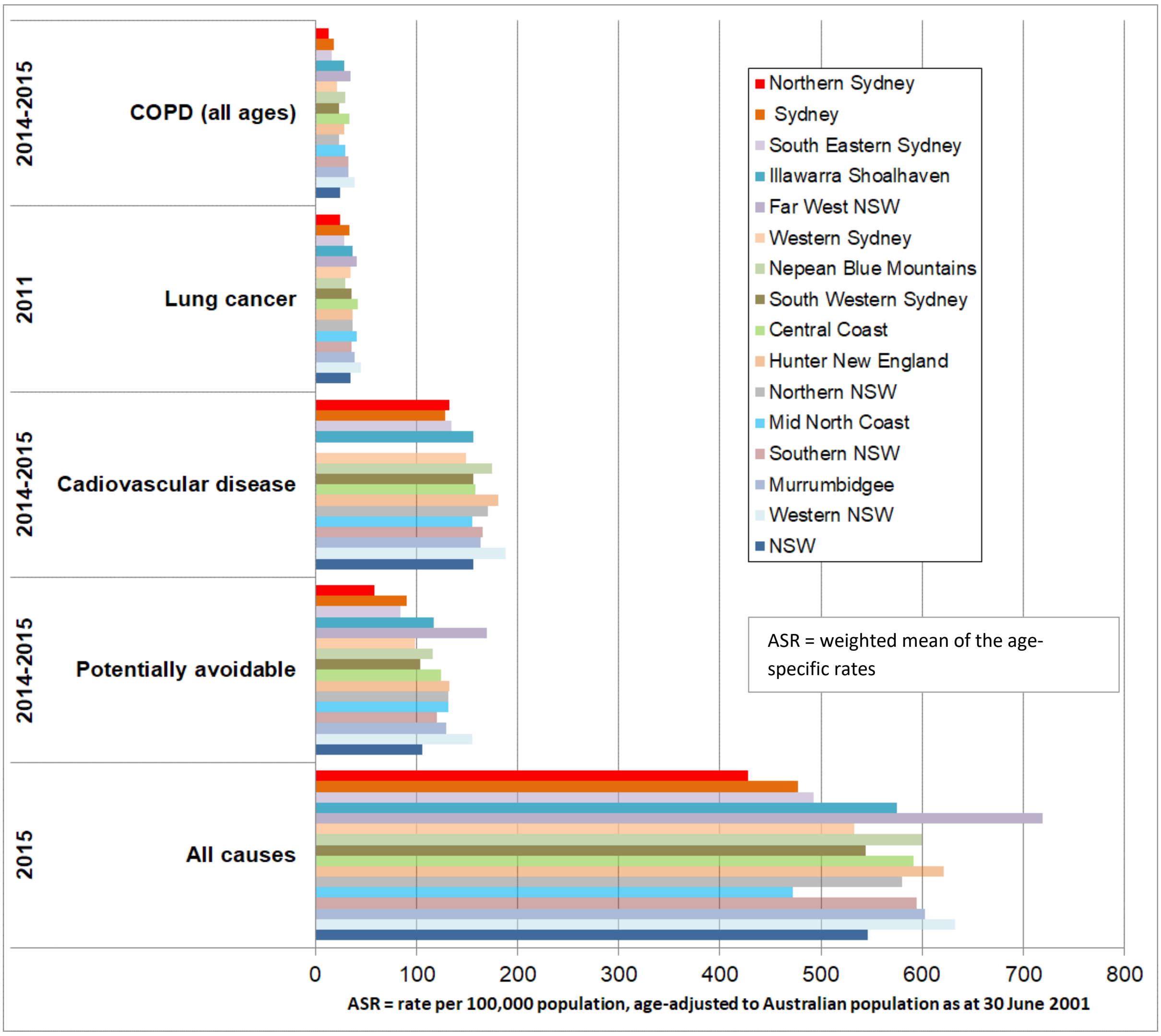


Figure 3-4 **Summary of mortality data 2011–2015 (Source: HealthStats NSW 2018)**

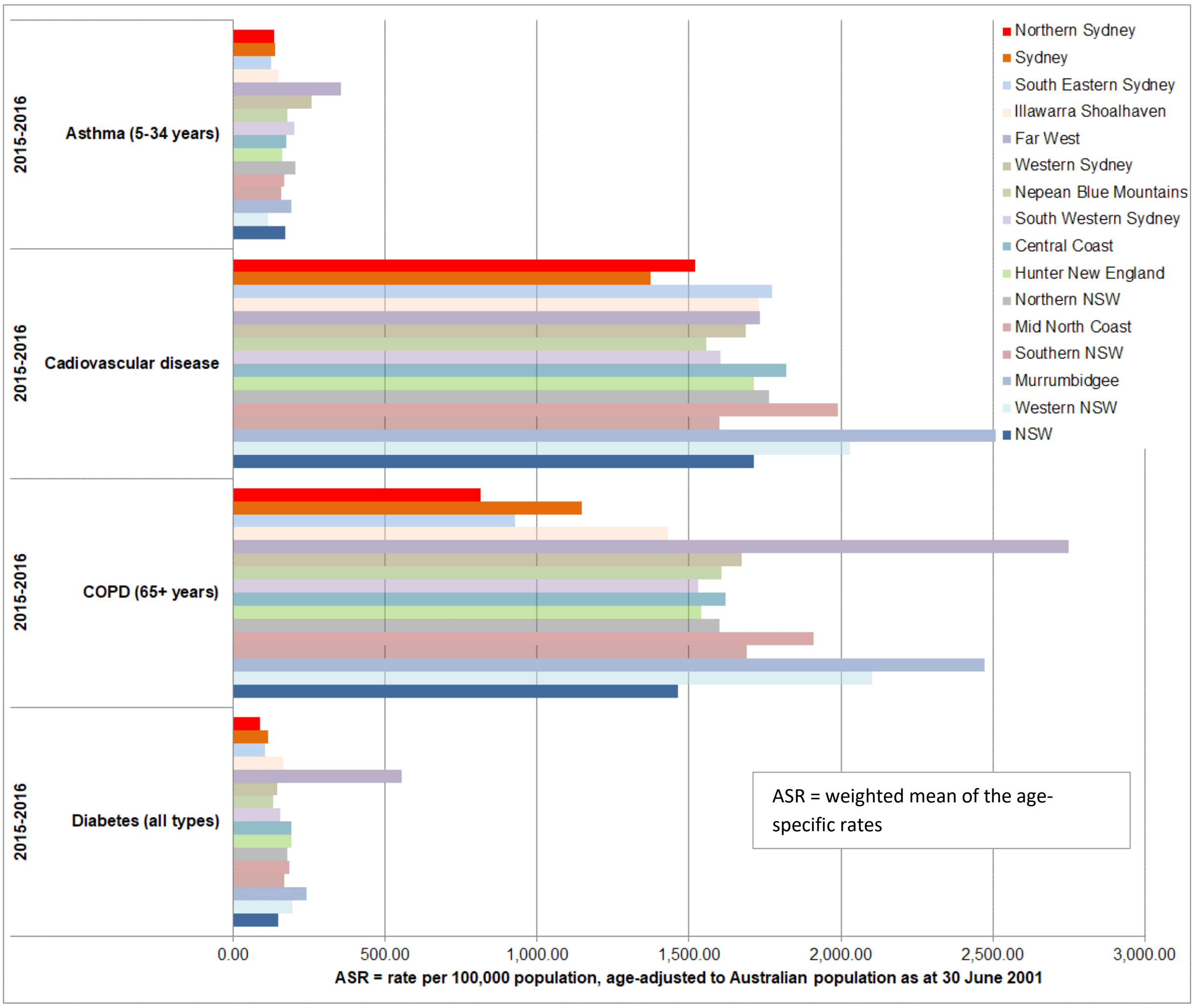


Figure 3-5 Summary of hospitalisation data 2015–2016 (Source: HealthStats NSW 2018)

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 percent) 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 percent 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.

Review of the data presented in Table 3-5 generally indicates that for the population in the study 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 study 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 in 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. Hence 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 3-6 provides other key indicators for mental health.

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															
	LGAs											Local Health Districts			Sydney (wider metro area)*	NSW
	Canada Bay	Inner West	Sydney	Woollahra	Mosman	North Sydney	Lane Cove	Hunters Hill	Willoughby	Northern Beaches	Ku-ring-gai	Northern Sydney LHD	Sydney LHD	South Eastern Sydney LHD		
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]
Cardiovascular disease																
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**	
Respiratory disease																
All ages	--	--	--	--	--	--	--	--	--	--	--	1539.0 [E]	1494.3 [E]	1441.8 [E]	**2003**	1731.3 [E]
>65 years	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**3978**	
Asthma																
Asthma hospitalisations (ages 5–34 years)	--	--	--	--	--	--	--	--	--	--	--	134.2 [E]	137.6 [E]	124.0 [E]	--	171.1 [E]

Health indicator	Rate per 100,000 population (for the year, or years as referenced) – for each area evaluated															
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 Inner City	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	Number of comments 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 Northern Beaches 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 of construction support sites, hours of work, night work, spoil transport, cumulative impacts, light spill	383	3475
Request for more project information	327	520
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, need for land bridges, open space, drainage and flooding	226	3766
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

Feedback topic	Number of comments 2017	Number of comments 2018
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
EIS 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement. 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 NO_2, sulfur dioxide (SO_2) and CO continue to be below national standards, levels of ozone (O_3) and PM can exceed the standards adopted in NSW (NSW EPA 2016) from time to time.

O_3 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 and hence 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) 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, Transport for NSW 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 Transport for NSW sites (shown on Figure 5-1 as CBMS, T1, U1, X1) are in the vicinity of the M5 East ventilation outlet. Two Transport for NSW sites (shown on Figure 5-2 as F1 and M1) were much closer to busy roads near the M5 East Motorway tunnel portals. Other Transport for NSW 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 Transport for NSW 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.

Transport for NSW also established a WestConnex monitoring network including monitoring stations at both urban background and near road stations. Five monitoring stations were introduced in the WestConnex M4 area (see M4E), seven stations in the WestConnex M8 area (see New M5), and two stations in the WestConnex M4-M5 Link area. Some of the WestConnex monitoring stations were subsequently relocated or decommissioned. Of the WestConnex 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.

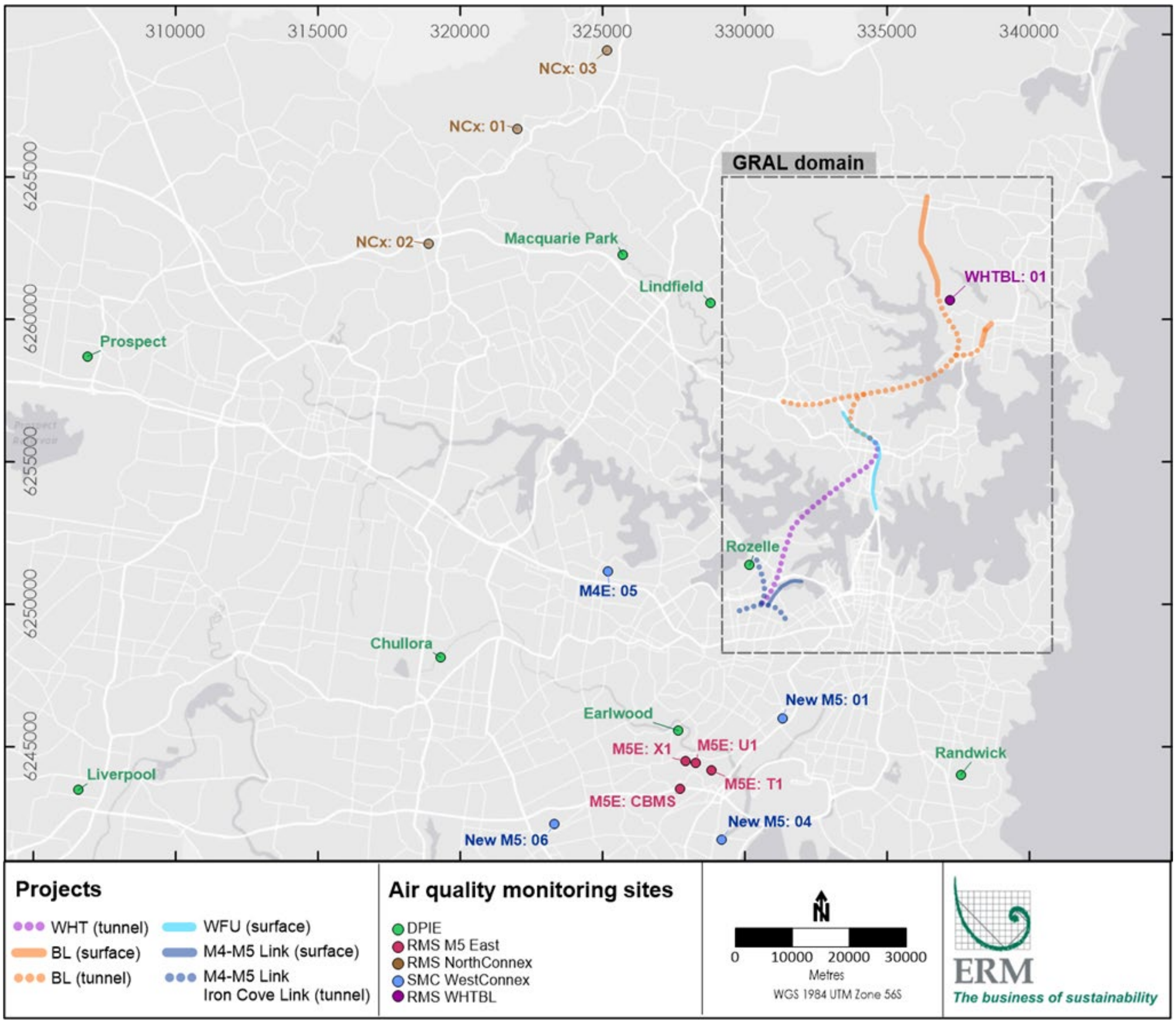


Figure 5-1 **Locations of background air quality monitoring sites**

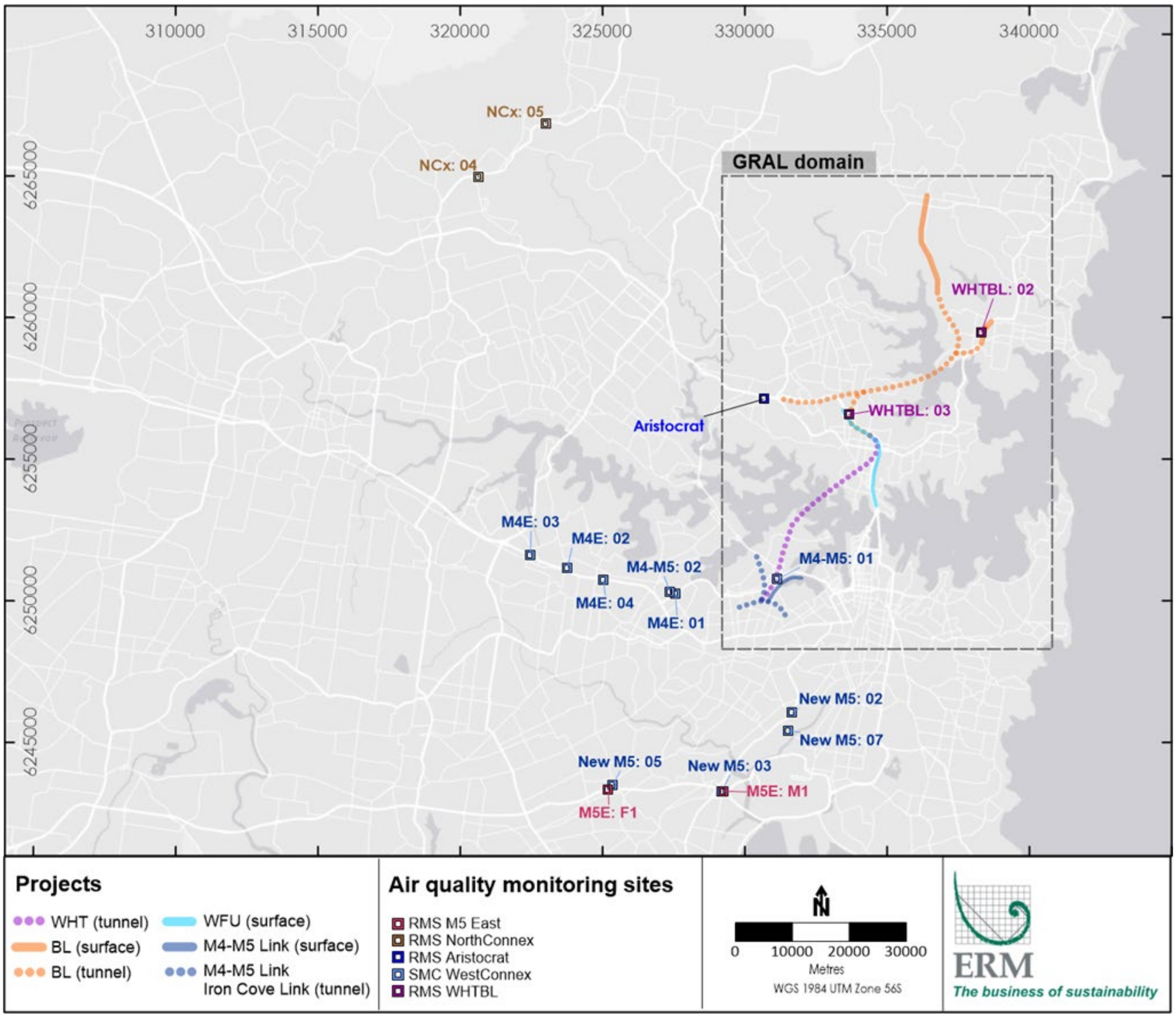


Figure 5-2 Locations of road air quality monitoring sites

Background air quality relevant to the assessment of carbon monoxide, nitrogen dioxide and particulate matter were determined in Appendix H (Technical working paper: Air quality) of the environmental impact statement on the basis of data from these monitoring stations. The background air quality considered in Appendix H (Technical working paper: Air quality) of the environmental impact statement related to air quality in areas away from major roadways.

In relation to the background air quality considered in Appendix H (Technical working paper: Air quality) of the environmental impact statement for the study area, the following is 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
- **NO_2:** 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 NO_2 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
- **O_3:** 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 O_3 concentrations were stable between 2004 – 2016
- **PM_{10}:** background concentrations of PM_{10} (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 eight micrograms per cubic metre. There have been a number of exceedances of the 24 hour average criterion of 25 micrograms per cubic metre
- **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

Appendix H (Technical working paper: Air quality) of the environmental impact statement 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	BL3, BL4, BL5, BL6	Construction works associated with Beaches Link component of the project. Construction works associated with the upgrade and realignment of the Gore Hill Freeway. Collectively, this would include (but not limited to) tunnel decline structures and construction of tunnel portals and ramps, construction of operational ancillary infrastructure and adjustments to other infrastructure (eg shared user transport infrastructure).	Q1 2023 – Q2 2027
Zone 2	BL1, BL2	Construction works associated with Beaches Link tunnel decline structures and tunnel portals at Cammeray Golf Course (BL1) and Flat Rock Drive (BL2), and connections to Warringah Freeway, including fitout of the Warringah Freeway ventilation outlet.	Q11 2023 – Q4 2027
Zone 3	BL7, BL8, BL9	Construction of the harbour crossing (including cofferdam excavation, dredging and handling of dredged material).	Q1 2023 – Q2 2027
Zone 4	BL10, BL11	Construction works associated with connections and integration of Beaches Link to the surrounding road network at Balgowlah. This includes (but is not limited to) construction of portals and the new access road, modifications to existing surface roads (including Burnt Bridge Creek Deviation), construction of the Burnt Bridge Creek Deviation ventilation outlet and motorway facility and construction of the new and improved open space and recreation facilities at Balgowlah	Q1 2023 – Q4 2028
Zone 5	BL12, BL13, BL14	Construction works associated with connections and integration of Beaches Link with Wakehurst Parkway at Seaforth and Killarney Heights. This includes (but is not limited to) surface road works associated with the realignment and upgrade of Wakehurst Parkway and minor changes to intersections, as well as the construction of the ventilation outlet and motorway facilities at the Wakehurst Parkway.	Q1 2023 – Q4 2027

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 Appendix H (Technical working paper: Air quality) of the environmental impact statement during construction works. The figure also shows the location of the zones considered in each of the construction sites.

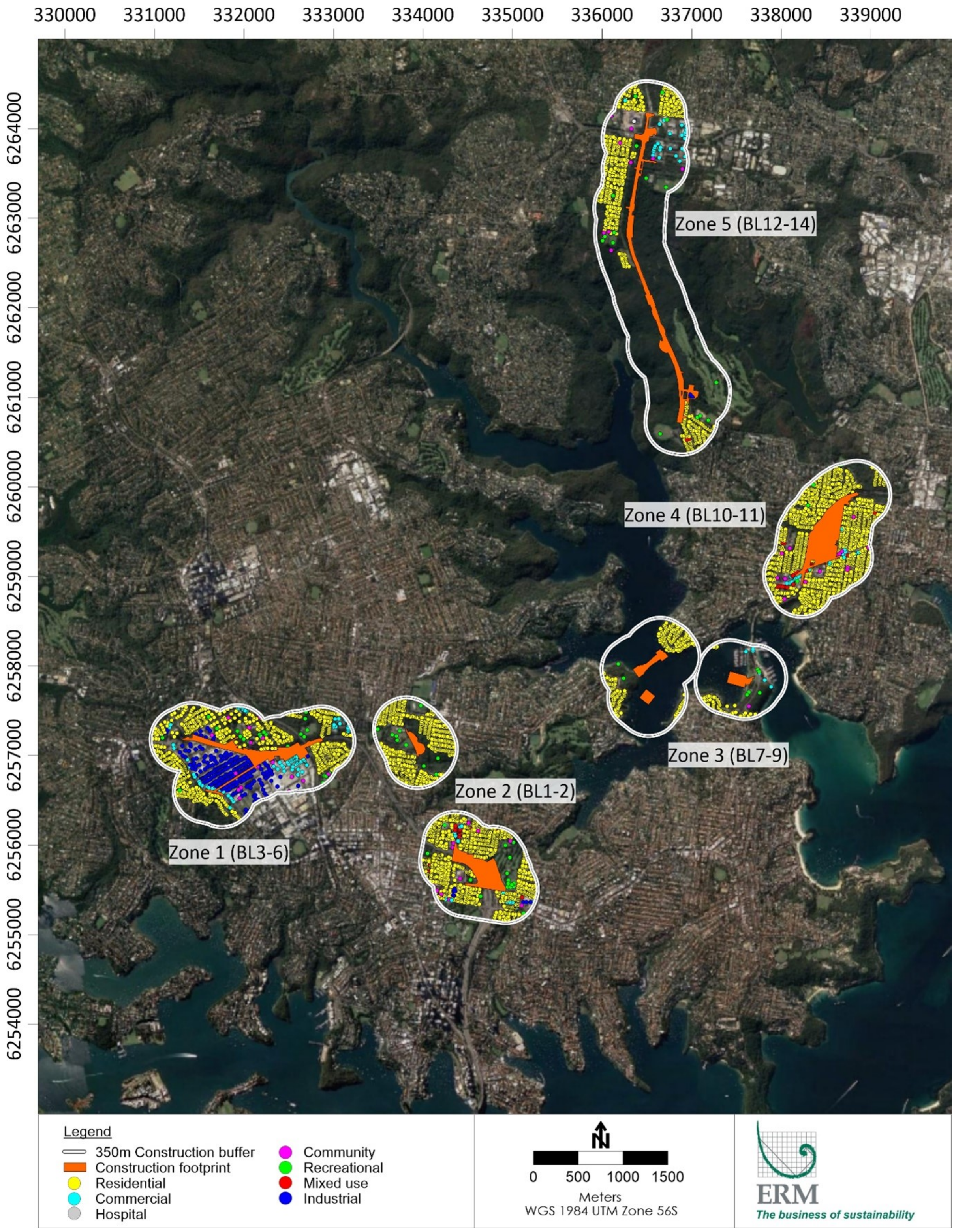


Figure 5-3 Location of sensitive human receptors near the construction of the project

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. Hence 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement. In relation to health impacts, the following levels of risk were identified for the following sites (see Table 5-1 for scenario details):

- Zone 1: High risk for all activities
- Zone 2: Medium risk for all activities
- Zone 3: Low risk for earthworks, construction and track-out, with no applicable risk for demolition
- Zone 4: Medium risk for demolition and high risk for all other activities
- Zone 5: Medium 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. Hence, where mitigation measures are appropriately implemented, Appendix H (Technical working paper: Air quality) of the environmental impact statement concluded that the residual risk level would normally be 'not significant'.

However, even with a rigorous dust mitigation and management measures in place, it is not possible to guarantee that the dust mitigation measures will 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 effects will be not significant.

Construction air quality management measures will 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement 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 dredged 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 Australian Government Department of the Department of the Agriculture, Water and the Environment (DAWE). For material that is unsuitable for sea 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 licensed 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. The material has the potential to generate odour once the material is exposed to air. The location for onshore transfer would be determined during detailed design (with necessary environmental assessments and approvals obtained prior to the activity commencing). Assessment of the potential for odours to be generated (ERM, 2020) determined that it is unlikely that there would be detectable odours at any sensitive receptor from dredged material from Middle Harbour.

The area to the west of Flat Rock Drive and the proposed location of the Flat Rock Drive construction support site (BL2) within Flat Rock Reserve were used extensively as a municipal landfill prior to redevelopment as open space and recreation facilities. Following the construction of Flat Rock Drive in 1968, and prior to 1971, some areas to the east of the road where the construction support site is proposed were filled with material comprising of putrescible waste. Since that time the majority of fill east of the road has been non-putrescible, predominantly consisting of building and demolition waste. There is, however, some potential that putrescible material could be encountered during excavation that occur at the construction support site. There is also some potential that potentially odorous landfill gases might be present in the soils underneath the Flat Rock Drive construction support site (BL2) from any putrescible waste present, or that might have migrated from the landfilled areas to the west. Excavations on site could release these landfill gases (if present). The investigation that was carried out on site in the vicinity of the locations where excavations are proposed as part of the project did not encounter odorous materials and gases, indicating that the potential to find a significant amount of odorous materials and gases is low. Further investigations are proposed prior to commencement of excavations at the construction support site to confirm potential odour issues and identify appropriate mitigation and management measures that would reduce the potential for impacts at sensitive receivers in the vicinity.

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 Beaches Link tunnel) outlined below, and shown on Figure 5-4:

- Existing facility:
  - Outlet A Lane Cove Tunnel (Marden Street, Artarmon)
  - Outlet B Cross City Tunnel (west of Harbour St, 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 ventilation facilities for the Western Harbour Tunnel:
  - Outlet F Rozelle Interchange
  - Outlet G Warringah Freeway

- Proposed ventilation facilities for the Beaches Link (the project subject to this health impact assessment):
  - 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 H, I, J and K. The remaining outlets (A, B, C, D, E, F and G) were included to assess potential cumulative impacts only. Further details of the ventilation facilities considered in the assessment are provided in Appendix H (Technical working paper: Air quality) of the environmental impact statement.

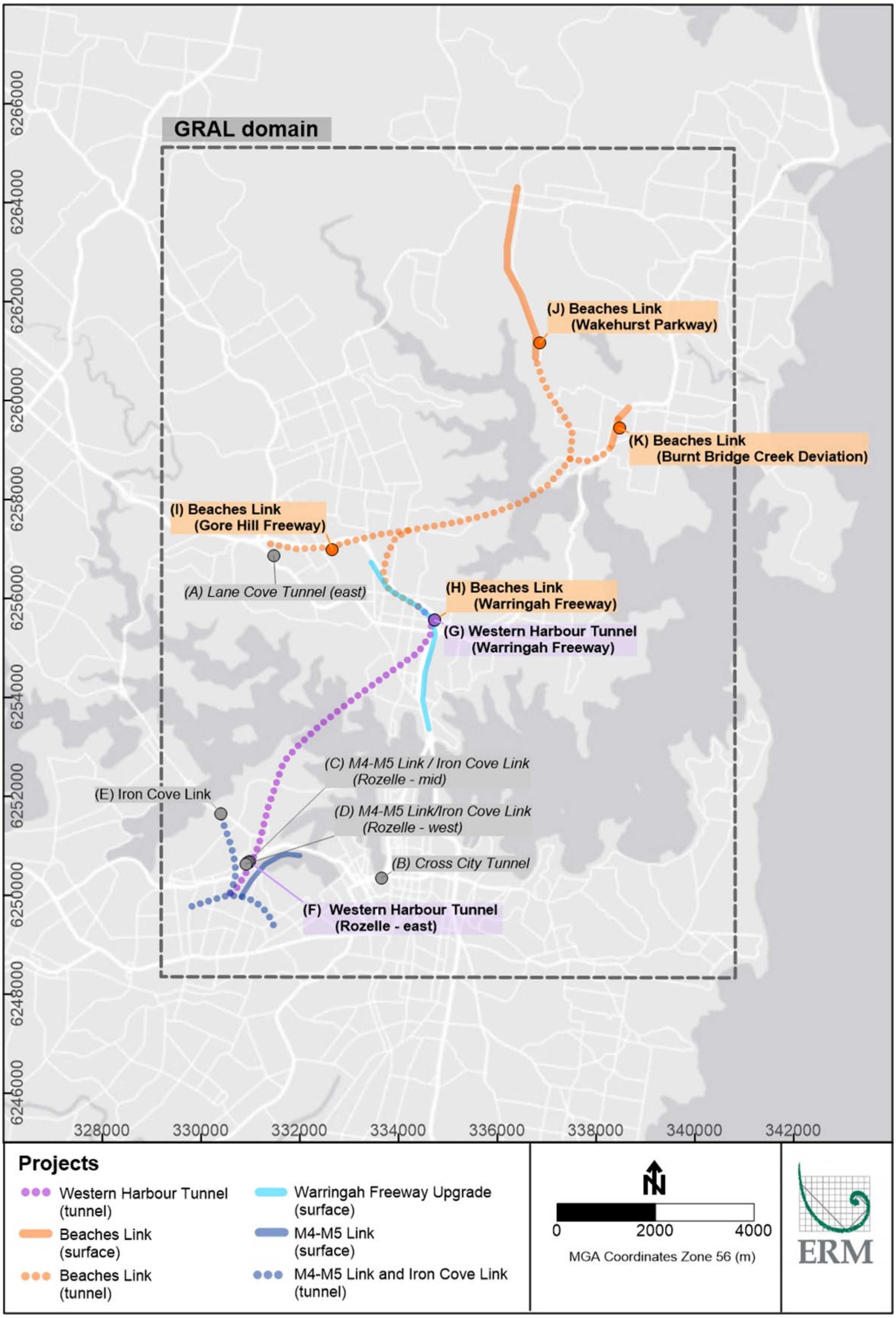


Figure 5-4 Locations of all tunnel ventilation outlets included in the assessment of air quality

The operational ambient air quality assessment was based upon 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 5-5) that includes the study area, local terrain, and project-specific emission sources.

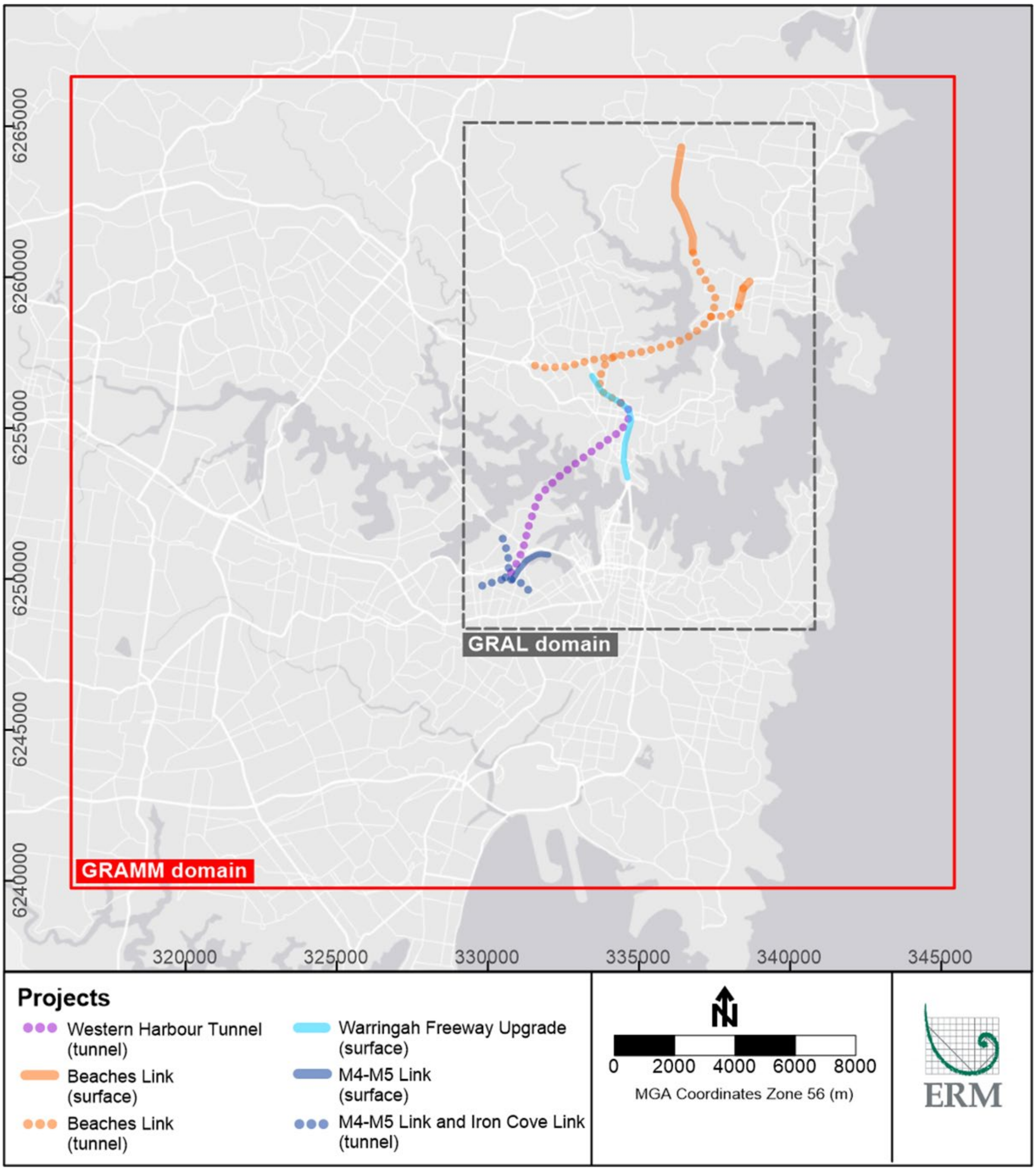


Figure 5-5 Modelling domains for GRAMM and GRAL

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

- 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement 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 WestConnex is complete. It is called ‘do minimum’ rather than ‘do nothing’ as it assumes that on-going 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 (including Warringah Freeway Upgrade) also completed
- **‘Do something cumulative 2027’:** As for the ‘Do something 2027’, but with Sydney Gateway, Western Harbour Tunnel, Warringah Freeway Upgrade and M6 Motorway – 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 M6 Motorway also completed.

More specific details associated with each of these scenarios is outlined in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement (Jacobs, 2020).

5.4.1 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement).

5.6 Assessment of volatile organic compounds and polycyclic aromatic hydrocarbons

5.6.1 General

Technical working paper: Air quality 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 speciated (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 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) (NSW 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; NSW 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* (NSW EPA, 2012), for the vehicle fleet assessed in Appendix H (Technical working paper: Air quality) of the environmental impact statement (as summarised above). In relation to passenger vehicles it has been assumed that 60 per cent[2] 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 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.

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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 DAWE) (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). 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 relates 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 study 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 Polycyclic aromatic hydrocarbon 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 undertaken 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, 2012a) 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 volatile organic compounds 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 ($\mu g/m^3$)	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, 2015).
Toluene	15,000	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, 2013d).
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, 2013c).
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.

Compound assessed	Acute health based guideline (µg/m^3)	Basis
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 µg/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 µg/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 µg/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 µg/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 µg/m^3	Formaldehyde is classified by IARC as carcinogenic to humans. The guideline developed by TCEQ (TCEQ 2013b) 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).
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 that 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.

Compound assessed	Chronic health based guideline	Basis
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 2009a). # 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.
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 2013a). 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 toxicity equivalent (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 2012a):

- 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 the program of works) one-hour average concentration against the relevant acute guidelines. This is the maximum one-hour average concentration reported anywhere in the study 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 2012a). 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement. For assessments presented in Tables 5-6 to 5-9 the concentrations modelled are the total concentrations, namely background or background plus project or program of works, while in Tables 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/m^3)	Hazard Index	Maximum concentration (µg/m^3)	Hazard Index	Maximum concentration (µg/m^3)	Hazard Index
Benzene	8.7	0.015	7.8	0.013	8.4	0.015
Toluene	15.7	0.0010	14.2	0.00094	15.3	0.001
Xylenes	13.0	0.0018	11.7	0.0016	12.6	0.0017
1,3-Butadiene	2.3	0.0035	2.1	0.0032	2.3	0.0034
Formaldehyde	7.5	0.15	6.8	0.14	7.3	0.15
Acetaldehyde	3.5	0.007	3.1	0.0066	3.4	0.0072
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/m^3)	Hazard Index	Maximum concentration (µg/m^3)	Hazard Index	Maximum concentration (µg/m^3)	Hazard Index
Benzene	5.8	0.010	5.8	0.010	5.5	0.0094
Toluene	10.1	0.0007	10.1	0.00068	9.5	0.00063
Xylenes	8.3	0.0012	8.4	0.0011	7.8	0.001
1,3-Butadiene	1.6	0.0024	1.6	0.0024	1.5	0.0023
Formaldehyde	7.9	0.16	7.9	0.16	7.4	0.15
Acetaldehyde	3.4	0.007	3.4	0.0073	3.2	0.0068
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/m^3)	Hazard Index	Max concentration (µg/m^3)	Hazard Index	Max concentration (µg/m^3)	Hazard Index
Benzene	0.44	0.015	0.44	0.015	0.47	0.016
Toluene	0.81	0.00016	0.81	0.00016	0.86	0.00017
Xylenes	0.67	0.0030	0.67	0.0030	0.71	0.0032
Formaldehyde	0.39	0.12	0.39	0.12	0.41	0.12
Acetaldehyde	0.18	0.020	0.18	0.020	0.19	0.021
Naphthalene	0.063	0.022	0.063	0.022	0.067	0.022
Acenaphthylene	0.0044	2.2x10^{-5}	0.0044	2.2x10^{-5}	0.0047	2.3x10^{-5}
Acenaphthene	0.0018	8.9x10^{-6}	0.0018	8.9x10^{-6}	0.0019	9.5x10^{-6}
Fluorene	0.0045	3.2x10^{-5}	0.0045	3.2x10^{-5}	0.0048	3.4x10^{-5}
Phenanthrene	0.0030	2. x10^{-5}	0.0030	2.2x10^{-5}	0.0032	2.3x10^{-5}
Anthracene	0.00044	4.4x10^{-7}	0.00044	4.4x10^{-7}	0.00047	4.7x10^{-7}
Fluoranthene	0.00040	2.9x10^{-6}	0.00040	2.9x10^{-6}	0.00043	3.1x10^{-6}
Pyrene	0.00064	6.4x10^{-6}	0.00066	6.4x10^{-6}	0.00067	6.7x10^{-6}
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	0.28	0.009	0.32	0.011
Toluene	0.52	0.00010	0.48	0.00010	0.56	0.00011
Xylenes	0.43	0.0019	0.40	0.0018	0.46	0.0021
Formaldehyde	0.41	0.12	0.38	0.11	0.44	0.13
Acetaldehyde	0.18	0.019	0.16	0.018	0.19	0.021
Naphthalene	0.059	0.020	0.055	0.018	0.063	0.021
Acenaphthylene	0.0041	1.9×10^{-5}	0.0038	1.9×10^{-5}	0.0044	2.2×10^{-5}
Acenaphthene	0.0017	7.8×10^{-6}	0.0016	7.8×10^{-6}	0.0018	9.0×10^{-6}
Fluorene	0.0042	2.8×10^{-5}	0.0039	2.8×10^{-5}	0.0045	3.2×10^{-5}
Phenanthrene	0.0028	1.9×10^{-5}	0.0027	1.9×10^{-5}	0.0031	2.2×10^{-5}
Anthracene	0.00041	3.8×10^{-7}	0.00038	3.8×10^{-7}	0.00044	4.4×10^{-7}
Fluoranthene	0.00038	2.5×10^{-6}	0.00035	2.5×10^{-6}	0.00041	2.9×10^{-6}
Pyrene	0.00059	5.5×10^{-6}	0.00055	5.5×10^{-6}	0.00064	6.4×10^{-6}
Total Hazard Index – Residential		**0.2**		**0.2**		**0.2**
Max Hazard Index – Commercial/Industrial		**0.04**		**0.03**		**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	0.047	1×10^{-7}	0.051	1×10^{-7}
1,3-Butadiene	0.013	2×10^{-9}	0.014	3×10^{-9}
Benzo(a)pyrene TEQ	0.00044	2×10^{-5}	0.00047	2×10^{-5}
Total carcinogenic risk – Residential		**2×10^{-5}**		**2×10^{-5}**
Maximum carcinogenic risk – Commercial/Industrial		**4×10^{-6}**		**4×10^{-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 ($\mu g/m^3$)	ILCR	Maximum concentration ($\mu g/m^3$)	ILCR
Benzene	0.082	$2x10^{-7}$	0.041	$1x10^{-7}$
1,3-Butadiene	0.022	$4x10^{-9}$	0.011	$2x10^{-9}$
Benzo(a)pyrene TEQ	0.0011	$4x10^{-5}$	0.00053	$2x10^{-5}$
Total carcinogenic risk – Residential		**$4x10^{-5}$**		**$2x10^{-5}$**
Maximum carcinogenic risk – Commercial/Industrial		**$8x10^{-6}$**		**$4x10^{-6}$**

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 (Tables 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 $4x10^{-5}$ 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 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 1998 amended 2016) 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 studies[3] 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

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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.

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.

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 milligrams per cubic metre or 10,000 micrograms per cubic metre) over an eight-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 milligrams per cubic metre) and one-hour average (30 milligrams per cubic metre) concentrations of CO in ambient air. These guidelines are based on criteria established by the WHO (WHO 2000c) 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 one-hour average and eight-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	5.5	4.2	3.8	3.8
2037						
Maximum	5.1	4.8	5.0	3.5	3.4	3.5
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 NO_2, 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, the NSW EPA (2019) estimated that on-road vehicles account for about 55 per cent of emissions of NO_X, industrial facilities account for 13 per cent, other mobile sources account for about 27 per cent, with the remainder from domestic/commercial sources.

In terms of health effects, NO_2 is the only oxide of nitrogen that may be of concern (WHO 2000a). NO_2 can cause inflammation of the respiratory system and increase susceptibility to respiratory infection. Exposure to elevated levels of NO_2 has also been associated with increased mortality, particularly related to respiratory disease, and with increased hospital admissions for asthma and heart disease patients (WHO 2013a). Asthmatics, the elderly and people with existing cardiovascular and respiratory disease are particularly susceptible to the effects of NO_2 (Morgan, Broom & Jalaludin 2013; NEPC 2010). The health effects associated with exposure to NO_2 depend on the duration of exposure as well as the concentration.

Guidelines are available from the NSW EPA and NEPC (NEPC 1998 amended 2016) which indicate acceptable concentrations of NO_2. 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, 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 NO_2 it is important to consider the following:

- Whether the evidence suggests that associations between exposure to NO_2 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 nitrogen dioxide (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 NO_2 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 NO_2 after adjustment/correction for co-exposures with particulate matter (COMEAP 2015)
- Whether the assessment of potential health effects associated with exposure to different levels of NO_2 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 NO_2 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 study area evaluated in this assessment) background levels of NO_2 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 nitrogen dioxide concentration in the local community using appropriate risk calculations. For the conduct of risk assessments in relation to exposure to NO_2, the WHO (WHO 2013a) 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 NO_2 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 NO_2 relates to the maximum predicted total (ie background plus project) one-hour average concentration in air. The guideline of 246 micrograms per cubic metre (or 120 parts per billion by volume) is based on a LOAEL of 409–613 micrograms per cubic metre 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 Environment

Protection Authority) 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 one-hour average concentrations of NO_2 from the modelled scenarios.

Table 5-13 Review of potential acute health impacts – NO_2

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	475	363
2037			
Maximum	433	485	442
Acute health based guideline	**246**	**246**	**246**

The maximum total concentrations of NO_2 presented in the above table exceed the acute NEPC guideline of 246 micrograms per cubic metre 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 for converting NO_X to NO_2 (that overestimates short-term one-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 NO_2 concentrations that is not likely to ever occur (refer to Appendix H (Technical working paper: Air quality) of the environmental impact statement for more detailed discussion). As a result, the magnitude of the maximum total concentrations reported for NO_2 over a one-hour average cannot be used to evaluate the potential for adverse health effects in the community.

As assessment of total concentrations to NO_2 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 NO_2, 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 NO_2 relates to the maximum predicted total (ie background plus project) annual average concentration in air. The guideline of 62 micrograms per cubic metre (or 30 ppbv [parts per billion by volume]) is based on a LOAEL of the order of 40 to 80 parts per billion by volume (around 75 to 150 micrograms per cubic metre) during early and middle childhood years which 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 to 40 parts per billion by volume (38 to 75 micrograms per cubic metre) (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 NO_2 from the modelled scenarios.

Table 5-14 Review of potential chronic health impacts – NO_2

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	43.5	40.7	35.5
2037			
Maximum	39.4	40.6	33.9
Chronic health based guideline	**62**		

All the concentrations of NO_2 presented in the above table are below the chronic NEPC guideline of 62 micrograms per cubic metre. In addition, the concentrations of NO_2 are lower for the cumulative scenario. Hence there are no adverse health effects expected in relation to chronic exposures to NO_2 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 NO_2, 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 NO_2 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 NO_2 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[1]	0.00188 (0.19%)	Relationship derived from modelling undertaken for 5 cities in Australia and 1 day lag (EPHC 2010; Golder 2013)
Mortality, respiratory	Short term	All ages[1]	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 1: Relationships established for all ages, including young children and the elderly

It is noted that while the maximum concentrations of NO_2 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 NO_2 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 5-4 presents a summary of the calculated change in risk associated with changes in NO_2 concentrations at each community receptor location evaluated. This change is the predicted NO_2 concentrations with the project ('Do something' or 'Do something cumulative') minus the NO_2 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 NO_2 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 NO_2 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 NO_2 concentrations with operation of the project

Scenario and receptor	Maximum change in individual risk from short term exposure to NO_2 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	$3x10^{-5}$	$5x10^{-6}$	$6x10^{-5}$
Maximum workplace	$4x10^{-5}$	$8x10^{-6}$	$8x10^{-5}$
Maximum childcare and schools	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$
Maximum aged care	$9x10^{-6}$	$2x10^{-6}$	$2x10^{-5}$
Maximum hospitals/medical	$5x10^{-6}$	$9x10^{-7}$	$9x10^{-6}$
Maximum open space	$2x10^{-5}$	$3x10^{-6}$	$3x10^{-5}$
Maximum from sensitive receptors	$7x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
'Do something cumulative 2027'			
Maximum residential	$3x10^{-5}$	$5x10^{-6}$	$5x10^{-5}$
Maximum workplace	$2x10^{-5}$	$3x10^{-6}$	$3x10^{-5}$
Maximum childcare and schools	$8x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
Maximum aged care	$8x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
Maximum hospitals/medical	$5x10^{-6}$	$9x10^{-7}$	$9x10^{-6}$
Maximum open space	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$

Scenario and receptor	**Maximum change in individual risk from short term exposure to NO_2 for the following health endpoints**		
	Mortality: All causes (all ages)	**Mortality: Respiratory (all ages)**	**Asthma ED Admissions (1–14 years)**
Maximum from sensitive receptors	$7x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
'Do something 2037' (ie with project)			
Maximum residential	$3x10^{-5}$	$5x10^{-6}$	$5x10^{-5}$
Maximum workplace	$5x10^{-5}$	$8x10^{-6}$	$8x10^{-5}$
Maximum childcare and schools	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$
Maximum aged care	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$
Maximum hospitals/medical	$8x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
Maximum open space	$2x10^{-5}$	$3x10^{-6}$	$3x10^{-5}$
Maximum from sensitive receptors	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$
'Do something cumulative 2037'			
Maximum residential	$2x10^{-5}$	$4x10^{-6}$	$4x10^{-5}$
Maximum workplace	$2x10^{-5}$	$4x10^{-6}$	$4x10^{-5}$
Maximum childcare and schools	$1x10^{-5}$	$2x10^{-6}$	$2x10^{-5}$
Maximum aged care	$7x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
Maximum hospitals/medical	$9x10^{-6}$	$2x10^{-6}$	$2x10^{-5}$
Maximum open space	$2x10^{-5}$	$3x10^{-6}$	$3x10^{-5}$
Maximum from sensitive receptors	$8 x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$
Negligible risks	$<1x10^{-6}$		
Tolerable/acceptable risks	$\geq1x10^{-6}$ and $\leq1x10^{-4}$		
Unacceptable risks	$>1x10^{-4}$		

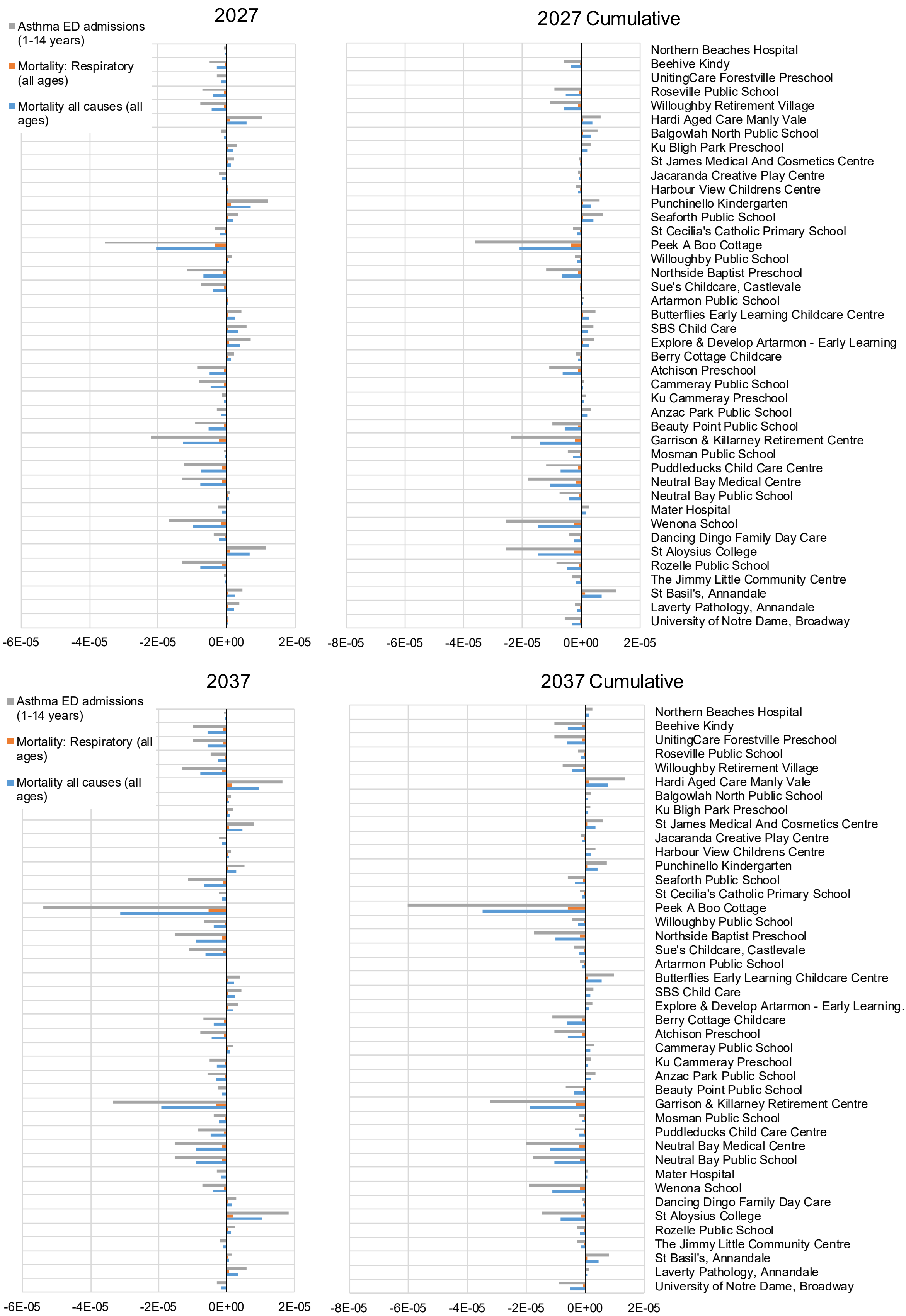

Figure 5-6 **Change in calculated risk for key health endpoints associated with changes in NO_2 concentrations at community receptors ('Do something 2027' Scenario and 'Do something cumulative 2037')**

Table 5-17 Calculated changes in incidence of health effects in population associated with changes in NO_2 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’ (with project)						
Canada Bay	0.000030	0.0000055	0.0000083	-0.00071	-0.00013	-0.00019
North Sydney - Mosman	-0.26	-0.048	-0.068	-0.27	-0.050	-0.070
Sydney Inner West	0.0029	0.00039	0.00056	-0.013	-0.0018	-0.0026
Sydney	-0.55	-0.079	-0.047	-0.31	-0.044	-0.027
Lane Cove - Chatswood	-0.12	-0.026	-0.045	-0.12	-0.025	-0.044
Hunters Hill	-0.00057	-0.000083	-0.00015	0.0015	0.00022	0.00040
Woollahra (Eastern Suburbs - North)	-0.029	-0.0054	-0.0079	-0.019	-0.0035	-0.0052
Northern Beaches	-0.029	-0.0046	-0.0086	-0.039	-0.0061	-0.012
Ku-ring-gai	-0.028	-0.0055	-0.011	-0.024	-0.0048	-0.0094
Total for all LGAs	**-1.0**	**-0.17**	**-0.19**	**-0.79**	**-0.14**	**-0.17**
‘Do something cumulative’						
Canada Bay	0.00050	0.000090	0.00014	-0.0015	-0.00026	-0.00040
North Sydney - Mosman	-0.33	-0.061	-0.086	-0.37	-0.068	-0.096
Sydney Inner West	0.0022	0.00030	0.00043	-0.016	-0.0022	-0.0032
Sydney	-0.92	-0.13	-0.079	-0.72	-0.10	-0.062
Lane Cove - Chatswood	-0.097	-0.021	-0.037	-0.091	-0.020	-0.034
Hunters Hill	-0.00054	-0.000078	-0.00014	0.00051	0.000074	0.00014
Woollahra (Eastern Suburbs - North)	-0.050	-0.0092	-0.013	-0.049	-0.0090	-0.013
Northern Beaches	-0.011	-0.0017	-0.0033	0.021	0.0033	0.0063
Ku-ring-gai	-0.027	-0.0054	-0.011	-0.023	-0.0045	-0.0089
Total for all LGAs	**-1.4**	**-0.23**	**-0.23**	**-1.2**	**-0.20**	**-0.21**

Note: Negative value (also shaded blue) 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 NO_2 levels associated with the project, indicates the following:

- The maximum risks calculated for exposures in residential areas are less than $1x10^{-4}$ and are therefore considered to be tolerable/acceptable
- The maximum risks calculated for exposures in commercial/industrial areas are less than $1x10^{-4}$ 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 $1x10^{-4}$ and considered to be tolerable/acceptable
- All risks calculated for exposures at community receptors are below $1x10^{-4}$ 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 NO_2 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 about 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 (Canada Bay, Sydney, Inner West, 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 studies[5] 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 particle[6] size generally below 50 to 100 microns in diameter[7]. 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 system[8] 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
- PM_{10} (particulate matter less than 10 microns in diameter), $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter), PM_1 (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 tract[9] 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 PM_{10}). 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 NO_2 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, PM_{10} and adverse health effects (USEPA 2009b; WHO 2003).

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 PM_{10}. 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 PM_{10} are well established and provide

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.

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 PM_{10} data. This means this data on PM_{10} 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 PM_{10} 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 PM_{10} data and assuming that a certain percentage of PM_{10} 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 PM_1 and the current science is inconclusive in relation to ultrafine particulates. The associations developed for $PM_{2.5}$ would include a significant contribution from PM_1 (as PM_1 comprises a significant proportion of $PM_{2.5}$) and hence health effects observed for PM_1 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, PM_{10}. 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 2009b):

- 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 2009b).

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 PM_{10}, 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 PM_{10} 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 PM_{10}) and effects on health that are causal. The effects related to exposures to $PM_{2.5}$ (or PM_{10}) 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 PM_{10}, even where the concentrations are below the current guidelines. Guidelines are currently available for the assessment of $PM_{2.5}$ and PM_{10} in New South Wales (DEC 2005) and Australia (NEPC 1998 amended 2016, 2002, 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 PM_{10} 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 PM_{10} 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 PM_{10} is based on a comparison of the total concentrations predicted in 2027 and 2037 (ie without the project ('Do minimum'), with the project ('Do something') and for the cumulative scenario ('Do something cumulative'), 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 Annual	25 with goal of 20 by 2025 8 with goal of 7 by 2025	(NEPC 2016)

In relation to the current NEPC guidelines, the following is noted (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 PM_{10} 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 OEH	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 µg/m^3 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 PM_{10} relate to total concentrations in the air (from all sources including the project). The background air quality data that has been used in Appendix H (Technical working paper: Air quality) of the environmental impact statement 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 PM_{10} 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/m³)			Maximum 24 hour average PM_{10} concentration (µg/m³)		
	'Do minimum'	'Do something'	'Do something cumulative'	'Do minimum'	'Do something'	'Do something cumulative'
2027						
Maximum	37.2	35.9	33.9	71.2	71.1	65.9
Maximum residential	33.8	33.1	31.0	66.3	65.1	62.3
Maximum commercial	37.2	35.1	33.3	71.2	69.2	64.9
2037						
Maximum	36.3	36.5	33.4	70.8	70.4	68.8
Maximum residential	34.0	34.3	30.8	67.2	65.6	64.1
Maximum commercial	36.3	36.5	33.4	68.2	70.3	67.1
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/m³)			Maximum annual average PM_{10} concentration (µg/m³)		
	'Do minimum'	'Do something'	'Do something cumulative'	'Do minimum'	'Do something'	'Do something cumulative'
2027						
Maximum	14.2	14.3	11.8	26.0	26.9	23.2
Maximum residential	11.7	11.4	10.6	22.3	21.8	21.0
Maximum commercial	14.2	14.3	11.2	26.0	26.9	22.4
2037						
Maximum	14.3	14.5	11.7	26.3	27.1	23.8
Maximum residential	11.8	11.4	10.6	22.9	22.2	21.3
Maximum commercial	14.3	14.5	11.3	26.3	27.1	22.8
Guideline	**8** **7 by 2025 (goal)**			**25**		

Due in large part to the existing levels of $PM_{2.5}$ in air within the 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 PM_{10} presented in the above tables 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 PM_{10} is due to the existing levels of PM_{10} 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 PM_{10}, 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 PM_{10} 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 PM_{10}

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 PM_{10} the assessment of impacts on health has utilised robust, published, quantitative relationships (exposure-response relationships) that relate a change in $PM_{2.5}$ or PM_{10} 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 PM_{10} 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 PM_{10} 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 to 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 µg/m^3	Adopted β coefficient (as per cent) for 1 µg/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 about 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 µg/m^3	Adopted β coefficient (as per cent) for 1 µg/m^3 increase in PM	Reference
$PM_{2.5}$: Cardio-pulmonary mortality	Long term	≥30yrs	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 PM_{10} exposure levels due to the project in 2027 and 2037 (as provided in Appendix H (Technical working paper: Air quality) of the environmental impact statement) 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 micrograms per cubic metre 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 $PM_{2.5}$ concentrations 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 PM_{10} guidelines. However, the potential for exposure to DPM to result 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 World Health Organization (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 an acceptable risk for specific development projects might be.

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) in order 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’.

Hence 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 is 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 PM_{10}. For a number of receptors there is an increase in the concentration of $PM_{2.5}$ and PM_{10}, 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement). This is illustrated in Figure 5-7, 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 some roadways (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 PM_{10} 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 PM_{10} 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 5-8 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 5-7 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 PM_{10} 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	short-term	short-term	short-term	short-term	long-term	short-term	short-term	short-term	long-term
			≥30 yrs	≥65 yrs	≥65 yrs	all	all	≥30 yrs	all	all	1–14 yrs	all
'Do something 2027' (ie with project)												
Maximum residential	1.10	0.82	$5x10^{-5}$	$6x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$3x10^{-6}$	$4x10^{-5}$	$1x10^{-6}$	$5x10^{-7}$	$1x10^{-5}$	$3x10^{-5}$
Maximum childcare	0.36	0.20	$1x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$9x10^{-7}$	$8x10^{-7}$	$1x10^{-5}$	$3x10^{-7}$	$1x10^{-7}$	$4x10^{-6}$	$7x10^{-6}$
Maximum schools	0.39	0.24	$1x10^{-5}$	$2x10^{-5}$	$4x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-5}$	$3x10^{-7}$	$1x10^{-7}$	$4x10^{-6}$	$8x10^{-6}$
Maximum aged care	0.18	0.33	$2x10^{-5}$	$2x10^{-5}$	$5x10^{-6}$	$5x10^{-7}$	$1x10^{-6}$	$2x10^{-5}$	$4x10^{-7}$	$2x10^{-7}$	$6x10^{-6}$	$1x10^{-5}$
Maximum hospital	0.19	0.11	$7x10^{-6}$	$8x10^{-6}$	$2x10^{-6}$	$5x10^{-7}$	$4x10^{-7}$	$6x10^{-6}$	$1x10^{-7}$	$7x10^{-8}$	$2x10^{-6}$	$4x10^{-6}$
Maximum commercial/ industrial	2.30	1.28	$8x10^{-5}$	$9x10^{-5}$	$2x10^{-5}$	$6x10^{-6}$	$5x10^{-6}$	$7x10^{-5}$	$2x10^{-6}$	$8x10^{-7}$	$2x10^{-5}$	$4x10^{-5}$
Maximum open space	0.56	0.45	$3x10^{-5}$	$3x10^{-5}$	$7x10^{-6}$	$1x10^{-6}$	$2x10^{-6}$	$2x10^{-5}$	$6x10^{-7}$	$3x10^{-7}$	$8x10^{-6}$	$2x10^{-5}$
Maximum community receptors	0.35	0.15	$9x10^{-6}$	$1x10^{-5}$	$2x10^{-6}$	$9x10^{-7}$	$6x10^{-7}$	$8x10^{-6}$	$2x10^{-7}$	$9x10^{-8}$	$3x10^{-6}$	$5x10^{-6}$
'Do something cumulative 2027'												
Maximum residential	1.00	0.86	$5x10^{-5}$	$6x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$3x10^{-6}$	$5x10^{-5}$	$1x10^{-6}$	$5x10^{-7}$	$2x10^{-5}$	$3x10^{-5}$
Maximum childcare	0.22	0.20	$1x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$6x10^{-7}$	$8x10^{-7}$	$1x10^{-5}$	$3x10^{-7}$	$1x10^{-7}$	$4x10^{-6}$	$7x10^{-6}$
Maximum schools	0.26	0.13	$8x10^{-6}$	$1x10^{-5}$	$2x10^{-6}$	$7x10^{-7}$	$5x10^{-7}$	$7x10^{-6}$	$2x10^{-7}$	$8x10^{-8}$	$2x10^{-6}$	$4x10^{-6}$
Maximum aged care	0.46	0.11	$7x10^{-6}$	$8x10^{-6}$	$2x10^{-6}$	$1x10^{-6}$	$4x10^{-7}$	$6x10^{-6}$	$1x10^{-7}$	$7x10^{-8}$	$2x10^{-6}$	$4x10^{-6}$
Maximum hospital	0.27	0.15	$9x10^{-6}$	$1x10^{-5}$	$2x10^{-6}$	$7x10^{-7}$	$6x10^{-7}$	$8x10^{-6}$	$2x10^{-7}$	$9x10^{-8}$	$3x10^{-6}$	$5x10^{-6}$
Maximum commercial/ industrial	0.74	0.50	$3x10^{-5}$	$4x10^{-5}$	$8x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$	$3x10^{-5}$	$6x10^{-7}$	$3x10^{-7}$	$9x10^{-6}$	$2x10^{-5}$
Maximum open space	0.73	0.18	$1x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-5}$	$2x10^{-7}$	$1x10^{-7}$	$3 x10^{-6}$	$6x10^{-6}$

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	short-term	short-term	short-term	short-term	long-term	short-term	short-term	short-term	long-term
			≥30 yrs	≥65 yrs	≥65 yrs	all	all	≥30 yrs	all	all	1–14 yrs	all
Maximum community receptors	0.15	0.11	$7x10^{-6}$	$8x10^{-6}$	$2x10^{-6}$	$4x10^{-7}$	$4x10^{-7}$	$6x10^{-6}$	$1x10^{-7}$	$7x10^{-8}$	$2\ x10^{-6}$	$4x10^{-6}$
Negligible risks			**$<1x10^{-6}$**									
Tolerable/acceptable risks			**$≥1x10^{-6}$ and $≤1x10^{-4}$**									
Unacceptable risks			**$>1x10^{-4}$**									

Table 5-24 Calculated individual risk associated with changes in $PM_{2.5}$ and PM_{10} 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	short-term	short-term	short-term	short-term	long-term	short-term	short-term	short-term	long-term
			≥30 yrs	≥65 yrs	≥65 yrs	all	all	≥30 yrs	all	all	1–14 yrs	all
‘Do something 2037’ (ie with project)												
Maximum residential	1.30	0.82	5x10^{-5}	6x10^{-5}	1x10^{-5}	3x10^{-6}	3x10^{-6}	4x10^{-5}	1x10^{-6}	5x10^{-7}	1x10^{-5}	3x10^{-5}
Maximum childcare	0.42	0.25	1x10^{-5}	2x10^{-5}	4x10^{-6}	1x10^{-6}	1x10^{-6}	1x10^{-5}	3x10^{-7}	2x10^{-7}	4x10^{-6}	9x10^{-6}
Maximum schools	0.50	0.31	2x10^{-5}	2x10^{-5}	5x10^{-6}	1x10^{-6}	1x10^{-6}	2x10^{-5}	4x10^{-7}	2x10^{-7}	6x10^{-6}	1x10^{-5}
Maximum aged care	0.12	0.22	1x10^{-5}	2x10^{-5}	4x10^{-6}	3x10^{-7}	9x10^{-7}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	7x10^{-6}
Maximum hospital	0.15	0.21	1x10^{-5}	2x10^{-5}	3x10^{-6}	4x10^{-7}	8x10^{-7}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	7x10^{-6}
Maximum commercial/ industrial	2.3	1.65	1x10^{-4}	1x10^{-4}	3x10^{-5}	6x10^{-6}	7x10^{-6}	9x10^{-5}	2x10^{-6}	1x10^{-7}	3x10^{-5}	6x10^{-5}
Maximum open space	0.72	0.44	3x10^{-5}	3x10^{-5}	7x10^{-6}	2x10^{-6}	2x10^{-6}	2x10^{-5}	6x10^{-7}	3x10^{-7}	8x10^{-6}	1x10^{-5}
Maximum community receptors	0.29	0.17	1x10^{-5}	1x10^{-5}	3x10^{-6}	8x10^{-7}	7x10^{-7}	9x10^{-6}	2x10^{-7}	1x10^{-7}	3x10^{-6}	6x10^{-6}
‘Do something cumulative 2037’												
Maximum residential	1.20	0.71	4x10^{-5}	5x10^{-5}	1x10^{-5}	3x10^{-6}	3x10^{-6}	4x10^{-5}	9x10^{-7}	4x10^{-7}	1x10^{-5}	2x10^{-5}
Maximum childcare	0.26	0.24	1x10^{-5}	2x10^{-5}	4x10^{-6}	7x10^{-7}	1x10^{-6}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	8x10^{-6}
Maximum schools	0.34	0.24	1x10^{-5}	2x10^{-5}	4x10^{-6}	9x10^{-7}	1x10^{-6}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	8x10^{-6}
Maximum aged care	0.25	0.20	1x10^{-5}	1x10^{-5}	3x10^{-6}	6x10^{-7}	8x10^{-7}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	7x10^{-6}
Maximum hospital	0.35	0.21	1x10^{-5}	2x10^{-5}	3x10^{-6}	9x10^{-7}	8x10^{-7}	1x10^{-5}	3x10^{-7}	1x10^{-7}	4x10^{-6}	7x10^{-6}
Maximum commercial/ industrial	0.77	0.47	3x10^{-5}	3x10^{-5}	8x10^{-6}	2x10^{-6}	2x10^{-6}	3x10^{-5}	6x10^{-7}	3x10^{-7}	8x10^{-6}	2x10^{-5}
Maximum open space	0.89	0.62	4x10^{-5}	5x10^{-5}	1x10^{-5}	2x10^{-6}	2x10^{-6}	3x10^{-5}	8x10^{-7}	4x10^{-7}	1x10^{-5}	2x10^{-5}
Maximum community receptors	0.49	0.30	2x10^{-5}	2x10^{-5}	5x10^{-6}	1x10^{-6}	1x10^{-6}	2x10^{-5}	4x10^{-7}	2x10^{-7}	5x10^{-6}	1x10^{-5}
Negligible risks			**<1x10^{-6}**									
Tolerable/acceptable risks			**≥1x10^{-6} and ≤1x10^{-4}**									
Unacceptable risks			**>1x10^{-4}**									

Figure 5-8 **Calculated change in individual risk at community receptors from change in $PM_{2.5}$ concentrations (primary health endpoints) – project in 2027 and 2037**

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	0.00047	0.00014	0.000030	0.000048	0.00042	0.000014	0.000012	0.000033
North Sydney - Mosman	-0.22	-0.078	-0.017	-0.018	-0.20	-0.0053	-0.0052	-0.017
Sydney Inner West	0.0039	0.00092	0.00020	0.00051	0.0035	0.00014	0.00010	0.00026
Sydney	-0.45	-0.080	-0.018	-0.063	-0.41	-0.018	-0.012	-0.014
Lane Cove - Chatswood	-0.089	-0.024	-0.0054	-0.0091	-0.080	-0.0026	-0.0023	-0.0074
Hunters Hill	0.00064	0.00027	0.000059	0.000079	0.00057	0.000022	0.000016	0.000054
Woollahra (Eastern Suburbs - North)	-0.040	-0.014	-0.0031	-0.0038	-0.036	-0.0011	-0.00097	-0.0027
Northern Beaches	-0.013	-0.0042	-0.00092	-0.0015	-0.012	-0.00042	-0.00032	-0.0011
Ku-ring-gai	-0.015	-0.0055	-0.0012	-0.0014	-0.014	-0.00043	-0.00038	-0.0014
Total for all LGAs	**-0.83**	**-0.21**	**-0.045**	**-0.096**	**-0.75**	**-0.028**	**-0.021**	**-0.043**
'Do something cumulative 2027'								
Canada Bay	0.0026	0.00075	0.00017	0.00026	0.0023	0.000076	0.000065	0.00018
North Sydney - Mosman	-0.36	-0.13	-0.028	-0.029	-0.33	-0.0087	-0.0086	-0.027
Sydney Inner West	0.018	0.0042	0.00092	0.0023	0.016	0.00066	0.00043	0.0012
Sydney	-0.73	-0.13	-0.029	-0.10	-0.66	-0.029	-0.020	-0.023
Lane Cove - Chatswood	-0.10	-0.027	-0.0060	-0.010	-0.090	-0.0030	-0.0025	-0.0082
Hunters Hill	0.00066	0.00027	0.000061	0.000081	0.00059	0.000022	0.000016	0.000056
Woollahra (Eastern Suburbs - North)	-0.051	-0.018	-0.0039	-0.0048	-0.046	-0.0014	-0.0012	-0.0034
Northern Beaches	-0.011	-0.0036	-0.00081	-0.0013	-0.010	-0.00036	-0.00028	-0.00098
Ku-ring-gai	-0.020	-0.0073	-0.0016	-0.0019	-0.018	-0.00056	-0.00051	-0.0019
Total for all LGAs	**-1.3**	**-0.31**	**-0.068**	**-0.15**	**-1.1**	**-0.042**	**-0.033**	**-0.063**

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	0.0014	0.00041	0.000090	0.00014	0.0013	0.000041	0.000035	0.00010
North Sydney - Mosman	-0.21	-0.075	-0.017	-0.017	-0.19	-0.0051	-0.0050	-0.016
Sydney Inner West	-0.0019	-0.00046	-0.00010	-0.00026	-0.0017	-0.000073	-0.000048	-0.00013
Sydney	-0.27	-0.047	-0.010	-0.037	-0.24	-0.010	-0.0073	-0.0082
Lane Cove - Chatswood	-0.081	-0.022	-0.0049	-0.0083	-0.073	-0.0024	-0.0021	-0.0067
Hunters Hill	0.00039	0.00016	0.000036	0.000048	0.00035	0.000013	0.0000095	0.000033
Woollahra (Eastern Suburbs - North)	-0.018	-0.0063	-0.0014	-0.0017	-0.016	-0.00049	-0.00043	-0.0012
Northern Beaches	-0.015	-0.0047	-0.0010	-0.0016	-0.013	-0.00047	-0.00036	-0.0013
Ku-ring-gai	-0.016	-0.0059	-0.0013	-0.0015	-0.015	-0.00046	-0.00041	-0.0015
Total for all LGAs	**-0.61**	**-0.16**	**-0.036**	**-0.067**	**-0.55**	**-0.019**	**-0.016**	**-0.035**
'Do something cumulative 2037'								
Canada Bay	0.00088	0.00026	0.000057	0.000090	0.00079	0.000026	0.000022	0.000063
North Sydney - Mosman	-0.35	-0.12	-0.027	-0.028	-0.32	-0.0084	-0.0082	-0.026
Sydney Inner West	0.017	0.0041	0.00090	0.0023	0.015	0.00064	0.00042	0.0011
Sydney	-0.59	-0.10	-0.023	-0.082	-0.53	-0.023	-0.016	-0.018
Lane Cove - Chatswood	-0.061	-0.017	-0.0036	-0.0062	-0.055	-0.0018	-0.0015	-0.0050
Hunters Hill	0.00011	0.000046	0.000010	0.000014	0.000099	0.0000037	0.0000027	0.0000093
Woollahra (Eastern Suburbs - North)	-0.040	-0.014	-0.0031	-0.0038	-0.036	-0.0011	-0.00095	-0.0026
Northern Beaches	-0.017	-0.0056	-0.0012	-0.0020	-0.016	-0.00056	-0.00043	-0.0015
Ku-ring-gai	-0.014	-0.0051	-0.0011	-0.0013	-0.013	-0.00040	-0.00036	-0.0013
Total for all LGAs	**-1.1**	**-0.27**	**-0.059**	**-0.12**	**-0.95**	**-0.035**	**-0.027**	**-0.054**

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 $1x10^{-4}$ and considered to be tolerable/acceptable
- The maximum risks calculated for exposures in commercial/industrial areas are less than or equal to $1x10^{-4}$ 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 $1x10^{-4}$ 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 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
- 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. Hence 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).

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 undertaken 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, M6 Motorway 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement 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 at all receptor locations within 300 m of the project's ventilation outlets. 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 for areas south of the Gore Hill Freeway and within 300 metres of the Gore Hill Freeway ventilation outlet. Elsewhere within 300 metres of the ventilation outlets for the project, 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)	0.08	0.11	0.23	0.85
Primary health indicators: $PM_{2.5}$				
Mortality all causes (long term effects, ages 30+)	$5x10^{-6}$	$7x10^{-6}$	$1x10^{-5}$	$5x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$6x10^{-6}$	$8x10^{-6}$	$2x10^{-5}$	$6x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$1x10^{-6}$	$2x10^{-6}$	$4x10^{-6}$	$1x10^{-5}$
Secondary health indicators: $PM_{2.5}$				
Mortality all causes (short term effects, all ages)	$3x10^{-7}$	$5x10^{-7}$	$9x10^{-7}$	$3x10^{-6}$
Mortality, cardiopulmonary (long term effects, ages 30+)	$5x10^{-7}$	$6x10^{-6}$	$1x10^{-5}$	$5x10^{-5}$
Mortality, cardiovascular (short term effects, all ages)	$1x10^{-7}$	$1x10^{-7}$	$3x10^{-7}$	$1x10^{-6}$
Mortality, respiratory (short term effects, all ages)	$8x10^{-8}$	$7x10^{-8}$	$1x10^{-7}$	$5x10^{-7}$
Asthma emergency department hospitalisations (1–14 years)	$1x10^{-6}$	$2x10^{-6}$	$4x10^{-6}$	$2x10^{-5}$
Negligible risks	$<1x10^{-6}$			
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$			
Unacceptable risks	$>1x10^{-4}$			

Note: Shaded cells indicate calculated risks that are considered unacceptable

For elevated receptors at 10 metres, 20 metres, 30 metres height and 45 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 0.15 micrograms per cubic metre, where the maximum individual risk is $1x10^{-5}$.

Further assessment of risks related to exposure to NO_2 and VOCs at elevated receptors in the 300 metres surrounding the project's ventilation outlets for the expected traffic scenario is presented in Annexure H. These calculations do not change the conclusions presented above in relation to exposure to $PM_{2.5}$ for this scenario.

Annexure H also includes calculations of risk associated with exposure to $PM_{2.5}$, NO_2 and VOCs for the regulatory worst case scenario. The calculations have been undertaken on the assumption that emissions to air from the ventilation outlets occur at the regulatory worst case level all of the time, which is considered unrealistic.

Based on the more detailed assessment undertaken for $PM_{2.5}$, NO_2 and VOC the following was identified:

- The assessment of potential health risks for elevated receptors is dominated by the assessment of individual risks relevant to changes in NO_2 and $PM_{2.5}$.
- **Existing and expected traffic emissions**: No unacceptable risks have been identified.
- **Regulatory worst case emissions**: Unacceptable risks have been identified for elevated receptors in the 300 metres adjacent to ventilation outlets at Warringah Freeway, Gore Hill Freeway and Burnt Bridge Creek Deviation for elevated receptors that may be present at 45 metres in height.

Based on the assessment undertaken the following should be noted:

- 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 necessary preclude such development. Further consideration at rezoning or development application stage would be required
- 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
- Transport for NSW would assist North Sydney Council, Willoughby City Council, Northern Beaches 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 Transport for NSW for proposed rezoning or development applications.

5.10 Assessment of regulatory worst case scenario.

A regulatory worst case scenario has been evaluated in Appendix H (Technical working paper: Air quality) of the environmental impact statement. 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 all the 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 one-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 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 $1x10^{-4}$ and hence there are no unacceptable risks identified in the community surrounding the project

- The calculated maximum individual risks are in the range $1x10^{-6}$ to $1x10^{-4}$ 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	$5x10^{-5}$	$1x10^{-5}$	$3x10^{-6}$	$9x10^{-7}$	$4x10^{-7}$	$1x10^{-5}$
Increase in risk for 1 day of worst case emissions (24 hours which is highly conservative)	$2x10^{-6}$	$4x10^{-7}$	$9x10^{-8}$	$3x10^{-8}$	$1x10^{-8}$	$4x10^{-7}$
Increase in risk assuming worst case event occurs 1 day each week (52 days per year)*	$9x10^{-5}$	$2x10^{-5}$	$5x10^{-6}$	$1x10^{-6}$	$7x10^{-7}$	$2x10^{-5}$
Maximum annual risk – expected conditions plus worst case event**	$1x10^{-4}$	$3x10^{-5}$	$8x10^{-6}$	$2x10^{-6}$	$1x10^{-6}$	$3x10^{-5}$
Negligible risks	$< 1x10^{-6}$					
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$					
Unacceptable risks	$> 1x10^{-4}$					

* 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) one day per week, for the whole year. This will be conservative as the concentration and location of maximum impacts will vary depending on the meteorological conditions, in particular the wind direction. The meteorological conditions will not be the same for each worst case event that has been assumed to occur.

5.11 Sensitivity analysis

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 carried out in 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 carried out for the 2027 'Do something cumulative' emissions scenario, with ground level concentrations predicted for the 10 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. Figure 5-9 shows the different contributions to $PM_{2.5}$ concentrations for the expected traffic conditions (for background plus traffic), the sensitivity test (one hour per day $PM_{2.5}$ concentrations reach the emission limit) and regulatory worse case (24 hours per day of $PM_{2.5}$ concentrations reaching the emission limit) for the 'Do something cumulative' scenario. This figure essentially shows that all assumptions for ventilation outlets result in relatively small contributions compared with the total.

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 $PM_{2.5}$, for the expected traffic conditions and the sensitivity test, relevant to receptors surrounding the project's ventilation outlets.

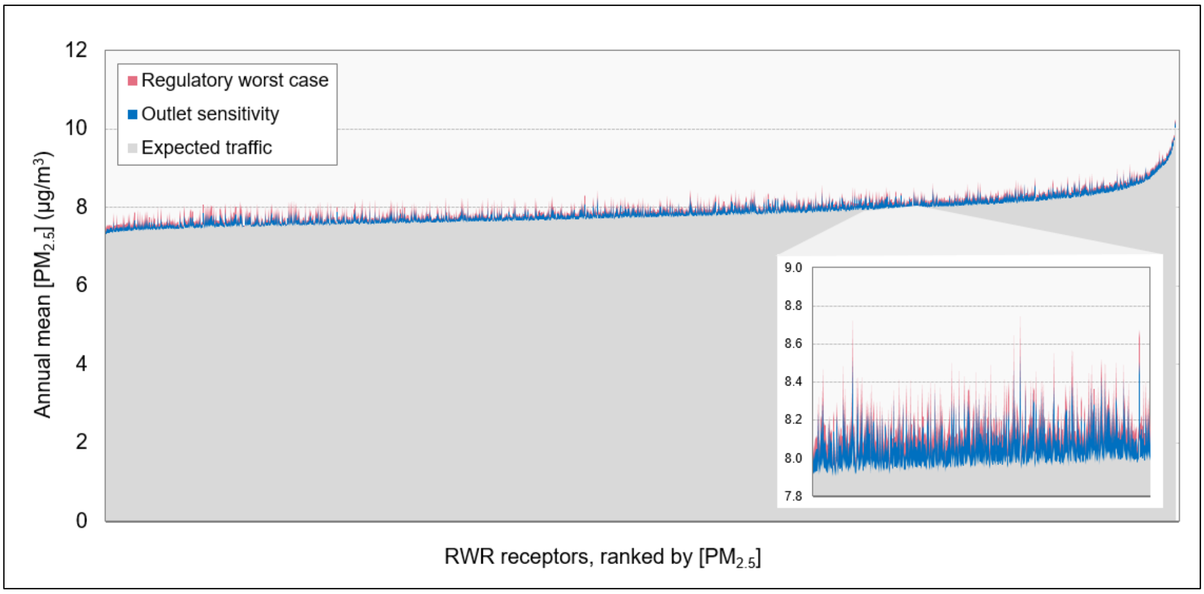

Figure 5-9 **Results of sensitivity tests for ventilation outlets – total annual mean PM2.5 concentration at RWR receptors ('Do something cumulative 2027' scenario)**

Table 5-29 Calculated individual risk associated with maximum changes in $PM_{2.5}$ concentrations associated with emissions from the project's ventilation outlets: sensitivity test – 'Do something cumulative 2027' scenario

Health endpoint	Maximum calculated	
	Expected traffic	Sensitivity test
Primary health indicators: $PM_{2.5}$		
Mortality all causes (long term effects, ages 30+)	$4x10^{-6}$	$2x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$5x10^{-6}$	$2x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$1x10^{-6}$	$4x10^{-6}$
Negligible risks	$<1x10^{-6}$	
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$	
Unacceptable risks	$>1x10^{-4}$	

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 an 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) require 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 guideline *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). Appendix H (Technical working paper: Air quality) of the environmental impact statement 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' (without project):

- A reduction and an increase in total emissions in the 'Do something' 2027 scenario
- An increase in total emissions in the 'Do Something' 2037 and 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 study 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 (2019) prices, based on the inflation calculator from the Reserve Bank of Australia[10] the damage cost is $688,392 per tonne of $PM_{2.5}$. Following this approach, the damage costs/savings associated with $PM_{2.5}$ are calculated to be:

- Minus $3,717,317 (saving) in 2027, when comparing the change in total emissions between the 'Do minimum' and the 'Do something' scenarios
- $275,357 (cost) in 2037, when comparing the change in total emissions between the 'Do minimum' and the 'Do something' scenarios
- $826,070 (cost) in 2027 and $5,713,654 (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 NO_2 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 WestConnex M4 WestConnex M8 WestConnex M4-M5 Link	200(a)	87(b)	50(b)	0.5(b)

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 Western Harbour Tunnel.

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
NO2	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 NO_2 criteria is the hardest to achieve and 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 (NO_2) 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 Western Harbour 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 NO_2 has been assessed for every possible route through the system with this assessment considering the highest average NO_2 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.

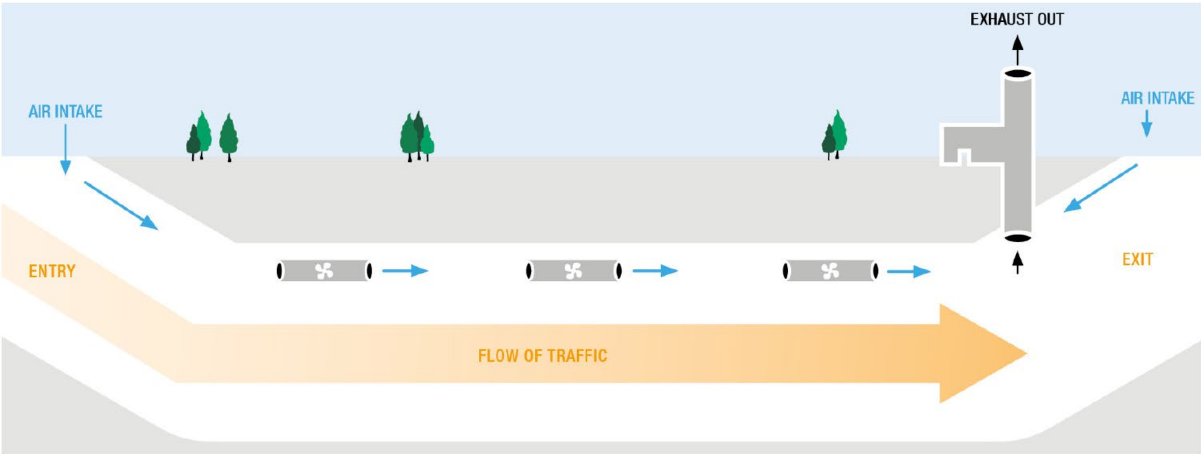

Figure 6-1 **Conceptualisation of longitudinal tunnel ventilation and portal extraction**

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 Beaches Link tunnels would be limited, taking around six to seven minutes to travel the full distance of the tunnels (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. Hence 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 to 75 per cent for CO and NO_2, 80 per cent for fine particulates and 50 per cent for VOCs. Further testing of the reduction in NO_2 levels inside vehicles using road tunnels was commissioned by Transport for NSW 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 Beaches Link tunnels may also use part of other connecting tunnels for their trip. This may include the Western Harbour Tunnel, WestConnex tunnels, and M6 Motorway – Stage 1. 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 30.6 kilometre trip from the WestConnex M8 Kingsgrove portal to the Wakehurst Parkway and a 28.5 kilometre trip from the M6 Motorway – Stage 1 Rockdale portal 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 Beaches Link and Gore Hill Freeway Connection Ventilation Report (WSP/ARUP, 2020) (see Annexure K and Appendix H (Technical working paper: Air quality) of the environmental impact statement).

6.2 Carbon monoxide

Under normal operations, the average concentration of CO predicted in the Beaches Link tunnel while travelling in both directions is less than 3.5 ppm (refer to Tables 7.1 – 7.8 in the Beaches Link Tunnel and Gore Hill Freeway Ventilation Report (WSP/ARUP, 2020)). Even under a worst case scenario, the maximum estimated average concentration is 4.6 ppm.

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

- The maximum average concentration of CO in the tunnels is predicted to be less than five ppm in all 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 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 carbon monoxide 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 Beaches Link tunnel, or within longer journeys that include the Beaches Link tunnel.

6.3 Nitrogen dioxide

The Beaches Link Tunnel and Gore Hill Freeway Connection Ventilation Report (WSP/ARUP, 2020) has modelled average NO_2 concentrations across specified tunnel lengths for selected time periods. Tables 6-2 and 6-3 present the average concentration of NO_2 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 NO_2 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 NO_2 concentrations within the cumulative scenarios.

Table 6-2 2037 predicted average NO_2 tunnel concentrations (northbound) through the tunnel (ppm) (WSP/ARUP 2020)

Period	Entry	Warringah Freeway Upgrade	Warringah Freeway Upgrade	Gore Hill	Gore Hill
	Exit	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway
		7.2 km	8.8 km	6.6 km	8.1 km
7:00 to 9:00		0.12	0.16	0.12	0.17
9:00 to 10:00		0.14	0.19	0.14	0.20
10:00 to 15:00		0.14	0.19	0.14	0.20
15:00 to 16:00		0.15	0.22	0.16	0.23
16:00 to 17:00		0.15	0.22	0.16	0.23
17:00 to 18:00		0.15	0.22	0.16	0.23
18:00 to 19:00		0.094	0.12	0.098	0.13
19:00 to 7:00		0.090	0.11	0.093	0.12

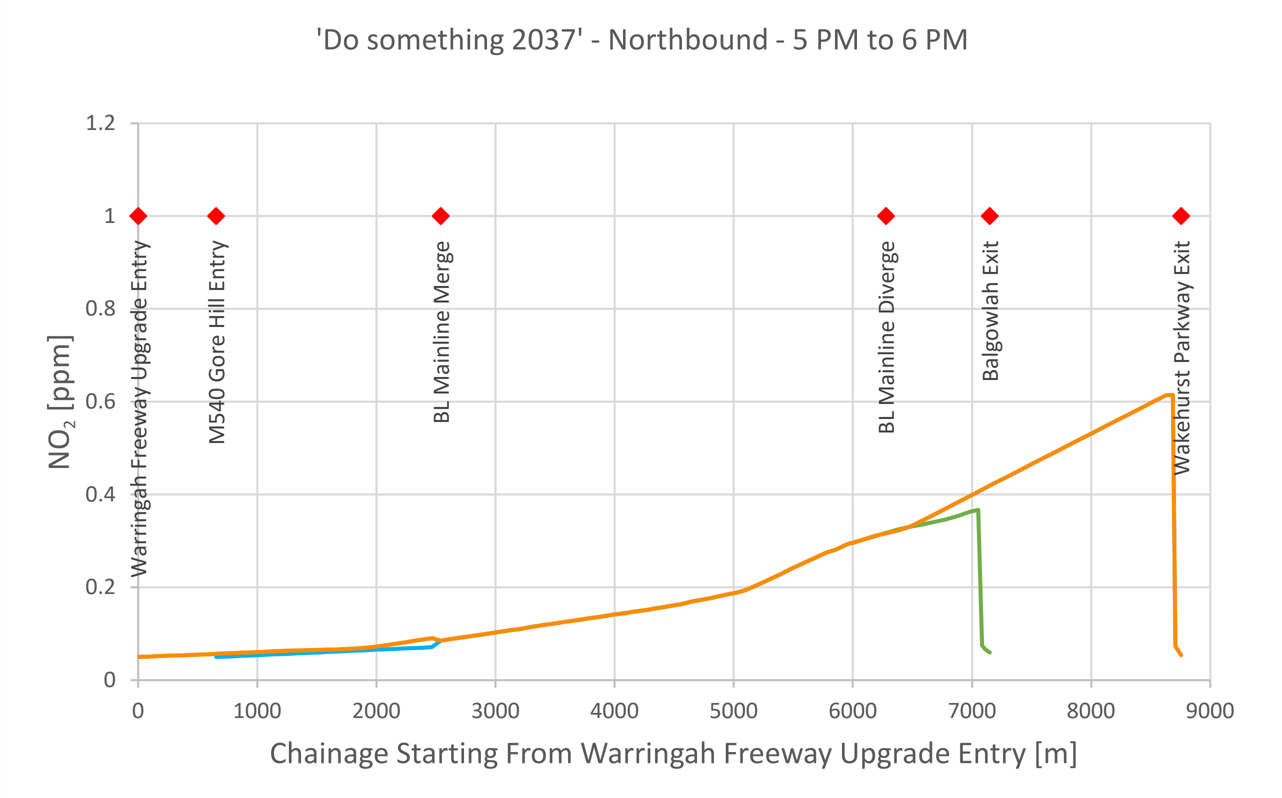

Figure 6-2 **Highest NO_2 concentrations along tunnel routes – 'Do something 2037' northbound – 5pm to 6pm (WSP/ARUP 2020)**

Table 6-3 **2037 predicted NO_2 tunnel concentrations (southbound) through the tunnel (ppm) (WSP/ARUP 2020)**

Period	Entry Exit	Wakehurst Parkway M540 Gore Hill 8.2 km	Wakehurst Parkway M555 Gore Hill 8.4 km	Balgowlah M540 Gore Hill 6.6 km	Balgowlah M555 Gore Hill 6.8 km	Balgowlah Warringah Freeway Upgrade 7.1 km	Wakehurst Parkway Warringah Freeway Upgrade 8.9 km
7:00 to 8:00		0.16	0.16	0.18	0.18	0.20	0.18
8:00 to 9:00		0.16	0.16	0.18	0.18	0.20	0.18
9:00 to 10:00		0.13	0.13	0.15	0.15	0.17	0.15
10:00 to 15:00		0.13	0.13	0.15	0.15	0.17	0.15
15:00 to 16:00		0.12	0.12	0.14	0.13	0.15	0.13
16:00 to 17:00		0.12	0.12	0.14	0.13	0.15	0.13
17:00 to 18:00		0.12	0.12	0.14	0.13	0.15	0.13
18:00 to 19:00		0.084	0.083	0.092	0.091	0.099	0.090
19:00 to 6:00		0.084	0.083	0.091	0.090	0.098	0.090
6:00 to 7:00		0.084	0.084	0.092	0.091	0.099	0.091

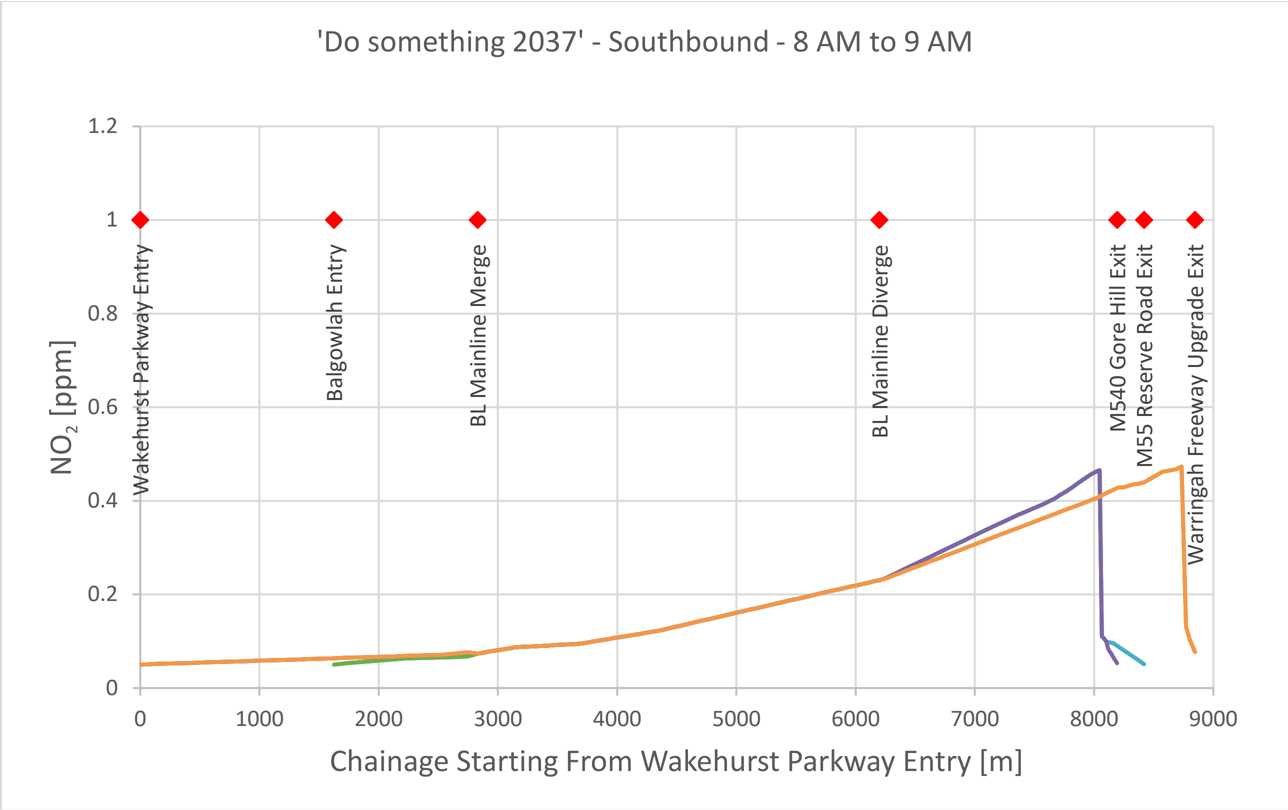

Figure 6-3 **Highest NO_2 concentrations along tunnel routes – 'Do something 2037' southbound – 8am to 9am (WSP/ARUP 2020)**

Table 6-4 2037 'do something' cumulative predicted NO_2 Western Harbour and Beaches Link tunnel concentrations (northbound) (ppm) (WSP/ARUP 2020)

Time period	Entry	Warringah Freeway Upgrade	Warringah Freeway Upgrade	Gore Hill	Gore Hill	WHT-BL Connection	WHT-BL Connection	Rozelle Interchange	Rozelle Interchange	M4-M5 Link	M4-M5 Link
	Exit	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway	Balgowlah	Wakehurst Parkway
		7.2 km	8.8 km	6.6 km	8.1 km	8.9 km	10.5 km	14.3 km	15.9 km	13.5 km	15.1 km
7:00 to 9:00		0.131	0.178	0.134	0.185	0.139	0.183	0.190	0.210	0.198	0.218
9:00 to 10:00		0.150	0.208	0.154	0.216	0.155	0.210	0.188	0.216	0.196	0.225
10:00 to 15:00		0.149	0.207	0.154	0.215	0.155	0.210	0.188	0.216	0.195	0.224
15:00 to 16:00		0.163	0.232	0.167	0.241	0.168	0.233	0.189	0.224	0.197	0.233
16:00 to 17:00		0.164	0.235	0.169	0.244	0.169	0.236	0.189	0.226	0.197	0.235
17:00 to 18:00		0.166	0.237	0.171	0.246	0.171	0.238	0.190	0.227	0.198	0.236
18:00 to 19:00		0.097	0.123	0.099	0.128	0.099	0.124	0.111	0.124	0.114	0.128
19:00 to 7:00		0.093	0.117	0.095	0.120	0.095	0.118	0.109	0.121	0.112	0.124

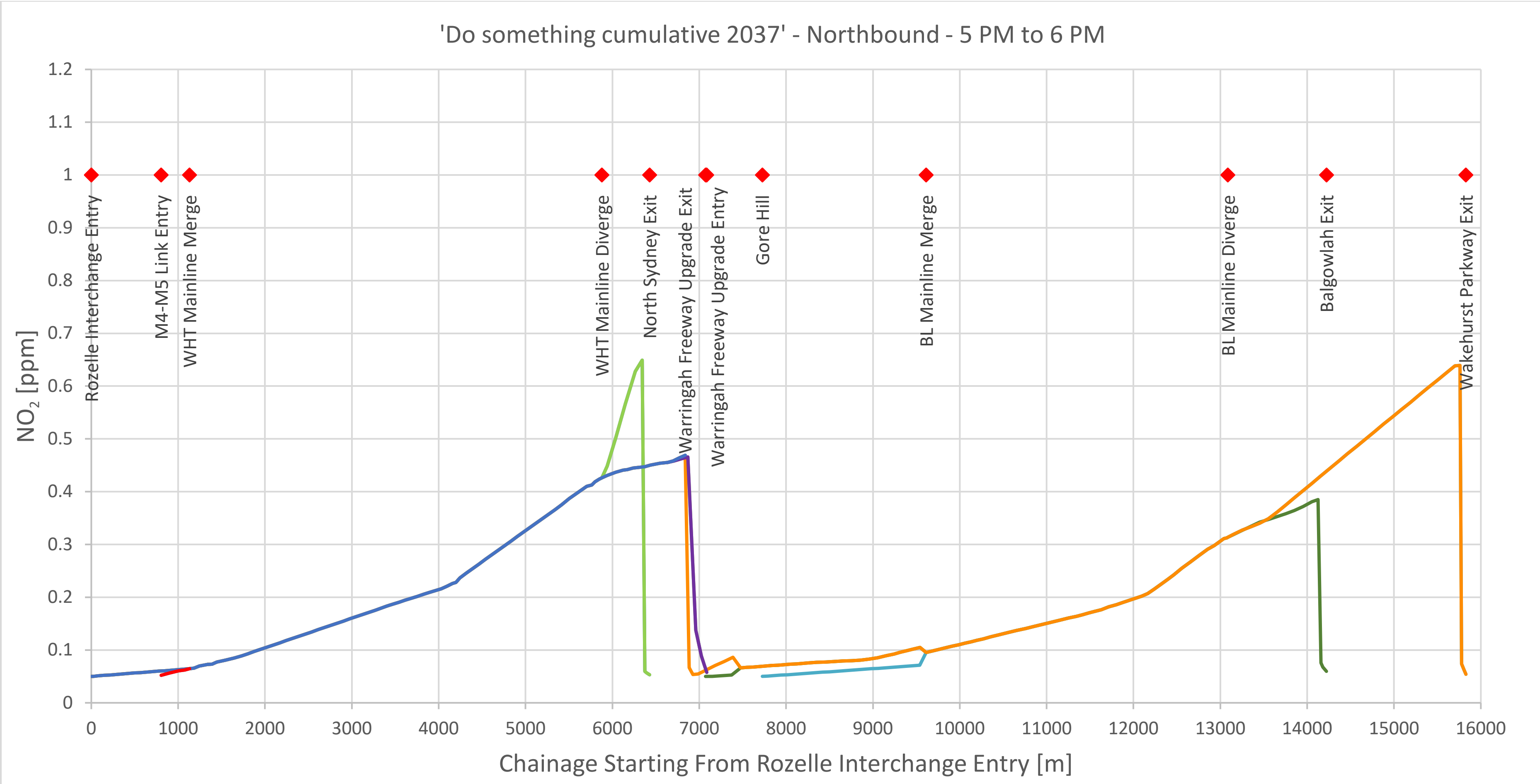

Figure 6-4 Highest NO_2 concentrations along tunnel routes – 'Do something cumulative 2037' northbound – 5pm to 6pm (WSP/ARUP 2020)

Table 6-5 2037 'do something' cumulative predicted NO_2 Western Harbour and Beaches Link tunnel concentrations (southbound) (ppm) (WSP/ARUP 2020)

Time period	Entry	Wakehurst Parkway	Wakehurst Parkway	Balgowlah	Balgowlah	Balgowlah	Balgowlah	Wakehurst Parkway	Wakehurst Parkway	Balgowlah	Balgowlah	Balgowlah	Wakehurst Parkway	Wakehurst Parkway	Wakehurst Parkway
	Exit	M540 Gore Hill	M555 Gore Hill	M540 Gore Hill	M555 Gore Hill	WHT-BL Connection	Warringah Freeway	WHT-BL Connection	Warringah Freeway	M116 Rozelle	M115 Rozelle	M4-M5 Link	M116 Rozelle	M115 Rozelle	M4-M5 Link
		8.2 km	8.4 km	6.6 km	6.8 km	7.7 km	7.3 km	9.3 km	8.9 km	14.2 km	14.3 km	13.6 km	15.9 km	15.9 km	15.2 km
7:00 to 8:00		0.161	0.159	0.185	0.181	0.207	0.211	0.182	0.184	0.194	0.193	0.187	0.180	0.180	0.174
8:00 to 9:00		0.162	0.160	0.187	0.183	0.209	0.213	0.183	0.185	0.194	0.194	0.188	0.180	0.180	0.175
9:00 to 10:00		0.140	0.137	0.159	0.156	0.174	0.179	0.154	0.157	0.168	0.168	0.163	0.157	0.157	0.152
10:00 to 15:00		0.138	0.136	0.158	0.155	0.174	0.178	0.154	0.156	0.168	0.168	0.162	0.157	0.157	0.151
15:00 to 16:00		0.126	0.124	0.143	0.140	0.152	0.156	0.136	0.138	0.153	0.153	0.147	0.143	0.143	0.137
16:00 to 17:00		0.126	0.124	0.143	0.140	0.152	0.156	0.136	0.138	0.153	0.153	0.147	0.143	0.143	0.138
17:00 to 18:00		0.126	0.124	0.143	0.140	0.153	0.157	0.136	0.138	0.153	0.153	0.147	0.143	0.143	0.138
18:00 to 19:00		0.086	0.085	0.094	0.092	0.098	0.100	0.090	0.092	0.094	0.094	0.092	0.089	0.089	0.088
19:00 to 6:00		0.085	0.084	0.093	0.092	0.098	0.100	0.090	0.091	0.093	0.093	0.092	0.089	0.089	0.088
6:00 to 7:00		0.086	0.085	0.094	0.093	0.099	0.101	0.091	0.092	0.094	0.094	0.092	0.089	0.090	0.088

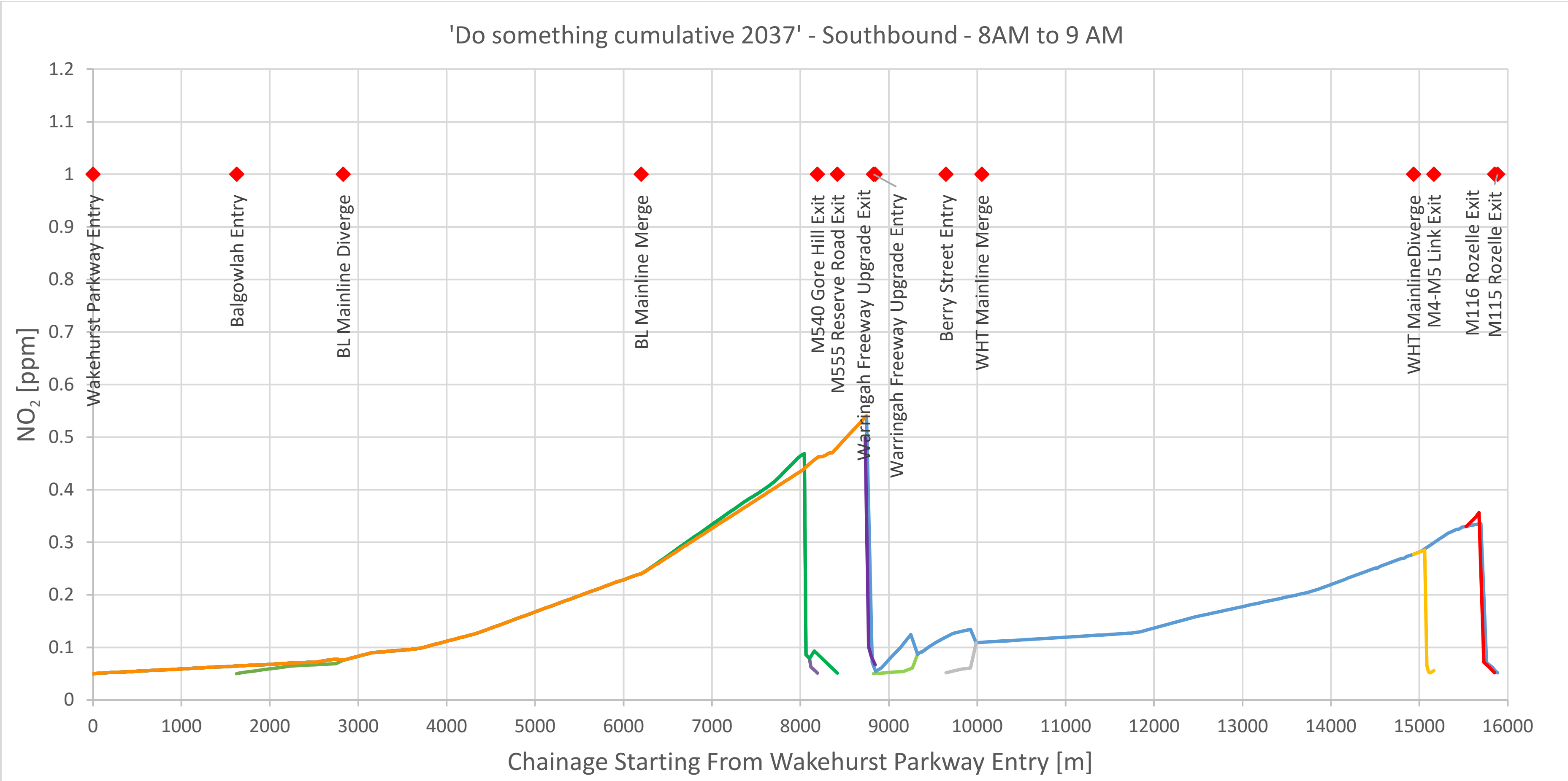

Figure 6-5 Highest NO_2 concentrations along tunnel routes – 'Do something cumulative 2037' southbound – 8am to 9am (WSP/ARUP 2020)

The following is noted in relation to the NO_2 concentrations predicted within the 'Do something cumulative' scenario in 2037:

- The average concentrations in the tunnels vary throughout the day, with average concentration through the entire tunnel (trip average) expected to be (at most) around 0.25 ppm, which is less than the in-tunnel limit of 0.5 ppm. Lower average concentrations may occur with windows up and ventilation on recirculation
- 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 to 63 kilometres per hour along the tunnel ramps varies from less than 0.1 ppm when entering the tunnels, depending on the direction of travel to approximately 0.63 ppm at the Wakehurst Parkway exit when travelling northbound and approximately 0.55 ppm at the Warringah Freeway exit when travelling southbound. These maximum concentrations only occur at specific tunnel exits where exposures of less than one minute would occur.

The concentrations discussed above relate to NO_2 levels inside the tunnels, not inside the vehicles. A study of NO_2 concentrations inside vehicles travelling in Sydney and using existing road tunnels was commissioned by Transport for NSW in 2016 (PEL 2016) to better understand the relationship between NO_2 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 NO_2 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 NO_2 would be generally less than 0.15 ppm. During periods of high traffic volumes and high proportions of heavy vehicles, the trip average concentrations inside the M5 East existing tunnels have been recorded in excess of 0.5 ppm, with levels up to 0.7 ppm. The average concentrations inside the vehicles when ventilation was on recirculation, however, were less than 0.2 ppm. The most recent tunnels in Sydney are designed to ensure that trip average concentrations of NO_2 do not exceed the 0.5 ppm criterion.

The study found that the use of ventilation on recirculation can significantly reduce concentrations of NO_2 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 NO_2 where ventilation was set to recirculation. When ventilation was not set to recirculation the concentration of NO_2 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 NO_2 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 NO_2 in-tunnel guideline, evaluated available studies in relation to health effects from in-tunnel and short term exposures to NO_2. 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 review identified the following (Jalaludin 2015):

- There were no effects identified in relation to lung function for individuals exposed to NO_2 between 0.12 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 NO_2 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 NO_2 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 NO_2 leads to cumulative effects.

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

- There were no effects identified in relation to lung function for individuals exposed to NO_2 between 0.3 and four ppm
- The results for inflammatory markers are mixed, however overall, inflammatory markers increased after exposure to NO_2
- An effect of exposure to NO_2 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 review identified the following (Jalaludin, 2015):

- Exposures to NO_2 were 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 NO_2 exposures of up to 60 minutes. This review supported the conclusions of the Jalaludin report, even for exposures of NO_2 up to 60 minutes. It found that for NO_2 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 NO_2. Further, when considering the studies conducted in road tunnels, busy roadways and in subways it is important to note that NO_2 is only part of a complex mixture of air pollution, including $PM_{2.5}$, and determining health effects that may be only related to NO_2 is difficult.

For the assessment of short duration exposures to NO_2 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 NO_2 within tunnels.

Table 6-6 Summary of NO_2 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 NO_2 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 NO_2 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. Exposures to NO_2 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 NO_2 inside the vehicle is the point of exposure and what should be considered in relation to the potential for health effects.

In-vehicle NO_2 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 to outdoor NO_2 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 (WestConnex M8 Kingsgrove portal to the Wakehurst Parkway exit) would be exposed to an average NO_2 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 NO_2 concentrations within the Beaches Link tunnel were estimated to be below 0.5 ppm. The WestConnex M4–M5 Link environmental impact statement provided a cumulative congested assessment of average NO_2 concentration for vehicles travelling through the Sydney tunnel network which was also estimated to be below 0.5 ppm. The Western Harbour Tunnel environmental impact statement also estimated average nitrogen dioxide concentrations to be below 0.5 ppm under congested traffic conditions. Therefore, since all tunnel networks have predicted an average concentration of 0.5 ppm under congested conditions, it is taken that the average NO_2 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. Therefore, 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 NO_2 inside the bus. It is understood that NSW buses have air conditioning and ventilation systems that include recirculation, with new buses[11] allowing a minimum of 10 per cent fresh air at all times to maximise passenger comfort and minimise excess levels of carbon dioxide. 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 and hence 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 NO_2 model established by Transport for NSW (PEL 2016), a well ventilated older bus with 16 air exchanges per hour results in an indoor to outdoor ratio for NO_2 of 0.3, the same as measured for the older/leakier vehicles considered in the Transport for NSW study. A lower ratio is calculated for a tighter modern bus. Hence the adjustment of 0.3 to calculate indoor air concentrations of NO_2 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 0.25 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 protective of all health effects for all individuals as the available studies relied on to evaluate potential health effects do not include sever asthmatics. Hence 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 NO_2 concentrations are higher, the time spent inside the tunnels under these conditions would remain short for motorcyclists. The average NO_2 levels within the tunnel can be compared against the 15-minute average guideline. Average NO_2 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 will 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 NO_2 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 break 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 PM_{10} and $PM_{2.5}$ from relevant emissions studies.

PM from exhaust is expected to be largely fine particulates, ie PM_{10} and $PM_{2.5}$, that are of importance to health.

In relation to the PM concentrations predicted within the tunnel, the following is noted:

- The in-tunnel concentrations for PM are taken to be PM_{10} concentrations where concentrations of $PM_{2.5}$ are likely to comprise a significant portion of the PM_{10} concentration, particularly for exhaust emissions
- PM_{10} 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 PM_{10} in the tunnels evaluated are up 0.2 milligrams per cubic metre for the 2037 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 PM_{10}) 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 milligrams per cubic metre (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 2013a) 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 2009b)
  - 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 (upon 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 particulate matter 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 milligrams per cubic metre for passenger cars and 0.026 to 0.13 milligrams per cubic metre 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 milligrams per cubic metre (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 NO_2 and particulates in tunnels, the above assessment has relied on Transport for NSW 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 CO_2 inside the vehicle. An assessment of in-cabin levels of CO_2 and potential effects on the health and safety of drivers travelling through tunnels over varying distances and times, was completed by Transport for NSW 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 carbon dioxide 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 CO_2 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 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 Transport for NSW 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:

- The tunnel and associated ventilation system would be designed to ensure that all relevant health based in-tunnel air quality criteria would be met at all times (with windows down) for all potential operational conditions. This is consistent with all recently constructed tunnels in Sydney where health based in-tunnel air quality criteria would be met at all times for all operational conditions
- Where windows are up and ventilation is on recirculation, exposure to NO_2 inside vehicles is expected to be less than outside the vehicle and remain below the current health based criteria. Even in congested conditions inside the tunnels, it is considered unlikely that significant adverse health effects would occur. Placing ventilation on recirculation is 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 NO_2 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 NO_2 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 CO_2 levels inside the vehicle that may adversely affect driver safety. However, where Transport for NSW 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 Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement (Renzo Tonin & Associates, 2020).

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 Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement.

The assessment of noise during construction and operations involved consideration of impacts at 87 noise catchment areas (NCAs) (NCA 15.1 to NCA 60.5) presented in the figures 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 47 locations (refer to Annexure I for locations) between May 2017 and April 2019. Monitoring was undertaken by a noise logger. A noise logger 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 36 to 73 decibels (dB(A)) during the daytime, 32 to 71 dB(A) during the evening and 27 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 7am-10pm) and night-time (nine hours from 10pm-7am). During the daytime, $L_{Aeq\ 15\text{-}hour}$ noise levels ranged from 54 to 74 dB(A). During the night-time, $L_{Aeq\ 9\text{-}hour}$ noise levels ranged from 48 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 NPfI (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 Services 2016) (CNVG) outlines Transport for NSW's approach to assessing and mitigating construction noise. The *Noise Mitigation Guide* (Roads and Maritime Services 2015a) (NMG) 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
- Operations – 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 hence 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.

Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement has considered potential construction noise impacts associated with construction activities for the project, proposed to occur from 2023 to 2028. Potential impacts associated with construction noise and vibration are assessed using typical and worst case works scenarios. Construction noise levels would typically be less that the predicted worst case noise levels. 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 9.8.

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 to 55 dB(A) is considered unlikely to cause awakening
- One or two noise events per night, with a maximum internal noise level of 65 to 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 great noise level performance.

The NPfI 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:

- $L_{aeq,15min}$ 40dB(A) or the prevailing RBL plus 5 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 db(A) has been adopted.

The assessment of noise impacts during construction has been carried out based on 87 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 RNP 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 is 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 (10pm-7am) 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 to 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 Transport for NSW's *Noise Criteria Guideline* (Roads and Maritime Services 2015b) (NCG) and NMG. 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 (7am-10pm) and night-time (10pm-7am). 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 further considered.

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 to 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 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 and has assessed both typical and worst case works scenarios. 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 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 NCA 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 Gore Hill Freeway and at Balgowlah) to better reflect the actual construction noise levels from these activities.

The reasonable worst case scenario is conservative because it assumes 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. While the noise levels for the realistic worst case might occur at a sensitive receiver during the works at some point during construction, noise levels associated with the typical scenario would occur more frequently.

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. Use of the construction support sites for the project is unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible. H

Maximum noise levels from truck movements associated with movements to some construction support sites are predicted to exceed both the sleep disturbance screening level and the awakening reaction level. However, as night time heavy vehicle movements from these sites would be limited and/or would not noticeably increase the number of maximum noise events that occur due to existing vehicle movements.

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.

Ground-borne noise would primarily be due to roadheader tunnelling, which would occur 24 hours a day, and the use of rock hammers, which could be kept to standard work hours where feasible and reasonable. 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. Receivers might also experience ground-borne noise on multiple occasions, associated with excavation of different tunnel tubes and other subsurface elements such as ventilation shafts, cross-passages and niches for motorway operational equipment.

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

- For roadheader tunnelling, 107 residential receptor buildings have been identified as exceeding the night time noise criteria. No residential receptor buildings are predicted to be exposed to

ground-borne noise levels above 45 dB(A). No other noise sensitive receptors and commercial/industrial receptors would exceed the criteria
- For rock hammer tunnelling, 638 and 419 residential receptor buildings have been identified as exceeding the night time and evening noise criteria, should this activity occur outside standard work hours. Five hundred and thirty-one residential receptor buildings have been identified as exceeding the daytime criteria, with 24 other non-residential sensitive receptors that may be affected by ground-borne noise. Ground-borne noise impact impacts would be managed by restricting rock-hammer excavation to standard construction hours where feasible and reasonable, unless verification monitoring determines that the activity can comply with ground-borne noise management levels.

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 the construction scenarios evaluated (subject to further design and construction planning):

- Vibration levels from the roadheader tunnelling would be below the vibration limit for human comfort at all receivers. For tunnelling using rock hammers, up to 440 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 *Construction Noise and Vibration Guideline* (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. Three heritage items would potentially exceed the vibration screening criterion for heritage. These items 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 9.10). 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 Section 6 of Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement. 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 recommended to limit the impact of noise and vibration include:

- Early installation of operational noise mitigation measures, where practical (see Section 7.4.2)
- Development of location and activity specific construction noise and vibration statements to identify potential noise and vibration impacts associated with specific work activities and to identify the mitigation measures required to adequately manage the impacts. These assessments should focus on works outside standard construction hours and other works likely to result in exceedances of the various noise and vibration management objectives
- 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 impacts in the more sensitive evening and night time periods, and with consideration of respite periods

- Use of temporary acoustic screens where practicable for construction works generating moderately intrusive to highly intrusive noise levels. Temporary noise screens can provide five to 10 dB noise reduction
- Detailed construction programming to provide respite
- Development of a project specific out of hours work protocol that classifies the works based on the level of impact and the triggers for respite as negotiated with the community
- Use of weekend possessions for the surface works of the project to enable for increased daytime construction works and decreasing the overall required night time noise impacts for any individual works stage
- The enactment of minimum vibration distances for sensitive receptors
- The addition of at property treatments such as temporary localised shielding or permanent forms of mitigation for receptors who are impacted by noise from long term construction works, were other options have been exhausted
- Monitoring to assess the effectiveness of mitigation measures.

Construction noise and vibration mitigation and management measures should be reviewed during detailed design, with consideration of cumulative and consecutive construction impacts during detailed design to reflect the contractor's preferred constructability approach.

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 CNVG, should be implemented to manage the noise and vibration impacts from the project.

Underwater impacts

Piling in Middle Harbour would be carried out for the construction of Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams. Piling would predominately consist of vibratory piling (in harbour sediments) and impact piling (through rock). Impact piling would generate the 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 distances determined vary depending on the type of equipment and operation being carried out. Based on the proposed methodology, the shortest distance is 75 metres for pile drilling, with the largest distance potentially around two kilometres for impact pile driving. As identified in Chapter 6 (Construction works) of the environmental impact statement, the piling program would be refined during detailed construction planning which would also allow for the consideration of reasonable and feasible alternatives and environmental management measures where required.

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 subjected to excessive sound pressure level 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 should be informed by:

- Final construction methodologies and mitigation measures for piling activities, as refined during detailed construction planning
- An impact piling trial including measurement of actual sound pressure levels to check expected levels which should be produced in the actual location to be piled accounting for actual marine conditions and geological conditions. The trial results should be used to confirm methodology and mitigation measures suitable for ongoing production impact piling

- Monitoring during piling activities to validate the predicted underwater acoustic thresholds and management areas, and to further adapt management measures (as required). This should include a monitoring program with corresponding communication measures to validate the predicted underwater acoustic thresholds and management zone. The monitoring results and management zone should be peer-reviewed prior to implementation to ensure they are appropriately protective of health
- Monitoring should include ongoing measurements of sound pressure levels during impact piling to ensure adopted methodology is in line with planned outcomes
- Surveillance procedures should be developed as part of the monitoring program to manage swimmers or divers within the management zone. In addition, the plan should include emergency procedures for the unlikely occurrence of distressed swimmers or divers
- Management measures according to the type of works occurring and the extent to which exceedances of the precautionary guideline are predicted (ie the management zone) Management measures should be reviewed and, if required, amended over the piling program to reflect monitoring outcomes.

The communication tools and management measures that should 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 precautionary guideline level is exceeded to proactively monitor users in the prior to and during relevant activities that could pose a risk to recreational users.

Through careful planning and implementation of impact piling methodologies and mitigation measures, this risk is considered negligible.

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 either side of the project’s surface works as well as the community adjacent to a number of collector roads, sub-arterial and arterial roads associated with the Warringah Freeway, Gore Hill Freeway, Sydney Road, Burnt Bridge Creek Deviation and the Wakehurst Parkway.

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 plus or minus 2 dB(A).

The assessment of operational noise impacts considered the following:

- ‘Do minimum’ scenario: 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’ and ‘Do something cumulative’ scenario: 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 and/or increased height noise barriers (where four or more properties are identified that are close together).

Consideration of these additional noise mitigation measures is provided in Section 7.2.1 and Section 7.2.2 of Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement respectively.

There are some properties where the relevant criteria for road traffic noise are not likely to be met even with all feasible and reasonable mitigation measures in place. In those cases, at-property treatment of individual receptors or homes would be considered. Such measures depend on the age and condition of the property. The aim of at-property treatments is to reduce road traffic noise levels in habitable rooms by 10 dB(A).

The noise modelling identified that:

- The project is predicted to typically decrease the number of receiver buildings exceeding the NCG noise criteria when compared to the “Do Minimum” scenario during the day and night periods in the vicinity of connections to and from Gore Hill Freeway, Burnt Bridge Creek Deviation and Warringah Freeway. The decrease in the number of receiver buildings would be due to the reduction in forecast traffic volumes as a result of the project, as traffic along existing surface roads would move to the proposed tunnels
- At the connections to and from Burnt Bridge Creek Deviation and the connections to and from the Wakehurst Parkway and surface road works at Seaforth, Killarney Heights and Frenchs Forest, the project is predicted to increase the overall number of receiver buildings exceeding the NCG noise criteria when compared to the ‘Do Minimum’ scenario during the day and night periods. This is due to the widening of the Burnt Bridge Creek Deviation and the Wakehurst Parkway and the predicted increases in traffic along the Wakehurst Parkway associated with vehicles accessing and egressing the Beaches Link tunnels increase in traffic volumes along the Wakehurst Parkway due to the project
- For Balgowlah, North Balgowlah and Allambie Heights the number of receiver buildings exceeding the NCG noise criteria during the night period are predicted to increase due to the project when compared to the ‘Do Minimum’ scenario. A review of the traffic data indicates that traffic volumes during the night period along Wanganella Street, Balgowlah are forecast to increase due to the project, increasing traffic noise levels for some receiver buildings within Balgowlah. Similarly, traffic volumes during the night period along Judith Street, Seaforth and Woodbine Street, North Balgowlah are forecast to increase significantly, resulting in an increase in traffic noise levels for some receivers in this area. The predicted increase in traffic volumes are modelled without inclusion of mitigation through proposed traffic calming measures. Appropriate traffic calming measures will be developed in consultation with Northern Beaches Council during further design development of the project with the objective of minimising the increase in traffic volumes as a consequence of the project on local roads in Seaforth, North Balgowlah and Balgowlah
- On average the project is predicted to result in reduced traffic noise for about 59 per cent of receivers at the Warringah Freeway, Gore Hill Freeway Connection, the connections to and from Burnt Bridge Creek Deviation and the connections to and from the Wakehurst Parkway noise catchment areas
- An average of about 37 per cent of receivers within the noise catchment areas are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP as a minor impact which is barely perceptible
- An average of about four per cent of receiver buildings within the noise catchment areas are predicted to experience increases in traffic noise of more than 2 dB(A) due to the project

- The Warringah Freeway surface road works are predicted to reduce traffic noise levels at a significant number of receiver buildings (about 81 per cent), mainly due to traffic being moved to tunnels.

For the majority of receptor buildings within the NCAs, there is either a reduction or relatively minor change in traffic noise levels (less than two 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 $L_{Aeq\ 15\ hour} \geq$ 65 dB(A) or night $L_{Aeq\ 9\ hour)} \geq$ 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).

Peak/maximum noise levels (L_{Amax}) may potentially increase east of the Warringah Freeway, in the vicinity of the new access road that forms part of the connection to and from the Burnt Bridge Creek Deviation and to the east and west of Wakehurst Parkway. See Section 7 of Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement for discussion on maximum noise levels.

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.

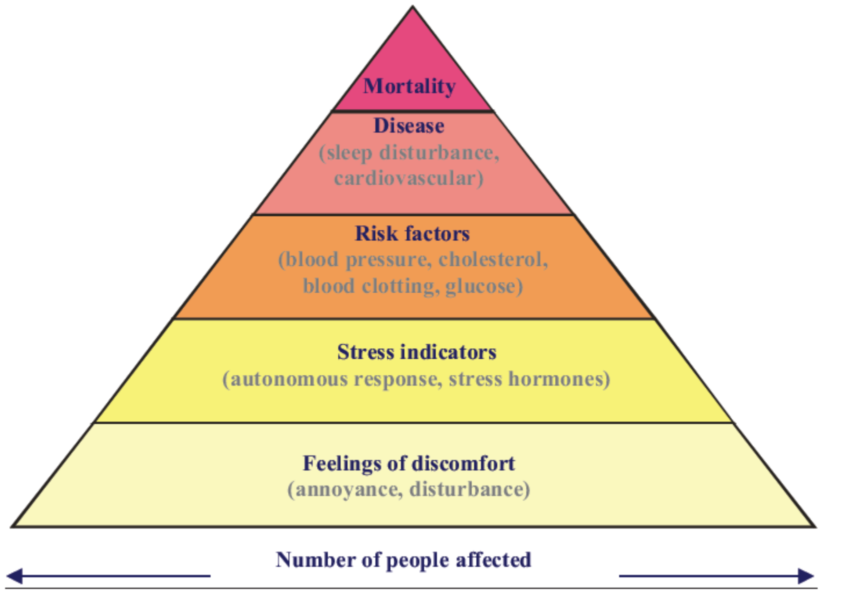

Figure 7-1 **Schematic of severity of health effects of exposure to noise and the number of people affected (WHO 2011)**

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, 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 (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.

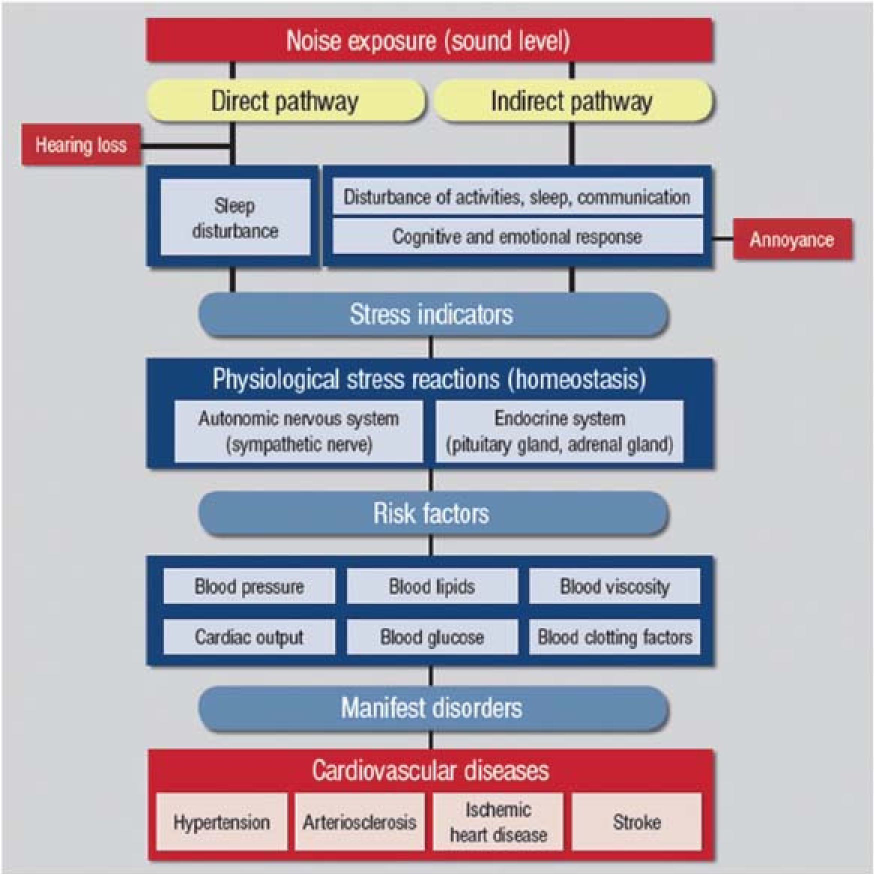

Figure 7-2 Noise reaction model/hypothesis (Babisch 2014)

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 two dB(A) adopted. Where an increase in noise by two 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 exiting or predicted total noise levels (as L_{den}) are 55 dB(A) and higher, an increase of five 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 evaluate 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 (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 two 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 five dB(A) is considered (consistent with the increase in noise identified in the discussion above that may be associate 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 & Schuemer 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 five 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 (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 five, 10, 15 and 20 dB(A) may result in an approximate three, seven, 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.

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

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 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 NPfI, the ICNG and RNP. 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 will 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 relevant noise management levels even with all feasible and reasonable mitigation measures implemented. This is particularly evident in locations where surface road works would occur adjacent to densely populated residential areas. The worst case exceedances would typically occur 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. The most noise intensive activities would be scheduled during standard daytime construction hours wherever practicable. There are, however, noise intensive activities that would be required outside standard construction hours at certain locations, typically to avoid significant and widespread disruption on the road network.

Maximum night time noise levels would be generated during truck arrival, unloading, and departure; rock-hammering, 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 15 dB(A) and therefore exceed the sleep disturbance screening level (refer to Section 7.5.2). 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 five 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 be 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. Actual noise levels would usually 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 Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement, 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, should be prepared during further design development to document how all feasible and reasonable mitigation measures would be considered and implemented (refer to Section 6 of Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement), and periodic monitoring conducted to monitor the performance and effectiveness of these measures. This should include 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 Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement), and to minimise potential health impacts

Operational noise

The operational noise assessment identified that a significant number of receptor buildings 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 two 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 $L_{Aeq\ 15\ hour} \geq 65$ dB(A) or night $L_{Aeq\ 9\ hour} \geq 60$ 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 five 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 the Wakehurst Parkway, a total of eight receptor buildings for the 2037 'do something' scenario (night time) and 12 receptor buildings for the 2037 'do something cumulative' scenario (night time) would experience an increase of 5 dB(A) or more, primarily in Frenchs Forest
- At Balgowlah, there are 37 receptor buildings for the 2037 'do something' scenario (night time) and 39 receptor buildings for the 2037 'do something cumulative' scenario (night time) would experience an increase of 5 dB(A) or more, mostly located along Wanganella Street
- At Gore Hill Freeway, there is two receptor buildings for the 2037 'do something' (night time) and one receptor building for the 2037 'do something cumulative' scenarios (night time) would experience an increase of 5 dB(A) or more in Artarmon
- At the Warringah Freeway, a total of two receiver buildings for the 2037 'do something' scenario and 2037 'do something cumulative' scenario (night time) would experience an increase of 5 dB(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.

Mitigation measures considered during operation would principally involve the use of low noise pavement where functionally appropriate and noise barriers. Following consideration of mitigation measures such as quiet pavements and barriers, around 616 receiver buildings in the project study area are potentially eligible for consideration for at-property treatment.

For most properties the implementation of mitigation measures as detailed in Section 6 of Appendix G (Technical working paper: Noise and vibration) of the environmental impact statement (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 internal relief from excessive external 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. 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 will 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 23 (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 Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement. 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 Appendix M (Technical working paper: Contamination) of the environmental impact statement (Jacobs, 2020).

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.	Store all materials 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.	Transport all materials 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. Worst case modelling without tunnel linings installed shows Flat Rock Reserve may experience a maximum impact of subsistence of 'very severe', although no buildings are present in the affected locations. Mitigation such as tunnel linings to limit groundwater infiltration into the tunnels would reduce this maximum impact of subsidence to 'slight'.	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. Carry out building/structure condition surveys as applicable prior to commencement of construction. Rectify any impacts from settlement caused by the project to the building/structure as required.
Acid sulfate soils, that may result in acidification and the mobilisation of metals, adversely impacting groundwater that can then migrate off-site	Low	Develop acid sulfate management measures 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	Investigate potentially contaminated areas directly affected by the project and manage in accordance with the requirements of guidance endorsed under section 105 of the *Contaminated Land Management Act 1997*. This should include, but not be limited to, further investigations in potential areas of environment interest in the project footprint. Prepare and implement a Remediation Action Plan if contamination posing a risk to human or ecological receptors is identified.
Interactions between maritime traffic and tunnel infrastructure	Low	Put maritime traffic restrictions 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 – High	Some construction support sites are located in close proximity to bushfire prone land. For these sites, develop a site specific bushfire risk assessment. Develop, consider and account for site layout, setbacks, access and emergency procedures.
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.
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 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. Carry out ongoing consultation and communication with managers and users of community facilities about haulage activities and potential safety risks to assist in managing potential impacts. Implement education and awareness programs for construction workers and transport operators about potential road safety impacts to help ensure safety for children and local communities.
Pedestrian and cycle safety	Low – Medium Construction and surface road works may require temporary detours for pedestrians and cyclists. In some cases, detours may not be possible.	Provide alternative safe pedestrian and cycle access where it is practical and safe to do so. Provide early notification (ie signage, newspaper notifications) about changes to allow users of the cycle path to plan their trips.

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	Low The storages are minor, with limited and infrequent transport of these materials required.	Store and transport all materials in accordance with the relevant legislation and codes.
Transport of dangerous goods and hazardous substances in project tunnels	Low The transport of these materials will be prohibited within the tunnels (as per Road Rules 2014, 300-2 NSW rule: carriage of dangerous goods in prohibited areas).	Provide signage near tunnel entry portals advising of the restrictions to ensure compliance.
Traffic accidents (including pedestrian and cycle safety)	Low to moderate (however the risk is considered to be reduced with the project). All use of public roadways carries an inherent risk of vehicle collision. The project has been designed to minimise these risks for travel within the tunnels.	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. A reduction of 562 crashes per year is estimated. 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.
Interactions between maritime traffic and tunnel infrastructure	Low	Place the immersed tube units to provide sufficient clearance for all harbour traffic in Middle Harbour. Design the immersed tube tunnel units to protect against falling and dragging anchors, sinking vessels and high currents and/or propeller wash.

Hazard: Public safety	Risk to public safety	Management measures
Subsidence	Low, based on the evaluation of maximum impact of subsidence as 'slight' in Chapter 16 (Geology, soils and groundwater) of the environmental impact statement. Worst case modelling without tunnel linings installed shows Flat Rock Reserve may experience a maximum impact of subsistence of 'very severe', although no buildings are present in the affected locations. Mitigation such as tunnel linings to limit groundwater infiltration into the tunnels would reduce this maximum impact of subsidence to 'slight'.	Carry out building/structure condition surveys as applicable prior to commencement of construction. Rectify any impacts from settlement caused by the project to the building/structure as required.
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 Australian Government Department of Infrastructure, Transport, Regional Development and Communications 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. Appendix M (Technical working paper: Contamination) of the environmental impact statement 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 soil and sediment contamination have been identified (see Figure 8-1), and ranked as posing a medium or high risk[13]:

- Unsealed areas next to the Warringah Freeway. This includes works at the Cammeray Golf Course (B1-B6)
- Punch Street, Artarmon (B7)
- The site of the proposed Motorway Control Centre and adjoining properties at Reserve Road, Artarmon (B8)
- Flat Rock Drive construction support site (BL2). This area, including the Willoughby Leisure Centre and Bicentennial Reserve has a history of landfilling and risks relate to the potential presence of contaminated soil/waste, groundwater and possible landfill gas generation (B9-B10)
- Spit West Reserve (BL9) due to former filing of reclaimed land (B11)
- Middle Harbour and The Spit due to the potential presence of contaminated harbour sediments (B12)
- Balgowlah Golf Course (B13)
- Former residential premises along Dudley Street at Balgowlah (B14)
- Adjacent to existing residential premises on the corner of Judith Street and Kirkwood Street with Wakehurst Parkway in Seaforth (B15)
- At the Sydney Water Reservoir site at Seaforth (B16)
- Adjacent to the Wakehurst Parkway from Seaforth to Frenchs Forest, including illegal dumping of waste (B17)
- Generally, at the site of structures and/or buildings located within the construction footprint that contain hazardous building materials.

Appendix M (Technical working paper: Contamination) of the environmental impact statement outlines the potential areas of contamination and recommends further investigations be carried out in these areas (where appropriate) to determine the extent of contamination. If significant contamination is identified, measures including the development and implementation 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 Services, 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 Cammeray Golf Course (BL1), Flat Rock Drive (BL2), Punch Street (BL3), Balgowlah Golf Course (BL10) and Wakehurst Parkway east (BL13) construction support sites. Treated wastewater collected at the Wakehurst Parkway east (BL13) construction support site would be re-used and discharged to nearby waterways. Water to be discharged to waterways would be treated to achieve the following criteria:

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

- The relevant physical and chemical stressors set out in of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000), and
- The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) 90 per cent species protection levels for toxicants generally, with the exception of those toxicants known to bioaccumulate, which will be treated to meet the ANZG (2018) 95 per cent species protection levels, and
- The draft ANZG default guideline values for iron (in fresh and marine water) and zinc (in marine water) which may be finalised in October 2020.

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 Willoughby Creek, Flat Rock Creek, Middle Harbour and Burnt Bridge 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 operational wastewater treatment plant located at the Gore Hill Freeway motorway facility, which would be designed to achieve the following discharge criteria:

- The relevant physical and chemical stressors set out in of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000), and
- The ANZG (2018) 95 per cent species protection levels for toxicants generally, with the exception of those toxicants known to bioaccumulate, which would be treated to meet the ANZG (2018) 99 per cent species protection levels, and
- The draft ANZG default guideline values for iron (in fresh and marine water) and zinc (in marine water) which may be finalised in October 2020.

Meeting the above criteria 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 Middle Harbour crossing and construction support sites (Douglas Partners and Golder Associates, 2017; Jacobs 2018). A further sediment investigation was undertaken in May 2018 by RHDHV following a shift in the Middle Harbour crossing alignment and to further assess the sediments suitability for unconfined sea disposal.

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 2013b) in samples collected from between zero and one metre below the surface of the sediment. This included metals (copper, mercury, lead, silver and zinc), PAHs, total recoverable hydrocarbons (TRH), organochlorine pesticides (OCPs) and tributyltin.

While the guidelines noted above relate to the protection of the environment (marine waters), these guidelines will 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 per- and poly-fluoroalkyl substances (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 the project. Dioxins were detected above laboratory levels of reporting in sediment samples collected from areas associated with the Middle Harbour crossing. PFAS and dioxin analysis was not carried out on sediment samples collected from The Spit.

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

- Offshore disposal – A permit for offshore disposal of suitable dredged material and material removed from the cofferdams has been submitted to the Commonwealth Department of the Agriculture, Water and the Environment. 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 with a closed environmental 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.

This 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 construction activities (Cardno, 2020).

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

- The suspended sediment released during the dredging activity would be transported in both an upstream and downstream direction, with a downstream dominance, particularly along the Seaforth shoreline. This is a result of the tidal currents that are predominately aligned with the main longitudinal axis of the estuary
- The dredge plume extents would be greater near the bed of the harbour than near the water surface
- The suspended sediment concentration modelling results consistently show that suspended sediment concentrations are generally low (less than five milligrams per litre) for areas outside of the silt curtains with higher concentrations predicted in the bottom layer.

The resuspension of sediments during dredging has the potential to result in the introduction of contaminants into the dissolved phase of the water column. Once in the dissolved phase, released contaminants can be subject to migration, by tidal currents for example, and can therefore result in different exposures and risks compared to the release of contaminants attached to suspended sediment particles. However, based on the elutriate test results carried out for the project and the assessed available natural dilution, water quality impacts at the dredging site due to contaminants in resuspended sediments entering the dissolved phase would not be expected.

Appropriate management measures would be further developed during detailed design and construction planning 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 Middle Harbour to facilitate construction of temporary wharf structures, cofferdams and immersed tube tunnel piled supports. Appendix Q (Technical working paper: Marine water quality) of the environmental impact statement (Cardno, 2020) indicates 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.

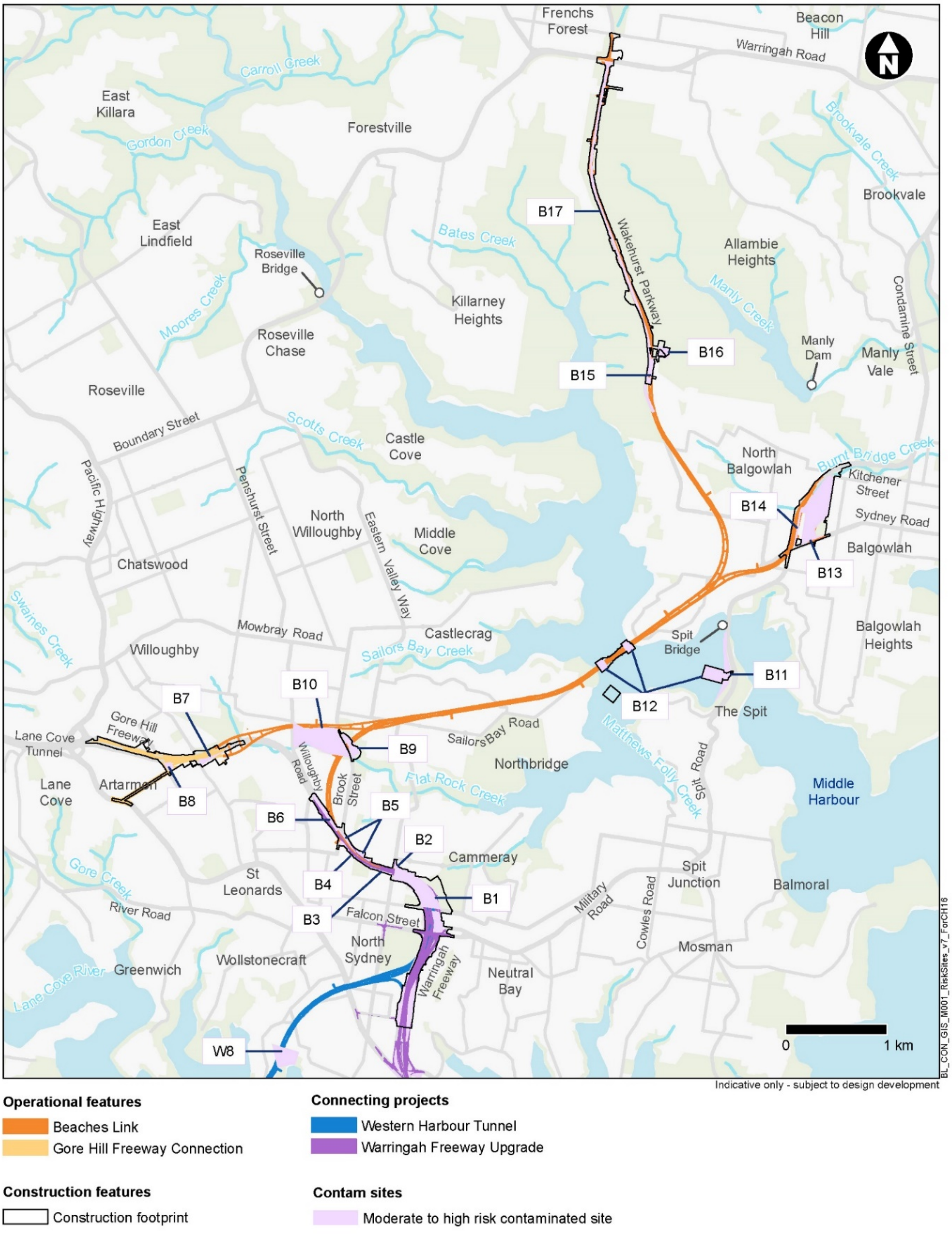

Figure 8-1 Areas of environmental interest with assigned moderate to high exposure risk rankings

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 depend 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.

Appendix U (Technical working paper: Socio-economic assessment) (Jacobs, 2020) and Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement provide 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 2000b). 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 2000b).

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 2000b). 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

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. Where closures are required, impacts would be minor and manageable
- 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. As detailed in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement, localised impacts are expected but most intersections would operate at a satisfactory Level of Service
- Potential disruptions to public transport services, including from 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. As detailed in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement, public transport impacts overall would be manageable
- Changes to pedestrian and cycle access near to construction works, resulting in possible disruptions. As detailed in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement, active transport impacts overall would be moderate and manageable
- Temporary changes to access to private properties near construction works, with suitable access arrangements implemented in consultation with affected property owners
- Relocation of moorings in the vicinity of works in Middle Harbour. Relocated moorings would be placed as close as possible to their original locations during construction where reasonable and feasible 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 used to access social infrastructure, including schools, child care, places of worship, open space, and 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 the Northern Beaches to nearby strategic centres such as Chatswood, St Leonards, North Sydney, Macquarie Park and the Sydney CBD.

The project is predicted to provide travel time savings and reliability benefits for users of the project, as well as users of existing key corridors which would benefit from reduced traffic demand Military Road, Spit Road, Warringah Road and Eastern Valley Way. It would enable better access to jobs and businesses, with direct access to the Northern Beaches Hospital at Frenchs Forest, and better access to businesses on the Northern Beaches from Greater Sydney.

The project would also enhance the resilience of the road network due to reduced demand on other surface roads, including Frenchs Forest Road and Ourimbah Road, and would enable a major reduction of heavy vehicle traffic on the Warringah Road, Spit Road and Military Road corridors.

The substantial additional travel that would be facilitated by the project would also increase localised traffic demands at either ends of the project where it would be integrated with the existing transportation network. At some locations there would be some residual delay at these interface precincts. This includes some increases in localised delays for traffic through French Forest, particularly on Warringah Road and Wakehurst Parkway as a result of changes to traffic patterns caused by the project. In such cases localised delays at these precincts would be offset by the strategic travel time benefits provided by the project at the broader network level.

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 heathy 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, minor adjustments would be required to some bus stops along Pacific Highway in Artarmon, Sydney Road, Kitchener Street and Myrtle Street in Balgowlah, and along the Wakehurst Parkway in Seaforth, Killarney Heights and Frenchs Forest. Some potential short-term adjustments to bus priority infrastructure on Burnt Bridge Creek Deviation in Balgowlah would also be required, resulting in a minor increase in bus travel times. Overall public transport impacts would be manageable.

Public transport customers would also benefit substantially from the project. Existing services would benefit from reduced traffic demand on key arterial bus corridors including Warringah Road, Eastern Valley Way, Spit Road and Military Road. As a result, there would be improved travel times and reliability for buses travelling along the existing key corridors, including Warringah Road and Military Road. The project itself would facilitate the operation of express buses that would provide direct access between major centres on the Northern Beaches and Frenchs Forest and key economic centres such as North Sydney, St Leonards, Macquarie Park, Sydney CBD and beyond. From a public transport network perspective, the project, once complete, is expected to improve public transport access and performance for local and regional communities.

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 2000b).

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. This includes temporary closure and subsequent diversion of the shared user paths along the Gore Hill Freeway between Reserve Road and Chelmsford Avenue, and near the Burnt Bridge Creek Deviation.

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 study area would be maintained, these 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 improve pedestrian and cyclist connectivity within the study area through the provision of new or upgraded infrastructure as highlighted in the Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement.

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. Once operational, emergency services would also benefit from travel time savings and reliability benefits of the project, including more direct access to the Northern Beaches Hospital at Frenchs Forest.

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:

- Refinement to the Cammeray Golf Course construction support site (BL1) layout to ensure a functional golf course can be reinstated
- Selecting construction support sites on Transport for NSW land where possible or at locations that do not require residential property acquisition
- At Spit West Reserve construction support site (BL9), the site has been optimised to minimise impact the public open space, car parking and Mosman Rowers
- At Balgowlah Golf Course, the project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved public open space and recreation facilities. A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council will take place to give the community an opportunity to provide comment on the final layout of the new and improved open space and recreation facilities at Balgowlah.

However, the project does require property acquisitions 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. Transport for NSW 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 (also referred to as open 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 flooding, 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 study 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 Western Harbour Tunnel and Beaches Link program of works has been designed to ensure a functional golf course can be reinstated. While the construction works may deter some from accessing and using this area during construction, ensuring a functional golf course is reinstated as quickly as possible, minimising potential health impacts
- Acquisition and temporary leasing of Balgowlah Golf Club (located on Government owned land), with construction resulting in the permanent closure of the golf course. Other golf courses are accessible in the area and hence, while some additional travel may be required, recreational golf activities are not expected to be affected. The open space of the golf course is also valued by local residents. The temporary and permanent changes to the golf course would alter the visual and landscape amenity. However, the project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved public open space and recreation facilities
- Temporary use of parks and open space areas for construction support sites (for example, Artarmon Park, Flat Rock Reserve, and the Spit West Reserve), 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 these areas and are easily accessed by the community. Hence the potential for this temporary access to affect community health is minimal
- Reduced amenity due to construction activities and construction support 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
Cammeray Golf Course	
The impacted section of the golf course adjoins the Warringah Freeway corridor and Ernest Street. Construction and long-term operation of the Warringah Freeway motorway facilities would require reconfiguration of the course prior to construction of the Western Harbour Tunnel and Warringah Freeway Upgrade project. 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. 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. The majority of these impacts would occur as a consequence of the Western Harbour Tunnel and Warringah Freeway Upgrade project, however, the continued use of parts of the site by the project would delay the reinstatement of residual land to open space.	The project would occupy parts of the site as acquired as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project 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. 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. Landscaping would be provided to reduce the visual impacts of these facilities when viewed from some locations.
Artarmon Park	
Construction of the project would require the temporary occupation of a portion of land within Artarmon Park for construction activities for the eastbound on-ramp from Lane Cove Tunnel/Longueville Road. The area mainly comprises vegetated land located next to the Gore Hill Freeway. Public access to the park from Parkes Road and Hampden Road would be maintained during construction. Clearing of mature trees would be required for construction and operation of the on-ramp. The loss of these trees would temporarily impact on the landscape and visual amenity of the park until new trees or landscaping becomes established. Clearing of these trees is also likely to be a concern for the local community.	The project would require the permanent acquisition of a portion of land at Artarmon Park to accommodate road infrastructure associated with the Gore Hill Freeway Connection. This is not expected to impact on the ongoing use or functioning of the park and facilities within the park. Land affected by construction would be reinstated after construction and is not expected to impact on the long-term use of Artarmon Park.

Construction impacts to open space	Operational impacts to open space
Flat Rock Reserve	
Construction of the project would require the temporary occupation of a portion of land within Flat Rock Reserve for use as a construction support site. Public access to other areas of the reserve outside of the construction support site would be maintained during construction although increased noise, dust and construction traffic would diminish the amenity of parts of these areas potentially detracting from the enjoyment of people visiting accessible parts of the parks or nearby facilities. Clearing of mostly mature regrowth/planted trees would be required for the construction support site establishment. The loss of these trees would temporarily impact on the landscape and visual amenity of the park until new trees or landscaping becomes established. Clearing of these trees is also likely to be a concern for the local community. Land affected by construction would be reinstated after construction and is not expected to impact on the long-term use of Flat Rock Reserve.	After construction, land affected by the project at Flat Rock Reserve would be rehabilitated and reinstated. Selection of the final land use will be subject to further consultation with Willoughby City Council. No operational impacts would be expected.
Spit West Reserve	
Spit West Reserve provides the opportunity for a number of formal and informal recreational activities and is likely to attract tourists and weekend visitors. During construction, part of the reserve would be unavailable for public use for a period of about 50 months for use as a construction support site. The existing cycleway along the foreshore of Middle Harbour and Spit West Reserve would be temporary diverted around the construction support site. The amenity of Spit West Reserve would also be diminished during construction and may detract from the enjoyment of people visiting accessible parts of the parks or nearby facilities.	After construction, land affected by the project at Spit West Reserve would be rehabilitated and reinstated. No operational impacts would be expected.
Impacts to water-based recreational activities (such as the Mosman Rowers Club) would require mitigation and management measure to minimise disruption.	
Balgowlah Golf Club	
Land owned by the NSW Government and occupied by the Balgowlah Golf Club would be acquired and/or temporarily leased for the operation of the Balgowlah Golf Club construction support site (BL10) and to allow for the construction of the connection to and from the Burnt Bridge Creek Deviation upgrade including the new access road, motorway facility and ventilation outlet within the site. Construction of the project would also require the clearing of established trees within the golf	The project would result in the permanent closure of the golf club. This would require members and visitors to access golf courses elsewhere, impacting on social networks associated with the club. It is likely that some members would use the closure of the club as a reason to stop playing golf. This is most likely to be long-term members or older golfers, potentially impacting individuals' general levels of physical activity, and overall wellbeing

Construction impacts to open space	Operational impacts to open space
course, including within the previously modified Burnt Bridge Creek riparian corridor where localised adjustment of the creek is required. The loss of these trees may be a concern for some community members and impact on visual and landscape amenity of the surrounding area. However, the final clearing requirements would be confirmed as part of a dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council. This would give the community an opportunity to provide input on the final layout of the new open space and recreation facilities at Balgowlah.	associated with the possible loss of social networks and personal relationships. However, engagement with Northern Beaches Council has identified potential for the residual land associated with Balgowlah Golf Course and properties acquired in Dudley Street to be developed for new and improved open space and recreation facilities in the future. Use of the residual land for such facilities would align with the *Northern Beaches Sportsground Strategy* (Northern Beaches Council, 2017) and address the current under supply of sporting grounds available for public use in the local area. A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council will take place to give the community an opportunity to provide input on the final layout of the new open space and recreation facilities at Balgowlah. This consultation will be separate to the consultation for the environmental impact statement. This process will start after the environmental impact statement public exhibition period and well in advance of construction starting. As part of this consultation process, a community reference group will be established, with representative stakeholder groups and the community, to support Transport for NSW and Northern Beaches Council with the development of this important public space. The project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved public open space and recreation facilities.

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 study 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.

Public transport in the Northern Beaches is almost exclusively on the road network (buses). Potential disruption to public transport services through construction works will disadvantage the young, elderly and some people with disabilities who are reliant on public transport for transportation.

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:

- Western Harbour Tunnel and Warringah Freeway Upgrade
- Sydney Metro City & Southwest (Chatswood to Sydenham).

The area is also subject to ongoing urban development, with many of the local government areas 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 potential cumulative impacts during construction of the project based on likely interactions with other projects may occur around North Sydney and Cammeray, Artarmon, and Naremburn and Willoughby. Potential cumulative impacts would be generated by interactions between the project and the Western Harbour Tunnel and Warringah Freeway Upgrade at North Sydney and Cammeray, the Sydney Metro City & Southwest (Chatswood to Sydenham) at Artarmon, and the Western Harbour Tunnel and Warringah Freeway Upgrade.

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.

There is also potential for residential receivers around Naremburn and Willoughby to experience construction fatigue as a result of the project and its proximity to Western Harbour Tunnel and Warringah Freeway Upgrade construction sites. Construction fatigue at this location is likely to be limited to temporary increases in construction noise and are expected to be minor.

Without mitigation, key cumulative impacts leading to construction fatigue would include temporary and prolonged increases in traffic volume, 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 9.10.

The design and construction methodology have 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 will be carried out with businesses potentially impacted during construction. Consultation will aim to identify specific potential construction impacts for individual businesses. Based on consultation with businesses that are potentially impacted, feasible and reasonable measures will 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, 2020).

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. However, it is noted that the business centre of Frenchs Forest would be adversely impacted due to reduced accessibility and reduced trade catchments. However, any impact is considered to be moderate to low, given the sensitivity of the centre and the magnitude of change by the project. Further changes are also expected in this area as associated with the development of the Northern Beaches Hospital Precinct Structure Plan.

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 Gross State Product (GSP) in 2011, this represented 13.8 per cent of NSW GSP at the time.

The project would result in the majority of heavy vehicle trips on the existing crossings to and from the Northern Beaches transferring to the project, with the largest proportional reductions in traffic volumes being on Spit Road and the Military Road corridor. While the project would not generally increase the heavy vehicle demand travelling into and out of the Northern Beaches, it would substantially reduce the travel times of these freight trips and increase their productivity. 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.

9.9 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 though the provision of half-priced or free vehicle registration.

9.10 Stress and anxiety issues

A number of changes within the community (discussed in Sections 9.2 to 9.9) 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 will 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, 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 will 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 potential construction impacts, may assist in reducing stress and associated physiological and mental health impacts within the urban environment when open to traffic and operational.

9.11 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 depend 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. Figure 9-1 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.

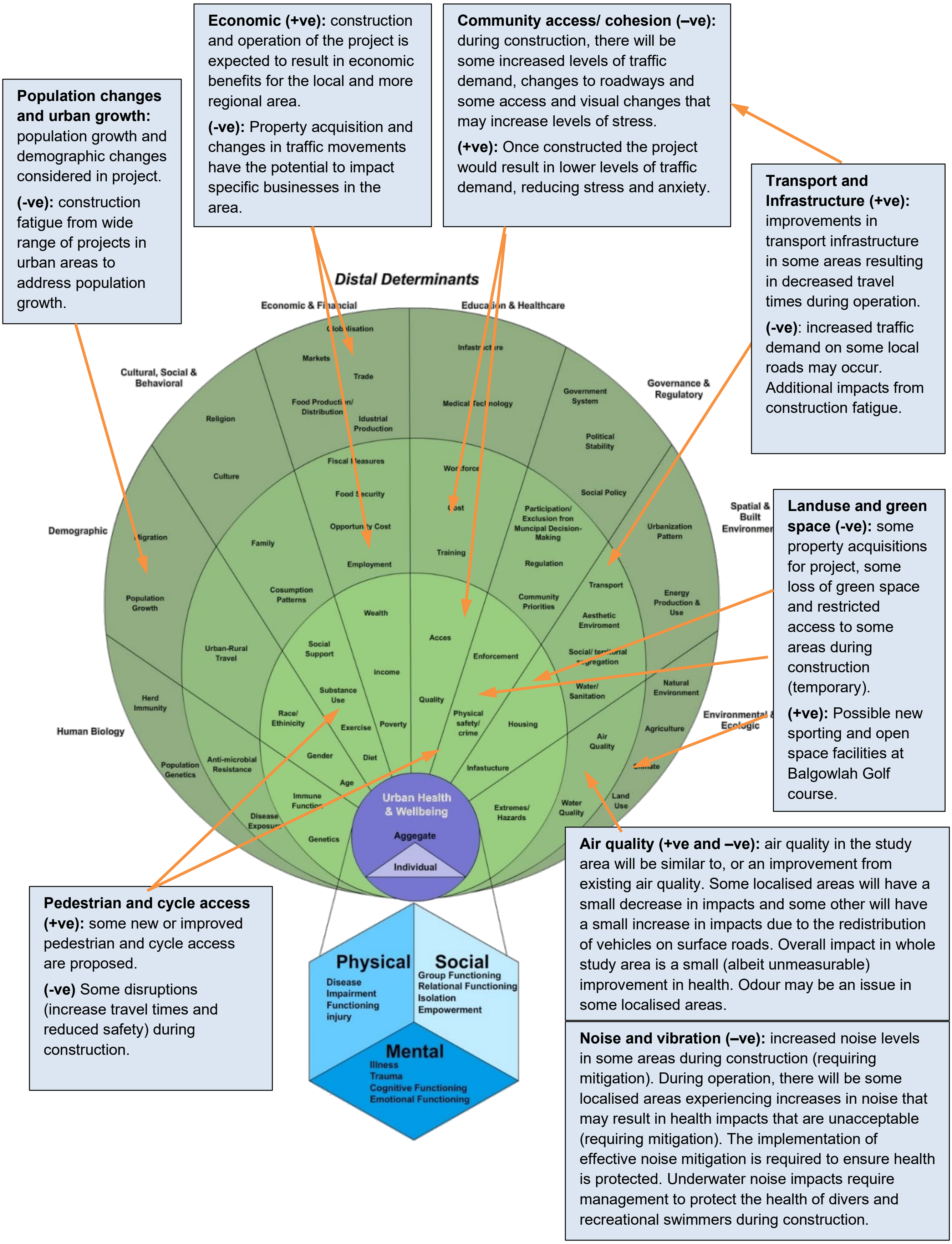

Figure 9-1 Conceptual framework for determinants of health and wellbeing in the urban environment and potential impacts from project (ICSU 2011)

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 Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement). The traffic demand modelling has forecast population growth projections over the Greater Sydney 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 NO_2 concentration during a given year. Any method which provides a ‘typical’ or ‘average’ one hour NO_2 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 are 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement). It found the modelling approach to have provided conservative estimates of exposure concentrations throughout the study area. Specifically:

- For PM_{10} the results suggested that the use of modelling should give good (and slightly conservative) estimates of the annual PM_{10} 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 plus or minus 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 that 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.

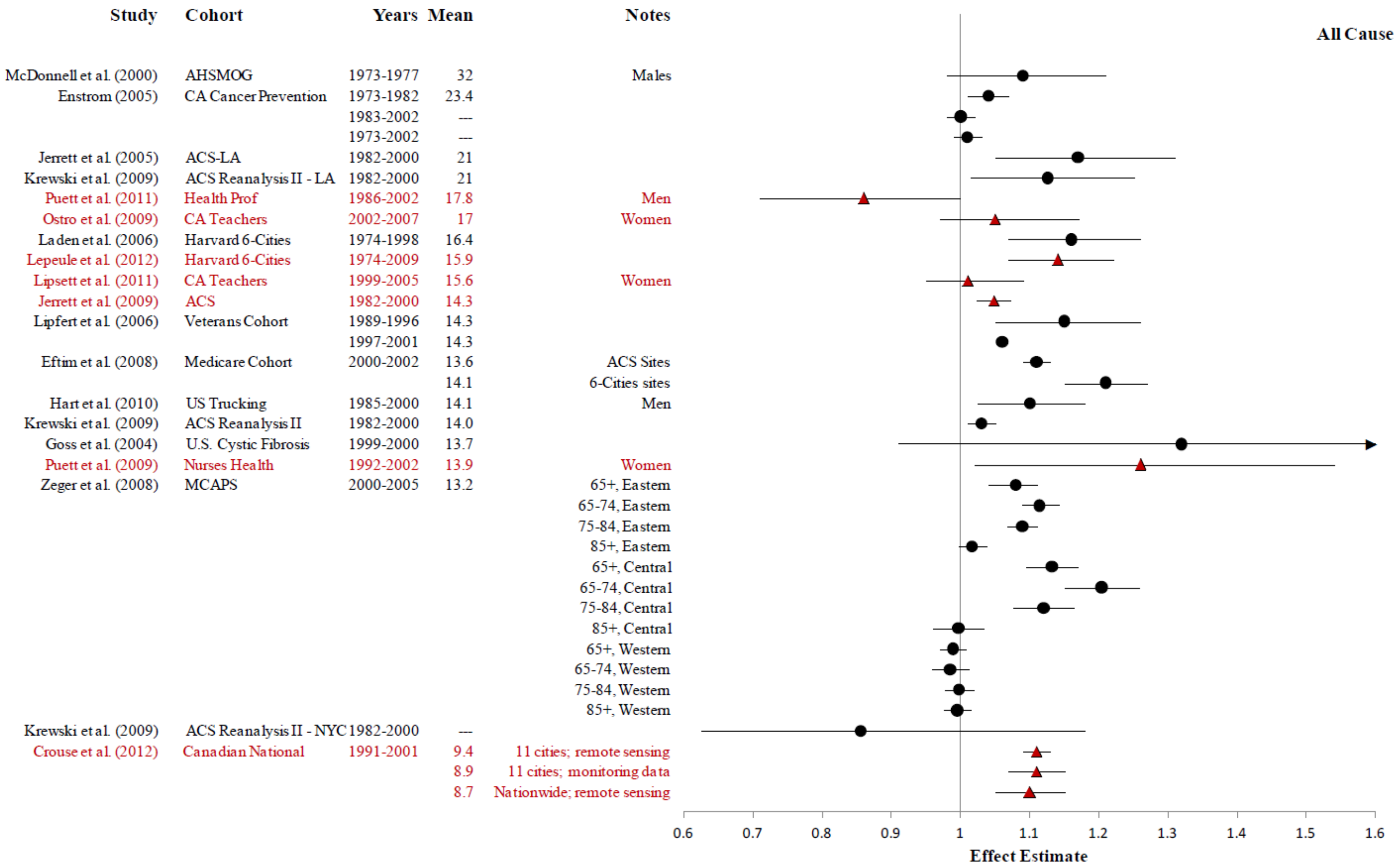

Figure 10-1 **All-cause mortality relative risk estimates for long term exposure to $PM_{2.5}$ (USEPA, 2012; note studies in red are those completed since 2009)**

Study	Location	Age	Lag	Mean	98th
Metzger et al. (2004)	Atlanta, GA	All	0-2	17.8	---
Tolbert et al. (2007)	Atlanta, GA	All	0-2	17.1	---
Zanobetti et al. (2009)*	26 U.S. Communities	65+	0-1	15.3	---
Ito et al. (2011)	New York, NY	40+	0	14.4	---
Bell et al. (2008)	202 U.S. Counties	65+	0	12.9	34.2
Slaughter et al. (2005)	Spokane, WA	All	1	10.8	29.6
Kloog et al. (2012)	New England	65+	0-1	9.6	---
Kim et al. (2012)	Denver, CO	All	0-2 DL	8.0	---
Burnett et al. (1999)	Toronto, CAN	All	0-1	18.0	---
Ito (2003)	Detroit, MI	65+	1	18.0	---
Metzger et al. (2004)	Atlanta, GA	All	0-3	17.8	---
Dominici et al. (2006)	204 U.S. Counties	65+	0-2 DL	13.3	34.8
Pope et al. (2006)	Utah Valley, UT	All	0	10.1-11.3	---
Zanobetti et al. (2009)*	26 U.S. Communities	65+	0-1	15.3	---
Sullivan et al. (2005)	King County, WA	21-98	24 h	12.8	---
Peters et al. (2001)	Boston, MA	61.6a	24 h	12.1	28.2
Zanobetti & Schwartz (2005)	Boston, MA	65+	0	11.1**	---
Stieb et al. (2009)*	7 Canadian cities	All	0	6.7-9.8	---
Burnett et al. (1999)	Toronto, CAN	All	0-2	18.0	---
Ito (2003)	Detroit, MI	65+	1	18.0	---
Metzger et al. (2004)*	Atlanta, GA	All	0-2	17.8	---
Symons et al. (2006)	Baltimore, MD	All	2	16.0	---
Zanobetti et al. (2009)*	26 U.S. Communities	65+	0-1	15.3	---
Dominici et al. (2006)	204 U.S. Counties	65+	0	13.3	34.8
Haley et al. (2009)	New York State	All	0-2	11.1-15.5	---
Pope et al. (2008)	Utah	All	0-13 DL	10.8	44.5
Stieb et al. (2009)*	7 Canadian cities	All	0	6.7-9.8	---
Metzger et al. (2004)*	Atlanta, GA	All	0-2	17.8	---
Dominici et al. (2006)	204 U.S. Counties	65+	0	13.3	34.8
Kloog et al. (2012)	New England	65+	0-1	9.6	---
Szyszkowicz et al. (2012)*	Edmonton, CAN	All	0-3	8.5	---

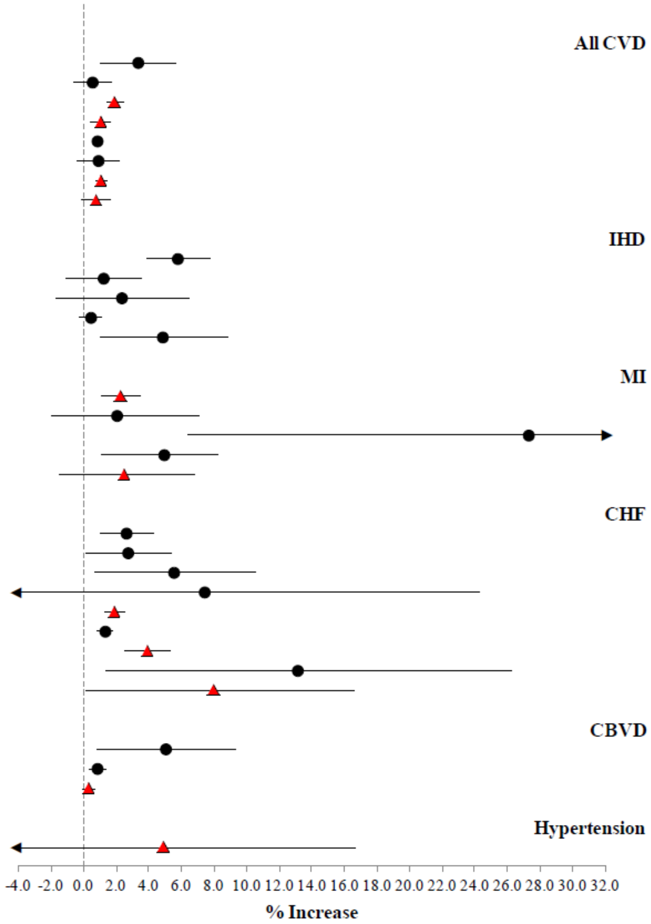

Figure 10-2 Per cent increase in cardiovascular-related hospital admissions for a 10 microgram per cubic metre increase in short term (24 hour average) exposure to $PM_{2.5}$ (USEPA, 2012; note studies in red are those completed since 2009)

(Note: CVD = cardiovascular disease; IHD = ischemic heart disease ; MI = myocardial infarction; CHF = congestive heart failure; CBVD = cerebrovascular disease)

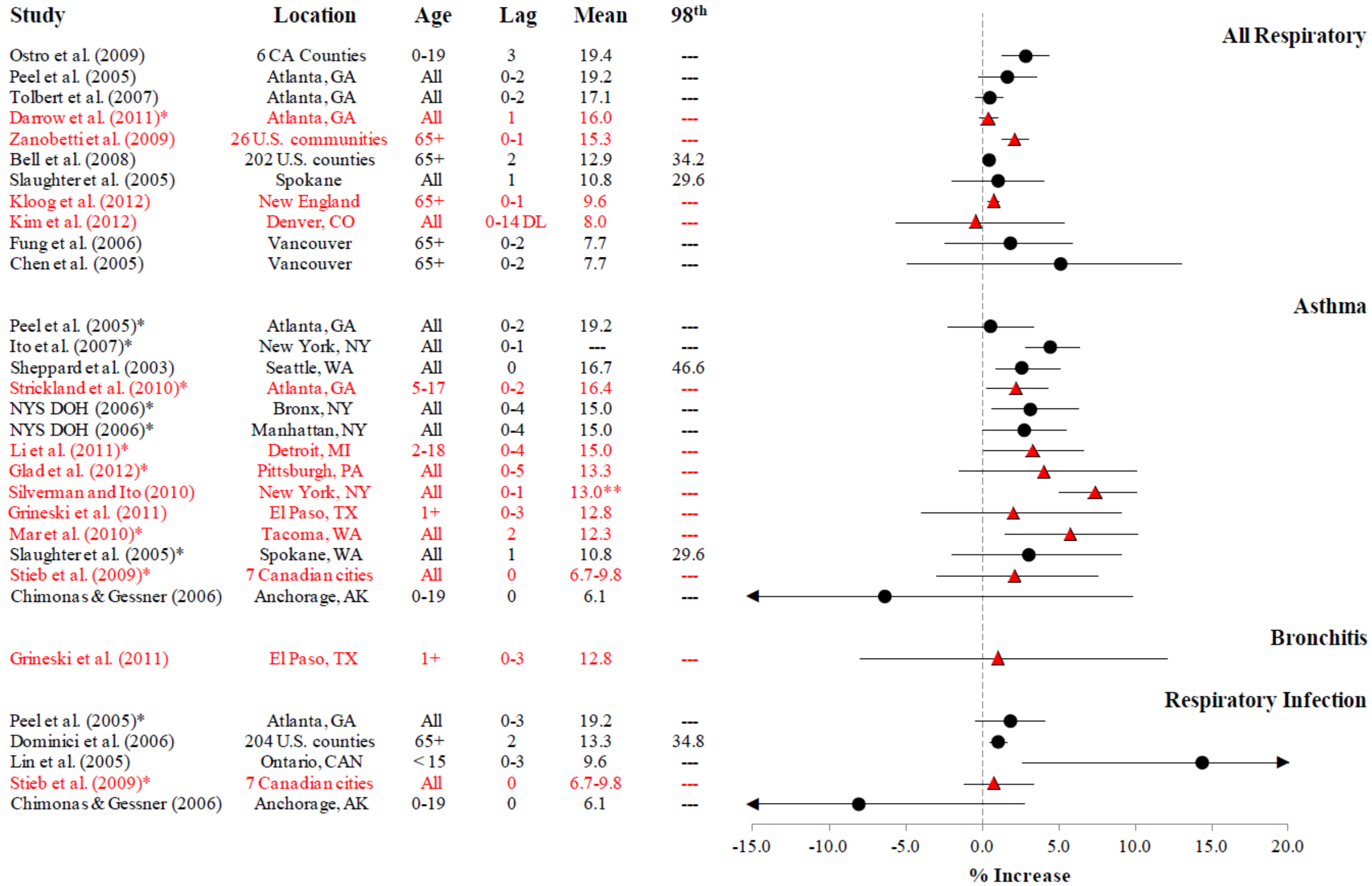

Figure 10-3 Per cent increase in respiratory-related hospital admissions for a 10 micrograms per cubic metre increase in short term (24 hour average) exposure to $PM_{2.5}$ (USEPA, 2012; note studies in red are those completed since 2009)

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 mid1990s. 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 NO_2, 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 NO_2) 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 NO_2, 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
- 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 are relate to health effects from exposure to changes in NO_2 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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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 nitrogen dioxide 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 linear[14]. 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[β(X-X0)]**

Where:
X-X0 = the change in particulate matter concentration to which the population is exposed (µg/m³)
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 µg/m³ increase in particulate matter exposure.

Based on this equation, where the published studies have derived relative risk values that are associated with a 10 micrograms per cubic metre 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 (µg/m³)
10 = increase in particulate matter concentration associated with the RR (where the RR is associated with a 10 µg/m³ 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 micrograms per cubic metre,(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 micrograms per cubic metre 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 nitrogen dioxide 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 NO_2 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.

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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).

When considering the potential impact of the project on the population, the calculation has been carried out using the following:

- 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 one microgram per cubic metre) as follows:

Equation 5 $E=\beta \times B \times \sum_{mesh}(\Delta X_{mesh} \times P_{mesh})$

Where:
β = slope coefficient relevant to the per cent change in response to a 1 μg/m³ change in exposure concentration
B = baseline incidence of a given health effect per person (eg annual mortality rate)
ΔXmesh = change (increment) in exposure concentration in μg/m³ as an average within a small area defined as a mesh block (from the ABS – where many mesh blocks make up a suburb)
Pmesh = population (residential – based on data form the ABS) within each small mesh block

An additional risk can then be calculated as:

Equation 6 $Risk=\beta \times \Delta X \times B$

Where:
β = slope coefficient relevant to the per cent change in response to a 1 μg/m³ change in exposure
ΔX = change (increment) in exposure concentration in μg/m³ 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 nitrogen dioxide 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 nitrogen dioxide 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 nitrogen dioxide 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 microgram per cubic metres 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 microgram per cubic metres 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 x 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 Appendix H (Technical working paper: Air quality) of the environmental impact statement (ERM, 2018); 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 2009a):

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 2012b). 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 1×10^{-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.

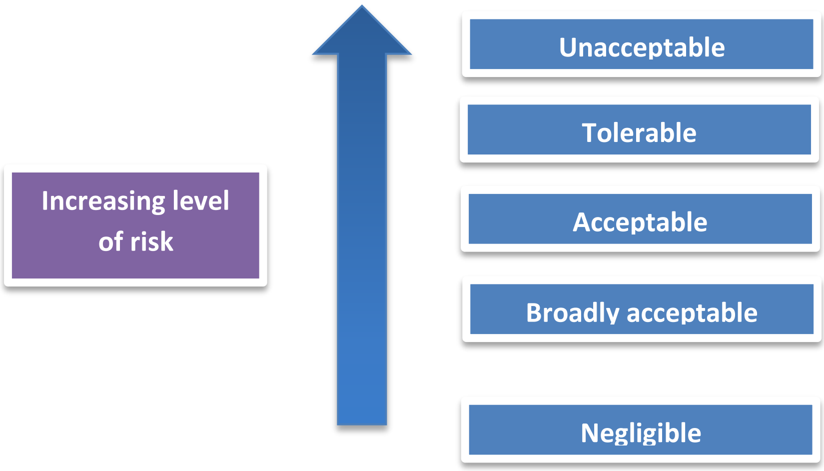
To provide more context in relation to the concept of a one in a million risk, the following presents a range of everyday life occurrences. The activity and the time spent undertaking the activity that is associated with reaching a risk of one in a million for mortality are listed below (Higson 1989; 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.

[1] Mortality risks as presented by: http://www.riskcomm.com/visualaids/riskscale/datasources.php.

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).

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 an acceptable risk for specific development projects might be.

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 is 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 percent confidence interval for data reported in Sydney) is around ± two percent. 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 ± 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 form 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 - NO_2
Beaches Link

	2027			2027 - Cumulative			2037			2037 - Cumulative		
Air quality indicator:	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2	NO_2
Endpoint:	**Mortality - All Causes**	**Mortality - Respiratory**	**Asthma - ED Hospital admissions**	**Mortality - All Causes**	**Mortality - Respiratory**	**Asthma - ED Hospital admissions**	**Mortality - All Causes**	**Mortality - Respiratory**	**Asthma - ED Hospital admissions**	**Mortality - All Causes**	**Mortality - Respiratory**	**Asthma - ED Hospital admissions**
Effect Exposure Duration:	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term	Short-term
Age Group:	All ages	All ages	1-14 years	All ages	All ages	1-14 years	All ages	All ages	1-14 years	All ages	All ages	1-14 years
β (change in effect per 1 μg/m³ NO2) (as per Table 5-15)	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115
Annual Baseline Incidence (as per Table 3-5)												
Annual baseline incidence (per 100,000)	428	32.1	1209	428	32.1	1209	428	32.1	1209	428	32.1	1209
Baseline Incidence (per person per year)	0.00428	0.000321	0.01209	0.00428	0.000321	0.01209	0.00428	0.000321	0.01209	0.00428	0.000321	0.01209

2027

Sensitive Receptors		Change in Annual Average NO2 Concentration (μg/m³)	Risk	Risk	Risk
Impacts from tunnel ventilation outlets					
Grid receptors: maximum regardless of land use		**5.5**	**4E-05**	**8E-06**	**8E-05**
Grid receptors: maximum residential		**4.0**	**3E-05**	**5E-06**	**6E-05**
Grid receptors: commercial/industrial		**5.5**	**4E-05**	**8E-06**	**8E-05**
Grid receptors: maximum childcare		**1.3**	**1E-05**	**2E-06**	**2E-05**
Grid receptors: maximum school		**1.3**	**1E-05**	**2E-06**	**2E-05**
Grid receptors: maximum aged care		**1.1**	**9E-06**	**2E-06**	**2E-05**
Grid receptors: maximum hospital and medical		**0.67**	**5E-06**	**9E-07**	**9E-06**
Grid receptors: open space		**1.9**	**2E-05**	**3E-06**	**3E-05**
Community Receptors					
University of Notre Dame, Broadway	University	0.015	1E-07	2E-08	2E-07
Laverty Pathology, Annandale	Medical centre	0.273	2E-06	4E-07	4E-06
St Basil's, Annandale	Aged care	0.324	3E-06	4E-07	5E-06
The Jimmy Little Community Centre	Community centre	-0.061	-5E-07	-8E-08	-9E-07
Rozelle Public School	Primary School	-0.941	-8E-06	-1E-06	-1E-05
St Aloysius College	High School	0.822	7E-06	1E-06	1E-05
Dancing Dingo Family Day Care	Child care	-0.278	-2E-06	-4E-07	-4E-06
Wenona School	Primary School	-1.217	-1E-05	-2E-06	-2E-05
Mater Hospital	Hospital	-0.175	-1E-06	-2E-07	-2E-06
Neutral Bay Public School	Primary School	0.073	6E-07	1E-07	1E-06
Neutral Bay Medical Centre	Medical Centre	-0.940	-8E-06	-1E-06	-1E-05
Puddleducks Child Care Centre	Childcare	-0.905	-7E-06	-1E-06	-1E-05
Mosman Public School	Primary School	-0.054	-4E-07	-7E-08	-7E-07
Garrison & Killarney Retirement Centre	Aged care	-1.592	-1E-05	-2E-06	-2E-05
Beauty Point Public School	Primary School	-0.665	-5E-06	-9E-07	-9E-06
Anzac Park Public School	Primary School	-0.214	-2E-06	-3E-07	-3E-06
Ku Cammeray Preschool	Preschool	-0.094	-8E-07	-1E-07	-1E-06
Cammeray Public School	Primary School	-0.583	-5E-06	-8E-07	-8E-06
Atchison Preschool	Preschool	-0.619	-5E-06	-8E-07	-9E-06
Berry Cottage Childcare	Child care	0.164	1E-06	2E-07	2E-06
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.502	4E-06	7E-07	7E-06
SBS Child Care	Child care	0.423	3E-06	6E-07	6E-06
Butterflies Early Learning Childcare Centre	Child care	0.305	2E-06	4E-07	4E-06
Artarmon Public School	Primary School	0.016	1E-07	2E-08	2E-07
Sue's Childcare, Castlevale	Child care	-0.520	-4E-06	-7E-07	-7E-06
Northside Baptist Preschool	Preschool	-0.828	-7E-06	-1E-06	-1E-05
Willoughby Public School	Primary School	0.107	9E-07	1E-07	1E-06
Peek A Boo Cottage	Child care	-2.555	-2E-05	-3E-06	-4E-05
St Cecilia's Catholic Primary School	Primary School	-0.248	-2E-06	-3E-07	-3E-06
Seaforth Public School	Primary School	0.253	2E-06	3E-07	4E-06
Punchinello Kindergarten	Preschool	0.873	7E-06	1E-06	1E-05
Harbour View Childrens Centre	Child care	0.022	2E-07	3E-08	3E-07
Jacaranda Creative Play Centre	Child care	-0.166	-1E-06	-2E-07	-2E-06
St James Medical And Cosmetics Centre	Medical Centre	0.155	1E-06	2E-07	2E-06
Ku Bligh Park Preschool	Preschool	0.231	2E-06	3E-07	3E-06
Balgowlah North Public School	Primary School	-0.110	-9E-07	-2E-07	-2E-06
Hardi Aged Care Manly Vale	Aged care	0.738	6E-06	1E-06	1E-05
Willoughby Retirement Village	Aged care	-0.557	-4E-06	-8E-07	-8E-06
Roseville Public School	Primary school	-0.511	-4E-06	-7E-07	-7E-06
UnitingCare Forestville Preschool	Childcare	-0.198	-2E-06	-3E-07	-3E-06
Beehive Kindy	Childcare	-0.359	-3E-06	-5E-07	-5E-06
Northern Beaches Hospital	Hospital	-0.056	-4E-07	-8E-08	-8E-07

2027 - Cumulative

Sensitive Receptors		Change in Annual Average NO2 Concentration (μg/m³)	Risk	Risk	Risk
Impacts from tunnel ventilation outlets					
Grid receptors: maximum regardless of land use		**3.9**	**3E-05**	**5E-06**	**5E-05**
Grid receptors: maximum residential		**3.9**	**3E-05**	**5E-06**	**5E-05**
Grid receptors: commercial/industrial		**2.3**	**2E-05**	**3E-06**	**3E-05**
Grid receptors: maximum childcare		**0.94**	**8E-06**	**1E-06**	**1E-05**
Grid receptors: maximum school		**0.75**	**6E-06**	**1E-06**	**1E-05**
Grid receptors: maximum aged care		**0.95**	**8E-06**	**1E-06**	**1E-05**
Grid receptors: maximum hospital and medical		**0.68**	**5E-06**	**9E-07**	**9E-06**
Grid receptors: open space		**1.7**	**1E-05**	**2E-06**	**2E-05**
Community Receptors					
University of Notre Dame, Broadway	University	-0.403	-3E-06	-6E-07	-6E-06
Laverty Pathology, Annandale	Medical centre	-0.168	-1E-06	-2E-07	-2E-06
St Basil's, Annandale	Aged care	0.857	7E-06	1E-06	1E-05
The Jimmy Little Community Centre	Community centre	-0.229	-2E-06	-3E-07	-3E-06
Rozelle Public School	Primary School	-0.600	-5E-06	-8E-07	-8E-06
St Aloysius College	High School	-1.833	-1E-05	-3E-06	-3E-05
Dancing Dingo Family Day Care	Child care	-0.303	-2E-06	-4E-07	-4E-06
Wenona School	Primary School	-1.845	-1E-05	-3E-06	-3E-05
Mater Hospital	Hospital	0.184	1E-06	3E-07	3E-06
Neutral Bay Public School	Primary School	-0.524	-4E-06	-7E-07	-7E-06
Neutral Bay Medical Centre	Medical Centre	-1.319	-1E-05	-2E-06	-2E-05
Puddleducks Child Care Centre	Childcare	-0.865	-7E-06	-1E-06	-1E-05
Mosman Public School	Primary School	-0.338	-3E-06	-5E-07	-5E-06
Garrison & Killarney Retirement Centre	Aged care	-1.726	-1E-05	-2E-06	-2E-05
Beauty Point Public School	Primary School	-0.719	-6E-06	-1E-06	-1E-05
Anzac Park Public School	Primary School	0.245	2E-06	3E-07	3E-06
Ku Cammeray Preschool	Preschool	0.127	1E-06	2E-07	2E-06
Cammeray Public School	Primary School	0.064	5E-07	9E-08	9E-07
Atchison Preschool	Preschool	-0.775	-6E-06	-1E-06	-1E-05
Berry Cottage Childcare	Child care	-0.120	-1E-06	-2E-07	-2E-06
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.329	3E-06	5E-07	5E-06
SBS Child Care	Child care	0.290	2E-06	4E-07	4E-06
Butterflies Early Learning Childcare Centre	Child care	0.344	3E-06	5E-07	5E-06
Artarmon Public School	Primary School	0.080	6E-07	1E-07	1E-06
Sue's Childcare, Castlevale	Child care	-0.012	-9E-08	-2E-08	-2E-07
Northside Baptist Preschool	Preschool	-0.848	-7E-06	-1E-06	-1E-05
Willoughby Public School	Primary School	-0.170	-1E-06	-2E-07	-2E-06
Peek A Boo Cottage	Child care	-2.601	-2E-05	-4E-06	-4E-05
St Cecilia's Catholic Primary School	Primary School	-0.197	-2E-06	-3E-07	-3E-06
Seaforth Public School	Primary School	0.515	4E-06	7E-07	7E-06
Punchinello Kindergarten	Preschool	0.441	4E-06	6E-07	6E-06
Harbour View Childrens Centre	Child care	-0.131	-1E-06	-2E-07	-2E-06
Jacaranda Creative Play Centre	Child care	-0.080	-6E-07	-1E-07	-1E-06
St James Medical And Cosmetics Centre	Medical Centre	-0.058	-5E-07	-8E-08	-8E-07
Ku Bligh Park Preschool	Preschool	0.232	2E-06	3E-07	3E-06
Balgowlah North Public School	Primary School	0.405	3E-06	6E-07	6E-06
Hardi Aged Care Manly Vale	Aged care	0.480	4E-06	7E-07	7E-06
Willoughby Retirement Village	Aged care	-0.763	-6E-06	-1E-06	-1E-05
Roseville Public School	Primary school	-0.670	-5E-06	-9E-07	-9E-06
UnitingCare Forestville Preschool	Childcare	0.019	2E-07	3E-08	3E-07
Beehive Kindy	Childcare	-0.437	-4E-06	-6E-07	-6E-06
Northern Beaches Hospital	Hospital	0.017	1E-07	2E-08	2E-07

2037

Sensitive Receptors		Change in Annual Average NO2 Concentration (μg/m³)	Risk	Risk	Risk
Impacts from tunnel ventilation outlets					
Grid receptors: maximum regardless of land use		**6**	**5E-05**	**8E-06**	**8E-05**
Grid receptors: maximum residential		**3.6**	**3E-05**	**5E-06**	**5E-05**
Grid receptors: commercial/industrial		**6**	**5E-05**	**8E-06**	**8E-05**
Grid receptors: maximum childcare		**1**	**8E-06**	**1E-06**	**1E-05**
Grid receptors: maximum school		**1.2**	**1E-05**	**2E-06**	**2E-05**
Grid receptors: maximum aged care		**1.7**	**1E-05**	**2E-06**	**2E-05**
Grid receptors: maximum hospital and medical		**0.94**	**8E-06**	**1E-06**	**1E-05**
Grid receptors: open space		**1.9**	**2E-05**	**3E-06**	**3E-05**
Community Receptors					
University of Notre Dame, Broadway	University	-0.202	-2E-06	-3E-07	-3E-06
Laverty Pathology, Annandale	Medical centre	0.430	3E-06	6E-07	6E-06
St Basil's, Annandale	Aged care	0.105	8E-07	1E-07	1E-06
The Jimmy Little Community Centre	Community centre	-0.146	-1E-06	-2E-07	-2E-06
Rozelle Public School	Primary School	0.176	1E-06	2E-07	2E-06
St Aloysius College	High School	1.299	1E-05	2E-06	2E-05
Dancing Dingo Family Day Care	Child care	0.199	2E-06	3E-07	3E-06
Wenona School	Primary School	-0.513	-4E-06	-7E-07	-7E-06
Mater Hospital	Hospital	-0.204	-2E-06	-3E-07	-3E-06
Neutral Bay Public School	Primary School	-1.094	-9E-06	-1E-06	-2E-05
Neutral Bay Medical Centre	Medical Centre	-1.098	-9E-06	-2E-06	-2E-05
Puddleducks Child Care Centre	Childcare	-0.603	-5E-06	-8E-07	-8E-06
Mosman Public School	Primary School	-0.269	-2E-06	-4E-07	-4E-06
Garrison & Killarney Retirement Centre	Aged care	-2.392	-2E-05	-3E-06	-3E-05
Beauty Point Public School	Primary School	-0.182	-1E-06	-2E-07	-3E-06
Anzac Park Public School	Primary School	-0.395	-3E-06	-5E-07	-5E-06
Ku Cammeray Preschool	Preschool	-0.365	-3E-06	-5E-07	-5E-06
Cammeray Public School	Primary School	0.136	1E-06	2E-07	2E-06
Atchison Preschool	Preschool	-0.550	-4E-06	-8E-07	-8E-06
Berry Cottage Childcare	Child care	-0.483	-4E-06	-7E-07	-7E-06
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.236	2E-06	3E-07	3E-06
SBS Child Care	Child care	0.317	3E-06	4E-07	4E-06
Butterflies Early Learning Childcare Centre	Child care	0.282	2E-06	4E-07	4E-06
Artarmon Public School	Primary School	-0.005	-4E-08	-6E-09	-6E-08
Sue's Childcare, Castlevale	Child care	-0.793	-6E-06	-1E-06	-1E-05
Northside Baptist Preschool	Preschool	-1.105	-9E-06	-2E-06	-2E-05
Willoughby Public School	Primary School	-0.465	-4E-06	-6E-07	-6E-06
Peek A Boo Cottage	Child care	-3.870	-3E-05	-5E-06	-5E-05
St Cecilia's Catholic Primary School	Primary School	-0.161	-1E-06	-2E-07	-2E-06
Seaforth Public School	Primary School	-0.826	-7E-06	-1E-06	-1E-05
Punchinello Kindergarten	Preschool	0.366	3E-06	5E-07	5E-06
Harbour View Childrens Centre	Child care	0.098	8E-07	1E-07	1E-06
Jacaranda Creative Play Centre	Child care	-0.158	-1E-06	-2E-07	-2E-06
St James Medical And Cosmetics Centre	Medical Centre	0.574	5E-06	8E-07	8E-06
Ku Bligh Park Preschool	Preschool	0.139	1E-06	2E-07	2E-06
Balgowlah North Public School	Primary School	0.097	8E-07	1E-07	1E-06
Hardi Aged Care Manly Vale	Aged care	1.174	9E-06	2E-06	2E-05
Willoughby Retirement Village	Aged care	-0.949	-8E-06	-1E-06	-1E-05
Roseville Public School	Primary school	-0.340	-3E-06	-5E-07	-5E-06
UnitingCare Forestville Preschool	Childcare	-0.703	-6E-06	-1E-06	-1E-05
Beehive Kindy	Childcare	-0.706	-6E-06	-1E-06	-1E-05
Northern Beaches Hospital	Hospital	-0.063	-5E-07	-9E-08	-9E-07

2037 - Cumulative

Sensitive Receptors		Change in Annual Average NO2 Concentration (μg/m³)	Risk	Risk	Risk
Impacts from tunnel ventilation outlets					
Grid receptors: maximum regardless of land use		**3.1**	**2E-05**	**4E-06**	**4E-05**
Grid receptors: maximum residential		**3.1**	**2E-05**	**4E-06**	**4E-05**
Grid receptors: commercial/industrial		**2.9**	**2E-05**	**4E-06**	**4E-05**
Grid receptors: maximum childcare		**1.4**	**1E-05**	**2E-06**	**2E-05**
Grid receptors: maximum school		**0.76**	**6E-06**	**1E-06**	**1E-05**
Grid receptors: maximum aged care		**0.86**	**7E-06**	**1E-06**	**1E-05**
Grid receptors: maximum hospital and medical		**1.1**	**9E-06**	**2E-06**	**2E-05**
Grid receptors: open space		**2.2**	**2E-05**	**3E-06**	**3E-05**
Community Receptors					
University of Notre Dame, Broadway	University	-0.645	-5E-06	-9E-07	-9E-06
Laverty Pathology, Annandale	Medical centre	0.095	8E-07	1E-07	1E-06
St Basil's, Annandale	Aged care	0.565	5E-06	8E-07	8E-06
The Jimmy Little Community Centre	Community centre	-0.197	-2E-06	-3E-07	-3E-06
Rozelle Public School	Primary School	-0.213	-2E-06	-3E-07	-3E-06
St Aloysius College	High School	-1.051	-8E-06	-1E-06	-1E-05
Dancing Dingo Family Day Care	Child care	-0.068	-6E-07	-9E-08	-1E-06
Wenona School	Primary School	-1.380	-1E-05	-2E-06	-2E-05
Mater Hospital	Hospital	0.068	5E-07	9E-08	9E-07
Neutral Bay Public School	Primary School	-1.284	-1E-05	-2E-06	-2E-05
Neutral Bay Medical Centre	Medical Centre	-1.451	-1E-05	-2E-06	-2E-05
Puddleducks Child Care Centre	Childcare	-0.255	-2E-06	-3E-07	-4E-06
Mosman Public School	Primary School	-0.146	-1E-06	-2E-07	-2E-06
Garrison & Killarney Retirement Centre	Aged care	-2.316	-2E-05	-3E-06	-3E-05
Beauty Point Public School	Primary School	-0.469	-4E-06	-6E-07	-7E-06
Anzac Park Public School	Primary School	0.245	2E-06	3E-07	3E-06
Ku Cammeray Preschool	Preschool	0.142	1E-06	2E-07	2E-06
Cammeray Public School	Primary School	0.216	2E-06	3E-07	3E-06
Atchison Preschool	Preschool	-0.740	-6E-06	-1E-06	-1E-05
Berry Cottage Childcare	Child care	-0.792	-6E-06	-1E-06	-1E-05
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.178	1E-06	2E-07	2E-06
SBS Child Care	Child care	0.209	2E-06	3E-07	3E-06
Butterflies Early Learning Childcare Centre	Child care	0.705	6E-06	1E-06	1E-05
Artarmon Public School	Primary School	-0.116	-9E-07	-2E-07	-2E-06
Sue's Childcare, Castlevale	Child care	-0.282	-2E-06	-4E-07	-4E-06
Northside Baptist Preschool	Preschool	-1.249	-1E-05	-2E-06	-2E-05
Willoughby Public School	Primary School	-0.320	-3E-06	-4E-07	-4E-06
Peek A Boo Cottage	Child care	-4.324	-3E-05	-6E-06	-6E-05
St Cecilia's Catholic Primary School	Primary School	-0.121	-1E-06	-2E-07	-2E-06
Seaforth Public School	Primary School	-0.434	-3E-06	-6E-07	-6E-06
Punchinello Kindergarten	Preschool	0.518	4E-06	7E-07	7E-06
Harbour View Childrens Centre	Child care	0.247	2E-06	3E-07	3E-06
Jacaranda Creative Play Centre	Child care	-0.112	-9E-07	-2E-07	-2E-06
St James Medical And Cosmetics Centre	Medical Centre	0.432	3E-06	6E-07	6E-06
Ku Bligh Park Preschool	Preschool	0.116	9E-07	2E-07	2E-06
Balgowlah North Public School	Primary School	0.142	1E-06	2E-07	2E-06
Hardi Aged Care Manly Vale	Aged care	0.966	8E-06	1E-06	1E-05
Willoughby Retirement Village	Aged care	-0.563	-5E-06	-8E-07	-8E-06
Roseville Public School	Primary school	-0.165	-1E-06	-2E-07	-2E-06
UnitingCare Forestville Preschool	Childcare	-0.764	-6E-06	-1E-06	-1E-05
Beehive Kindy	Childcare	-0.759	-6E-06	-1E-06	-1E-05
Northern Beaches Hospital	Hospital	0.169	1E-06	2E-07	2E-06

Annexure E – Population incidence calculations: Nitrogen dioxide

Assessment of Increased Incidence - NO_2
Beaches Link: 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/m3 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	4.01	4.01	4.01
Population weighted Δx (µg/m^3):	0.00171768	0.00171768	0.00171768
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:	1.000003	1.000007	1.000002
Attributable fraction (AF):	3.2E-06	7.3E-06	2.0E-06
Increased number of cases in population:	0.000030	0.0000055	0.0000083
Risk:	1.3E-08	2.3E-09	2.4E-08
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	4.01	4.01	4.01
Population weighted Δx (µg/m^3):	0.00171768	0.00171768	0.00171768
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:	1.000003	1.000007	1.000002
Attributable fraction (AF):	3.2E-06	7.3E-06	2.0E-06
Increased number of cases in population:	0.000030	0.0000055	0.0000083
Risk:	1.3E-08	2.3E-09	2.4E-08
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-35148	-35148	-35148
Population weighted Δx (µg/m^3):	-0.37332757	-0.37332757	-0.37332757
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:	0.999298	0.998411	0.999571
Attributable fraction (AF):	-7.0E-04	-1.6E-03	-4.3E-04
Increased number of cases in population:	-0.26	-0.048	-0.068
Risk:	-2.8E-06	-5.1E-07	-5.2E-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	-8572.4	-8572.4	-8572.4
Population weighted Δx (µg/m^3):	-0.45011385	-0.45011385	-0.45011385
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:	0.999154	0.998084	0.999483
Attributable fraction (AF):	-8.5E-04	-1.9E-03	-5.2E-04
Increased number of cases in population:	-0.0639	-0.0117	-0.0166
Risk:	-3.4E-06	-6.2E-07	-6.3E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	-1540.3	-1540.3	-1540.3
Population weighted Δx (µg/m^3):	-0.08527452	-0.08527452	-0.08527452
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:	0.999840	0.999637	0.999902
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.8E-05
Increased number of cases in population:	-0.0115	-0.0021	-0.0030
Risk:	-6.4E-07	-1.2E-07	-1.2E-06
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-13756	-13756	-13756
Population weighted Δx (µg/m^3):	-0.48330688	-0.48330688	-0.48330688
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:	0.999092	0.997943	0.999444
Attributable fraction (AF):	-9.1E-04	-2.1E-03	-5.6E-04
Increased number of cases in population:	-0.1026	-0.0188	-0.0266
Risk:	-3.6E-06	-6.6E-07	-6.7E-06
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-10079	-10079	-10079
Population weighted Δx (µg/m^3):	-0.56312969	-0.56312969	-0.56312969
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:	0.998942	0.997604	0.999353
Attributable fraction (AF):	-1.1E-03	-2.4E-03	-6.5E-04
Increased number of cases in population:	-0.0752	-0.0138	-0.0195
Risk:	-4.2E-06	-7.7E-07	-7.8E-06
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-1200.3	-1200.3	-1200.3
Population weighted Δx (µg/m^3):	-0.11239200	-0.11239200	-0.11239200

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)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999789	0.999521	0.999871
Attributable fraction (AF):	-2.1E-04	-4.8E-04	-1.3E-04
Increased number of cases in population:	-0.0089	-0.0016	-0.0023
Risk:	-8.4E-07	-1.5E-07	-1.6E-06
Sydney Inner West LGA (Leichhardt)			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	285.58	285.58	285.58
Population weighted Δx (µg/m^3):	0.00591230	0.00591230	0.00591230
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:	1.000011	1.000025	1.000007
Attributable fraction (AF):	1.1E-05	2.5E-05	6.8E-06
Increased number of cases in population:	0.0029	0.00039	0.00056
Risk:	5.9E-08	8.1E-09	8.2E-08
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	410.62	410.62	410.62
Population weighted Δx (µg/m^3):	0.02616609	0.02616609	0.02616609
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:	1.000049	1.000111	1.000030
Attributable fraction (AF):	4.9E-05	1.1E-04	3.0E-05
Increased number of cases in population:	0.0041	0.00056	0.000805
Risk:	2.6E-07	3.6E-08	3.6E-07
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	467.31	467.31	467.31
Population weighted Δx (µg/m^3):	0.02664118	0.02664118	0.02664118
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:	1.000050	1.000113	1.000031
Attributable fraction (AF):	5.0E-05	1.1E-04	3.1E-05
Increased number of cases in population:	0.005	0.00064	0.0009
Risk:	2.7E-07	3.6E-08	3.7E-07
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-592.36	-592.3553577	-592.3553577
Population weighted Δx (µg/m^3):	-0.04720339	-0.04720339	-0.04720339
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:	0.999911	0.999799	0.999946
Attributable fraction (AF):	-8.9E-05	-2.0E-04	-5.4E-05
Increased number of cases in population:	-0.006	-0.00081	-0.0012
Risk:	-4.7E-07	-6.5E-08	-6.6E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	289.33	289.33	289.33
Population weighted Δx (µg/m^3):	0.11481505	0.11481505	0.11481505
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:	1.000216	1.000489	1.000132
Attributable fraction (AF):	2.2E-04	4.9E-04	1.3E-04
Increased number of cases in population:	0.0029	0.00040	0.00057
Risk:	1.2E-06	1.6E-07	1.6E-06
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-57755	-57755	-57755
Population weighted Δx (µg/m^3):	-0.43775807	-0.43775807	-0.43775807
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:	0.999177	0.998137	0.999497
Attributable fraction (AF):	-8.2E-04	-1.9E-03	-5.0E-04
Increased number of cases in population:	-0.55	-0.079	-0.047
Risk:	-4.2E-06	-6.0E-07	-6.1E-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	-6703.5	-6703.5	-6703.5
Population weighted Δx (µg/m^3):	-0.59041149	-0.59041149	-0.59041149
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:	0.998891	0.997488	0.999321
Attributable fraction (AF):	-1.1E-03	-2.5E-03	-6.8E-04
Increased number of cases in population:	-0.064	-0.0092	-0.00550
Risk:	-5.6E-06	-8.1E-07	-8.2E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593

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%	5.9%
total change	1002.5	1002.5	1002.5
Population weighted Δx (µg/m^3):	0.05116828	0.05116828	0.05116828
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:	1.000096	1.000218	1.000059
Attributable fraction (AF):	9.6E-05	2.2E-04	5.9E-05
Increased number of cases in population:	0.010	0.0014	0.00082
Risk:	4.9E-07	7.0E-08	7.1E-07
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-1078.4	-1078.4	-1078.4
Population weighted Δx (µg/m^3):	-0.20924452	-0.20924452	-0.20924452
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:	0.999607	0.999109	0.999759
Attributable fraction (AF):	-3.9E-04	-8.9E-04	-2.4E-04
Increased number of cases in population:	-0.01030	-0.001475	-0.000885
Risk:	-2.0E-06	-2.9E-07	-2.9E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-41328	-41328	-41328
Population weighted Δx (µg/m^3):	-1.94943102	-1.94943102	-1.94943102
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:	0.996342	0.991730	0.997761
Attributable fraction (AF):	-3.7E-03	-8.3E-03	-2.2E-03
Increased number of cases in population:	-0.395	-0.057	-0.0339
Risk:	-1.9E-05	-2.7E-06	-2.7E-05
Pyrmont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	8.7252	8.7252	8.7252
Population weighted Δx (µg/m^3):	0.00040273	0.00040273	0.00040273
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:	1.000001	1.000002	1.000000
Attributable fraction (AF):	7.6E-07	1.7E-06	4.6E-07
Increased number of cases in population:	0.000083	0.000012	0.0000072
Risk:	3.8E-09	5.5E-10	5.6E-09
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	-391.52	-391.52	-391.52
Population weighted Δx (µg/m^3):	-0.03970351	-0.03970351	-0.03970351
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:	0.999925	0.999831	0.999954
Attributable fraction (AF):	-7.5E-05	-1.7E-04	-4.6E-05
Increased number of cases in population:	-0.00374	-0.000535	-0.000321
Risk:	-3.8E-07	-5.4E-08	-5.5E-07
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-6878.7	-6878.7	-6878.7
Population weighted Δx (µg/m^3):	-0.43816097	-0.43816097	-0.43816097
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:	0.999177	0.998135	0.999496
Attributable fraction (AF):	-8.2E-04	-1.9E-03	-5.0E-04
Increased number of cases in population:	-0.066	-0.0094	-0.00564
Risk:	-4.2E-06	-6.0E-07	-6.1E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-2385.9	-2385.9	-2385.9
Population weighted Δx (µg/m^3):	-0.08705365	-0.08705365	-0.08705365
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:	0.999836	0.999629	0.999900
Attributable fraction (AF):	-1.6E-04	-3.7E-04	-1.0E-04
Increased number of cases in population:	-0.0228	-0.0033	-0.00196
Risk:	-8.3E-07	-1.2E-07	-1.2E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-18839	-18839	-18839
Population weighted Δx (µg/m^3):	-0.18227522	-0.18227522	-0.18227522
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:	0.999657	0.999224	0.999790
Attributable fraction (AF):	-3.4E-04	-7.8E-04	-2.1E-04
Increased number of cases in population:	-0.12	-0.026	-0.045
Risk:	-1.1E-06	-2.5E-07	-2.5E-06
Individual subrubs within LGA			
Chatswood East - Artarmon			

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
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	-8202.8	-8202.8	-8202.8
Population weighted Δx (μg/m^3):	-0.28650076	-0.28650076	-0.28650076
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:	0.999462	0.998780	0.999671
Attributable fraction (AF):	-5.4E-04	-1.2E-03	-3.3E-04
Increased number of cases in population:	-0.0517	-0.0112	-0.0195
Risk:	-1.8E-06	-3.9E-07	-4.0E-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	-2788.0	-2788.0	-2788.0
Population weighted Δx (μg/m^3):	-0.15157823	-0.15157823	-0.15157823
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:	0.999715	0.999354	0.999826
Attributable fraction (AF):	-2.9E-04	-6.5E-04	-1.7E-04
Increased number of cases in population:	-0.0176	-0.0038	-0.0066
Risk:	-9.5E-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	641.79	641.79	641.79
Population weighted Δx (μg/m^3):	0.03145899	0.03145899	0.03145899
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:	1.000059	1.000134	1.000036
Attributable fraction (AF):	5.9E-05	1.3E-04	3.6E-05
Increased number of cases in population:	0.0040	0.0009	0.0015
Risk:	2.0E-07	4.3E-08	4.4E-07
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-1809.4	-1809.4	-1809.4
Population weighted Δx (μg/m^3):	-0.17268105	-0.17268105	-0.17268105
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:	0.999675	0.999265	0.999801
Attributable fraction (AF):	-3.2E-04	-7.4E-04	-2.0E-04
Increased number of cases in population:	-0.0114	-0.0025	-0.0043
Risk:	-1.1E-06	-2.4E-07	-2.4E-06
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-6680.7	-6680.7	-6680.7
Population weighted Δx (μg/m^3):	-0.26248297	-0.26248297	-0.26248297
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:	0.999507	0.998882	0.999698
Attributable fraction (AF):	-4.9E-04	-1.1E-03	-3.0E-04
Increased number of cases in population:	-0.0421	-0.0091	-0.0159
Risk:	-1.7E-06	-3.6E-07	-3.6E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	-60.549	-60.549	-60.549
Population weighted Δx (μg/m^3):	-0.02681552	-0.02681552	-0.02681552
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:	0.999950	0.999886	0.999969
Attributable fraction (AF):	-5.0E-05	-1.1E-04	-3.1E-05
Increased number of cases in population:	-0.00057	-0.000083	-0.00015
Risk:	-2.5E-07	-3.7E-08	-3.7E-07
Individual subrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	-60.549	-60.549	-60.549
Population weighted Δx (μg/m^3):	-0.02681552	-0.02681552	-0.02681552
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:	0.999950	0.999886	0.999969
Attributable fraction (AF):	-5.0E-05	-1.1E-04	-3.1E-05
Increased number of cases in population:	-0.0006	-0.00008	-0.0002
Risk:	-2.5E-07	-3.7E-08	-3.7E-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	-3936.5	-3936.5	-3936.5
Population weighted Δx (μg/m^3):	-0.05479455	-0.05479455	-0.05479455
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:	0.999897	0.999767	0.999937
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.3E-05
Increased number of cases in population:	-0.029	-0.0054	-0.0079

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
Risk:	-4.1E-07	-7.5E-08	-7.6E-07
Individual subrubs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184
% population in assessment age-group:	100%	100%	14.5%
total change	15.683	15.683	15.683
Population weighted Δx (µg/m^3):	0.00718101	0.00718101	0.00718101
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:	1.000014	1.000031	1.000008
Attributable fraction (AF):	1.4E-05	3.1E-05	8.3E-06
Increased number of cases in population:	0.0001	0.000021	0.00003
Risk:	5.3E-08	9.8E-09	1.0E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-52.403	-52.403	-52.403
Population weighted Δx (µg/m^3):	-0.00443383	-0.00443383	-0.00443383
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	0.999981	0.999995
Attributable fraction (AF):	-8.3E-06	-1.9E-05	-5.1E-06
Increased number of cases in population:	-0.0004	-0.000072	-0.00011
Risk:	-3.3E-08	-6.1E-09	-6.2E-08
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	-159.28	-159.28	-159.28
Population weighted Δx (µg/m^3):	-0.08369684	-0.08369684	-0.08369684
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:	0.999843	0.999644	0.999904
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.6E-05
Increased number of cases in population:	-0.0012	-0.00022	-0.00032
Risk:	-6.2E-07	-1.1E-07	-1.2E-06
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-1169.7	-1169.7	-1169.7
Population weighted Δx (µg/m^3):	-0.04716775	-0.04716775	-0.04716775
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:	0.999911	0.999799	0.999946
Attributable fraction (AF):	-8.9E-05	-2.0E-04	-5.4E-05
Increased number of cases in population:	-0.0087	-0.00160	-0.00236
Risk:	-3.5E-07	-6.5E-08	-6.6E-07
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-131.18	-131.18	-131.18
Population weighted Δx (µg/m^3):	-0.04126601	-0.04126601	-0.04126601
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:	0.999922	0.999824	0.999953
Attributable fraction (AF):	-7.8E-05	-1.8E-04	-4.7E-05
Increased number of cases in population:	-0.0010	-0.000179	-0.00026
Risk:	-3.1E-07	-5.6E-08	-5.7E-07
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-2273.4	-2273.4	-2273.4
Population weighted Δx (µg/m^3):	-0.17079123	-0.17079123	-0.17079123
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:	0.999679	0.999273	0.999804
Attributable fraction (AF):	-3.2E-04	-7.3E-04	-2.0E-04
Increased number of cases in population:	-0.01693	-0.00311	-0.004584
Risk:	-1.3E-06	-2.3E-07	-2.4E-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	-26.727	-26.727	-26.727
Population weighted Δx (µg/m^3):	-0.00382683	-0.00382683	-0.00382683
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:	0.999993	0.999984	0.999996
Attributable fraction (AF):	-7.2E-06	-1.6E-05	-4.4E-06
Increased number of cases in population:	-0.00020	-0.00004	-0.000054
Risk:	-2.8E-08	-5.2E-09	-5.3E-08
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-139.52	-139.52	-139.52
Population weighted Δx (µg/m^3):	-0.01820704	-0.01820704	-0.01820704
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:	0.999966	0.999922	0.999979
Attributable fraction (AF):	-3.4E-05	-7.8E-05	-2.1E-05
Increased number of cases in population:	-0.00104	-0.00019	-0.000281

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
Risk:	-1.4E-07	-2.5E-08	-2.5E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	-3329.2	-3329.2	-3329.2
Population weighted Δx (µg/m^3):	-0.03840229	-0.03840229	-0.03840229
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:	0.999928	0.999836	0.999956
Attributable fraction (AF):	-7.2E-05	-1.6E-04	-4.4E-05
Increased number of cases in population:	-0.029	-0.0046	-0.0086
Risk:	-3.3E-07	-5.3E-08	-5.3E-07
Individual subrubs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	-929.78	-929.78	-929.78
Population weighted Δx (µg/m^3):	-0.04599688	-0.04599688	-0.04599688
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	0.999804	0.999947
Attributable fraction (AF):	-8.6E-05	-2.0E-04	-5.3E-05
Increased number of cases in population:	-0.0081	-0.0013	-0.00240
Risk:	-4.0E-07	-6.3E-08	-6.4E-07
Beacon Hill - Narraweena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	-679.74	-679.74	-679.74
Population weighted Δx (µg/m^3):	-0.05328393	-0.05328393	-0.05328393
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:	0.999900	0.999773	0.999939
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.1E-05
Increased number of cases in population:	-0.0059	-0.0009	-0.00176
Risk:	-4.6E-07	-7.3E-08	-7.4E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	-113.47	-113.47	-113.47
Population weighted Δx (µg/m^3):	-0.49769218	-0.49769218	-0.49769218
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:	0.999065	0.997882	0.999428
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.7E-04
Increased number of cases in population:	-0.0010	-0.000155	-0.00029
Risk:	-4.3E-06	-6.8E-07	-6.9E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	-4450.1	-4450.1	-4450.1
Population weighted Δx (µg/m^3):	-0.34731003	-0.34731003	-0.34731003
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:	0.999347	0.998522	0.999601
Attributable fraction (AF):	-6.5E-04	-1.5E-03	-4.0E-04
Increased number of cases in population:	-0.0387	-0.0061	-0.01151
Risk:	-3.0E-06	-4.7E-07	-4.8E-06
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	19%
total change	-456.24	-456.24	-456.24
Population weighted Δx (µg/m^3):	-0.04491022	-0.04491022	-0.04491022
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:	0.999916	0.999809	0.999948
Attributable fraction (AF):	-8.4E-05	-1.9E-04	-5.2E-05
Increased number of cases in population:	-0.0040	-0.0006	-0.00118
Risk:	-3.9E-07	-6.1E-08	-6.2E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	-108.83	-108.83	-108.83
Population weighted Δx (µg/m^3):	-0.01352472	-0.01352472	-0.01352472
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:	0.999975	0.999942	0.999984
Attributable fraction (AF):	-2.5E-05	-5.8E-05	-1.6E-05
Increased number of cases in population:	-0.0009	-0.00015	-0.00028
Risk:	-1.2E-07	-1.8E-08	-1.9E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	-11.420	-11.420	-11.420
Population weighted Δx (µg/m^3):	-0.00204801	-0.00204801	-0.00204801
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:	0.999996	0.999991	0.999998
Attributable fraction (AF):	-3.9E-06	-8.7E-06	-2.4E-06

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
Increased number of cases in population:	-0.00010	-0.000016	-0.00003
Risk:	-1.8E-08	-2.8E-09	-2.8E-08
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	3420.3	3420.3	3420.3
Population weighted Δx (µg/m^3):	0.20238632	0.20238632	0.20238632
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:	1.000381	1.000863	1.000233
Attributable fraction (AF):	3.8E-04	8.6E-04	2.3E-04
Increased number of cases in population:	0.0297	0.0047	0.00884
Risk:	1.8E-06	2.8E-07	2.8E-06
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-4024.5	-4024.5	-4024.5
Population weighted Δx (µg/m^3):	-0.12501162	-0.12501162	-0.12501162
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:	0.999765	0.999468	0.999856
Attributable fraction (AF):	-2.4E-04	-5.3E-04	-1.4E-04
Increased number of cases in population:	-0.028	-0.0055	-0.011
Risk:	-8.6E-07	-1.7E-07	-1.7E-06
Individual subrubs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	-69.878	-69.878	-69.878
Population weighted Δx (µg/m^3):	-0.00712241	-0.00712241	-0.00712241
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:	0.999987	0.999970	0.999992
Attributable fraction (AF):	-1.3E-05	-3.0E-05	-8.2E-06
Increased number of cases in population:	-0.0005	-0.00010	-0.00019
Risk:	-4.9E-08	-9.7E-09	-9.9E-08
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-3876.3	-3876.3	-3876.3
Population weighted Δx (µg/m^3):	-0.18161818	-0.18161818	-0.18161818
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:	0.999659	0.999227	0.999791
Attributable fraction (AF):	-3.4E-04	-7.7E-04	-2.1E-04
Increased number of cases in population:	-0.0266	-0.0053	-0.01046
Risk:	-1.2E-06	-2.5E-07	-2.5E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-78.344	-78.344	-78.344
Population weighted Δx (µg/m^3):	-0.07540339	-0.07540339	-0.07540339
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:	0.999858	0.999679	0.999913
Attributable fraction (AF):	-1.4E-04	-3.2E-04	-8.7E-05
Increased number of cases in population:	-0.0005	-0.000107	-0.00021
Risk:	-5.2E-07	-1.0E-07	-1.0E-06
Total population incidence - All Suburbs	**-1.0**	**-0.17**	**-0.19**

Assessment of Increased Incidence - NO_2
Beaches Link: 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/m3 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	-93.16	-93.16	-93.16
Population weighted Δx (µg/m^3):	-0.03991290	-0.03991290	-0.03991290
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:	0.999925	0.999830	0.999954
Attributable fraction (AF):	-7.5E-05	-1.7E-04	-4.6E-05
Increased number of cases in population:	-0.00071	-0.00013	-0.00019
Risk:	-3.0E-07	-5.5E-08	-5.5E-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	-93.16	-93.16	-93.16
Population weighted Δx (µg/m^3):	-0.03991290	-0.03991290	-0.03991290
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:	0.999925	0.999830	0.999954
Attributable fraction (AF):	-7.5E-05	-1.7E-04	-4.6E-05
Increased number of cases in population:	-0.0007	-0.00013	-0.000193
Risk:	-3.0E-07	-5.5E-08	-5.5E-07
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-36186	-36186	-36186
Population weighted Δx (µg/m^3):	-0.38434664	-0.38434664	-0.38434664
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:	0.999278	0.998364	0.999558
Attributable fraction (AF):	-7.2E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.27	-0.050	-0.070
Risk:	-2.9E-06	-5.3E-07	-5.3E-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	-9545.8	-9545.8	-9545.8
Population weighted Δx (µg/m^3):	-0.50122108	-0.50122108	-0.50122108
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:	0.999058	0.997867	0.999424
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.8E-04
Increased number of cases in population:	-0.0712	-0.0131	-0.0185
Risk:	-3.7E-06	-6.9E-07	-7.0E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	-2176.2	-2176.2	-2176.2
Population weighted Δx (µg/m^3):	-0.12047613	-0.12047613	-0.12047613
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:	0.999774	0.999487	0.999861
Attributable fraction (AF):	-2.3E-04	-5.1E-04	-1.4E-04
Increased number of cases in population:	-0.0162	-0.0030	-0.0042
Risk:	-9.0E-07	-1.6E-07	-1.7E-06
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-14247	-14247	-14247
Population weighted Δx (µg/m^3):	-0.50055699	-0.50055699	-0.50055699
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:	0.999059	0.997870	0.999425
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.8E-04
Increased number of cases in population:	-0.1062	-0.0195	-0.0275
Risk:	-3.7E-06	-6.8E-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	-8785.2	-8785.2	-8785.2
Population weighted Δx (µg/m^3):	-0.49081895	-0.49081895	-0.49081895
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:	0.999078	0.997911	0.999436
Attributable fraction (AF):	-9.2E-04	-2.1E-03	-5.6E-04
Increased number of cases in population:	-0.0655	-0.0120	-0.0170
Risk:	-3.7E-06	-6.7E-07	-6.8E-06
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-1431.9	-1431.9	-1431.9
Population weighted Δx (µg/m^3):	-0.13407436	-0.13407436	-0.13407436

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)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.999748	0.999429	0.999846
Attributable fraction (AF):	-2.5E-04	-5.7E-04	-1.5E-04
Increased number of cases in population:	-0.0107	-0.0020	-0.0028
Risk:	-1.0E-06	-1.8E-07	-1.9E-06
Sydney Inner West LGA (Leichhardt)			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	-1326.8	-1326.8	-1326.8
Population weighted Δx (µg/m^3):	-0.02746825	-0.02746825	-0.02746825
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:	0.999948	0.999883	0.999968
Attributable fraction (AF):	-5.2E-05	-1.2E-04	-3.2E-05
Increased number of cases in population:	-0.013	-0.0018	-0.0026
Risk:	-2.8E-07	-3.8E-08	-3.8E-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	-803.18	-803.18	-803.18
Population weighted Δx (µg/m^3):	-0.05118082	-0.05118082	-0.05118082
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:	0.999904	0.999782	0.999941
Attributable fraction (AF):	-9.6E-05	-2.2E-04	-5.9E-05
Increased number of cases in population:	-0.0081	-0.00110	-0.001575
Risk:	-5.1E-07	-7.0E-08	-7.1E-07
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	93.820	93.820	93.820
Population weighted Δx (µg/m^3):	0.00534863	0.00534863	0.00534863
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:	1.000010	1.000023	1.000006
Attributable fraction (AF):	1.0E-05	2.3E-05	6.2E-06
Increased number of cases in population:	0.001	0.00013	0.0002
Risk:	5.4E-08	7.3E-09	7.4E-08
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-617.44	-617.44	-617.44
Population weighted Δx (µg/m^3):	-0.04920219	-0.04920219	-0.04920219
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:	0.999908	0.999790	0.999943
Attributable fraction (AF):	-9.3E-05	-2.1E-04	-5.7E-05
Increased number of cases in population:	-0.006	-0.00084	-0.0012
Risk:	-4.9E-07	-6.7E-08	-6.8E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-183.87	-183.87	-183.87
Population weighted Δx (µg/m^3):	-0.07296374	-0.07296374	-0.07296374
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:	0.999863	0.999689	0.999916
Attributable fraction (AF):	-1.4E-04	-3.1E-04	-8.4E-05
Increased number of cases in population:	-0.0018	-0.00025	-0.00036
Risk:	-7.3E-07	-1.0E-07	-1.0E-06
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-32505	-32505	-32505
Population weighted Δx (µg/m^3):	-0.24637153	-0.24637153	-0.24637153
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:	0.999537	0.998951	0.999717
Attributable fraction (AF):	-4.6E-04	-1.1E-03	-2.8E-04
Increased number of cases in population:	-0.31	-0.044	-0.027
Risk:	-2.4E-06	-3.4E-07	-3.4E-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	-4366.1	-4366.1	-4366.1
Population weighted Δx (µg/m^3):	-0.38453934	-0.38453934	-0.38453934
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:	0.999277	0.998363	0.999558
Attributable fraction (AF):	-7.2E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.042	-0.0060	-0.00358
Risk:	-3.7E-06	-5.3E-07	-5.3E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593

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%	5.9%
total change	873.32	873.32	873.32
Population weighted Δx (µg/m^3):	0.04457301	0.04457301	0.04457301
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:	1.000084	1.000190	1.000051
Attributable fraction (AF):	8.4E-05	1.9E-04	5.1E-05
Increased number of cases in population:	0.008	0.0012	0.00072
Risk:	4.3E-07	6.1E-08	6.2E-07
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-200.01	-200.01	-200.01
Population weighted Δx (µg/m^3):	-0.03880736	-0.03880736	-0.03880736
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:	0.999927	0.999835	0.999955
Attributable fraction (AF):	-7.3E-05	-1.7E-04	-4.5E-05
Increased number of cases in population:	-0.00191	-0.000274	-0.000164
Risk:	-3.7E-07	-5.3E-08	-5.4E-07
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-23527	-23527	-23527
Population weighted Δx (µg/m^3):	-1.10975256	-1.10975256	-1.10975256
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:	0.997916	0.995284	0.998725
Attributable fraction (AF):	-2.1E-03	-4.7E-03	-1.3E-03
Increased number of cases in population:	-0.225	-0.03225	-0.0193
Risk:	-1.1E-05	-1.5E-06	-1.5E-05
Pyrmont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	2128.1	2128.1	2128.1
Population weighted Δx (µg/m^3):	0.09822710	0.09822710	0.09822710
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:	1.000185	1.000419	1.000113
Attributable fraction (AF):	1.8E-04	4.2E-04	1.1E-04
Increased number of cases in population:	0.020	0.0029	0.0017
Risk:	9.4E-07	1.3E-07	1.4E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	249.25	249.25	249.25
Population weighted Δx (µg/m^3):	0.02527678	0.02527678	0.02527678
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:	1.000048	1.000108	1.000029
Attributable fraction (AF):	4.8E-05	1.1E-04	2.9E-05
Increased number of cases in population:	0.00238	0.000341	0.000204
Risk:	2.4E-07	3.5E-08	3.5E-07
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-5362.0	-5362.0	-5362.0
Population weighted Δx (µg/m^3):	-0.34154944	-0.34154944	-0.34154944
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:	0.999358	0.998546	0.999607
Attributable fraction (AF):	-6.4E-04	-1.5E-03	-3.9E-04
Increased number of cases in population:	-0.051	-0.0073	-0.00440
Risk:	-3.3E-06	-4.7E-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	-2300.4	-2300.4	-2300.4
Population weighted Δx (µg/m^3):	-0.08393425	-0.08393425	-0.08393425
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:	0.999842	0.999643	0.999903
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.7E-05
Increased number of cases in population:	-0.0220	-0.0031	-0.00189
Risk:	-8.0E-07	-1.1E-07	-1.2E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-18621	-18621	-18621
Population weighted Δx (µg/m^3):	-0.18016532	-0.18016532	-0.18016532
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:	0.999661	0.999233	0.999793
Attributable fraction (AF):	-3.4E-04	-7.7E-04	-2.1E-04
Increased number of cases in population:	-0.12	-0.025	-0.044
Risk:	-1.1E-06	-2.5E-07	-2.5E-06
Individual subrubs within LGA			
Chatswood East - Artarmon			

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
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	-7276.4	-7276.4	-7276.4
Population weighted Δx (µg/m^3):	-0.25414309	-0.25414309	-0.25414309
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:	0.999522	0.998918	0.999708
Attributable fraction (AF):	-4.8E-04	-1.1E-03	-2.9E-04
Increased number of cases in population:	-0.0458	-0.0100	-0.0173
Risk:	-1.6E-06	-3.5E-07	-3.5E-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	-2920.4	-2920.4	-2920.4
Population weighted Δx (µg/m^3):	-0.15877915	-0.15877915	-0.15877915
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:	0.999702	0.999324	0.999817
Attributable fraction (AF):	-3.0E-04	-6.8E-04	-1.8E-04
Increased number of cases in population:	-0.0184	-0.0040	-0.0069
Risk:	-1.0E-06	-2.2E-07	-2.2E-06
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	226.95	226.95	226.95
Population weighted Δx (µg/m^3):	0.01112450	0.01112450	0.01112450
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	1.000047	1.000013
Attributable fraction (AF):	2.1E-05	4.7E-05	1.3E-05
Increased number of cases in population:	0.0014	0.0003	0.0005
Risk:	7.0E-08	1.5E-08	1.5E-07
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-2437.1	-2437.1	-2437.1
Population weighted Δx (µg/m^3):	-0.23259598	-0.23259598	-0.23259598
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:	0.999563	0.999010	0.999733
Attributable fraction (AF):	-4.4E-04	-9.9E-04	-2.7E-04
Increased number of cases in population:	-0.0154	-0.0033	-0.0058
Risk:	-1.5E-06	-3.2E-07	-3.2E-06
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-6214.0	-6214.0	-6214.0
Population weighted Δx (µg/m^3):	-0.24414588	-0.24414588	-0.24414588
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:	0.999541	0.998960	0.999719
Attributable fraction (AF):	-4.6E-04	-1.0E-03	-2.8E-04
Increased number of cases in population:	-0.0391	-0.0085	-0.0148
Risk:	-1.5E-06	-3.3E-07	-3.4E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	157.50	157.50	157.50
Population weighted Δx (µg/m^3):	0.06975183	0.06975183	0.06975183
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:	1.000131	1.000297	1.000080
Attributable fraction (AF):	1.3E-04	3.0E-04	8.0E-05
Increased number of cases in population:	0.0015	0.00022	0.00040
Risk:	6.6E-07	9.5E-08	9.7E-07
Individual subrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	157.50	157.50	157.50
Population weighted Δx (µg/m^3):	0.06975183	0.06975183	0.06975183
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:	1.000131	1.000297	1.000080
Attributable fraction (AF):	1.3E-04	3.0E-04	8.0E-05
Increased number of cases in population:	0.0015	0.00022	0.0004
Risk:	6.6E-07	9.5E-08	9.7E-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	-2590.4	-2590.4	-2590.4
Population weighted Δx (µg/m^3):	-0.03605786	-0.03605786	-0.03605786
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:	0.999932	0.999846	0.999959
Attributable fraction (AF):	-6.8E-05	-1.5E-04	-4.1E-05
Increased number of cases in population:	-0.019	-0.0035	-0.0052

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
Risk:	-2.7E-07	-4.9E-08	-5.0E-07
Individual subrubs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184
% population in assessment age-group:	100%	100%	14.5%
total change	82.555	82.555	82.555
Population weighted Δx (µg/m^3):	0.03780000	0.03780000	0.03780000
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:	1.000071	1.000161	1.000043
Attributable fraction (AF):	7.1E-05	1.6E-04	4.3E-05
Increased number of cases in population:	0.0006	0.00011	0.00017
Risk:	2.8E-07	5.2E-08	5.3E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-174.44	-174.44	-174.44
Population weighted Δx (µg/m^3):	-0.01475941	-0.01475941	-0.01475941
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:	0.999972	0.999937	0.999983
Attributable fraction (AF):	-2.8E-05	-6.3E-05	-1.7E-05
Increased number of cases in population:	-0.0013	-0.0002	-0.00035
Risk:	-1.1E-07	-2.0E-08	-2.1E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	-111.62	-111.62	-111.62
Population weighted Δx (µg/m^3):	-0.05865390	-0.05865390	-0.05865390
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:	0.999890	0.999750	0.999933
Attributable fraction (AF):	-1.1E-04	-2.5E-04	-6.7E-05
Increased number of cases in population:	-0.0008	-0.00015	-0.00023
Risk:	-4.4E-07	-8.0E-08	-8.2E-07
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-9.0182	-9.0182	-9.0182
Population weighted Δx (µg/m^3):	-0.00036366	-0.00036366	-0.00036366
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:	0.999999	0.999998	1.000000
Attributable fraction (AF):	-6.8E-07	-1.5E-06	-4.2E-07
Increased number of cases in population:	-0.0001	-0.00001	-0.00002
Risk:	-2.7E-09	-5.0E-10	-5.1E-09
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	19.175	19.175	19.175
Population weighted Δx (µg/m^3):	0.00603178	0.00603178	0.00603178
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	1.000026	1.000007
Attributable fraction (AF):	1.1E-05	2.6E-05	6.9E-06
Increased number of cases in population:	0.0001	0.000026	0.00004
Risk:	4.5E-08	8.2E-09	8.4E-08
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-2234.3	-2234.3	-2234.3
Population weighted Δx (µg/m^3):	-0.16785288	-0.16785288	-0.16785288
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:	0.999684	0.999285	0.999807
Attributable fraction (AF):	-3.2E-04	-7.2E-04	-1.9E-04
Increased number of cases in population:	-0.01664	-0.00306	-0.004505
Risk:	-1.2E-06	-2.3E-07	-2.3E-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	92.712	92.712	92.712
Population weighted Δx (µg/m^3):	0.01327486	0.01327486	0.01327486
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:	1.000025	1.000057	1.000015
Attributable fraction (AF):	2.5E-05	5.7E-05	1.5E-05
Increased number of cases in population:	0.00069	0.00013	0.000187
Risk:	9.9E-08	1.8E-08	1.8E-07
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-255.51	-255.51	-255.51
Population weighted Δx (µg/m^3):	-0.03334289	-0.03334289	-0.03334289
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:	0.999937	0.999858	0.999962
Attributable fraction (AF):	-6.3E-05	-1.4E-04	-3.8E-05
Increased number of cases in population:	-0.00190	-0.00035	-0.000515

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
Risk:	-2.5E-07	-4.6E-08	-4.6E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	-4482.4	-4482.4	-4482.4
Population weighted Δx (µg/m^3):	-0.05170326	-0.05170326	-0.05170326
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:	0.999903	0.999780	0.999941
Attributable fraction (AF):	-9.7E-05	-2.2E-04	-5.9E-05
Increased number of cases in population:	-0.039	-0.0061	-0.012
Risk:	-4.5E-07	-7.1E-08	-7.2E-07
Individual subrubs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	-1083.0	-1083.0	-1083.0
Population weighted Δx (µg/m^3):	-0.05357482	-0.05357482	-0.05357482
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:	0.999899	0.999772	0.999938
Attributable fraction (AF):	-1.0E-04	-2.3E-04	-6.2E-05
Increased number of cases in population:	-0.0094	-0.0015	-0.00280
Risk:	-4.7E-07	-7.3E-08	-7.4E-07
Beacon Hill - Narraweena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	-1136.4	-1136.4	-1136.4
Population weighted Δx (µg/m^3):	-0.08908386	-0.08908386	-0.08908386
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:	0.999833	0.999621	0.999898
Attributable fraction (AF):	-1.7E-04	-3.8E-04	-1.0E-04
Increased number of cases in population:	-0.0099	-0.0016	-0.00294
Risk:	-7.7E-07	-1.2E-07	-1.2E-06
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	-20.961	-20.961	-20.961
Population weighted Δx (µg/m^3):	-0.09193277	-0.09193277	-0.09193277
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:	0.999827	0.999608	0.999894
Attributable fraction (AF):	-1.7E-04	-3.9E-04	-1.1E-04
Increased number of cases in population:	-0.0002	-0.000029	-0.00005
Risk:	-8.0E-07	-1.3E-07	-1.3E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	-5019.0	-5019.0	-5019.0
Population weighted Δx (µg/m^3):	-0.39171473	-0.39171473	-0.39171473
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:	0.999264	0.998333	0.999550
Attributable fraction (AF):	-7.4E-04	-1.7E-03	-4.5E-04
Increased number of cases in population:	-0.0436	-0.0069	-0.01298
Risk:	-3.4E-06	-5.4E-07	-5.4E-06
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	19%
total change	-520.77	-520.77	-520.77
Population weighted Δx (µg/m^3):	-0.05126152	-0.05126152	-0.05126152
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:	0.999904	0.999782	0.999941
Attributable fraction (AF):	-9.6E-05	-2.2E-04	-5.9E-05
Increased number of cases in population:	-0.0045	-0.0007	-0.00135
Risk:	-4.5E-07	-7.0E-08	-7.1E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	-122.65	-122.65	-122.65
Population weighted Δx (µg/m^3):	-0.01524191	-0.01524191	-0.01524191
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:	0.999971	0.999935	0.999982
Attributable fraction (AF):	-2.9E-05	-6.5E-05	-1.8E-05
Increased number of cases in population:	-0.0011	-0.0002	-0.00032
Risk:	-1.3E-07	-2.1E-08	-2.1E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	-211.17	-211.17	-211.17
Population weighted Δx (µg/m^3):	-0.03787153	-0.03787153	-0.03787153
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:	0.999929	0.999839	0.999956
Attributable fraction (AF):	-7.1E-05	-1.6E-04	-4.4E-05

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
Increased number of cases in population:	-0.0018	-0.0003	-0.00055
Risk:	-3.3E-07	-5.2E-08	-5.3E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	3631.6	3631.6	3631.6
Population weighted Δx (µg/m^3):	0.21488951	0.21488951	0.21488951
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:	1.000404	1.000916	1.000247
Attributable fraction (AF):	4.0E-04	9.2E-04	2.5E-04
Increased number of cases in population:	0.0316	0.0050	0.00939
Risk:	1.9E-06	2.9E-07	3.0E-06
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-3483.6	-3483.6	-3483.6
Population weighted Δx (µg/m^3):	-0.10821043	-0.10821043	-0.10821043
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:	0.999797	0.999539	0.999876
Attributable fraction (AF):	-2.0E-04	-4.6E-04	-1.2E-04
Increased number of cases in population:	-0.024	-0.0048	-0.0094
Risk:	-7.4E-07	-1.5E-07	-1.5E-06
Individual subrubs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	-221.90	-221.90	-221.90
Population weighted Δx (µg/m^3):	-0.02261788	-0.02261788	-0.02261788
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:	0.999957	0.999904	0.999974
Attributable fraction (AF):	-4.3E-05	-9.6E-05	-2.6E-05
Increased number of cases in population:	-0.0015	-0.00030	-0.00060
Risk:	-1.6E-07	-3.1E-08	-3.1E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-3239.0	-3239.0	-3239.0
Population weighted Δx (µg/m^3):	-0.15175703	-0.15175703	-0.15175703
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:	0.999715	0.999354	0.999825
Attributable fraction (AF):	-2.9E-04	-6.5E-04	-1.7E-04
Increased number of cases in population:	-0.0222	-0.0044	-0.00874
Risk:	-1.0E-06	-2.1E-07	-2.1E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-22.764	-22.764	-22.764
Population weighted Δx (µg/m^3):	-0.02190948	-0.02190948	-0.02190948
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:	0.999959	0.999907	0.999975
Attributable fraction (AF):	-4.1E-05	-9.3E-05	-2.5E-05
Increased number of cases in population:	-0.0002	-0.000031	-0.00006
Risk:	-1.5E-07	-3.0E-08	-3.0E-07
Total population incidence - All Suburbs	**-0.79**	**-0.14**	**-0.17**

Assessment of Increased Incidence - NO_2
Beaches Link: 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/m3 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	66.15	66.15	66.15
Population weighted Δx (μg/m^3):	0.02834294	0.02834294	0.02834294
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:	1.000053	1.000121	1.000033
Attributable fraction (AF):	5.3E-05	1.2E-04	3.3E-05
Increased number of cases in population:	0.00050	0.000090	0.00014
Risk:	2.1E-07	3.9E-08	3.9E-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	66.15	66.15	66.15
Population weighted Δx (μg/m^3):	0.02834294	0.02834294	0.02834294
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:	1.000053	1.000121	1.000033
Attributable fraction (AF):	5.3E-05	1.2E-04	3.3E-05
Increased number of cases in population:	0.0005	0.00009	0.000137
Risk:	2.1E-07	3.9E-08	3.9E-07
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-44247	-44247	-44247
Population weighted Δx (μg/m^3):	-0.46996339	-0.46996339	-0.46996339
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:	0.999117	0.998000	0.999460
Attributable fraction (AF):	-8.8E-04	-2.0E-03	-5.4E-04
Increased number of cases in population:	-0.33	-0.061	-0.086
Risk:	-3.5E-06	-6.4E-07	-6.5E-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	-6252.4	-6252.4	-6252.4
Population weighted Δx (μg/m^3):	-0.32829353	-0.32829353	-0.32829353
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:	0.999383	0.998602	0.999623
Attributable fraction (AF):	-6.2E-04	-1.4E-03	-3.8E-04
Increased number of cases in population:	-0.0466	-0.0086	-0.0121
Risk:	-2.4E-06	-4.5E-07	-4.6E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	1037.1	1037.1	1037.1
Population weighted Δx (μg/m^3):	0.05741803	0.05741803	0.05741803
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:	1.000108	1.000245	1.000066
Attributable fraction (AF):	1.1E-04	2.4E-04	6.6E-05
Increased number of cases in population:	0.0077	0.0014	0.0020
Risk:	4.3E-07	7.9E-08	8.0E-07
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-11821	-11821	-11821
Population weighted Δx (μg/m^3):	-0.41531637	-0.41531637	-0.41531637
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:	0.999220	0.998232	0.999523
Attributable fraction (AF):	-7.8E-04	-1.8E-03	-4.8E-04
Increased number of cases in population:	-0.0881	-0.0162	-0.0229
Risk:	-3.1E-06	-5.7E-07	-5.8E-06
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-21136	-21136	-21136
Population weighted Δx (μg/m^3):	-1.18082821	-1.18082821	-1.18082821
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:	0.997783	0.994982	0.998643
Attributable fraction (AF):	-2.2E-03	-5.0E-03	-1.4E-03
Increased number of cases in population:	-0.1577	-0.0290	-0.0409
Risk:	-8.8E-06	-1.6E-06	-1.6E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-6075.0	-6075.0	-6075.0
Population weighted Δx (μg/m^3):	-0.56881987	-0.56881987	-0.56881987

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)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998931	0.997580	0.999346
Attributable fraction (AF):	-1.1E-03	-2.4E-03	-6.5E-04
Increased number of cases in population:	-0.0453	-0.0083	-0.0117
Risk:	-4.2E-06	-7.8E-07	-7.9E-06
Sydney Inner West LGA (Leichhardt)			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	221.09	221.09	221.09
Population weighted Δx (µg/m^3):	0.00457715	0.00457715	0.00457715
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:	1.000009	1.000019	1.000005
Attributable fraction (AF):	8.6E-06	1.9E-05	5.3E-06
Increased number of cases in population:	0.0022	0.00030	0.00043
Risk:	4.6E-08	6.3E-09	6.4E-08
Individual subrubs within LGA			
Balmain			
Total Population in study area:	15693	15693	15693
% population in assessment age-group:	100%	100%	14.1%
total change	-1443.0	-1443.0	-1443.0
Population weighted Δx (µg/m^3):	-0.09195424	-0.09195424	-0.09195424
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:	0.999827	0.999608	0.999894
Attributable fraction (AF):	-1.7E-04	-3.9E-04	-1.1E-04
Increased number of cases in population:	-0.0145	-0.00197	-0.002829
Risk:	-9.2E-07	-1.3E-07	-1.3E-06
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	1928.5	1928.5	1928.5
Population weighted Δx (µg/m^3):	0.10994420	0.10994420	0.10994420
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:	1.000207	1.000468	1.000126
Attributable fraction (AF):	2.1E-04	4.7E-04	1.3E-04
Increased number of cases in population:	0.019	0.003	0.0038
Risk:	1.1E-06	1.5E-07	1.5E-06
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-264.40	-264.40	-264.40
Population weighted Δx (µg/m^3):	-0.02106967	-0.02106967	-0.02106967
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:	0.999960	0.999910	0.999976
Attributable fraction (AF):	-4.0E-05	-9.0E-05	-2.4E-05
Increased number of cases in population:	-0.003	-0.00036	-0.0005
Risk:	-2.1E-07	-2.9E-08	-2.9E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-104.50	-104.50	-104.50
Population weighted Δx (µg/m^3):	-0.04146812	-0.04146812	-0.04146812
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:	0.999922	0.999823	0.999952
Attributable fraction (AF):	-7.8E-05	-1.8E-04	-4.8E-05
Increased number of cases in population:	-0.0010	-0.00014	-0.00020
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	-96185	-96185	-96185
Population weighted Δx (µg/m^3):	-0.72904486	-0.72904486	-0.72904486
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:	0.998630	0.996899	0.999162
Attributable fraction (AF):	-1.4E-03	-3.1E-03	-8.4E-04
Increased number of cases in population:	-0.92	-0.13	-0.079
Risk:	-7.0E-06	-1.0E-06	-1.0E-05
Individual subrubs within LGA			
Darlinghurst			
Total Population in study area:	11354	11354	11354
% population in assessment age-group:	100%	100%	5.9%
total change	-8714.5	-8714.5	-8714.5
Population weighted Δx (µg/m^3):	-0.76752968	-0.76752968	-0.76752968
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:	0.998558	0.996736	0.999118
Attributable fraction (AF):	-1.4E-03	-3.3E-03	-8.8E-04
Increased number of cases in population:	-0.083	-0.0119	-0.00715
Risk:	-7.3E-06	-1.0E-06	-1.1E-05
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593

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%	5.9%
total change	-3671.8	-3671.8	-3671.8
Population weighted Δx (µg/m^3):	-0.18740294	-0.18740294	-0.18740294
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:	0.999648	0.999202	0.999785
Attributable fraction (AF):	-3.5E-04	-8.0E-04	-2.2E-04
Increased number of cases in population:	-0.035	-0.0050	-0.00301
Risk:	-1.8E-06	-2.6E-07	-2.6E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-1975.0	-1975.0	-1975.0
Population weighted Δx (µg/m^3):	-0.38319557	-0.38319557	-0.38319557
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	0.999559
Attributable fraction (AF):	-7.2E-04	-1.6E-03	-4.4E-04
Increased number of cases in population:	-0.01887	-0.002703	-0.001620
Risk:	-3.7E-06	-5.2E-07	-5.3E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-46247	-46247	-46247
Population weighted Δx (µg/m^3):	-2.18148108	-2.18148108	-2.18148108
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:	0.995907	0.990750	0.997494
Attributable fraction (AF):	-4.1E-03	-9.3E-03	-2.5E-03
Increased number of cases in population:	-0.443	-0.064	-0.0380
Risk:	-2.1E-05	-3.0E-06	-3.0E-05
Pyrmont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-9551.3	-9551.3	-9551.3
Population weighted Δx (µg/m^3):	-0.44086136	-0.44086136	-0.44086136
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:	0.999172	0.998124	0.999493
Attributable fraction (AF):	-8.3E-04	-1.9E-03	-5.1E-04
Increased number of cases in population:	-0.091	-0.0131	-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	-1667.3	-1667.3	-1667.3
Population weighted Δx (µg/m^3):	-0.16908251	-0.16908251	-0.16908251
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:	-0.01593	-0.002281	-0.001368
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	-10462	-10462	-10462
Population weighted Δx (µg/m^3):	-0.66638560	-0.66638560	-0.66638560
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:	0.998748	0.997165	0.999234
Attributable fraction (AF):	-1.3E-03	-2.8E-03	-7.7E-04
Increased number of cases in population:	-0.100	-0.0143	-0.00858
Risk:	-6.4E-06	-9.1E-07	-9.3E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-13896	-13896	-13896
Population weighted Δx (µg/m^3):	-0.50703098	-0.50703098	-0.50703098
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:	0.999047	0.997842	0.999417
Attributable fraction (AF):	-9.5E-04	-2.2E-03	-5.8E-04
Increased number of cases in population:	-0.1328	-0.0190	-0.01140
Risk:	-4.8E-06	-6.9E-07	-7.0E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-15462	-15462	-15462
Population weighted Δx (µg/m^3):	-0.14960190	-0.14960190	-0.14960190
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:	0.999719	0.999363	0.999828
Attributable fraction (AF):	-2.8E-04	-6.4E-04	-1.7E-04
Increased number of cases in population:	-0.097	-0.021	-0.037
Risk:	-9.4E-07	-2.0E-07	-2.1E-06
Individual subrubs within LGA			
Chatswood East - Artarmon			

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
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	-6414.6	-6414.6	-6414.6
Population weighted Δx (μg/m^3):	-0.22404475	-0.22404475	-0.22404475
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:	0.999579	0.999046	0.999742
Attributable fraction (AF):	-4.2E-04	-9.5E-04	-2.6E-04
Increased number of cases in population:	-0.0404	-0.0088	-0.0153
Risk:	-1.4E-06	-3.1E-07	-3.1E-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	-3555.3	-3555.3	-3555.3
Population weighted Δx (μg/m^3):	-0.19329824	-0.19329824	-0.19329824
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:	0.999637	0.999177	0.999778
Attributable fraction (AF):	-3.6E-04	-8.2E-04	-2.2E-04
Increased number of cases in population:	-0.0224	-0.0049	-0.0085
Risk:	-1.2E-06	-2.6E-07	-2.7E-06
Lane Cove - Greenwich			
Total Population in study area:	20401	20401	20401
% population in assessment age-group:	100%	100%	17.1%
total change	-50.305	-50.305	-50.305
Population weighted Δx (μg/m^3):	-0.00246580	-0.00246580	-0.00246580
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:	0.999995	0.999989	0.999997
Attributable fraction (AF):	-4.6E-06	-1.1E-05	-2.8E-06
Increased number of cases in population:	-0.00032	-0.000069	-0.00012
Risk:	-1.6E-08	-3.4E-09	-3.4E-08
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-717.61	-717.61	-717.61
Population weighted Δx (μg/m^3):	-0.06848717	-0.06848717	-0.06848717
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:	0.999871	0.999708	0.999921
Attributable fraction (AF):	-1.3E-04	-2.9E-04	-7.9E-05
Increased number of cases in population:	-0.0045	-0.0010	-0.0017
Risk:	-4.3E-07	-9.4E-08	-9.5E-07
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-4724.2	-4724.2	-4724.2
Population weighted Δx (μg/m^3):	-0.18561337	-0.18561337	-0.18561337
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:	0.999651	0.999210	0.999787
Attributable fraction (AF):	-3.5E-04	-7.9E-04	-2.1E-04
Increased number of cases in population:	-0.0298	-0.0065	-0.0112
Risk:	-1.2E-06	-2.5E-07	-2.6E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	-56.979	-56.979	-56.979
Population weighted Δx (μg/m^3):	-0.02523414	-0.02523414	-0.02523414
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:	0.999953	0.999893	0.999971
Attributable fraction (AF):	-4.7E-05	-1.1E-04	-2.9E-05
Increased number of cases in population:	-0.00054	-0.000078	-0.00014
Risk:	-2.4E-07	-3.5E-08	-3.5E-07
Individual subrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	-56.979	-56.979	-56.979
Population weighted Δx (μg/m^3):	-0.02523414	-0.02523414	-0.02523414
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:	0.999953	0.999893	0.999971
Attributable fraction (AF):	-4.7E-05	-1.1E-04	-2.9E-05
Increased number of cases in population:	-0.0005	-0.00008	-0.00014
Risk:	-2.4E-07	-3.5E-08	-3.5E-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	-6694.0	-6694.0	-6694.0
Population weighted Δx (μg/m^3):	-0.09317745	-0.09317745	-0.09317745
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:	0.999825	0.999603	0.999893
Attributable fraction (AF):	-1.8E-04	-4.0E-04	-1.1E-04
Increased number of cases in population:	-0.050	-0.0092	-0.013

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
Risk:	-6.9E-07	-1.3E-07	-1.3E-06
Individual subrubs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184
% population in assessment age-group:	100%	100%	14.5%
total change	21.499	21.499	21.499
Population weighted Δx (µg/m^3):	0.00984409	0.00984409	0.00984409
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	1.000042	1.000011
Attributable fraction (AF):	1.9E-05	4.2E-05	1.1E-05
Increased number of cases in population:	0.0002	0.00003	0.00004
Risk:	7.3E-08	1.3E-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	-656.15	-656.15	-656.15
Population weighted Δx (µg/m^3):	-0.05551648	-0.05551648	-0.05551648
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:	0.999896	0.999764	0.999936
Attributable fraction (AF):	-1.0E-04	-2.4E-04	-6.4E-05
Increased number of cases in population:	-0.0049	-0.0009	-0.00132
Risk:	-4.1E-07	-7.6E-08	-7.7E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	-106.77	-106.77	-106.77
Population weighted Δx (µg/m^3):	-0.05610461	-0.05610461	-0.05610461
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:	0.999895	0.999761	0.999935
Attributable fraction (AF):	-1.1E-04	-2.4E-04	-6.5E-05
Increased number of cases in population:	-0.0008	-0.00015	-0.00022
Risk:	-4.2E-07	-7.7E-08	-7.8E-07
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-1844.1	-1844.1	-1844.1
Population weighted Δx (µg/m^3):	-0.07436630	-0.07436630	-0.07436630
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:	0.999860	0.999683	0.999914
Attributable fraction (AF):	-1.4E-04	-3.2E-04	-8.6E-05
Increased number of cases in population:	-0.0137	-0.00252	-0.00372
Risk:	-5.5E-07	-1.0E-07	-1.0E-06
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-239.66	-239.66	-239.66
Population weighted Δx (µg/m^3):	-0.07538849	-0.07538849	-0.07538849
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:	0.999858	0.999679	0.999913
Attributable fraction (AF):	-1.4E-04	-3.2E-04	-8.7E-05
Increased number of cases in population:	-0.0018	-0.000328	-0.00048
Risk:	-5.6E-07	-1.0E-07	-1.0E-06
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-2977.5	-2977.5	-2977.5
Population weighted Δx (µg/m^3):	-0.22368436	-0.22368436	-0.22368436
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:	0.999580	0.999048	0.999743
Attributable fraction (AF):	-4.2E-04	-9.5E-04	-2.6E-04
Increased number of cases in population:	-0.02217	-0.00407	-0.006003
Risk:	-1.7E-06	-3.1E-07	-3.1E-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	-581.94	-581.94	-581.94
Population weighted Δx (µg/m^3):	-0.08332458	-0.08332458	-0.08332458
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:	0.999843	0.999645	0.999904
Attributable fraction (AF):	-1.6E-04	-3.6E-04	-9.6E-05
Increased number of cases in population:	-0.00433	-0.00080	-0.001173
Risk:	-6.2E-07	-1.1E-07	-1.2E-06
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-309.35	-309.35	-309.35
Population weighted Δx (µg/m^3):	-0.04036899	-0.04036899	-0.04036899
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:	0.999924	0.999828	0.999954
Attributable fraction (AF):	-7.6E-05	-1.7E-04	-4.6E-05
Increased number of cases in population:	-0.00230	-0.00042	-0.000624

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
Risk:	-3.0E-07	-5.5E-08	-5.6E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	19%
total change	-1259.4	-1259.4	-1259.4
Population weighted Δx (µg/m^3):	-0.01452683	-0.01452683	-0.01452683
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:	0.999973	0.999938	0.999983
Attributable fraction (AF):	-0.000027	-0.000062	-0.000017
Increased number of cases in population:	-0.011	-0.0017	-0.0033
Risk:	-1.3E-07	-2.0E-08	-2.0E-07
Individual subrubs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	19%
total change	-491.67	-491.67	-491.67
Population weighted Δx (µg/m^3):	-0.02432326	-0.02432326	-0.02432326
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:	0.999954	0.999896	0.999972
Attributable fraction (AF):	-4.6E-05	-1.0E-04	-2.8E-05
Increased number of cases in population:	-0.0043	-0.0007	-0.00127
Risk:	-2.1E-07	-3.3E-08	-3.4E-07
Beacon Hill - Narraweena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	19%
total change	-659.94	-659.94	-659.94
Population weighted Δx (µg/m^3):	-0.05173128	-0.05173128	-0.05173128
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:	0.999903	0.999780	0.999941
Attributable fraction (AF):	-9.7E-05	-2.2E-04	-5.9E-05
Increased number of cases in population:	-0.0057	-0.0009	-0.00171
Risk:	-4.5E-07	-7.1E-08	-7.2E-07
Dee Why - North Curl Curl			
Total Population in study area:	228	228	228
% population in assessment age-group:	100%	100%	19%
total change	-120.77	-120.77	-120.77
Population weighted Δx (µg/m^3):	-0.52969142	-0.52969142	-0.52969142
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:	0.999005	0.997746	0.999391
Attributable fraction (AF):	-1.0E-03	-2.3E-03	-6.1E-04
Increased number of cases in population:	-0.0011	-0.000165	-0.00031
Risk:	-4.6E-06	-7.2E-07	-7.4E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	19%
total change	-4371.2	-4371.2	-4371.2
Population weighted Δx (µg/m^3):	-0.34115270	-0.34115270	-0.34115270
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	0.998548	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%	19%
total change	-113.01	-113.01	-113.01
Population weighted Δx (µg/m^3):	-0.01112454	-0.01112454	-0.01112454
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:	0.999979	0.999953	0.999987
Attributable fraction (AF):	-2.1E-05	-4.7E-05	-1.3E-05
Increased number of cases in population:	-0.0010	-0.00015	-0.00029
Risk:	-9.7E-08	-1.5E-08	-1.5E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	19%
total change	550.29	550.29	550.29
Population weighted Δx (µg/m^3):	0.06838461	0.06838461	0.06838461
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:	1.000129	1.000291	1.000079
Attributable fraction (AF):	1.3E-04	2.9E-04	7.9E-05
Increased number of cases in population:	0.0048	0.00075	0.00142
Risk:	5.9E-07	9.4E-08	9.5E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	19%
total change	6.9900	6.9900	6.9900
Population weighted Δx (µg/m^3):	0.00125359	0.00125359	0.00125359
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):	2.4E-06	5.3E-06	1.4E-06

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
Increased number of cases in population:	0.000061	0.000010	0.000018
Risk:	1.1E-08	1.7E-09	1.7E-08
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	19%
total change	3939.9	3939.9	3939.9
Population weighted Δx (µg/m^3):	0.23313073	0.23313073	0.23313073
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:	1.000438	1.000994	1.000268
Attributable fraction (AF):	4.4E-04	9.9E-04	2.7E-04
Increased number of cases in population:	0.0342	0.0054	0.01019
Risk:	2.0E-06	3.2E-07	3.2E-06
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19%
total change	-3963.8	-3963.8	-3963.8
Population weighted Δx (µg/m^3):	-0.12312594	-0.12312594	-0.12312594
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:	0.999769	0.999476	0.999858
Attributable fraction (AF):	-2.3E-04	-5.2E-04	-1.4E-04
Increased number of cases in population:	-0.027	-0.0054	-0.011
Risk:	-8.4E-07	-1.7E-07	-1.7E-06
Individual subrubs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19%
total change	-184.37	-184.37	-184.37
Population weighted Δx (µg/m^3):	-0.01879216	-0.01879216	-0.01879216
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:	0.999965	0.999920	0.999978
Attributable fraction (AF):	-3.5E-05	-8.0E-05	-2.2E-05
Increased number of cases in population:	-0.0013	-0.00025	-0.00050
Risk:	-1.3E-07	-2.6E-08	-2.6E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19%
total change	-3772.6	-3772.6	-3772.6
Population weighted Δx (µg/m^3):	-0.17675887	-0.17675887	-0.17675887
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:	0.999668	0.999247	0.999797
Attributable fraction (AF):	-3.3E-04	-7.5E-04	-2.0E-04
Increased number of cases in population:	-0.0259	-0.0052	-0.01018
Risk:	-1.2E-06	-2.4E-07	-2.5E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19%
total change	-6.8590	-6.8590	-6.8590
Population weighted Δx (µg/m^3):	-0.00660150	-0.00660150	-0.00660150
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:	0.999988	0.999972	0.999992
Attributable fraction (AF):	-1.2E-05	-2.8E-05	-7.6E-06
Increased number of cases in population:	-0.000047	-0.0000094	-0.000019
Risk:	-4.5E-08	-9.0E-09	-9.2E-08
Total population incidence - All Suburbs	**-1.4**	**-0.23**	**-0.23**

Assessment of Increased Incidence - NO_2
Beaches Link: 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/m3 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	-192.43	-192.43	-192.43
Population weighted Δx (µg/m^3):	-0.08244698	-0.08244698	-0.08244698
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:	0.999845	0.999649	0.999905
Attributable fraction (AF):	-1.6E-04	-3.5E-04	-9.5E-05
Increased number of cases in population:	-0.0015	-0.00026	-0.00040
Risk:	-6.3E-07	-1.1E-07	-1.1E-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	-192.43	-192.43	-192.43
Population weighted Δx (µg/m^3):	-0.08244698	-0.08244698	-0.08244698
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:	0.999845	0.999649	0.999905
Attributable fraction (AF):	-1.6E-04	-3.5E-04	-9.5E-05
Increased number of cases in population:	-0.0015	-0.00026	-0.000399
Risk:	-6.3E-07	-1.1E-07	-1.1E-06
North Sydney - Mosman			
Total Population in study area:	94149	94149	94149
% population in assessment age-group:	100%	100%	13.9%
total change	-49821	-49821	-49821
Population weighted Δx (µg/m^3):	-0.52916773	-0.52916773	-0.52916773
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:	0.999006	0.997748	0.999392
Attributable fraction (AF):	-1.0E-03	-2.3E-03	-6.1E-04
Increased number of cases in population:	-0.37	-0.068	-0.096
Risk:	-3.9E-06	-7.2E-07	-7.4E-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	-7670.8	-7670.8	-7670.8
Population weighted Δx (µg/m^3):	-0.40277260	-0.40277260	-0.40277260
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:	0.999243	0.998286	0.999537
Attributable fraction (AF):	-7.6E-04	-1.7E-03	-4.6E-04
Increased number of cases in population:	-0.0572	-0.0105	-0.0148
Risk:	-3.0E-06	-5.5E-07	-5.6E-06
Crows Nest - Waverton			
Total Population in study area:	18063	18063	18063
% population in assessment age-group:	100%	100%	13.9%
total change	545.61	545.61	545.61
Population weighted Δx (µg/m^3):	0.03020585	0.03020585	0.03020585
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	1.000129	1.000035
Attributable fraction (AF):	5.7E-05	1.3E-04	3.5E-05
Increased number of cases in population:	0.0041	0.0007	0.0011
Risk:	2.3E-07	4.1E-08	4.2E-07
Mosman			
Total Population in study area:	28462	28462	28462
% population in assessment age-group:	100%	100%	13.9%
total change	-13259	-13259	-13259
Population weighted Δx (µg/m^3):	-0.46586385	-0.46586385	-0.46586385
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:	0.999125	0.998017	0.999464
Attributable fraction (AF):	-8.8E-04	-2.0E-03	-5.4E-04
Increased number of cases in population:	-0.0989	-0.0181	-0.0256
Risk:	-3.5E-06	-6.4E-07	-6.5E-06
Neutral Bay - Kirribilli			
Total Population in study area:	17899	17899	17899
% population in assessment age-group:	100%	100%	13.9%
total change	-21876	-21876	-21876
Population weighted Δx (µg/m^3):	-1.22219438	-1.22219438	-1.22219438
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:	0.997705	0.994807	0.998595
Attributable fraction (AF):	-2.3E-03	-5.2E-03	-1.4E-03
Increased number of cases in population:	-0.1632	-0.0300	-0.0423
Risk:	-9.1E-06	-1.7E-06	-1.7E-05
North Sydney - Lavender Bay			
Total Population in study area:	10680	10680	10680
% population in assessment age-group:	100%	100%	13.9%
total change	-7559.9	-7559.9	-7559.9
Population weighted Δx (µg/m^3):	-0.70785975	-0.70785975	-0.70785975

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)	396	32	1209
Baseline Incidence (per person)	0.00396	0.00032	0.01209
Relative Risk:	0.998670	0.996989	0.999186
Attributable fraction (AF):	-1.3E-03	-3.0E-03	-8.1E-04
Increased number of cases in population:	-0.0564	-0.0104	-0.0146
Risk:	-5.3E-06	-9.7E-07	-9.8E-06
Sydney Inner West LGA (Leichhardt)			
Total Population in study area:	48303	48303	48303
% population in assessment age-group:	100%	100%	14.1%
total change	-1619.8	-1619.8	-1619.8
Population weighted Δx (µg/m^3):	-0.03353409	-0.03353409	-0.03353409
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:	0.999937	0.999857	0.999961
Attributable fraction (AF):	-6.3E-05	-1.4E-04	-3.9E-05
Increased number of cases in population:	-0.016	-0.0022	-0.0032
Risk:	-3.4E-07	-4.6E-08	-4.7E-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	-2317.4	-2317.4	-2317.4
Population weighted Δx (µg/m^3):	-0.14767077	-0.14767077	-0.14767077
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:	0.999722	0.999371	0.999830
Attributable fraction (AF):	-2.8E-04	-6.3E-04	-1.7E-04
Increased number of cases in population:	-0.0233	-0.00317	-0.004543
Risk:	-1.5E-06	-2.0E-07	-2.1E-06
Leichhardt - Annandale			
Total Population in study area:	17541	17541	17541
% population in assessment age-group:	100%	100%	14.1%
total change	1203.2	1203.2	1203.2
Population weighted Δx (µg/m^3):	0.06859237	0.06859237	0.06859237
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:	1.000129	1.000292	1.000079
Attributable fraction (AF):	1.3E-04	2.9E-04	7.9E-05
Increased number of cases in population:	0.012	0.002	0.0024
Risk:	6.9E-07	9.4E-08	9.5E-07
Lilyfield - Rozelle			
Total Population in study area:	12549	12549	12549
% population in assessment age-group:	100%	100%	14.1%
total change	-505.58	-505.58	-505.58
Population weighted Δx (µg/m^3):	-0.04028836	-0.04028836	-0.04028836
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:	0.999924	0.999828	0.999954
Attributable fraction (AF):	-7.6E-05	-1.7E-04	-4.6E-05
Increased number of cases in population:	-0.005	-0.00069	-0.0010
Risk:	-4.0E-07	-5.5E-08	-5.6E-07
Petersham - Stanmore			
Total Population in study area:	2520	2520	2520
% population in assessment age-group:	100%	100%	14.1%
total change	-34.794	-34.794	-34.794
Population weighted Δx (µg/m^3):	-0.01380722	-0.01380722	-0.01380722
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:	0.999974	0.999941	0.999984
Attributable fraction (AF):	-2.6E-05	-5.9E-05	-1.6E-05
Increased number of cases in population:	-0.0003	-0.00005	-0.00007
Risk:	-1.4E-07	-1.9E-08	-1.9E-07
Sydney LGA			
Total Population in study area:	131933	131933	131933
% population in assessment age-group:	100%	100%	5.9%
total change	-74982	-74982	-74982
Population weighted Δx (µg/m^3):	-0.56833133	-0.56833133	-0.56833133
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:	0.998932	0.997582	0.999347
Attributable fraction (AF):	-1.1E-03	-2.4E-03	-6.5E-04
Increased number of cases in population:	-0.72	-0.10	-0.062
Risk:	-5.4E-06	-7.8E-07	-7.9E-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	-6721.5	-6721.5	-6721.5
Population weighted Δx (µg/m^3):	-0.59198996	-0.59198996	-0.59198996
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:	0.998888	0.997481	0.999319
Attributable fraction (AF):	-1.1E-03	-2.5E-03	-6.8E-04
Increased number of cases in population:	-0.064	-0.0092	-0.00552
Risk:	-5.7E-06	-8.1E-07	-8.2E-06
Glebe - Forest Lodge			
Total Population in study area:	19593	19593	19593

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%	5.9%
total change	-3680.3	-3680.3	-3680.3
Population weighted Δx (µg/m^3):	-0.18783495	-0.18783495	-0.18783495
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:	0.999647	0.999200	0.999784
Attributable fraction (AF):	-3.5E-04	-8.0E-04	-2.2E-04
Increased number of cases in population:	-0.035	-0.0050	-0.00302
Risk:	-1.8E-06	-2.6E-07	-2.6E-06
Newtown - Camperdown - Darlington			
Total Population in study area:	5154	5154	5154
% population in assessment age-group:	100%	100%	5.9%
total change	-385.72	-385.72	-385.72
Population weighted Δx (µg/m^3):	-0.07483949	-0.07483949	-0.07483949
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:	0.999859	0.999681	0.999914
Attributable fraction (AF):	-1.4E-04	-3.2E-04	-8.6E-05
Increased number of cases in population:	-0.00368	-0.000528	-0.000316
Risk:	-7.1E-07	-1.0E-07	-1.0E-06
Potts Point - Woolloomooloo			
Total Population in study area:	21200	21200	21200
% population in assessment age-group:	100%	100%	5.9%
total change	-28066	-28066	-28066
Population weighted Δx (µg/m^3):	-1.32386485	-1.32386485	-1.32386485
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:	0.997514	0.994376	0.998479
Attributable fraction (AF):	-2.5E-03	-5.7E-03	-1.5E-03
Increased number of cases in population:	-0.268	-0.038	-0.0230
Risk:	-1.3E-05	-1.8E-06	-1.8E-05
Pyrmont - Ultimo			
Total Population in study area:	21665	21665	21665
% population in assessment age-group:	100%	100%	5.9%
total change	-10847	-10847	-10847
Population weighted Δx (µg/m^3):	-0.50068570	-0.50068570	-0.50068570
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:	0.999059	0.997869	0.999424
Attributable fraction (AF):	-9.4E-04	-2.1E-03	-5.8E-04
Increased number of cases in population:	-0.104	-0.0148	-0.0089
Risk:	-4.8E-06	-6.8E-07	-7.0E-06
Redfern - Chippendale			
Total Population in study area:	9861	9861	9861
% population in assessment age-group:	100%	100%	5.9%
total change	-1830.5	-1830.5	-1830.5
Population weighted Δx (µg/m^3):	-0.18563339	-0.18563339	-0.18563339
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:	0.999651	0.999210	0.999787
Attributable fraction (AF):	-3.5E-04	-7.9E-04	-2.1E-04
Increased number of cases in population:	-0.01749	-0.002504	-0.001502
Risk:	-1.8E-06	-2.5E-07	-2.6E-06
Surry Hills			
Total Population in study area:	15699	15699	15699
% population in assessment age-group:	100%	100%	5.9%
total change	-9078.4	-9078.4	-9078.4
Population weighted Δx (µg/m^3):	-0.57827698	-0.57827698	-0.57827698
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:	0.998913	0.997540	0.999335
Attributable fraction (AF):	-1.1E-03	-2.5E-03	-6.7E-04
Increased number of cases in population:	-0.087	-0.0124	-0.00745
Risk:	-5.5E-06	-7.9E-07	-8.0E-06
Sydney - Haymarket - The Rocks			
Total Population in study area:	27407	27407	27407
% population in assessment age-group:	100%	100%	5.9%
total change	-14372	-14372	-14372
Population weighted Δx (µg/m^3):	-0.52439300	-0.52439300	-0.52439300
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:	0.999015	0.997769	0.999397
Attributable fraction (AF):	-9.9E-04	-2.2E-03	-6.0E-04
Increased number of cases in population:	-0.1373	-0.0197	-0.01179
Risk:	-5.0E-06	-7.2E-07	-7.3E-06
Lane Cove - Chatswood LGA			
Total Population in study area:	103355	103355	103355
% population in assessment age-group:	100%	100%	17.1%
total change	-14379	-14379	-14379
Population weighted Δx (µg/m^3):	-0.13912702	-0.13912702	-0.13912702
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:	0.999738	0.999407	0.999840
Attributable fraction (AF):	-2.6E-04	-5.9E-04	-1.6E-04
Increased number of cases in population:	-0.091	-0.020	-0.034
Risk:	-8.8E-07	-1.9E-07	-1.9E-06
Individual subrubs within LGA			
Chatswood East - Artarmon			

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
Total Population in study area:	28631	28631	28631
% population in assessment age-group:	100%	100%	17.1%
total change	-7084.0	-7084.0	-7084.0
Population weighted Δx (μg/m^3):	-0.24742522	-0.24742522	-0.24742522
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:	0.999535	0.998947	0.999716
Attributable fraction (AF):	-4.7E-04	-1.1E-03	-2.8E-04
Increased number of cases in population:	-0.0446	-0.0097	-0.0168
Risk:	-1.6E-06	-3.4E-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	-3205.9	-3205.9	-3205.9
Population weighted Δx (μg/m^3):	-0.17430243	-0.17430243	-0.17430243
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:	0.999672	0.999258	0.999800
Attributable fraction (AF):	-3.3E-04	-7.4E-04	-2.0E-04
Increased number of cases in population:	-0.0202	-0.0044	-0.0076
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	341.92	341.92	341.92
Population weighted Δx (μg/m^3):	0.01675974	0.01675974	0.01675974
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:	1.000032	1.000071	1.000019
Attributable fraction (AF):	3.2E-05	7.1E-05	1.9E-05
Increased number of cases in population:	0.0022	0.0005	0.0008
Risk:	1.1E-07	2.3E-08	2.3E-07
St Leonards - Naremburn			
Total Population in study area:	10478	10478	10478
% population in assessment age-group:	100%	100%	17.1%
total change	-182.98	-182.98	-182.98
Population weighted Δx (μg/m^3):	-0.01746329	-0.01746329	-0.01746329
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:	0.999967	0.999926	0.999980
Attributable fraction (AF):	-3.3E-05	-7.4E-05	-2.0E-05
Increased number of cases in population:	-0.0012	-0.0003	-0.0004
Risk:	-1.1E-07	-2.4E-08	-2.4E-07
Willoughby - Castle Cove - Northbridge			
Total Population in study area:	25452	25452	25452
% population in assessment age-group:	100%	100%	17.1%
total change	-4248.43	-4248.43	-4248.43
Population weighted Δx (μg/m^3):	-0.16691940	-0.16691940	-0.16691940
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:	0.999686	0.999289	0.999808
Attributable fraction (AF):	-3.1E-04	-7.1E-04	-1.9E-04
Increased number of cases in population:	-0.0268	-0.0058	-0.0101
Risk:	-1.1E-06	-2.3E-07	-2.3E-06
Hunters Hill LGA			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	54.354	54.354	54.354
Population weighted Δx (μg/m^3):	0.02407176	0.02407176	0.02407176
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:	1.000045	1.000103	1.000028
Attributable fraction (AF):	4.5E-05	1.0E-04	2.8E-05
Increased number of cases in population:	0.00051	0.000074	0.00014
Risk:	2.3E-07	3.3E-08	3.3E-07
Individual subrubs within LGA			
Hunters Hill - Woolwich			
Total Population in study area:	2258	2258	2258
% population in assessment age-group:	100%	100%	18.1%
total change	54.354	54.354	54.354
Population weighted Δx (μg/m^3):	0.02407176	0.02407176	0.02407176
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:	1.000045	1.000103	1.000028
Attributable fraction (AF):	4.5E-05	1.0E-04	2.8E-05
Increased number of cases in population:	0.0005	0.00007	0.0001
Risk:	2.3E-07	3.3E-08	3.3E-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	-6605.5	-6605.5	-6605.5
Population weighted Δx (μg/m^3):	-0.09194545	-0.09194545	-0.09194545
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:	0.999827	0.999608	0.999894
Attributable fraction (AF):	-1.7E-04	-3.9E-04	-1.1E-04
Increased number of cases in population:	-0.049	-0.0090	-0.013

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
Risk:	-6.8E-07	-1.3E-07	-1.3E-06
Individual suburbs within LGA			
Bondi - Tamarama - Bronte			
Total Population in study area:	2184	2184	2184
% population in assessment age-group:	100%	100%	14.5%
total change	-20.239	-20.239	-20.239
Population weighted Δx (µg/m^3):	-0.00926696	-0.00926696	-0.00926696
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:	0.999983	0.999961	0.999989
Attributable fraction (AF):	-1.7E-05	-3.9E-05	-1.1E-05
Increased number of cases in population:	-0.0002	-0.000028	-0.00004
Risk:	-6.9E-08	-1.3E-08	-1.3E-07
Bondi Beach - North Bondi			
Total Population in study area:	11819	11819	11819
% population in assessment age-group:	100%	100%	14.5%
total change	-348.08	-348.08	-348.08
Population weighted Δx (µg/m^3):	-0.02945078	-0.02945078	-0.02945078
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:	0.999945	0.999875	0.999966
Attributable fraction (AF):	-5.5E-05	-1.3E-04	-3.4E-05
Increased number of cases in population:	-0.0026	-0.0005	-0.00070
Risk:	-2.2E-07	-4.0E-08	-4.1E-07
Bondi Junction - Waverly			
Total Population in study area:	1903	1903	1903
% population in assessment age-group:	100%	100%	14.5%
total change	87.429	87.429	87.429
Population weighted Δx (µg/m^3):	0.04594268	0.04594268	0.04594268
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:	1.000086	1.000196	1.000053
Attributable fraction (AF):	8.6E-05	2.0E-04	5.3E-05
Increased number of cases in population:	0.0007	0.00012	0.00018
Risk:	3.4E-07	6.3E-08	6.4E-07
Double Bay - Bellevue Hill			
Total Population in study area:	24798	24798	24798
% population in assessment age-group:	100%	100%	14.5%
total change	-1931.2	-1931.2	-1931.2
Population weighted Δx (µg/m^3):	-0.07787914	-0.07787914	-0.07787914
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:	0.999854	0.999668	0.999910
Attributable fraction (AF):	-1.5E-04	-3.3E-04	-9.0E-05
Increased number of cases in population:	-0.0144	-0.00264	-0.00389
Risk:	-5.8E-07	-1.1E-07	-1.1E-06
Dover Heights			
Total Population in study area:	3179	3179	3179
% population in assessment age-group:	100%	100%	14.5%
total change	-193.26	-193.26	-193.26
Population weighted Δx (µg/m^3):	-0.06079383	-0.06079383	-0.06079383
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:	0.999886	0.999741	0.999930
Attributable fraction (AF):	-1.1E-04	-2.6E-04	-7.0E-05
Increased number of cases in population:	-0.0014	-0.000264	-0.00039
Risk:	-4.5E-07	-8.3E-08	-8.5E-07
Paddington - Moore Park			
Total Population in study area:	13311	13311	13311
% population in assessment age-group:	100%	100%	14.5%
total change	-3105.05	-3105.05	-3105.05
Population weighted Δx (µg/m^3):	-0.23326981	-0.23326981	-0.23326981
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:	0.999562	0.999007	0.999732
Attributable fraction (AF):	-4.4E-04	-9.9E-04	-2.7E-04
Increased number of cases in population:	-0.02312	-0.00425	-0.006261
Risk:	-1.7E-06	-3.2E-07	-3.2E-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	-818.16	-818.16	-818.16
Population weighted Δx (µg/m^3):	-0.11714748	-0.11714748	-0.11714748
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:	0.999780	0.999501	0.999865
Attributable fraction (AF):	-2.2E-04	-5.0E-04	-1.3E-04
Increased number of cases in population:	-0.00609	-0.00112	-0.001650
Risk:	-8.7E-07	-1.6E-07	-1.6E-06
Woollahra			
Total Population in study area:	7663	7663	7663
% population in assessment age-group:	100%	100%	14.5%
total change	-276.84	-276.84	-276.84
Population weighted Δx (µg/m^3):	-0.03612703	-0.03612703	-0.03612703
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:	0.999932	0.999846	0.999958
Attributable fraction (AF):	-6.8E-05	-1.5E-04	-4.2E-05
Increased number of cases in population:	-0.00206	-0.00038	-0.000558

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
Risk:	-2.7E-07	-4.9E-08	-5.0E-07
Northern Beaches LGA			
Total Population in study area:	86694	86694	86694
% population in assessment age-group:	100%	100%	18.6%
total change	2423.8	2423.8	2423.8
Population weighted Δx (µg/m^3):	0.02795795	0.02795795	0.02795795
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:	1.000053	1.000119	1.000032
Attributable fraction (AF):	5.3E-05	1.2E-04	3.2E-05
Increased number of cases in population:	0.021	0.0033	0.0063
Risk:	2.4E-07	3.8E-08	3.9E-07
Individual subrubs within LGA			
Balgowlah - Clontarf - Seaforth			
Total Population in study area:	20214	20214	20214
% population in assessment age-group:	100%	100%	18.6%
total change	1026.9	1026.9	1026.9
Population weighted Δx (µg/m^3):	0.05080283	0.05080283	0.05080283
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	1.000216	1.000058
Attributable fraction (AF):	9.6E-05	2.2E-04	5.8E-05
Increased number of cases in population:	0.0089	0.0014	0.00266
Risk:	4.4E-07	6.9E-08	7.1E-07
Beacon Hill - Narraweena			
Total Population in study area:	12757	12757	12757
% population in assessment age-group:	100%	100%	18.6%
total change	-403.38	-403.38	-403.38
Population weighted Δx (µg/m^3):	-0.03162043	-0.03162043	-0.03162043
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:	0.999941	0.999865	0.999964
Attributable fraction (AF):	-5.9E-05	-1.3E-04	-3.6E-05
Increased number of cases in population:	-0.0035	-0.0006	-0.00104
Risk:	-2.7E-07	-4.3E-08	-4.4E-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	84.729	84.729	84.729
Population weighted Δx (µg/m^3):	0.37161675	0.37161675	0.37161675
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:	1.000699	1.001584	1.000427
Attributable fraction (AF):	7.0E-04	1.6E-03	4.3E-04
Increased number of cases in population:	0.0007	0.000116	0.00022
Risk:	3.2E-06	5.1E-07	5.2E-06
Forrestville - Killarney Heights			
Total Population in study area:	12813	12813	12813
% population in assessment age-group:	100%	100%	18.6%
total change	-4518.5	-4518.5	-4518.5
Population weighted Δx (µg/m^3):	-0.35264679	-0.35264679	-0.35264679
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:	0.999337	0.998499	0.999595
Attributable fraction (AF):	-6.6E-04	-1.5E-03	-4.1E-04
Increased number of cases in population:	-0.0393	-0.0062	-0.01169
Risk:	-3.1E-06	-4.8E-07	-4.9E-06
Frenchs Forrest - Belrose			
Total Population in study area:	10159	10159	10159
% population in assessment age-group:	100%	100%	18.6%
total change	362.65	362.65	362.65
Population weighted Δx (µg/m^3):	0.03569740	0.03569740	0.03569740
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:	1.000067	1.000152	1.000041
Attributable fraction (AF):	6.7E-05	1.5E-04	4.1E-05
Increased number of cases in population:	0.0032	0.0005	0.00094
Risk:	3.1E-07	4.9E-08	5.0E-07
Freshwater - Brookvale			
Total Population in study area:	8047	8047	8047
% population in assessment age-group:	100%	100%	18.6%
total change	280.95	280.95	280.95
Population weighted Δx (µg/m^3):	0.03491394	0.03491394	0.03491394
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:	0.0024	0.0004	0.00073
Risk:	3.0E-07	4.8E-08	4.9E-07
Manly - Fairlight			
Total Population in study area:	5576	5576	5576
% population in assessment age-group:	100%	100%	18.6%
total change	265.54	265.54	265.54
Population weighted Δx (µg/m^3):	0.04762230	0.04762230	0.04762230
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:	1.000090	1.000203	1.000055
Attributable fraction (AF):	9.0E-05	2.0E-04	5.5E-05

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
Increased number of cases in population:	0.0023	0.0004	0.00069
Risk:	4.1E-07	6.5E-08	6.6E-07
Manly Vale - Allambie Heights			
Total Population in study area:	16900	16900	16900
% population in assessment age-group:	100%	100%	18.6%
total change	5324.8	5324.8	5324.8
Population weighted Δx (µg/m^3):	0.31507871	0.31507871	0.31507871
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:	1.000593	1.001343	1.000362
Attributable fraction (AF):	5.9E-04	1.3E-03	3.6E-04
Increased number of cases in population:	0.0463	0.0073	0.01377
Risk:	2.7E-06	4.3E-07	4.4E-06
Ku-ring-gai LGA			
Total Population in study area:	32193	32193	32193
% population in assessment age-group:	100%	100%	19.4%
total change	-3287.6	-3287.6	-3287.6
Population weighted Δx (µg/m^3):	-0.10212178	-0.10212178	-0.10212178
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:	0.999808	0.999565	0.999883
Attributable fraction (AF):	-1.9E-04	-4.4E-04	-1.2E-04
Increased number of cases in population:	-0.023	-0.0045	-0.0089
Risk:	-7.0E-07	-1.4E-07	-1.4E-06
Individual subrubs within LGA			
Gordon-Killara			
Total Population in study area:	9811	9811	9811
% population in assessment age-group:	100%	100%	19.4%
total change	96.21	96.21	96.21
Population weighted Δx (µg/m^3):	0.01	0.01	0.01
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:	1.000018	1.000042	1.000011
Attributable fraction (AF):	1.8E-05	4.2E-05	1.1E-05
Increased number of cases in population:	0.0007	0.00013	0.00026
Risk:	6.7E-08	1.3E-08	1.4E-07
Lindfield - Roseville			
Total Population in study area:	21343	21343	21343
% population in assessment age-group:	100%	100%	19.4%
total change	-3338.1	-3338.1	-3338.1
Population weighted Δx (µg/m^3):	-0.15640412	-0.15640412	-0.15640412
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:	0.999706	0.999334	0.999820
Attributable fraction (AF):	-2.9E-04	-6.7E-04	-1.8E-04
Increased number of cases in population:	-0.0229	-0.0046	-0.00900
Risk:	-1.1E-06	-2.1E-07	-2.2E-06
St Ives			
Total Population in study area:	1039	1039	1039
% population in assessment age-group:	100%	100%	19.4%
total change	-45.685	-45.685	-45.685
Population weighted Δx (µg/m^3):	-0.04397027	-0.04397027	-0.04397027
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:	0.999917	0.999813	0.999949
Attributable fraction (AF):	-8.3E-05	-1.9E-04	-5.1E-05
Increased number of cases in population:	-0.0003	-0.000062	-0.00012
Risk:	-3.0E-07	-6.0E-08	-6.1E-07
Total population incidence - All Suburbs	**-1.2**	**-0.20**	**-0.21**

Annexure F – Risk calculations: Particulate matter

Quantification of Effects - $PM_{2.5}$ and PM_{10}
Beaches Link: 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/m³) (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 PM10 Concentration (μg/m³)	Change in Annual Average PM2.5 Concentration (μg/m³)	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk	Risk
Impacts from project (ventilation outlets and roads)													
Grid receptors: maximum regardless of land use		**2.30**	**1.28**	**8E-05**	**9E-05**	**2E-05**	**6E-06**	**5E-06**	**7E-05**	**2E-06**	**8E-07**	**2E-05**	**4E-05**
Grid receptors: maximum residential		**1.10**	**0.82**	**5E-05**	**6E-05**	**1E-05**	**3E-06**	**3E-06**	**4E-05**	**1E-06**	**5E-07**	**1E-05**	**3E-05**
Grid receptors: maximum childcare		**0.36**	**0.20**	**1E-05**	**1E-05**	**3E-06**	**9E-07**	**8E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: maximum school		**0.39**	**0.24**	**1E-05**	**2E-05**	**4E-06**	**1E-06**	**1E-06**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**8E-06**
Grid receptors: maximum aged care		**0.18**	**0.33**	**2E-05**	**2E-05**	**5E-06**	**5E-07**	**1E-06**	**2E-05**	**4E-07**	**2E-07**	**6E-06**	**1E-05**
Grid receptors: maximum hospital and medical		**0.19**	**0.11**	**7E-06**	**8E-06**	**2E-06**	**5E-07**	**4E-07**	**6E-06**	**1E-07**	**7E-08**	**2E-06**	**4E-06**
Grid receptors: commercial/industrial		**2.30**	**1.28**	**8E-05**	**9E-05**	**2E-05**	**6E-06**	**5E-06**	**7E-05**	**2E-06**	**8E-07**	**2E-05**	**4E-05**
Grid receptors: open space		**0.56**	**0.45**	**3E-05**	**3E-05**	**7E-06**	**1E-06**	**2E-06**	**2E-05**	**6E-07**	**3E-07**	**8E-06**	**2E-05**
Community Receptors													
University of Notre Dame, Broadway	University	0.2607	0.0671	4E-06	5E-06	1E-06	7E-07	3E-07	4E-06	9E-08	4E-08	1E-06	**2E-06**
Laverty Pathology, Annandale	Medical centre	0.1975	-0.0933	-6E-06	-7E-06	-2E-06	5E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06	**-3E-06**
St Basil's, Annandale	Aged care	-0.1200	-0.0841	-5E-06	-6E-06	-1E-06	-3E-07	-3E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
The Jimmy Little Community Centre	Community centre	0.1675	-0.0866	-5E-06	-6E-06	-1E-06	4E-07	-3E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
Rozelle Public School	Primary School	0.0523	-0.0154	-9E-07	-1E-06	-3E-07	1E-07	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	**-5E-07**
St Aloysius College	High School	0.3489	0.0975	6E-06	7E-06	2E-06	9E-07	4E-07	5E-06	1E-07	6E-08	2E-06	**3E-06**
Dancing Dingo Family Day Care	Child care	-0.0611	-0.0393	-2E-06	-3E-06	-6E-07	-2E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Wenona School	Primary School	0.0057	-0.0206	-1E-06	-2E-06	-3E-07	1E-08	-8E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-7E-07**
Mater Hospital	Hospital	0.0335	-0.0413	-2E-06	-3E-06	-7E-07	9E-08	-2E-07	-2E-06	-5E-08	-3E-08	-7E-07	**-1E-06**
Neutral Bay Public School	Primary School	-0.1049	-0.1460	-9E-06	-1E-05	-2E-06	-3E-07	-6E-07	-8E-06	-2E-07	-9E-08	-3E-06	**-5E-06**
Neutral Bay Medical Centre	Medical Centre	-0.3955	-0.2614	-2E-05	-2E-05	-4E-06	-1E-06	-1E-06	-1E-05	-3E-07	-2E-07	-5E-06	**-9E-06**
Puddleducks Child Care Centre	Childcare	-0.1554	-0.0255	-2E-06	-2E-06	-4E-07	-4E-07	-1E-07	-1E-06	-3E-08	-2E-08	-5E-07	**-9E-07**
Mosman Public School	Primary School	0.0188	-0.0572	-3E-06	-4E-06	-9E-07	5E-08	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	**-2E-06**
Garrison & Killarney Retirement Centre	Aged care	-0.6995	-0.3877	-2E-05	-3E-05	-6E-06	-2E-06	-2E-06	-2E-05	-5E-07	-2E-07	-7E-06	**-1E-05**
Beauty Point Public School	Primary School	-0.1101	-0.0368	-2E-06	-3E-06	-6E-07	-3E-07	-1E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Anzac Park Public School	Primary School	0.0172	-0.0724	-4E-06	-5E-06	-1E-06	4E-08	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Ku Cammeray Preschool	Preschool	0.0216	-0.0211	-1E-06	-2E-06	-3E-07	6E-08	-9E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-7E-07**
Cammeray Public School	Primary School	-0.0332	-0.0096	-6E-07	-7E-07	-2E-07	-9E-08	-4E-08	-5E-07	-1E-08	-6E-09	-2E-07	**-3E-07**
Atchison Preschool	Preschool	-0.2383	-0.0754	-4E-06	-6E-06	-1E-06	-6E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Berry Cottage Childcare	Child care	0.2423	0.1122	7E-06	8E-06	2E-06	6E-07	5E-07	6E-06	1E-07	7E-08	2E-06	**4E-06**
Explore & Develop Artarmon - Early Learning Centre	Preschool	-0.0338	0.0555	3E-06	4E-06	9E-07	-9E-08	2E-07	3E-06	7E-08	3E-08	1E-06	**2E-06**
SBS Child Care	Child care	0.0178	0.0664	4E-06	5E-06	1E-06	5E-08	3E-07	4E-06	8E-08	4E-08	1E-06	**2E-06**
Butterflies Early Learning Childcare Centre	Child care	0.3295	0.0245	1E-06	2E-06	4E-07	8E-07	1E-07	1E-06	3E-08	1E-08	4E-07	**8E-07**
Artarmon Public School	Primary School	-0.1374	-0.0545	-3E-06	-4E-06	-9E-07	-4E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	**-2E-06**
Sue's Childcare, Castlevale	Child care	-0.1842	-0.0783	-5E-06	-6E-06	-1E-06	-5E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Northside Baptist Preschool	Preschool	-0.1389	-0.0474	-3E-06	-3E-06	-8E-07	-4E-07	-2E-07	-3E-06	-6E-08	-3E-08	-8E-07	**-2E-06**
Willoughby Public School	Primary School	-0.0867	-0.0848	-5E-06	-6E-06	-1E-06	-2E-07	-3E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
Peek A Boo Cottage	Child care	-1.3625	-0.8527	-5E-05	-6E-05	-1E-05	-3E-06	-3E-06	-5E-05	-1E-06	-5E-07	-2E-05	**-3E-05**
St Cecilia's Catholic Primary School	Primary School	0.0004	-0.0509	-3E-06	-4E-06	-8E-07	1E-09	-2E-07	-3E-06	-7E-08	-3E-08	-9E-07	**-2E-06**
Seaforth Public School	Primary School	0.0457	-0.0422	-3E-06	-3E-06	-7E-07	1E-07	-2E-07	-2E-06	-5E-08	-3E-08	-8E-07	**-1E-06**
Punchinello Kindergarten	Preschool	0.1092	0.1533	9E-06	1E-05	2E-06	3E-07	6E-07	8E-06	2E-07	9E-08	3E-06	**5E-06**
Harbour View Childrens Centre	Child care	0.0144	-0.0101	-6E-07	-7E-07	-2E-07	4E-08	-4E-08	-5E-07	-1E-08	-6E-09	-2E-07	**-3E-07**
Jacaranda Creative Play Centre	Child care	0.0396	0.0099	6E-07	7E-07	2E-07	1E-07	4E-08	5E-07	1E-08	6E-09	2E-07	**3E-07**
St James Medical And Cosmetics Centre	Medical Centre	0.1541	0.0469	3E-06	3E-06	8E-07	4E-07	2E-07	3E-06	6E-08	3E-08	8E-07	**2E-06**
Ku Bligh Park Preschool	Preschool	0.0068	0.0091	5E-07	7E-07	1E-07	2E-08	4E-08	5E-07	1E-08	6E-09	2E-07	**3E-07**
Balgowlah North Public School	Primary School	0.0595	0.0339	2E-06	3E-06	6E-07	2E-07	1E-07	2E-06	4E-08	2E-08	6E-07	**1E-06**
Hardi Aged Care Manly Vale	Aged care	0.2077	0.0757	5E-06	6E-06	1E-06	5E-07	3E-07	4E-06	1E-07	5E-08	1E-06	**3E-06**
Willoughby Retirement Village	Aged care	-0.1335	-0.0062	-4E-07	-5E-07	-1E-07	-3E-07	-2E-08	-3E-07	-8E-09	-4E-09	-1E-07	**-2E-07**
Roseville Public School	Primary school	-0.0371	-0.0401	-2E-06	-3E-06	-7E-07	-1E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
UnitingCare Forestville Preschool	Childcare	-0.0195	-0.0512	-3E-06	-4E-06	-8E-07	-5E-08	-2E-07	-3E-06	-7E-08	-3E-08	-9E-07	**-2E-06**
Beehive Kindy	Childcare	-0.0995	-0.0605	-4E-06	-4E-06	-1E-06	-3E-07	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06	**-2E-06**
Northern Beaches Hospital	Hospital	0.0466	0.0109	6E-07	8E-07	2E-07	1E-07	4E-08	6E-07	1E-08	7E-09	2E-07	**4E-07**

Quantification of Effects - $PM_{2.5}$ and PM_{10}
Beaches Link: 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/m³) (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 PM10 Concentration (μg/m³)**	**Change in Annual Average PM2.5 Concentration (μg/m³)**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**
Impacts from project (ventilation outlets and roads)													
Grid receptors: maximum regardless of land use		**1.00**	**0.86**	**5E-05**	**6E-05**	**1E-05**	**3E-06**	**3E-06**	**5E-05**	**1E-06**	**5E-07**	**2E-05**	**3E-05**
Grid receptors: maximum residential		**1.00**	**0.86**	**5E-05**	**6E-05**	**1E-05**	**3E-06**	**3E-06**	**5E-05**	**1E-06**	**5E-07**	**2E-05**	**3E-05**
Grid receptors: maximum childcare		**0.22**	**0.20**	**1E-05**	**1E-05**	**3E-06**	**6E-07**	**8E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: maximum school		**0.26**	**0.13**	**8E-06**	**1E-05**	**2E-06**	**7E-07**	**5E-07**	**7E-06**	**2E-07**	**8E-08**	**2E-06**	**4E-06**
Grid receptors: maximum aged care		**0.46**	**0.11**	**7E-06**	**8E-06**	**2E-06**	**1E-06**	**4E-07**	**6E-06**	**1E-07**	**7E-08**	**2E-06**	**4E-06**
Grid receptors: maximum hospital and medical		**0.27**	**0.15**	**9E-06**	**1E-05**	**2E-06**	**7E-07**	**6E-07**	**8E-06**	**2E-07**	**9E-08**	**3E-06**	**5E-06**
Grid receptors: commercial/industrial		**0.74**	**0.50**	**3E-05**	**4E-05**	**8E-06**	**2E-06**	**2E-06**	**3E-05**	**6E-07**	**3E-07**	**9E-06**	**2E-05**
Grid receptors: open space		**0.73**	**0.18**	**1E-05**	**1E-05**	**3E-06**	**2E-06**	**7E-07**	**1E-05**	**2E-07**	**1E-07**	**3E-06**	**6E-06**
Community Receptors													
University of Notre Dame, Broadway	University	-0.0539	-0.1770	-1E-05	-1E-05	-3E-06	-1E-07	-7E-07	-9E-06	-2E-07	-1E-07	-3E-06	**-6E-06**
Laverty Pathology, Annandale	Medical centre	-0.0055	0.0348	2E-06	3E-06	6E-07	-1E-08	1E-07	2E-06	4E-08	2E-08	6E-07	**1E-06**
St Basil's, Annandale	Aged care	0.1500	-0.0791	-5E-06	-6E-06	-1E-06	4E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
The Jimmy Little Community Centre	Community centre	-0.0264	0.0219	1E-06	2E-06	4E-07	-7E-08	9E-08	1E-06	3E-08	1E-08	4E-07	**7E-07**
Rozelle Public School	Primary School	0.0418	0.0136	8E-07	1E-06	2E-07	1E-07	5E-08	7E-07	2E-08	8E-09	2E-07	**5E-07**
St Aloysius College	High School	-0.2986	-0.2566	-2E-05	-2E-05	-4E-06	-8E-07	-1E-06	-1E-05	-3E-07	-2E-07	-5E-06	**-9E-06**
Dancing Dingo Family Day Care	Child care	-0.0079	-0.0213	-1E-06	-2E-06	-3E-07	-2E-08	-9E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-7E-07**
Wenona School	Primary School	-0.2239	-0.1575	-9E-06	-1E-05	-3E-06	-6E-07	-6E-07	-8E-06	-2E-07	-1E-07	-3E-06	**-5E-06**
Mater Hospital	Hospital	0.0930	-0.0711	-4E-06	-5E-06	-1E-06	2E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Neutral Bay Public School	Primary School	-0.2302	-0.1136	-7E-06	-8E-06	-2E-06	-6E-07	-5E-07	-6E-06	-1E-07	-7E-08	-2E-06	**-4E-06**
Neutral Bay Medical Centre	Medical Centre	-0.3236	-0.2726	-2E-05	-2E-05	-4E-06	-8E-07	-1E-06	-1E-05	-3E-07	-2E-07	-5E-06	**-9E-06**
Puddleducks Child Care Centre	Childcare	0.0131	-0.0836	-5E-06	-6E-06	-1E-06	3E-08	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Mosman Public School	Primary School	0.0229	-0.0123	-7E-07	-9E-07	-2E-07	6E-08	-5E-08	-7E-07	-2E-08	-8E-09	-2E-07	**-4E-07**
Garrison & Killarney Retirement Centre	Aged care	-0.6876	-0.4957	-3E-05	-4E-05	-8E-06	-2E-06	-2E-06	-3E-05	-6E-07	-3E-07	-9E-06	**-2E-05**
Beauty Point Public School	Primary School	-0.0499	-0.0500	-3E-06	-4E-06	-8E-07	-1E-07	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07	**-2E-06**
Anzac Park Public School	Primary School	0.0219	0.0156	9E-07	1E-06	3E-07	6E-08	6E-08	8E-07	2E-08	1E-08	3E-07	**5E-07**
Ku Cammeray Preschool	Preschool	-0.0695	-0.0381	-2E-06	-3E-06	-6E-07	-2E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Cammeray Public School	Primary School	-0.0002	-0.0195	-1E-06	-1E-06	-3E-07	-4E-10	-8E-08	-1E-06	-2E-08	-1E-08	-3E-07	**-7E-07**
Atchison Preschool	Preschool	-0.1384	-0.0904	-5E-06	-7E-06	-1E-06	-4E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06	**-3E-06**
Berry Cottage Childcare	Child care	-0.0009	-0.0144	-9E-07	-1E-06	-2E-07	-2E-09	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	**-5E-07**
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.0098	0.0439	3E-06	3E-06	7E-07	3E-08	2E-07	2E-06	6E-08	3E-08	8E-07	**1E-06**
SBS Child Care	Child care	-0.0033	0.0708	4E-06	5E-06	1E-06	-9E-09	3E-07	4E-06	9E-08	4E-08	1E-06	**2E-06**
Butterflies Early Learning Childcare Centre	Child care	0.0952	0.0606	4E-06	4E-06	1E-06	2E-07	2E-07	3E-06	8E-08	4E-08	1E-06	**2E-06**
Artarmon Public School	Primary School	-0.0677	-0.0380	-2E-06	-3E-06	-6E-07	-2E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Sue's Childcare, Castlevale	Child care	-0.0037	-0.0798	-5E-06	-6E-06	-1E-06	-1E-08	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Northside Baptist Preschool	Preschool	-0.1700	-0.0746	-4E-06	-6E-06	-1E-06	-4E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Willoughby Public School	Primary School	-0.0259	-0.0870	-5E-06	-6E-06	-1E-06	-7E-08	-4E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
Peek A Boo Cottage	Child care	-1.5096	-0.8979	-5E-05	-7E-05	-1E-05	-4E-06	-4E-06	-5E-05	-1E-06	-5E-07	-2E-05	**-3E-05**
St Cecilia's Catholic Primary School	Primary School	-0.0224	-0.0500	-3E-06	-4E-06	-8E-07	-6E-08	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07	**-2E-06**
Seaforth Public School	Primary School	-0.0017	-0.1060	-6E-06	-8E-06	-2E-06	-4E-09	-4E-07	-6E-06	-1E-07	-6E-08	-2E-06	**-4E-06**
Punchinello Kindergarten	Preschool	0.1420	0.1115	7E-06	8E-06	2E-06	4E-07	4E-07	6E-06	1E-07	7E-08	2E-06	**4E-06**
Harbour View Childrens Centre	Child care	-0.0009	-0.0174	-1E-06	-1E-06	-3E-07	-2E-09	-7E-08	-9E-07	-2E-08	-1E-08	-3E-07	**-6E-07**
Jacaranda Creative Play Centre	Child care	0.0132	0.0370	2E-06	3E-06	6E-07	3E-08	1E-07	2E-06	5E-08	2E-08	7E-07	**1E-06**
St James Medical And Cosmetics Centre	Medical Centre	0.0602	0.0370	2E-06	3E-06	6E-07	2E-07	1E-07	2E-06	5E-08	2E-08	7E-07	**1E-06**
Ku Bligh Park Preschool	Preschool	0.0607	0.0104	6E-07	8E-07	2E-07	2E-07	4E-08	6E-07	1E-08	6E-09	2E-07	**4E-07**
Balgowlah North Public School	Primary School	0.0624	0.0449	3E-06	3E-06	7E-07	2E-07	2E-07	2E-06	6E-08	3E-08	8E-07	**2E-06**
Hardi Aged Care Manly Vale	Aged care	0.1054	0.0455	3E-06	3E-06	7E-07	3E-07	2E-07	2E-06	6E-08	3E-08	8E-07	**2E-06**
Willoughby Retirement Village	Aged care	-0.1227	-0.0538	-3E-06	-4E-06	-9E-07	-3E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	**-2E-06**
Roseville Public School	Primary school	-0.0671	-0.0254	-2E-06	-2E-06	-4E-07	-2E-07	-1E-07	-1E-06	-3E-08	-2E-08	-5E-07	**-9E-07**
UnitingCare Forestville Preschool	Childcare	-0.1124	-0.0620	-4E-06	-5E-06	-1E-06	-3E-07	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06	**-2E-06**
Beehive Kindy	Childcare	-0.1115	-0.0866	-5E-06	-6E-06	-1E-06	-3E-07	-3E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
Northern Beaches Hospital	Hospital	-0.0108	-0.0098	-6E-07	-7E-07	-2E-07	-3E-08	-4E-08	-5E-07	-1E-08	-6E-09	-2E-07	**-3E-07**

Quantification of Effects - $PM_{2.5}$ and PM_{10}
Beaches Link: 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/m³) (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 PM10 Concentration (μg/m³)**	**Change in Annual Average PM2.5 Concentration (μg/m³)**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**
Impacts from project (ventilation outlets and roads)													
Grid receptors: maximum regardless of land use		**2.3**	**1.65**	**1E-04**	**1E-04**	**3E-05**	**6E-06**	**7E-06**	**9E-05**	**2E-06**	**1E-06**	**3E-05**	**6E-05**
Grid receptors: maximum residential		**1.30**	**0.82**	**5E-05**	**6E-05**	**1E-05**	**3E-06**	**3E-06**	**4E-05**	**1E-06**	**5E-07**	**1E-05**	**3E-05**
Grid receptors: maximum childcare		**0.42**	**0.25**	**1E-05**	**2E-05**	**4E-06**	**1E-06**	**1E-06**	**1E-05**	**3E-07**	**2E-07**	**4E-06**	**9E-06**
Grid receptors: maximum school		**0.50**	**0.31**	**2E-05**	**2E-05**	**5E-06**	**1E-06**	**1E-06**	**2E-05**	**4E-07**	**2E-07**	**6E-06**	**1E-05**
Grid receptors: maximum aged care		**0.12**	**0.22**	**1E-05**	**2E-05**	**4E-06**	**3E-07**	**9E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: maximum hospital and medical		**0.15**	**0.21**	**1E-05**	**2E-05**	**3E-06**	**4E-07**	**8E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: commercial/industrial		**2.3**	**1.65**	**1E-04**	**1E-04**	**3E-05**	**6E-06**	**7E-06**	**9E-05**	**2E-06**	**1E-06**	**3E-05**	**6E-05**
Grid receptors: open space		**0.72**	**0.44**	**3E-05**	**3E-05**	**7E-06**	**2E-06**	**2E-06**	**2E-05**	**6E-07**	**3E-07**	**8E-06**	**1E-05**
Community Receptors													
University of Notre Dame, Broadway	University	-0.0081	0.0335	2E-06	2E-06	5E-07	-2E-08	1E-07	2E-06	4E-08	2E-08	6E-07	**1E-06**
Laverty Pathology, Annandale	Medical centre	0.0041	-0.1818	-1E-05	-1E-05	-3E-06	1E-08	-7E-07	-1E-05	-2E-07	-1E-07	-3E-06	**-6E-06**
St Basil's, Annandale	Aged care	0.0886	0.0696	4E-06	5E-06	1E-06	2E-07	3E-07	4E-06	9E-08	4E-08	1E-06	**2E-06**
The Jimmy Little Community Centre	Community centre	0.0477	-0.0813	-5E-06	-6E-06	-1E-06	1E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Rozelle Public School	Primary School	-0.0893	0.0207	1E-06	2E-06	3E-07	-2E-07	8E-08	1E-06	3E-08	1E-08	4E-07	**7E-07**
St Aloysius College	High School	0.2699	0.1704	1E-05	1E-05	3E-06	7E-07	7E-07	9E-06	2E-07	1E-07	3E-06	**6E-06**
Dancing Dingo Family Day Care	Child care	0.0895	0.0205	1E-06	2E-06	3E-07	2E-07	8E-08	1E-06	3E-08	1E-08	4E-07	**7E-07**
Wenona School	Primary School	0.0429	0.0067	4E-07	5E-07	1E-07	1E-07	3E-08	4E-07	9E-09	4E-09	1E-07	**2E-07**
Mater Hospital	Hospital	0.1517	-0.0019	-1E-07	-1E-07	-3E-08	4E-07	-8E-09	-1E-07	-2E-09	-1E-09	-3E-08	**-6E-08**
Neutral Bay Public School	Primary School	-0.0850	-0.0678	-4E-06	-5E-06	-1E-06	-2E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Neutral Bay Medical Centre	Medical Centre	-0.2816	-0.1797	-1E-05	-1E-05	-3E-06	-7E-07	-7E-07	-1E-05	-2E-07	-1E-07	-3E-06	**-6E-06**
Puddleducks Child Care Centre	Childcare	-0.1808	-0.0008	-5E-08	-6E-08	-1E-08	-5E-07	-3E-09	-5E-08	-1E-09	-5E-10	-2E-08	**-3E-08**
Mosman Public School	Primary School	-0.0672	-0.0489	-3E-06	-4E-06	-8E-07	-2E-07	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07	**-2E-06**
Garrison & Killarney Retirement Centre	Aged care	-0.6302	-0.5059	-3E-05	-4E-05	-8E-06	-2E-06	-2E-06	-3E-05	-6E-07	-3E-07	-9E-06	**-2E-05**
Beauty Point Public School	Primary School	-0.1651	-0.0568	-3E-06	-4E-06	-9E-07	-4E-07	-2E-07	-3E-06	-7E-08	-3E-08	-1E-06	**-2E-06**
Anzac Park Public School	Primary School	0.0824	0.0207	1E-06	2E-06	3E-07	2E-07	8E-08	1E-06	3E-08	1E-08	4E-07	**7E-07**
Ku Cammeray Preschool	Preschool	-0.0655	0.0384	2E-06	3E-06	6E-07	-2E-07	2E-07	2E-06	5E-08	2E-08	7E-07	**1E-06**
Cammeray Public School	Primary School	-0.0247	-0.0221	-1E-06	-2E-06	-4E-07	-6E-08	-9E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-8E-07**
Atchison Preschool	Preschool	-0.0067	-0.0254	-2E-06	-2E-06	-4E-07	-2E-08	-1E-07	-1E-06	-3E-08	-2E-08	-5E-07	**-9E-07**
Berry Cottage Childcare	Child care	0.0617	0.0718	4E-06	5E-06	1E-06	2E-07	3E-07	4E-06	9E-08	4E-08	1E-06	**2E-06**
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.1786	0.0491	3E-06	4E-06	8E-07	5E-07	2E-07	3E-06	6E-08	3E-08	9E-07	**2E-06**
SBS Child Care	Child care	0.0587	0.0853	5E-06	6E-06	1E-06	2E-07	3E-07	5E-06	1E-07	5E-08	2E-06	**3E-06**
Butterflies Early Learning Childcare Centre	Child care	-0.1835	0.0978	6E-06	7E-06	2E-06	-5E-07	4E-07	5E-06	1E-07	6E-08	2E-06	**3E-06**
Artarmon Public School	Primary School	0.0458	0.0315	2E-06	2E-06	5E-07	1E-07	1E-07	2E-06	4E-08	2E-08	6E-07	**1E-06**
Sue's Childcare, Castlevale	Child care	0.0578	-0.0924	-6E-06	-7E-06	-2E-06	1E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06	**-3E-06**
Northside Baptist Preschool	Preschool	-0.0760	-0.1636	-1E-05	-1E-05	-3E-06	-2E-07	-7E-07	-9E-06	-2E-07	-1E-07	-3E-06	**-6E-06**
Willoughby Public School	Primary School	-0.0506	-0.0413	-2E-06	-3E-06	-7E-07	-1E-07	-2E-07	-2E-06	-5E-08	-3E-08	-7E-07	**-1E-06**
Peek A Boo Cottage	Child care	-1.3013	-0.8640	-5E-05	-6E-05	-1E-05	-3E-06	-3E-06	-5E-05	-1E-06	-5E-07	-2E-05	**-3E-05**
St Cecilia's Catholic Primary School	Primary School	-0.0038	-0.0027	-2E-07	-2E-07	-4E-08	-1E-08	-1E-08	-1E-07	-3E-09	-2E-09	-5E-08	**-9E-08**
Seaforth Public School	Primary School	0.1604	-0.0693	-4E-06	-5E-06	-1E-06	4E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Punchinello Kindergarten	Preschool	0.2927	0.1282	8E-06	9E-06	2E-06	8E-07	5E-07	7E-06	2E-07	8E-08	2E-06	**4E-06**
Harbour View Childrens Centre	Child care	-0.0889	-0.0314	-2E-06	-2E-06	-5E-07	-2E-07	-1E-07	-2E-06	-4E-08	-2E-08	-6E-07	**-1E-06**
Jacaranda Creative Play Centre	Child care	-0.0140	-0.0154	-9E-07	-1E-06	-3E-07	-4E-08	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	**-5E-07**
St James Medical And Cosmetics Centre	Medical Centre	0.0631	0.0828	5E-06	6E-06	1E-06	2E-07	3E-07	4E-06	1E-07	5E-08	1E-06	**3E-06**
Ku Bligh Park Preschool	Preschool	-0.0121	0.0118	7E-07	9E-07	2E-07	-3E-08	5E-08	6E-07	2E-08	7E-09	2E-07	**4E-07**
Balgowlah North Public School	Primary School	0.0091	0.0128	8E-07	9E-07	2E-07	2E-08	5E-08	7E-07	2E-08	8E-09	2E-07	**4E-07**
Hardi Aged Care Manly Vale	Aged care	0.1077	0.0912	5E-06	7E-06	1E-06	3E-07	4E-07	5E-06	1E-07	6E-08	2E-06	**3E-06**
Willoughby Retirement Village	Aged care	-0.1418	-0.0202	-1E-06	-1E-06	-3E-07	-4E-07	-8E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-7E-07**
Roseville Public School	Primary school	-0.0476	-0.0249	-1E-06	-2E-06	-4E-07	-1E-07	-1E-07	-1E-06	-3E-08	-2E-08	-4E-07	**-8E-07**
UnitingCare Forestville Preschool	Childcare	-0.1324	-0.0156	-9E-07	-1E-06	-3E-07	-3E-07	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	**-5E-07**
Beehive Kindy	Childcare	-0.1046	-0.0709	-4E-06	-5E-06	-1E-06	-3E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Northern Beaches Hospital	Hospital	0.0125	-0.0055	-3E-07	-4E-07	-9E-08	3E-08	-2E-08	-3E-07	-7E-09	-3E-09	-1E-07	**-2E-07**

Quantification of Effects - $PM_{2.5}$ and PM_{10}
Beaches Link: 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
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 PM10 Concentration (μg/m^3)**	**Change in Annual Average PM2.5 Concentration (μg/m^3)**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**
Impacts from project (ventilation outlets and roads)													
Grid receptors: maximum regardless of land use		**1.20**	**0.71**	**4E-05**	**5E-05**	**1E-05**	**3E-06**	**3E-06**	**4E-05**	**9E-07**	**4E-07**	**1E-05**	**2E-05**
Grid receptors: maximum residential		**1.20**	**0.71**	**4E-05**	**5E-05**	**1E-05**	**3E-06**	**3E-06**	**4E-05**	**9E-07**	**4E-07**	**1E-05**	**2E-05**
Grid receptors: maximum childcare		**0.26**	**0.24**	**1E-05**	**2E-05**	**4E-06**	**7E-07**	**1E-06**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**8E-06**
Grid receptors: maximum school		**0.34**	**0.24**	**1E-05**	**2E-05**	**4E-06**	**9E-07**	**1E-06**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**8E-06**
Grid receptors: maximum aged care		**0.25**	**0.20**	**1E-05**	**1E-05**	**3E-06**	**6E-07**	**8E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: maximum hospital and medical		**0.35**	**0.21**	**1E-05**	**2E-05**	**3E-06**	**9E-07**	**8E-07**	**1E-05**	**3E-07**	**1E-07**	**4E-06**	**7E-06**
Grid receptors: commercial/industrial		**0.77**	**0.47**	**3E-05**	**3E-05**	**8E-06**	**2E-06**	**2E-06**	**3E-05**	**6E-07**	**3E-07**	**8E-06**	**2E-05**
Grid receptors: open space		**0.89**	**0.62**	**4E-05**	**5E-05**	**1E-05**	**2E-06**	**2E-06**	**3E-05**	**8E-07**	**4E-07**	**1E-05**	**2E-05**
Community Receptors													
University of Notre Dame, Broadway	University	-0.1760	-0.0784	-5E-06	-6E-06	-1E-06	-5E-07	-3E-07	-4E-06	-1E-07	-5E-08	-1E-06	**-3E-06**
Laverty Pathology, Annandale	Medical centre	0.1332	-0.2206	-1E-05	-2E-05	-4E-06	3E-07	-9E-07	-1E-05	-3E-07	-1E-07	-4E-06	**-8E-06**
St Basil's, Annandale	Aged care	0.4896	0.2954	2E-05	2E-05	5E-06	1E-06	1E-06	2E-05	4E-07	2E-07	5E-06	**1E-05**
The Jimmy Little Community Centre	Community centre	-0.0441	-0.1368	-8E-06	-1E-05	-2E-06	-1E-07	-6E-07	-7E-06	-2E-07	-8E-08	-2E-06	**-5E-06**
Rozelle Public School	Primary School	0.0482	-0.0582	-3E-06	-4E-06	-9E-07	1E-07	-2E-07	-3E-06	-7E-08	-4E-08	-1E-06	**-2E-06**
St Aloysius College	High School	-0.4702	-0.3720	-2E-05	-3E-05	-6E-06	-1E-06	-1E-06	-2E-05	-5E-07	-2E-07	-7E-06	**-1E-05**
Dancing Dingo Family Day Care	Child care	-0.0883	-0.0375	-2E-06	-3E-06	-6E-07	-2E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Wenona School	Primary School	-0.0567	-0.1227	-7E-06	-9E-06	-2E-06	-1E-07	-5E-07	-7E-06	-2E-07	-7E-08	-2E-06	**-4E-06**
Mater Hospital	Hospital	0.1206	-0.0013	-8E-08	-1E-07	-2E-08	3E-07	-5E-09	-7E-08	-2E-09	-8E-10	-2E-08	**-4E-08**
Neutral Bay Public School	Primary School	-0.0454	-0.1003	-6E-06	-7E-06	-2E-06	-1E-07	-4E-07	-5E-06	-1E-07	-6E-08	-2E-06	**-3E-06**
Neutral Bay Medical Centre	Medical Centre	-0.3685	-0.2648	-2E-05	-2E-05	-4E-06	-9E-07	-1E-06	-1E-05	-3E-07	-2E-07	-5E-06	**-9E-06**
Puddleducks Child Care Centre	Childcare	-0.2608	-0.0580	-3E-06	-4E-06	-9E-07	-7E-07	-2E-07	-3E-06	-7E-08	-4E-08	-1E-06	**-2E-06**
Mosman Public School	Primary School	-0.1351	-0.0607	-4E-06	-4E-06	-1E-06	-3E-07	-2E-07	-3E-06	-8E-08	-4E-08	-1E-06	**-2E-06**
Garrison & Killarney Retirement Centre	Aged care	-0.7929	-0.4543	-3E-05	-3E-05	-7E-06	-2E-06	-2E-06	-2E-05	-6E-07	-3E-07	-8E-06	**-2E-05**
Beauty Point Public School	Primary School	-0.1582	-0.0294	-2E-06	-2E-06	-5E-07	-4E-07	-1E-07	-2E-06	-4E-08	-2E-08	-5E-07	**-1E-06**
Anzac Park Public School	Primary School	0.3225	0.0450	3E-06	3E-06	7E-07	8E-07	2E-07	2E-06	6E-08	3E-08	8E-07	**2E-06**
Ku Cammeray Preschool	Preschool	-0.0793	-0.0056	-3E-07	-4E-07	-9E-08	-2E-07	-2E-08	-3E-07	-7E-09	-3E-09	-1E-07	**-2E-07**
Cammeray Public School	Primary School	-0.0152	0.0539	3E-06	4E-06	9E-07	-4E-08	2E-07	3E-06	7E-08	3E-08	1E-06	**2E-06**
Atchison Preschool	Preschool	-0.1172	-0.0379	-2E-06	-3E-06	-6E-07	-3E-07	-2E-07	-2E-06	-5E-08	-2E-08	-7E-07	**-1E-06**
Berry Cottage Childcare	Child care	0.1899	0.0536	3E-06	4E-06	9E-07	5E-07	2E-07	3E-06	7E-08	3E-08	1E-06	**2E-06**
Explore & Develop Artarmon - Early Learning Centre	Preschool	0.0939	0.0098	6E-07	7E-07	2E-07	2E-07	4E-08	5E-07	1E-08	6E-09	2E-07	**3E-07**
SBS Child Care	Child care	0.1581	0.0702	4E-06	5E-06	1E-06	4E-07	3E-07	4E-06	9E-08	4E-08	1E-06	**2E-06**
Butterflies Early Learning Childcare Centre	Child care	-0.2149	0.0238	1E-06	2E-06	4E-07	-6E-07	1E-07	1E-06	3E-08	1E-08	4E-07	**8E-07**
Artarmon Public School	Primary School	0.1166	-0.0150	-9E-07	-1E-06	-2E-07	3E-07	-6E-08	-8E-07	-2E-08	-9E-09	-3E-07	**-5E-07**
Sue's Childcare, Castlevale	Child care	0.0082	-0.0024	-1E-07	-2E-07	-4E-08	2E-08	-1E-08	-1E-07	-3E-09	-1E-09	-4E-08	**-8E-08**
Northside Baptist Preschool	Preschool	-0.0677	-0.0873	-5E-06	-6E-06	-1E-06	-2E-07	-4E-07	-5E-06	-1E-07	-5E-08	-2E-06	**-3E-06**
Willoughby Public School	Primary School	-0.0600	-0.0106	-6E-07	-8E-07	-2E-07	-2E-07	-4E-08	-6E-07	-1E-08	-6E-09	-2E-07	**-4E-07**
Peek A Boo Cottage	Child care	-1.2706	-1.0916	-6E-05	-8E-05	-2E-05	-3E-06	-4E-06	-6E-05	-1E-06	-7E-07	-2E-05	**-4E-05**
St Cecilia's Catholic Primary School	Primary School	-0.0082	0.0505	3E-06	4E-06	8E-07	-2E-08	2E-07	3E-06	6E-08	3E-08	9E-07	**2E-06**
Seaforth Public School	Primary School	0.0710	-0.0667	-4E-06	-5E-06	-1E-06	2E-07	-3E-07	-4E-06	-9E-08	-4E-08	-1E-06	**-2E-06**
Punchinello Kindergarten	Preschool	0.1980	0.0893	5E-06	7E-06	1E-06	5E-07	4E-07	5E-06	1E-07	5E-08	2E-06	**3E-06**
Harbour View Childrens Centre	Child care	-0.0286	-0.0203	-1E-06	-2E-06	-3E-07	-7E-08	-8E-08	-1E-06	-3E-08	-1E-08	-4E-07	**-7E-07**
Jacaranda Creative Play Centre	Child care	-0.0352	-0.0238	-1E-06	-2E-06	-4E-07	-9E-08	-1E-07	-1E-06	-3E-08	-1E-08	-4E-07	**-8E-07**
St James Medical And Cosmetics Centre	Medical Centre	0.1138	0.0736	4E-06	5E-06	1E-06	3E-07	3E-07	4E-06	9E-08	4E-08	1E-06	**3E-06**
Ku Bligh Park Preschool	Preschool	-0.0106	0.0061	4E-07	5E-07	1E-07	-3E-08	2E-08	3E-07	8E-09	4E-09	1E-07	**2E-07**
Balgowlah North Public School	Primary School	0.0221	0.0035	2E-07	3E-07	6E-08	6E-08	1E-08	2E-07	5E-09	2E-09	6E-08	**1E-07**
Hardi Aged Care Manly Vale	Aged care	-0.1060	0.0434	3E-06	3E-06	7E-07	-3E-07	2E-07	2E-06	6E-08	3E-08	8E-07	**1E-06**
Willoughby Retirement Village	Aged care	-0.1135	-0.0506	-3E-06	-4E-06	-8E-07	-3E-07	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07	**-2E-06**
Roseville Public School	Primary school	-0.0828	-0.0442	-3E-06	-3E-06	-7E-07	-2E-07	-2E-07	-2E-06	-6E-08	-3E-08	-8E-07	**-2E-06**
UnitingCare Forestville Preschool	Childcare	-0.1469	-0.0423	-3E-06	-3E-06	-7E-07	-4E-07	-2E-07	-2E-06	-5E-08	-3E-08	-8E-07	**-1E-06**
Beehive Kindy	Childcare	-0.1312	-0.0500	-3E-06	-4E-06	-8E-07	-3E-07	-2E-07	-3E-06	-6E-08	-3E-08	-9E-07	**-2E-06**
Northern Beaches Hospital	Hospital	0.0753	-0.0061	-4E-07	-5E-07	-1E-07	2E-07	-2E-08	-3E-07	-8E-09	-4E-09	-1E-07	**-2E-07**

Annexure G – Population incidence calculations: Particulate matter

Assessment of Increased Incidence - $PM_{2.5}$
Beaches Link: 2027

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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
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	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Population weighted Δx (µg/m^3):	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961
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:	1.000031	1.000004	1.000002	1.000005	1.000070	1.000005	1.000010	1.000008
Attributable fraction (AF):	3.1E-05	4.3E-06	2.2E-06	5.1E-06	7.0E-05	5.2E-06	1.0E-05	8.0E-06
Increased number of cases in population:	0.00047	0.00014	0.000030	0.000048	0.00042	0.000014	0.000012	0.000033
Risk:	3.2E-07	4.0E-07	8.8E-08	2.0E-08	2.9E-07	5.9E-09	5.0E-09	9.6E-08
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	12.56	12.56	12.56	12.56	12.56	12.56	12.56	12.56
Population weighted Δx (µg/m^3):	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961	0.00537961
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:	1.000031	1.000004	1.000002	1.000005	1.000070	1.000005	1.000010	1.000008
Attributable fraction (AF):	3.1E-05	4.3E-06	2.2E-06	5.1E-06	7.0E-05	5.2E-06	1.0E-05	8.0E-06
Increased number of cases in population:	0.0005	0.00014	0.000030	0.00005	0.0004	0.000014	0.000012	0.00003
Risk:	3.2E-07	4.0E-07	8.8E-08	2.0E-08	2.9E-07	5.9E-09	5.0E-09	9.6E-08
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	-5560.2	-5560.2	-5560.2	-5560.2	-5560.2	-5560.2	-5560.2	-5560.2
Population weighted Δx (µg/m^3):	-0.05905725	-0.05905725	-0.05905725	-0.05905725	-0.05905725	-0.05905725	-0.05905725	-0.05905725
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:	0.999658	0.999953	0.999976	0.999944	0.999233	0.999943	0.999888	0.999913
Attributable fraction (AF):	-3.4E-04	-4.7E-05	-2.4E-05	-5.6E-05	-7.7E-04	-5.7E-05	-1.1E-04	-8.7E-05
Increased number of cases in population:	-0.22	-0.078	-0.017	-0.018	-0.20	-0.0053	-0.0052	-0.017
Risk:	-3.5E-06	-4.4E-06	-9.6E-07	-1.9E-07	-3.2E-06	-5.7E-08	-5.5E-08	-1.1E-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	-1333.7	-1333.7	-1333.7	-1333.7	-1333.7	-1333.7	-1333.7	-1333.7
Population weighted Δx (µg/m^3):	-0.07002804	-0.07002804	-0.07002804	-0.07002804	-0.07002804	-0.07002804	-0.07002804	-0.07002804
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:	0.999594	0.999944	0.999971	0.999934	0.999090	0.999932	0.999867	0.999896
Attributable fraction (AF):	-4.1E-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:	-0.05326	-0.01882	-0.00415	-0.00420	-0.04795	-0.00128	-0.00125	-0.00396
Risk:	-4.2E-06	-5.2E-06	-1.1E-06	-2.2E-07	-3.8E-06	-6.7E-08	-6.6E-08	-1.3E-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	-150.97	-150.97	-150.97	-150.97	-150.97	-150.97	-150.97	-150.97
Population weighted Δx (µg/m^3):	-0.00835779	-0.00835779	-0.00835779	-0.00835779	-0.00835779	-0.00835779	-0.00835779	-0.00835779
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:	0.999952	0.999993	0.999997	0.999992	0.999891	0.999992	0.999984	0.999988
Attributable fraction (AF):	-4.8E-05	-6.7E-06	-3.4E-06	-7.9E-06	-1.1E-04	-8.1E-06	-1.6E-05	-1.2E-05
Increased number of cases in population:	-0.0061	-0.0016	-0.0004	-0.0005	-0.0055	-0.0001	-0.0001	-0.0003
Risk:	-5.0E-07	-6.2E-07	-1.4E-07	-2.6E-08	-4.5E-07	-8.0E-09	-7.8E-09	-1.5E-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	-2154.8	-2154.8	-2154.8	-2154.8	-2154.8	-2154.8	-2154.8	-2154.8
Population weighted Δx (µg/m^3):	-0.07570737	-0.07570737	-0.07570737	-0.07570737	-0.07570737	-0.07570737	-0.07570737	-0.07570737
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:	0.999561	0.999939	0.999969	0.999929	0.999016	0.999927	0.999856	0.999888
Attributable fraction (AF):	-4.4E-04	-6.1E-05	-3.1E-05	-7.1E-05	-9.8E-04	-7.3E-05	-1.4E-04	-1.1E-04
Increased number of cases in population:	-0.0861	-0.0304	-0.0067	-0.0068	-0.0775	-0.0021	-0.0020	-0.0064
Risk:	-4.5E-06	-5.6E-06	-1.2E-06	-2.4E-07	-4.1E-06	-7.2E-08	-7.1E-08	-1.4E-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	-1698.3	-1698.3	-1698.3	-1698.3	-1698.3	-1698.3	-1698.3	-1698.3
Population weighted Δx (µg/m^3):	-0.09488433	-0.09488433	-0.09488433	-0.09488433	-0.09488433	-0.09488433	-0.09488433	-0.09488433
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:	0.999450	0.999924	0.999961	0.999911	0.998767	0.999908	0.999820	0.999860
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:	-0.0691	-0.0181	-0.0040	-0.0053	-0.0623	-0.0016	-0.0016	-0.0034
Risk:	-5.6E-06	-7.0E-06	-1.5E-06	-3.0E-07	-5.1E-06	-9.1E-08	-8.9E-08	-1.7E-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	-222.41	-222.41	-222.41	-222.41	-222.41	-222.41	-222.41	-222.41
Population weighted Δx (µg/m^3):	-0.02082513	-0.02082513	-0.02082513	-0.02082513	-0.02082513	-0.02082513	-0.02082513	-0.02082513
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999879	0.999983	0.999991	0.999980	0.999729	0.999980	0.999960	0.999969
Attributable fraction (AF):	-1.2E-04	-1.7E-05	-8.5E-06	-2.0E-05	-2.7E-04	-2.0E-05	-4.0E-05	-3.1E-05
Increased number of cases in population:	-0.009054	-0.002366	-0.000522	-0.000700	-0.008149	-0.000213	-0.000209	-0.000446
Risk:	-1.2E-06	-1.5E-06	-3.4E-07	-6.6E-08	-1.1E-06	-2.0E-08	-2.0E-08	-3.7E-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	101.80	101.80	101.80	101.80	101.80	101.80	101.80	101.80
Population weighted Δx (µg/m^3):	0.00210757	0.00210757	0.00210757	0.00210757	0.00210757	0.00210757	0.00210757	0.00210757
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:	1.000012	1.000002	1.000001	1.000002	1.000027	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.2E-05	1.7E-06	8.6E-07	2.0E-06	2.7E-05	2.0E-06	4.0E-06	3.1E-06
Increased number of cases in population:	0.0039	0.00092	0.00020	0.00051	0.0035	0.00014	0.00010	0.00026
Risk:	1.3E-07	1.6E-07	3.4E-08	1.1E-08	1.1E-07	3.0E-09	2.0E-09	3.8E-08
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	106.39	106.39	106.39	106.39	106.39	106.39	106.39	106.39
Population weighted Δx (µg/m^3):	0.00677915	0.00677915	0.00677915	0.00677915	0.00677915	0.00677915	0.00677915	0.00677915
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:	1.000039	1.000005	1.000003	1.000006	1.000088	1.000007	1.000013	1.000010
Attributable fraction (AF):	3.9E-05	5.4E-06	2.8E-06	6.4E-06	8.8E-05	6.6E-06	1.3E-05	1.0E-05
Increased number of cases in population:	0.0040	0.00096	0.000212	0.00053	0.0036	0.000151	0.000100	0.000268
Risk:	4.0E-07	5.0E-07	1.1E-07	3.4E-08	3.6E-07	9.6E-09	6.4E-09	1.2E-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	11.532	11.532	11.532	11.532	11.532	11.532	11.532	11.532
Population weighted Δx (µg/m^3):	0.00065741	0.00065741	0.00065741	0.00065741	0.00065741	0.00065741	0.00065741	0.00065741
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:	1.000004	1.000001	1.000000	1.000001	1.000009	1.000001	1.000001	1.000001
Attributable fraction (AF):	3.8E-06	5.3E-07	2.7E-07	6.2E-07	8.5E-06	6.4E-07	1.2E-06	9.7E-07
Increased number of cases in population:	0.00044	0.00010	0.000023	0.000058	0.00039	0.000016	0.0000108	0.000029
Risk:	3.9E-08	4.9E-08	1.1E-08	3.3E-09	3.5E-08	9.3E-10	6.2E-10	1.2E-08
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	-16.115	-16.115	-16.115	-16.115	-16.115	-16.115	-16.115	-16.115
Population weighted Δx (µg/m^3):	-0.00128414	-0.00128414	-0.00128414	-0.00128414	-0.00128414	-0.00128414	-0.00128414	-0.00128414
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:	0.999993	0.999999	0.999999	0.999999	0.999983	0.999999	0.999998	0.999998
Attributable fraction (AF):	-7.4E-06	-1.0E-06	-5.3E-07	-1.2E-06	-1.7E-05	-1.2E-06	-2.4E-06	-1.9E-06
Increased number of cases in population:	-0.00061	-0.00015	-0.000032	-0.000081	-0.00055	-0.000023	-0.000015	-0.000041
Risk:	-7.6E-08	-9.5E-08	-2.1E-08	-6.4E-09	-6.9E-08	-1.8E-09	-1.2E-09	-2.3E-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	18.700	18.700	18.700	18.700	18.700	18.700	18.700	18.700
Population weighted Δx (µg/m^3):	0.00742067	0.00742067	0.00742067	0.00742067	0.00742067	0.00742067	0.00742067	0.00742067
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:	1.000043	1.000006	1.000003	1.000007	1.000096	1.000007	1.000014	1.000011
Attributable fraction (AF):	4.3E-05	5.9E-06	3.0E-06	7.0E-06	9.6E-05	7.2E-06	1.4E-05	1.1E-05
Increased number of cases in population:	0.000710	0.000169	0.000037	0.000094	0.000639	0.000027	0.000018	0.000047
Risk:	4.4E-07	5.5E-07	1.2E-07	3.7E-08	4.0E-07	1.1E-08	7.0E-09	1.3E-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	-13219	-13219	-13219	-13219	-13219	-13219	-13219	-13219
Population weighted Δx (µg/m^3):	-0.10019563	-0.10019563	-0.10019563	-0.10019563	-0.10019563	-0.10019563	-0.10019563	-0.10019563
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:	0.999419	0.999920	0.999959	0.999906	0.998698	0.999903	0.999810	0.999852
Attributable fraction (AF):	-5.8E-04	-8.0E-05	-4.1E-05	-9.4E-05	-1.3E-03	-9.7E-05	-1.9E-04	-1.5E-04
Increased number of cases in population:	-0.45	-0.080	-0.018	-0.063	-0.41	-0.018	-0.012	-0.014
Risk:	-6.0E-06	-7.4E-06	-1.6E-06	-4.8E-07	-5.4E-06	-1.3E-07	-9.4E-08	-1.8E-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	-1132.5	-1132.5	-1132.5	-1132.5	-1132.5	-1132.5	-1132.5	-1132.5
Population weighted Δx (µg/m^3):	-0.09974852	-0.09974852	-0.09974852	-0.09974852	-0.09974852	-0.09974852	-0.09974852	-0.09974852
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:	0.999422	0.999920	0.999959	0.999906	0.998704	0.999903	0.999810	0.999852
Attributable fraction (AF):	-5.8E-04	-8.0E-05	-4.1E-05	-9.4E-05	-1.3E-03	-9.7E-05	-1.9E-04	-1.5E-04
Increased number of cases in population:	-0.039	-0.0069	-0.00151	-0.0054	-0.035	-0.00153	-0.00106	-0.00120
Risk:	-5.9E-06	-7.4E-06	-1.6E-06	-4.8E-07	-5.3E-06	-1.3E-07	-9.4E-08	-1.8E-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	-150.90	-150.90	-150.90	-150.90	-150.90	-150.90	-150.90	-150.90
Population weighted Δx (µg/m^3):	-0.00770168	-0.00770168	-0.00770168	-0.00770168	-0.00770168	-0.00770168	-0.00770168	-0.00770168
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999955	0.999994	0.999997	0.999993	0.999900	0.999993	0.999985	0.999989
Attributable fraction (AF):	-4.5E-05	-6.2E-06	-3.2E-06	-7.2E-06	-1.0E-04	-7.5E-06	-1.5E-05	-1.1E-05
Increased number of cases in population:	-0.005	-0.0009	-0.00020	-0.0007	-0.005	-0.00020	-0.00014	-0.00016
Risk:	-4.6E-07	-5.7E-07	-1.3E-07	-3.7E-08	-4.1E-07	-1.0E-08	-7.2E-09	-1.4E-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	-218.49	-218.49	-218.49	-218.49	-218.49	-218.49	-218.49	-218.49
Population weighted Δx (μg/m^3):	-0.04239225	-0.04239225	-0.04239225	-0.04239225	-0.04239225	-0.04239225	-0.04239225	-0.04239225
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:	0.999754	0.999966	0.999983	0.999960	0.999449	0.999959	0.999919	0.999937
Attributable fraction (AF):	-2.5E-04	-3.4E-05	-1.7E-05	-4.0E-05	-5.5E-04	-4.1E-05	-8.1E-05	-6.3E-05
Increased number of cases in population:	-0.007	-0.0013	-0.0003	-0.0010	-0.007	-0.0003	-0.00021	-0.00023
Risk:	-2.5E-06	-3.1E-06	-6.9E-07	-2.0E-07	-2.3E-06	-5.7E-08	-4.0E-08	-7.6E-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	-9465.3	-9465.3	-9465.3	-9465.3	-9465.3	-9465.3	-9465.3	-9465.3
Population weighted Δx (μg/m^3):	-0.44647513	-0.44647513	-0.44647513	-0.44647513	-0.44647513	-0.44647513	-0.44647513	-0.44647513
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:	0.997414	0.999643	0.999817	0.999580	0.994213	0.999567	0.999152	0.999339
Attributable fraction (AF):	-2.6E-03	-3.6E-04	-1.8E-04	-4.2E-04	-5.8E-03	-4.3E-04	-8.5E-04	-6.6E-04
Increased number of cases in population:	-0.325	-0.057	-0.0127	-0.045	-0.293	-0.0128	-0.0089	-0.0100
Risk:	-2.7E-05	-3.3E-05	-7.3E-06	-2.1E-06	-2.4E-05	-6.0E-07	-4.2E-07	-8.0E-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	89.025	89.025	89.025	89.025	89.025	89.025	89.025	89.025
Population weighted Δx (μg/m^3):	0.00410915	0.00410915	0.00410915	0.00410915	0.00410915	0.00410915	0.00410915	0.00410915
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:	1.000024	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:	0.003	0.0005	0.00012	0.0004	0.003	0.00012	0.00008	0.00009
Risk:	2.4E-07	3.0E-07	6.7E-08	2.0E-08	2.2E-07	5.5E-09	3.9E-09	7.4E-08
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	-156.91	-156.91	-156.91	-156.91	-156.91	-156.91	-156.91	-156.91
Population weighted Δx (μg/m^3):	-0.01591184	-0.01591184	-0.01591184	-0.01591184	-0.01591184	-0.01591184	-0.01591184	-0.01591184
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:	0.999908	0.999987	0.999993	0.999985	0.999793	0.999985	0.999970	0.999976
Attributable fraction (AF):	-9.2E-05	-1.3E-05	-6.5E-06	-1.5E-05	-2.1E-04	-1.5E-05	-3.0E-05	-2.4E-05
Increased number of cases in population:	-0.00538	-0.000951	-0.000210	-0.000749	-0.00484	-0.000211	-0.000147	-0.000166
Risk:	-9.5E-07	-1.2E-06	-2.6E-07	-7.6E-08	-8.5E-07	-2.1E-08	-1.5E-08	-2.8E-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	-1556.1	-1556.1	-1556.1	-1556.1	-1556.1	-1556.1	-1556.1	-1556.1
Population weighted Δx (μg/m^3):	-0.09912095	-0.09912095	-0.09912095	-0.09912095	-0.09912095	-0.09912095	-0.09912095	-0.09912095
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:	0.999425	0.999921	0.999959	0.999907	0.998712	0.999904	0.999812	0.999853
Attributable fraction (AF):	-5.8E-04	-7.9E-05	-4.1E-05	-9.3E-05	-1.3E-03	-9.6E-05	-1.9E-04	-1.5E-04
Increased number of cases in population:	-0.053	-0.0094	-0.00208	-0.0074	-0.048	-0.00210	-0.00146	-0.00164
Risk:	-5.9E-06	-7.3E-06	-1.6E-06	-4.7E-07	-5.3E-06	-1.3E-07	-9.3E-08	-1.8E-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	-627.92	-627.92	-627.92	-627.92	-627.92	-627.92	-627.92	-627.92
Population weighted Δx (μg/m^3):	-0.02291102	-0.02291102	-0.02291102	-0.02291102	-0.02291102	-0.02291102	-0.02291102	-0.02291102
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:	0.999867	0.999982	0.999991	0.999978	0.999702	0.999978	0.999956	0.999966
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:	-0.0215	-0.0038	-0.00084	-0.0030	-0.0194	-0.00085	-0.00059	-0.00066
Risk:	-1.4E-06	-1.7E-06	-3.7E-07	-1.1E-07	-1.2E-06	-3.1E-08	-2.2E-08	-4.1E-07
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	-2402.4	-2402.4	-2402.4	-2402.4	-2402.4	-2402.4	-2402.4	-2402.4
Population weighted Δx (μg/m^3):	-0.02324418	-0.02324418	-0.02324418	-0.02324418	-0.02324418	-0.02324418	-0.02324418	-0.02324418
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	0.999698	0.999977	0.999956	0.999966
Attributable fraction (AF):	-1.3E-04	-1.9E-05	-9.5E-06	-2.2E-05	-3.0E-04	-2.3E-05	-4.4E-05	-3.4E-05
Increased number of cases in population:	-0.089	-0.024	-0.0054	-0.0091	-0.080	-0.0026	-0.0023	-0.0074
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
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	-861.85	-861.85	-861.85	-861.85	-861.85	-861.85	-861.85	-861.85
Population weighted Δx (μg/m^3):	-0.03010197	-0.03010197	-0.03010197	-0.03010197	-0.03010197	-0.03010197	-0.03010197	-0.03010197
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999825	0.999976	0.999988	0.999972	0.999609	0.999971	0.999943	0.999955
Attributable fraction (AF):	-1.7E-04	-2.4E-05	-1.2E-05	-2.8E-05	-3.9E-04	-2.9E-05	-5.7E-05	-4.5E-05
Increased number of cases in population:	-0.0321	-0.0087	-0.0019	-0.0033	-0.0289	-0.0009	-0.00081	-0.0026
Risk:	-1.8E-06	-2.2E-06	-4.9E-07	-1.1E-07	-1.6E-06	-3.3E-08	-2.8E-08	-5.4E-07
Chatswood West - Lane Cove North								
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	-286.20	-286.20	-286.20	-286.20	-286.20	-286.20	-286.20	-286.20
Population weighted Δx (µg/m^3):	-0.01556049	-0.01556049	-0.01556049	-0.01556049	-0.01556049	-0.01556049	-0.01556049	-0.01556049
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:	0.999910	0.999988	0.999994	0.999985	0.999798	0.999985	0.999970	0.999977
Attributable fraction (AF):	-9.0E-05	-1.2E-05	-6.4E-06	-1.5E-05	-2.0E-04	-1.5E-05	-3.0E-05	-2.3E-05
Increased number of cases in population:	-0.0106	-0.0029	-0.00064	-0.0011	-0.0096	-0.00031	-0.00027	-0.0009
Risk:	-9.3E-07	-1.1E-06	-2.5E-07	-5.9E-08	-8.3E-07	-1.7E-08	-1.5E-08	-2.8E-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	-19.764	-19.764	-19.764	-19.764	-19.764	-19.764	-19.764	-19.764
Population weighted Δx (µg/m^3):	-0.00096878	-0.00096878	-0.00096878	-0.00096878	-0.00096878	-0.00096878	-0.00096878	-0.00096878
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:	0.999994	0.999999	1.000000	0.999999	0.999987	0.999999	0.999998	0.999999
Attributable fraction (AF):	-5.6E-06	-7.8E-07	-4.0E-07	-9.1E-07	-1.3E-05	-9.4E-07	-1.8E-06	-1.4E-06
Increased number of cases in population:	-0.0007	-0.0002	-0.000044	-0.000075	-0.0007	-0.00002	-0.00002	-0.0001
Risk:	-5.8E-08	-7.2E-08	-1.6E-08	-3.7E-09	-5.2E-08	-1.1E-09	-9.1E-10	-1.7E-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	-445.57	-445.57	-445.57	-445.57	-445.57	-445.57	-445.57	-445.57
Population weighted Δx (µg/m^3):	-0.04252477	-0.04252477	-0.04252477	-0.04252477	-0.04252477	-0.04252477	-0.04252477	-0.04252477
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:	0.999753	0.999966	0.999983	0.999960	0.999447	0.999959	0.999919	0.999937
Attributable fraction (AF):	-2.5E-04	-3.4E-05	-1.7E-05	-4.0E-05	-5.5E-04	-4.1E-05	-8.1E-05	-6.3E-05
Increased number of cases in population:	-0.0166	-0.0045	-0.00100	-0.00168	-0.0149	-0.00049	-0.00042	-0.00136
Risk:	-2.5E-06	-3.1E-06	-6.9E-07	-1.6E-07	-2.3E-06	-4.7E-08	-4.0E-08	-7.6E-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	-789.01	-789.01	-789.01	-789.01	-789.01	-789.01	-789.01	-789.01
Population weighted Δx (µg/m^3):	-0.03099990	-0.03099990	-0.03099990	-0.03099990	-0.03099990	-0.03099990	-0.03099990	-0.03099990
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:	0.999820	0.999975	0.999987	0.999971	0.999597	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:	-0.0293	-0.0080	-0.0018	-0.0030	-0.0264	-0.0009	-0.0007	-0.0024
Risk:	-1.8E-06	-2.3E-06	-5.1E-07	-1.2E-07	-1.7E-06	-3.4E-08	-2.9E-08	-5.5E-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	16.648	16.648	16.648	16.648	16.648	16.648	16.648	16.648
Population weighted Δx (µg/m^3):	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295
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:	1.000043	1.000006	1.000003	1.000007	1.000096	1.000007	1.000014	1.000011
Attributable fraction (AF):	4.3E-05	5.9E-06	3.0E-06	6.9E-06	9.6E-05	7.2E-06	1.4E-05	1.1E-05
Increased number of cases in population:	0.00064	0.00027	0.000059	0.000079	0.00057	0.000022	0.000016	0.000054
Risk:	4.4E-07	5.4E-07	1.2E-07	3.5E-08	3.9E-07	9.6E-09	6.9E-09	1.3E-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	16.648	16.648	16.648	16.648	16.648	16.648	16.648	16.648
Population weighted Δx (µg/m^3):	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295	0.00737295
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:	1.000043	1.000006	1.000003	1.000007	1.000096	1.000007	1.000014	1.000011
Attributable fraction (AF):	4.3E-05	5.9E-06	3.0E-06	6.9E-06	9.6E-05	7.2E-06	1.4E-05	1.1E-05
Increased number of cases in population:	0.00064	0.00027	0.00006	0.00008	0.00057	0.00002	0.00002	0.00005
Risk:	4.4E-07	5.4E-07	1.2E-07	3.5E-08	3.9E-07	9.6E-09	6.9E-09	1.3E-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	-1029.9	-1029.9	-1029.9	-1029.9	-1029.9	-1029.9	-1029.9	-1029.9
Population weighted Δx (µg/m^3):	-0.01433616	-0.01433616	-0.01433616	-0.01433616	-0.01433616	-0.01433616	-0.01433616	-0.01433616
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:	0.999917	0.999989	0.999994	0.999987	0.999814	0.999986	0.999973	0.999979
Attributable fraction (AF):	-8.3E-05	-1.1E-05	-5.9E-06	-1.3E-05	-1.9E-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	-0.00097	-0.0027
Risk:	-8.5E-07	-1.1E-06	-2.3E-07	-5.3E-08	-7.7E-07	-1.5E-08	-1.3E-08	-2.6E-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	4.0511	4.0511	4.0511	4.0511	4.0511	4.0511	4.0511	4.0511
Population weighted Δx (µg/m^3):	0.00185489	0.00185489	0.00185489	0.00185489	0.00185489	0.00185489	0.00185489	0.00185489
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000011	1.000001	1.000001	1.000002	1.000024	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.1E-05	1.5E-06	7.6E-07	1.7E-06	2.4E-05	1.8E-06	3.5E-06	2.7E-06
Increased number of cases in population:	0.0002	0.00006	0.000012	0.00002	0.00014	0.000004	0.000004	0.000011
Risk:	1.1E-07	1.4E-07	3.0E-08	6.9E-09	9.9E-08	2.0E-09	1.7E-09	3.3E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-116.10	-116.10	-116.10	-116.10	-116.10	-116.10	-116.10	-116.10
Population weighted Δx (µg/m^3):	-0.00982308	-0.00982308	-0.00982308	-0.00982308	-0.00982308	-0.00982308	-0.00982308	-0.00982308
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:	0.999943	0.999992	0.999996	0.999991	0.999872	0.999990	0.999981	0.999985
Attributable fraction (AF):	-5.7E-05	-7.9E-06	-4.0E-06	-9.2E-06	-1.3E-04	-9.5E-06	-1.9E-05	-1.5E-05
Increased number of cases in population:	-0.0045	-0.0016	-0.00035	-0.00043	-0.0041	-0.000124	-0.000109	-0.00030
Risk:	-5.8E-07	-7.3E-07	-1.6E-07	-3.7E-08	-5.3E-07	-1.1E-08	-9.2E-09	-1.8E-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	-26.489	-26.489	-26.489	-26.489	-26.489	-26.489	-26.489	-26.489
Population weighted Δx (µg/m^3):	-0.01391969	-0.01391969	-0.01391969	-0.01391969	-0.01391969	-0.01391969	-0.01391969	-0.01391969
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	0.999819	0.999986	0.999974	0.999979
Attributable fraction (AF):	-8.1E-05	-1.1E-05	-5.7E-06	-1.3E-05	-1.8E-04	-1.4E-05	-2.6E-05	-2.1E-05
Increased number of cases in population:	-0.001034	-0.000364	-0.000080	-0.000099	-0.000931	-0.000028	-0.000025	-0.000069
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
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	-173.30	-173.30	-173.30	-173.30	-173.30	-173.30	-173.30	-173.30
Population weighted Δx (µg/m^3):	-0.00698843	-0.00698843	-0.00698843	-0.00698843	-0.00698843	-0.00698843	-0.00698843	-0.00698843
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	0.999909	0.999993	0.999987	0.999990
Attributable fraction (AF):	-4.1E-05	-5.6E-06	-2.9E-06	-6.6E-06	-9.1E-05	-6.8E-06	-1.3E-05	-1.0E-05
Increased number of cases in population:	-0.0068	-0.00238	-0.00053	-0.00065	-0.0061	-0.000186	-0.000163	-0.000450
Risk:	-4.2E-07	-5.2E-07	-1.1E-07	-2.6E-08	-3.7E-07	-7.5E-09	-6.6E-09	-1.3E-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	-28.871	-28.871	-28.871	-28.871	-28.871	-28.871	-28.871	-28.871
Population weighted Δx (µg/m^3):	-0.00908170	-0.00908170	-0.00908170	-0.00908170	-0.00908170	-0.00908170	-0.00908170	-0.00908170
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:	0.999947	0.999993	0.999996	0.999991	0.999882	0.999991	0.999983	0.999987
Attributable fraction (AF):	-5.3E-05	-7.3E-06	-3.7E-06	-8.5E-06	-1.2E-04	-8.8E-06	-1.7E-05	-1.3E-05
Increased number of cases in population:	-0.0011	-0.00040	-0.00009	-0.00011	-0.0010	-0.000031	-0.000027	-0.00007
Risk:	-5.4E-07	-6.7E-07	-1.5E-07	-3.4E-08	-4.9E-07	-9.7E-09	-8.5E-09	-1.6E-07
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	-528.25	-528.25	-528.25	-528.25	-528.25	-528.25	-528.25	-528.25
Population weighted Δx (µg/m^3):	-0.03968531	-0.03968531	-0.03968531	-0.03968531	-0.03968531	-0.03968531	-0.03968531	-0.03968531
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:	0.999770	0.999968	0.999984	0.999963	0.999484	0.999962	0.999925	0.999941
Attributable fraction (AF):	-2.3E-04	-3.2E-05	-1.6E-05	-3.7E-05	-5.2E-04	-3.8E-05	-7.5E-05	-5.9E-05
Increased number of cases in population:	-0.02062	-0.00726	-0.001603	-0.001966	-0.01857	-0.000566	-0.000496	-0.001371
Risk:	-2.4E-06	-2.9E-06	-6.5E-07	-1.5E-07	-2.1E-06	-4.3E-08	-3.7E-08	-7.1E-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	-47.408	-47.408	-47.408	-47.408	-47.408	-47.408	-47.408	-47.408
Population weighted Δx (µg/m^3):	-0.00678814	-0.00678814	-0.00678814	-0.00678814	-0.00678814	-0.00678814	-0.00678814	-0.00678814
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:	0.999961	0.999995	0.999997	0.999994	0.999912	0.999993	0.999987	0.999990
Attributable fraction (AF):	-3.9E-05	-5.4E-06	-2.8E-06	-6.4E-06	-8.8E-05	-6.6E-06	-1.3E-05	-1.0E-05
Increased number of cases in population:	-0.00185	-0.00065	-0.000144	-0.000176	-0.00167	-0.000051	-0.000044	-0.000123
Risk:	-4.0E-07	-5.0E-07	-1.1E-07	-2.5E-08	-3.6E-07	-7.3E-09	-6.4E-09	-1.2E-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	-113.56	-113.56	-113.56	-113.56	-113.56	-113.56	-113.56	-113.56
Population weighted Δx (µg/m^3):	-0.01481892	-0.01481892	-0.01481892	-0.01481892	-0.01481892	-0.01481892	-0.01481892	-0.01481892
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:	0.999914	0.999988	0.999994	0.999986	0.999807	0.999986	0.999972	0.999978
Attributable fraction (AF):	-8.6E-05	-1.2E-05	-6.1E-06	-1.4E-05	-1.9E-04	-1.4E-05	-2.8E-05	-2.2E-05
Increased number of cases in population:	-0.00443	-0.00156	-0.000344	-0.000423	-0.00399	-0.000122	-0.000107	-0.000295
Risk:	-8.8E-07	-1.1E-06	-2.4E-07	-5.5E-08	-7.9E-07	-1.6E-08	-1.4E-08	-2.7E-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	-336.61	-336.61	-336.61	-336.61	-336.61	-336.61	-336.61	-336.61
Population weighted Δx (µg/m^3):	-0.00388272	-0.00388272	-0.00388272	-0.00388272	-0.00388272	-0.00388272	-0.00388272	-0.00388272
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:	0.999977	0.999997	0.999998	0.999996	0.999950	0.999996	0.999993	0.999994

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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):	-2.3E-05	-3.1E-06	-1.6E-06	-3.6E-06	-5.0E-05	-3.8E-06	-7.4E-06	-5.7E-06
Increased number of cases in population:	-0.013	-0.0042	-0.00092	-0.0015	-0.012	-0.00042	-0.00032	-0.0011
Risk:	-2.3E-07	-2.9E-07	-6.3E-08	-1.7E-08	-2.1E-07	-4.8E-09	-3.6E-09	-6.9E-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	-182.93	-182.93	-182.93	-182.93	-182.93	-182.93	-182.93	-182.93
Population weighted Δx (µg/m^3):	-0.00904956	-0.00904956	-0.00904956	-0.00904956	-0.00904956	-0.00904956	-0.00904956	-0.00904956
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:	0.999948	0.999993	0.999996	0.999991	0.999882	0.999991	0.999983	0.999987
Attributable fraction (AF):	-5.2E-05	-7.2E-06	-3.7E-06	-8.5E-06	-1.2E-04	-8.8E-06	-1.7E-05	-1.3E-05
Increased number of cases in population:	-0.0070	-0.0023	-0.00050	-0.00079	-0.0063	-0.00023	-0.00017	-0.00061
Risk:	-5.4E-07	-6.7E-07	-1.5E-07	-3.9E-08	-4.8E-07	-1.1E-08	-8.5E-09	-1.6E-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	-75.736	-75.736	-75.736	-75.736	-75.736	-75.736	-75.736	-75.736
Population weighted Δx (µg/m^3):	-0.00593680	-0.00593680	-0.00593680	-0.00593680	-0.00593680	-0.00593680	-0.00593680	-0.00593680
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:	0.999966	0.999995	0.999998	0.999994	0.999923	0.999994	0.999989	0.999991
Attributable fraction (AF):	-3.4E-05	-4.7E-06	-2.4E-06	-5.6E-06	-7.7E-05	-5.8E-06	-1.1E-05	-8.8E-06
Increased number of cases in population:	-0.0029	-0.0009	-0.00021	-0.00033	-0.0026	-0.00009	-0.00007	-0.00025
Risk:	-3.5E-07	-4.4E-07	-9.7E-08	-2.6E-08	-3.2E-07	-7.3E-09	-5.6E-09	-1.1E-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	-17.693	-17.693	-17.693	-17.693	-17.693	-17.693	-17.693	-17.693
Population weighted Δx (µg/m^3):	-0.07760105	-0.07760105	-0.07760105	-0.07760105	-0.07760105	-0.07760105	-0.07760105	-0.07760105
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:	0.999550	0.999938	0.999968	0.999927	0.998992	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:	-0.000677	-0.000220	-0.000048	-0.000077	-0.000610	-0.000022	-0.000017	-0.000059
Risk:	-4.6E-06	-5.7E-06	-1.3E-06	-3.4E-07	-4.2E-06	-9.6E-08	-7.3E-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	-511.35	-511.35	-511.35	-511.35	-511.35	-511.35	-511.35	-511.35
Population weighted Δx (µg/m^3):	-0.03990848	-0.03990848	-0.03990848	-0.03990848	-0.03990848	-0.03990848	-0.03990848	-0.03990848
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:	0.999769	0.999968	0.999984	0.999962	0.999481	0.999961	0.999924	0.999941
Attributable fraction (AF):	-2.3E-04	-3.2E-05	-1.6E-05	-3.8E-05	-5.2E-04	-3.9E-05	-7.6E-05	-5.9E-05
Increased number of cases in population:	-0.0196	-0.0063	-0.00140	-0.00222	-0.0176	-0.00063	-0.00048	-0.00170
Risk:	-2.4E-06	-2.9E-06	-6.5E-07	-1.7E-07	-2.1E-06	-4.9E-08	-3.7E-08	-7.1E-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	3.5148	3.5148	3.5148	3.5148	3.5148	3.5148	3.5148	3.5148
Population weighted Δx (µg/m^3):	0.00034598	0.00034598	0.00034598	0.00034598	0.00034598	0.00034598	0.00034598	0.00034598
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:	1.000002	1.000000	1.000000	1.000000	1.000004	1.000000	1.000001	1.000001
Attributable fraction (AF):	2.0E-06	2.8E-07	1.4E-07	3.3E-07	4.5E-06	3.4E-07	6.6E-07	5.1E-07
Increased number of cases in population:	0.00013	0.000044	0.000010	0.000015	0.00012	0.0000043	0.0000033	0.000012
Risk:	2.1E-08	2.6E-08	5.6E-09	1.5E-09	1.9E-08	4.3E-10	3.2E-10	6.2E-09
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	-20.432	-20.432	-20.432	-20.432	-20.432	-20.432	-20.432	-20.432
Population weighted Δx (µg/m^3):	-0.00253905	-0.00253905	-0.00253905	-0.00253905	-0.00253905	-0.00253905	-0.00253905	-0.00253905
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	0.999998	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	-4.1E-08	-1.1E-08	-1.4E-07	-3.1E-09	-2.4E-09	-4.5E-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	-20.225	-20.225	-20.225	-20.225	-20.225	-20.225	-20.225	-20.225
Population weighted Δx (µg/m^3):	-0.00362721	-0.00362721	-0.00362721	-0.00362721	-0.00362721	-0.00362721	-0.00362721	-0.00362721
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:	0.999979	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:	-0.000774	-0.000251	-0.000055	-0.000088	-0.000697	-0.000025	-0.000019	-0.000067
Risk:	-2.2E-07	-2.7E-07	-5.9E-08	-1.6E-08	-1.9E-07	-4.5E-09	-3.4E-09	-6.5E-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	488.24	488.24	488.24	488.24	488.24	488.24	488.24	488.24
Population weighted Δx (µg/m^3):	0.02888982	0.02888982	0.02888982	0.02888982	0.02888982	0.02888982	0.02888982	0.02888982
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:	1.000168	1.000023	1.000012	1.000027	1.000376	1.000028	1.000055	1.000043
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.5E-05	4.3E-05
Increased number of cases in population:	0.0187	0.0061	0.00134	0.00212	0.0168	0.00060	0.00046	0.00162

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Risk:	1.7E-06	2.1E-06	4.7E-07	1.3E-07	1.5E-06	3.6E-08	2.7E-08	5.2E-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	-407.99	-407.99	-407.99	-407.99	-407.99	-407.99	-407.99	-407.99
Population weighted Δx (μg/m^3):	-0.01267321	-0.01267321	-0.01267321	-0.01267321	-0.01267321	-0.01267321	-0.01267321	-0.01267321
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:	0.999926	0.999990	0.999995	0.999988	0.999835	0.999988	0.999976	0.999981
Attributable fraction (AF):	-7.4E-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:	-0.015	-0.0055	-0.0012	-0.0014	-0.014	-0.00043	-0.00038	-0.0014
Risk:	-7.5E-07	-9.4E-07	-2.1E-07	-4.3E-08	-6.8E-07	-1.3E-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	-15.551	-15.551	-15.551	-15.551	-15.551	-15.551	-15.551	-15.551
Population weighted Δx (μg/m^3):	-0.00158502	-0.00158502	-0.00158502	-0.00158502	-0.00158502	-0.00158502	-0.00158502	-0.00158502
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:	0.999991	0.999999	0.999999	0.999999	0.999979	0.999998	0.999997	0.999998
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:	-0.0006	-0.0002	-0.00005	-0.00005	-0.0005	-0.00002	-0.000015	-0.00005
Risk:	-9.4E-08	-1.2E-07	-2.6E-08	-5.4E-09	-8.5E-08	-1.7E-09	-1.5E-09	-2.8E-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	-393.08	-393.08	-393.08	-393.08	-393.08	-393.08	-393.08	-393.08
Population weighted Δx (μg/m^3):	-0.01841721	-0.01841721	-0.01841721	-0.01841721	-0.01841721	-0.01841721	-0.01841721	-0.01841721
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:	0.999893	0.999985	0.999992	0.999983	0.999761	0.999982	0.999965	0.999973
Attributable fraction (AF):	-1.1E-04	-1.5E-05	-7.6E-06	-1.7E-05	-2.4E-04	-1.8E-05	-3.5E-05	-2.7E-05
Increased number of cases in population:	-0.0146	-0.0053	-0.00117	-0.00135	-0.0132	-0.00041	-0.00037	-0.00136
Risk:	-1.1E-06	-1.4E-06	-3.0E-07	-6.3E-08	-9.9E-07	-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	0.6405	0.6405	0.6405	0.6405	0.6405	0.6405	0.6405	0.6405
Population weighted Δx (μg/m^3):	0.00061646	0.00061646	0.00061646	0.00061646	0.00061646	0.00061646	0.00061646	0.00061646
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:	1.000004	1.000000	1.000000	1.000001	1.000008	1.000001	1.000001	1.000001
Attributable fraction (AF):	3.6E-06	4.9E-07	2.5E-07	5.8E-07	8.0E-06	6.0E-07	1.2E-06	9.1E-07
Increased number of cases in population:	0.000024	0.000009	0.000002	0.000002	0.000021	0.00000067	0.00000060	0.000002
Risk:	3.7E-08	4.6E-08	1.0E-08	2.1E-09	3.3E-08	6.4E-10	5.8E-10	1.1E-08
Total population incidence - All Suburbs	**-0.83**	**-0.21**	**-0.045**	**-0.096**	**-0.75**	**-0.028**	**-0.021**	**-0.043**

Assessment of Increased Incidence - $PM_{2.5}$
Beaches Link: 2037

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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
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	37.68	37.68	37.68	37.68	37.68	37.68	37.68	37.68
Population weighted Δx (µg/m³):	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566
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:	1.000094	1.000013	1.000007	1.000015	1.000210	1.000016	1.000031	1.000024
Attributable fraction (AF):	9.4E-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:	0.0014	0.00041	0.000090	0.00014	0.0013	0.000041	0.000035	0.00010
Risk:	9.6E-07	1.2E-06	2.6E-07	6.1E-08	8.6E-07	1.8E-08	1.5E-08	2.9E-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	37.68	37.68	37.68	37.68	37.68	37.68	37.68	37.68
Population weighted Δx (µg/m³):	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566	0.01614566
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:	1.000094	1.000013	1.000007	1.000015	1.000210	1.000016	1.000031	1.000024
Attributable fraction (AF):	9.4E-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:	0.0014	0.00041	0.000090	0.00014	0.0013	0.000041	0.000035	0.00010
Risk:	9.6E-07	1.2E-06	2.6E-07	6.1E-08	8.6E-07	1.8E-08	1.5E-08	2.9E-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	-5342.1	-5342.1	-5342.1	-5342.1	-5342.1	-5342.1	-5342.1	-5342.1
Population weighted Δx (µg/m³):	-0.05674109	-0.05674109	-0.05674109	-0.05674109	-0.05674109	-0.05674109	-0.05674109	-0.05674109
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:	0.999671	0.999955	0.999977	0.999947	0.999263	0.999945	0.999892	0.999916
Attributable fraction (AF):	-3.3E-04	-4.5E-05	-2.3E-05	-5.3E-05	-7.4E-04	-5.5E-05	-1.1E-04	-8.4E-05
Increased number of cases in population:	-0.21	-0.075	-0.017	-0.017	-0.19	-0.0051	-0.0050	-0.016
Risk:	-3.4E-06	-4.2E-06	-9.3E-07	-1.8E-07	-3.0E-06	-5.4E-08	-5.3E-08	-1.0E-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	-1275.7	-1275.7	-1275.7	-1275.7	-1275.7	-1275.7	-1275.7	-1275.7
Population weighted Δx (µg/m³):	-0.06698120	-0.06698120	-0.06698120	-0.06698120	-0.06698120	-0.06698120	-0.06698120	-0.06698120
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:	0.999612	0.999946	0.999973	0.999937	0.999130	0.999935	0.999873	0.999901
Attributable fraction (AF):	-3.9E-04	-5.4E-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:	-0.0509	-0.0180	-0.0040	-0.0040	-0.0459	-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	-178.08	-178.08	-178.08	-178.08	-178.08	-178.08	-178.08	-178.08
Population weighted Δx (µg/m³):	-0.00985874	-0.00985874	-0.00985874	-0.00985874	-0.00985874	-0.00985874	-0.00985874	-0.00985874
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:	0.999943	0.999992	0.999996	0.999991	0.999872	0.999990	0.999981	0.999985
Attributable fraction (AF):	-5.7E-05	-7.9E-06	-4.0E-06	-9.3E-06	-1.3E-04	-9.6E-06	-1.9E-05	-1.5E-05
Increased number of cases in population:	-0.0072	-0.0019	-0.0004	-0.0006	-0.0065	-0.0002	-0.0002	-0.0004
Risk:	-5.9E-07	-7.3E-07	-1.6E-07	-3.1E-08	-5.3E-07	-9.4E-09	-9.3E-09	-1.8E-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	-2082.2	-2082.2	-2082.2	-2082.2	-2082.2	-2082.2	-2082.2	-2082.2
Population weighted Δx (µg/m³):	-0.07315789	-0.07315789	-0.07315789	-0.07315789	-0.07315789	-0.07315789	-0.07315789	-0.07315789
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:	0.999576	0.999941	0.999970	0.999931	0.999049	0.999929	0.999861	0.999892
Attributable fraction (AF):	-4.2E-04	-5.9E-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:	-0.0832	-0.0294	-0.0065	-0.0066	-0.0749	-0.0020	-0.0020	-0.0062
Risk:	-4.4E-06	-5.4E-06	-1.2E-06	-2.3E-07	-3.9E-06	-7.0E-08	-6.9E-08	-1.3E-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	-1477.6	-1477.6	-1477.6	-1477.6	-1477.6	-1477.6	-1477.6	-1477.6
Population weighted Δx (µg/m³):	-0.08255071	-0.08255071	-0.08255071	-0.08255071	-0.08255071	-0.08255071	-0.08255071	-0.08255071
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:	0.999521	0.999934	0.999966	0.999922	0.998927	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:	-0.0602	-0.0157	-0.0035	-0.0047	-0.0542	-0.0014	-0.0014	-0.0030
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
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	-328.59	-328.59	-328.59	-328.59	-328.59	-328.59	-328.59	-328.59
Population weighted Δx (µg/m³):	-0.03076657	-0.03076657	-0.03076657	-0.03076657	-0.03076657	-0.03076657	-0.03076657	-0.03076657
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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:	0.999822	0.999975	0.999987	0.999971	0.999600	0.999970	0.999942	0.999954
Attributable fraction (AF):	-1.8E-04	-2.5E-05	-1.3E-05	-2.9E-05	-4.0E-04	-3.0E-05	-5.8E-05	-4.6E-05
Increased number of cases in population:	-0.0134	-0.0035	-0.0008	-0.0010	-0.0120	-0.00031	-0.00031	-0.0007
Risk:	-1.8E-06	-2.3E-06	-5.0E-07	-9.7E-08	-1.6E-06	-2.9E-08	-2.9E-08	-5.5E-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	-51.172	-51.172	-51.172	-51.172	-51.172	-51.172	-51.172	-51.172
Population weighted Δx (µg/m^3):	-0.00105940	-0.00105940	-0.00105940	-0.00105940	-0.00105940	-0.00105940	-0.00105940	-0.00105940
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:	0.999994	0.999999	1.000000	0.999999	0.999986	0.999999	0.999998	0.999998
Attributable fraction (AF):	-6.1E-06	-8.5E-07	-4.3E-07	-1.0E-06	-1.4E-05	-1.0E-06	-2.0E-06	-1.6E-06
Increased number of cases in population:	-0.0019	-0.00046	-0.00010	-0.00026	-0.0017	-0.000073	-0.000048	-0.00013
Risk:	-6.3E-08	-7.8E-08	-1.7E-08	-5.3E-09	-5.7E-08	-1.5E-09	-9.9E-10	-1.9E-08
Individual suburbs 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	-112.50	-112.50	-112.50	-112.50	-112.50	-112.50	-112.50	-112.50
Population weighted Δx (µg/m^3):	-0.00716911	-0.00716911	-0.00716911	-0.00716911	-0.00716911	-0.00716911	-0.00716911	-0.00716911
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:	0.999958	0.999994	0.999997	0.999993	0.999907	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.2E-05	-5.7E-06	-2.9E-06	-6.7E-06	-9.3E-05	-7.0E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.0043	-0.00101	-0.000224	-0.00056	-0.0038	-0.000160	-0.000106	-0.000284
Risk:	-4.3E-07	-5.3E-07	-1.2E-07	-3.6E-08	-3.8E-07	-1.0E-08	-6.7E-09	-1.3E-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	20.834	20.834	20.834	20.834	20.834	20.834	20.834	20.834
Population weighted Δx (µg/m^3):	0.00118771	0.00118771	0.00118771	0.00118771	0.00118771	0.00118771	0.00118771	0.00118771
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:	1.000007	1.000001	1.000000	1.000001	1.000015	1.000001	1.000002	1.000002
Attributable fraction (AF):	6.9E-06	9.5E-07	4.9E-07	1.1E-06	1.5E-05	1.2E-06	2.3E-06	1.8E-06
Increased number of cases in population:	0.00079	0.00019	0.000041	0.00010	0.00071	0.000030	0.000020	0.000053
Risk:	7.1E-08	8.8E-08	1.9E-08	6.0E-09	6.4E-08	1.7E-09	1.1E-09	2.1E-08
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	40.499	40.499	40.499	40.499	40.499	40.499	40.499	40.499
Population weighted Δx (µg/m^3):	0.00322726	0.00322726	0.00322726	0.00322726	0.00322726	0.00322726	0.00322726	0.00322726
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:	1.000019	1.000003	1.000001	1.000003	1.000042	1.000003	1.000006	1.000005
Attributable fraction (AF):	1.9E-05	2.6E-06	1.3E-06	3.0E-06	4.2E-05	3.1E-06	6.1E-06	4.8E-06
Increased number of cases in population:	0.0015	0.00037	0.000081	0.000203	0.0014	0.000058	0.000038	0.00010
Risk:	1.9E-07	2.4E-07	5.3E-08	1.6E-08	1.7E-07	4.6E-09	3.0E-09	5.8E-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	-10.162	-10.162	-10.162	-10.162	-10.162	-10.162	-10.162	-10.162
Population weighted Δx (µg/m^3):	-0.00403268	-0.00403268	-0.00403268	-0.00403268	-0.00403268	-0.00403268	-0.00403268	-0.00403268
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:	0.999977	0.999997	0.999998	0.999996	0.999948	0.999996	0.999992	0.999994
Attributable fraction (AF):	-2.3E-05	-3.2E-06	-1.7E-06	-3.8E-06	-5.2E-05	-3.9E-06	-7.7E-06	-6.0E-06
Increased number of cases in population:	-0.000386	-0.000092	-0.000020	-0.000051	-0.000347	-0.000014	-0.000010	-0.000026
Risk:	-2.4E-07	-3.0E-07	-6.6E-08	-2.0E-08	-2.2E-07	-5.7E-09	-3.8E-09	-7.2E-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	-7745.8	-7745.8	-7745.8	-7745.8	-7745.8	-7745.8	-7745.8	-7745.8
Population weighted Δx (µg/m^3):	-0.05870998	-0.05870998	-0.05870998	-0.05870998	-0.05870998	-0.05870998	-0.05870998	-0.05870998
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:	0.999660	0.999953	0.999976	0.999945	0.999237	0.999943	0.999888	0.999913
Attributable fraction (AF):	-3.4E-04	-4.7E-05	-2.4E-05	-5.5E-05	-7.6E-04	-5.7E-05	-1.1E-04	-8.7E-05
Increased number of cases in population:	-0.27	-0.047	-0.010	-0.037	-0.24	-0.010	-0.0073	-0.0082
Risk:	-3.5E-06	-4.3E-06	-9.6E-07	-2.8E-07	-3.1E-06	-7.9E-08	-5.5E-08	-1.1E-06
Individual suburbs 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	-792.81	-792.81	-792.81	-792.81	-792.81	-792.81	-792.81	-792.81
Population weighted Δx (µg/m^3):	-0.06982640	-0.06982640	-0.06982640	-0.06982640	-0.06982640	-0.06982640	-0.06982640	-0.06982640
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	0.999932	0.999867	0.999897
Attributable fraction (AF):	-4.1E-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:	-0.027180	-0.004803	-0.001060	-0.003786	-0.024470	-0.001068	-0.000744	-0.000837
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
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	246.90	246.90	246.90	246.90	246.90	246.90	246.90	246.90
Population weighted Δx (µg/m^3):	0.01260150	0.01260150	0.01260150	0.01260150	0.01260150	0.01260150	0.01260150	0.01260150
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0

	Primary Indicators			**Secondary Indicators**				
Health Endpoint:	**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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	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:	0.008	0.0015	0.00033	0.0012	0.008	0.00033	0.00023	0.00026
Risk:	7.5E-07	9.3E-07	2.1E-07	6.0E-08	6.7E-07	1.7E-08	1.2E-08	2.3E-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	96.923	96.923	96.923	96.923	96.923	96.923	96.923	96.923
Population weighted Δx (µg/m^3):	0.01880535	0.01880535	0.01880535	0.01880535	0.01880535	0.01880535	0.01880535	0.01880535
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:	1.000109	1.000015	1.000008	1.000018	1.000244	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:	0.003322	0.000587	0.000130	0.000463	0.002990	0.000131	0.000091	0.000102
Risk:	1.1E-06	1.4E-06	3.1E-07	9.0E-08	1.0E-06	2.5E-08	1.8E-08	3.4E-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	-5741.3	-5741.3	-5741.3	-5741.3	-5741.3	-5741.3	-5741.3	-5741.3
Population weighted Δx (µg/m^3):	-0.27081737	-0.27081737	-0.27081737	-0.27081737	-0.27081737	-0.27081737	-0.27081737	-0.27081737
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:	0.998430	0.999783	0.999889	0.999745	0.996486	0.999737	0.999486	0.999599
Attributable fraction (AF):	-1.6E-03	-2.2E-04	-1.1E-04	-2.5E-04	-3.5E-03	-2.6E-04	-5.1E-04	-4.0E-04
Increased number of cases in population:	-0.197	-0.035	-0.0077	-0.027	-0.177	-0.0077	-0.0054	-0.0061
Risk:	-1.6E-05	-2.0E-05	-4.4E-06	-1.3E-06	-1.5E-05	-3.6E-07	-2.5E-07	-4.8E-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	-81.574	-81.574	-81.574	-81.574	-81.574	-81.574	-81.574	-81.574
Population weighted Δx (µg/m^3):	-0.00376523	-0.00376523	-0.00376523	-0.00376523	-0.00376523	-0.00376523	-0.00376523	-0.00376523
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:	0.999978	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	-3.7E-06	-7.2E-06	-5.6E-06
Increased number of cases in population:	-0.003	-0.0005	-0.0001	-0.0004	-0.003	-0.00011	-0.00008	-0.00009
Risk:	-2.2E-07	-2.8E-07	-6.1E-08	-1.8E-08	-2.0E-07	-5.1E-09	-3.5E-09	-6.7E-08
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	57.253	57.253	57.253	57.253	57.253	57.253	57.253	57.253
Population weighted Δx (µg/m^3):	0.00580601	0.00580601	0.00580601	0.00580601	0.00580601	0.00580601	0.00580601	0.00580601
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:	1.000034	1.000005	1.000002	1.000005	1.000075	1.000006	1.000011	1.000009
Attributable fraction (AF):	3.4E-05	4.6E-06	2.4E-06	5.5E-06	7.5E-05	5.6E-06	1.1E-05	8.6E-06
Increased number of cases in population:	0.00196	0.000347	0.000077	0.000273	0.00177	0.000077	0.000054	0.000060
Risk:	3.5E-07	4.3E-07	9.5E-08	2.8E-08	3.1E-07	7.8E-09	5.4E-09	1.0E-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	-1224.8	-1224.8	-1224.8	-1224.8	-1224.8	-1224.8	-1224.8	-1224.8
Population weighted Δx (µg/m^3):	-0.07801858	-0.07801858	-0.07801858	-0.07801858	-0.07801858	-0.07801858	-0.07801858	-0.07801858
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:	0.999548	0.999938	0.999968	0.999927	0.998986	0.999924	0.999852	0.999885
Attributable fraction (AF):	-4.5E-04	-6.2E-05	-3.2E-05	-7.3E-05	-1.0E-03	-7.6E-05	-1.5E-04	-1.2E-04
Increased number of cases in population:	-0.042	-0.0074	-0.00164	-0.0058	-0.038	-0.00165	-0.00115	-0.00129
Risk:	-4.6E-06	-5.8E-06	-1.3E-06	-3.7E-07	-4.2E-06	-1.1E-07	-7.3E-08	-1.4E-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	-306.33574	-306.33574	-306.33574	-306.33574	-306.33574	-306.33574	-306.33574	-306.33574
Population weighted Δx (µg/m^3):	-0.01117728	-0.01117728	-0.01117728	-0.01117728	-0.01117728	-0.01117728	-0.01117728	-0.01117728
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:	0.999935	0.999991	0.999995	0.999989	0.999855	0.999989	0.999979	0.999983
Attributable fraction (AF):	-6.5E-05	-8.9E-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:	-0.0105	-0.0019	-0.00041	-0.0015	-0.0095	-0.00041	-0.00029	-0.00032
Risk:	-6.7E-07	-8.3E-07	-1.8E-07	-5.3E-08	-6.0E-07	-1.5E-08	-1.0E-08	-2.0E-07
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	-2186.62	-2186.61715	-2186.61715	-2186.61715	-2186.61715	-2186.61715	-2186.61715	-2186.61715
Population weighted Δx (µg/m^3):	-0.02115638	-0.02115638	-0.02115638	-0.02115638	-0.02115638	-0.02115638	-0.02115638	-0.02115638
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:	0.999877	0.999983	0.999991	0.999980	0.999725	0.999979	0.999960	0.999969
Attributable fraction (AF):	-1.2E-04	-1.7E-05	-8.7E-06	-2.0E-05	-2.8E-04	-2.1E-05	-4.0E-05	-3.1E-05
Increased number of cases in population:	-0.081	-0.022	-0.0049	-0.0083	-0.073	-0.0024	-0.0021	-0.0067
Risk:	-1.3E-06	-1.6E-06	-3.5E-07	-8.0E-08	-1.1E-06	-2.3E-08	-2.0E-08	-3.8E-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	-713.09	-713.09	-713.09	-713.09	-713.09	-713.09	-713.09	-713.09
Population weighted Δx (µg/m^3):	-0.02490638	-0.02490638	-0.02490638	-0.02490638	-0.02490638	-0.02490638	-0.02490638	-0.02490638
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999856	0.999980	0.999990	0.999977	0.999676	0.999976	0.999953	0.999963
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:	-0.0265	-0.0072	-0.0016	-0.0027	-0.0239	-0.0008	-0.0007	-0.0022
Risk:	-1.5E-06	-1.8E-06	-4.1E-07	-9.4E-08	-1.3E-06	-2.7E-08	-2.3E-08	-4.5E-07
Chatswood West - Lane Cove North								
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	-357.61	-357.61	-357.61	-357.61	-357.61	-357.61	-357.61	-357.61
Population weighted Δx (µg/m^3):	-0.01944297	-0.01944297	-0.01944297	-0.01944297	-0.01944297	-0.01944297	-0.01944297	-0.01944297
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:	0.999887	0.999984	0.999992	0.999982	0.999747	0.999981	0.999963	0.999971
Attributable fraction (AF):	-1.1E-04	-1.6E-05	-8.0E-06	-1.8E-05	-2.5E-04	-1.9E-05	-3.7E-05	-2.9E-05
Increased number of cases in population:	-0.0133	-0.0036	-0.0008	-0.0014	-0.0120	-0.0004	-0.0003	-0.0011
Risk:	-1.2E-06	-1.4E-06	-3.2E-07	-7.3E-08	-1.0E-06	-2.1E-08	-1.8E-08	-3.5E-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	79.880	79.880	79.880	79.880	79.880	79.880	79.880	79.880
Population weighted Δx (µg/m^3):	0.00391551	0.00391551	0.00391551	0.00391551	0.00391551	0.00391551	0.00391551	0.00391551
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:	1.000023	1.000003	1.000002	1.000004	1.000051	1.000004	1.000007	1.000006
Attributable fraction (AF):	2.3E-05	3.1E-06	1.6E-06	3.7E-06	5.1E-05	3.8E-06	7.4E-06	5.8E-06
Increased number of cases in population:	0.0030	0.0008	0.0002	0.0003	0.0027	0.00009	0.00007	0.0002
Risk:	2.3E-07	2.9E-07	6.4E-08	1.5E-08	2.1E-07	4.3E-09	3.7E-09	7.0E-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	-345.31	-345.31	-345.31	-345.31	-345.31	-345.31	-345.31	-345.31
Population weighted Δx (µg/m^3):	-0.03295546	-0.03295546	-0.03295546	-0.03295546	-0.03295546	-0.03295546	-0.03295546	-0.03295546
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:	0.999809	0.999974	0.999986	0.999969	0.999572	0.999968	0.999937	0.999951
Attributable fraction (AF):	-1.9E-04	-2.6E-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:	-0.0128	-0.0035	-0.00077	-0.00130	-0.0116	-0.00038	-0.00032	-0.00106
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	-850.48	-850.48	-850.48	-850.48	-850.48	-850.48	-850.48	-850.48
Population weighted Δx (µg/m^3):	-0.03341510	-0.03341510	-0.03341510	-0.03341510	-0.03341510	-0.03341510	-0.03341510	-0.03341510
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:	0.999806	0.999973	0.999986	0.999969	0.999566	0.999968	0.999937	0.999951
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:	-0.0316	-0.0086	-0.0019	-0.0032	-0.0285	-0.0009	-0.0008	-0.0026
Risk:	-2.0E-06	-2.5E-06	-5.4E-07	-1.3E-07	-1.8E-06	-3.7E-08	-3.1E-08	-6.0E-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	10.085	10.085	10.085	10.085	10.085	10.085	10.085	10.085
Population weighted Δx (µg/m^3):	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626
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:	1.000026	1.000004	1.000002	1.000004	1.000058	1.000004	1.000008	1.000007
Attributable fraction (AF):	2.6E-05	3.6E-06	1.8E-06	4.2E-06	5.8E-05	4.3E-06	8.5E-06	6.6E-06
Increased number of cases in population:	0.00039	0.00016	0.000036	0.000048	0.00035	0.000013	0.0000095	0.000033
Risk:	2.7E-07	3.3E-07	7.3E-08	2.1E-08	2.4E-07	5.8E-09	4.2E-09	8.0E-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	10.085	10.085	10.085	10.085	10.085	10.085	10.085	10.085
Population weighted Δx (µg/m^3):	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626	0.00446626
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:	1.000026	1.000004	1.000002	1.000004	1.000058	1.000004	1.000008	1.000007
Attributable fraction (AF):	2.6E-05	3.6E-06	1.8E-06	4.2E-06	5.8E-05	4.3E-06	8.5E-06	6.6E-06
Increased number of cases in population:	0.00039	0.00016	0.00004	0.00005	0.00035	0.000013	0.000009	0.00003
Risk:	2.7E-07	3.3E-07	7.3E-08	2.1E-08	2.4E-07	5.8E-09	4.2E-09	8.0E-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	-461.19	-461.19	-461.19	-461.19	-461.19	-461.19	-461.19	-461.19
Population weighted Δx (µg/m^3):	-0.00641955	-0.00641955	-0.00641955	-0.00641955	-0.00641955	-0.00641955	-0.00641955	-0.00641955
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:	0.999963	0.999995	0.999997	0.999994	0.999917	0.999994	0.999988	0.999990
Attributable fraction (AF):	-3.7E-05	-5.1E-06	-2.6E-06	-6.0E-06	-8.3E-05	-6.2E-06	-1.2E-05	-9.5E-06
Increased number of cases in population:	-0.018	-0.0063	-0.0014	-0.0017	-0.016	-0.00049	-0.00043	-0.0012
Risk:	-3.8E-07	-4.7E-07	-1.0E-07	-2.4E-08	-3.4E-07	-6.9E-09	-6.0E-09	-1.1E-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	2.4324	2.4324	2.4324	2.4324	2.4324	2.4324	2.4324	2.4324
Population weighted Δx (µg/m^3):	0.00111375	0.00111375	0.00111375	0.00111375	0.00111375	0.00111375	0.00111375	0.00111375
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000006	1.000001	1.000000	1.000001	1.000014	1.000001	1.000002	1.000002
Attributable fraction (AF):	6.5E-06	8.9E-07	4.6E-07	1.0E-06	1.4E-05	1.1E-06	2.1E-06	1.6E-06
Increased number of cases in population:	0.00009496	0.00003343	0.00000738	0.00000905	0.00008546	0.00000261	0.00000228	0.00000631
Risk:	6.6E-08	8.2E-08	1.8E-08	4.1E-09	6.0E-08	1.2E-09	1.0E-09	2.0E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-12.205	-12.205	-12.205	-12.205	-12.205	-12.205	-12.205	-12.205
Population weighted Δx (µg/m^3):	-0.00103264	-0.00103264	-0.00103264	-0.00103264	-0.00103264	-0.00103264	-0.00103264	-0.00103264
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:	0.999994	0.999999	1.000000	0.999999	0.999987	0.999999	0.999998	0.999998
Attributable fraction (AF):	-6.0E-06	-8.3E-07	-4.2E-07	-9.7E-07	-1.3E-05	-1.0E-06	-2.0E-06	-1.5E-06
Increased number of cases in population:	-0.0005	-0.0002	-0.00004	-0.00005	-0.0004	-0.000013	-0.000011	-0.00003
Risk:	-6.1E-08	-7.6E-08	-1.7E-08	-3.8E-09	-5.5E-08	-1.1E-09	-9.7E-10	-1.8E-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	11.618	11.618	11.618	11.618	11.618	11.618	11.618	11.618
Population weighted Δx (µg/m^3):	0.00610495	0.00610495	0.00610495	0.00610495	0.00610495	0.00610495	0.00610495	0.00610495
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:	1.000035	1.000005	1.000003	1.000006	1.000079	1.000006	1.000012	1.000009
Attributable fraction (AF):	3.5E-05	4.9E-06	2.5E-06	5.7E-06	7.9E-05	5.9E-06	1.2E-05	9.0E-06
Increased number of cases in population:	0.00045	0.00016	0.000035	0.000043	0.00041	0.000012	0.000011	0.000030
Risk:	3.6E-07	4.5E-07	1.0E-07	2.3E-08	3.3E-07	6.5E-09	5.7E-09	1.1E-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	-17.955	-17.955	-17.955	-17.955	-17.955	-17.955	-17.955	-17.955
Population weighted Δx (µg/m^3):	-0.00072405	-0.00072405	-0.00072405	-0.00072405	-0.00072405	-0.00072405	-0.00072405	-0.00072405
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:	0.999996	0.999999	1.000000	0.999999	0.999991	0.999999	0.999999	0.999999
Attributable fraction (AF):	-4.2E-06	-5.8E-07	-3.0E-07	-6.8E-07	-9.4E-06	-7.0E-07	-1.4E-06	-1.1E-06
Increased number of cases in population:	-0.0007	-0.00025	-0.00005	-0.00007	-0.0006	-0.000019	-0.000017	-0.000047
Risk:	-4.3E-08	-5.3E-08	-1.2E-08	-2.7E-09	-3.9E-08	-7.8E-10	-6.8E-10	-1.3E-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	32.848	32.848	32.848	32.848	32.848	32.848	32.848	32.848
Population weighted Δx (µg/m^3):	0.01033293	0.01033293	0.01033293	0.01033293	0.01033293	0.01033293	0.01033293	0.01033293
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:	1.000060	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:	0.0013	0.00045	0.00010	0.00012	0.0012	0.000035	0.000031	0.00009
Risk:	6.1E-07	7.6E-07	1.7E-07	3.8E-08	5.5E-07	1.1E-08	9.7E-09	1.8E-07
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	-391.54	-391.54	-391.54	-391.54	-391.54	-391.54	-391.54	-391.54
Population weighted Δx (µg/m^3):	-0.02941508	-0.02941508	-0.02941508	-0.02941508	-0.02941508	-0.02941508	-0.02941508	-0.02941508
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:	0.999829	0.999976	0.999988	0.999972	0.999618	0.999971	0.999944	0.999956
Attributable fraction (AF):	-1.7E-04	-2.4E-05	-1.2E-05	-2.8E-05	-3.8E-04	-2.9E-05	-5.6E-05	-4.4E-05
Increased number of cases in population:	-0.01529	-0.00538	-0.001188	-0.001458	-0.01376	-0.000420	-0.000368	-0.001016
Risk:	-1.8E-06	-2.2E-06	-4.8E-07	-1.1E-07	-1.6E-06	-3.2E-08	-2.8E-08	-5.3E-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	-6.9921	-6.9921	-6.9921	-6.9921	-6.9921	-6.9921	-6.9921	-6.9921
Population weighted Δx (µg/m^3):	-0.00100115	-0.00100115	-0.00100115	-0.00100115	-0.00100115	-0.00100115	-0.00100115	-0.00100115
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:	0.999994	0.999999	1.000000	0.999999	0.999987	0.999999	0.999998	0.999999
Attributable fraction (AF):	-5.8E-06	-8.0E-07	-4.1E-07	-9.4E-07	-1.3E-05	-9.7E-07	-1.9E-06	-1.5E-06
Increased number of cases in population:	-0.00027	-0.00010	-0.000021	-0.000026	-0.00025	-0.000007	-0.000007	-0.000018
Risk:	-6.0E-08	-7.4E-08	-1.6E-08	-3.7E-09	-5.4E-08	-1.1E-09	-9.4E-10	-1.8E-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	-79.390	-79.390	-79.390	-79.390	-79.390	-79.390	-79.390	-79.390
Population weighted Δx (µg/m^3):	-0.01036011	-0.01036011	-0.01036011	-0.01036011	-0.01036011	-0.01036011	-0.01036011	-0.01036011
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:	0.999940	0.999992	0.999996	0.999990	0.999865	0.999990	0.999980	0.999985
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:	-0.00310	-0.00109	-0.000241	-0.000296	-0.00279	-0.000085	-0.000075	-0.000206
Risk:	-6.2E-07	-7.7E-07	-1.7E-07	-3.9E-08	-5.5E-07	-1.1E-08	-9.7E-09	-1.9E-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	-379.17	-379.17	-379.17	-379.17	-379.17	-379.17	-379.17	-379.17
Population weighted Δx (µg/m^3):	-0.00437371	-0.00437371	-0.00437371	-0.00437371	-0.00437371	-0.00437371	-0.00437371	-0.00437371
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:	0.999975	0.999997	0.999998	0.999996	0.999943	0.999996	0.999992	0.999994

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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):	-2.5E-05	-3.5E-06	-1.8E-06	-4.1E-06	-5.7E-05	-4.2E-06	-8.3E-06	-6.5E-06
Increased number of cases in population:	-0.015	-0.0047	-0.0010	-0.0016	-0.013	-0.00047	-0.00036	-0.0013
Risk:	-2.6E-07	-3.2E-07	-7.1E-08	-1.9E-08	-2.3E-07	-5.4E-09	-4.1E-09	-7.8E-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	-118.83	-118.83	-118.83	-118.83	-118.83	-118.83	-118.83	-118.83
Population weighted Δx (µg/m^3):	-0.00587858	-0.00587858	-0.00587858	-0.00587858	-0.00587858	-0.00587858	-0.00587858	-0.00587858
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:	0.999966	0.999995	0.999998	0.999994	0.999924	0.999994	0.999989	0.999991
Attributable fraction (AF):	-3.4E-05	-4.7E-06	-2.4E-06	-5.5E-06	-7.6E-05	-5.7E-06	-1.1E-05	-8.7E-06
Increased number of cases in population:	-0.0045	-0.0015	-0.00033	-0.00052	-0.0041	-0.00015	-0.00011	-0.00040
Risk:	-3.5E-07	-4.3E-07	-9.6E-08	-2.6E-08	-3.1E-07	-7.3E-09	-5.5E-09	-1.1E-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	-127.58	-127.58	-127.58	-127.58	-127.58	-127.58	-127.58	-127.58
Population weighted Δx (µg/m^3):	-0.01000107	-0.01000107	-0.01000107	-0.01000107	-0.01000107	-0.01000107	-0.01000107	-0.01000107
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:	0.999942	0.999992	0.999996	0.999991	0.999870	0.999990	0.999981	0.999985
Attributable fraction (AF):	-5.8E-05	-8.0E-06	-4.1E-06	-9.4E-06	-1.3E-04	-9.7E-06	-1.9E-05	-1.5E-05
Increased number of cases in population:	-0.0049	-0.0016	-0.00035	-0.00055	-0.0044	-0.00016	-0.00012	-0.00042
Risk:	-6.0E-07	-7.4E-07	-1.6E-07	-4.3E-08	-5.4E-07	-1.2E-08	-9.4E-09	-1.8E-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	-8.178	-8.178	-8.178	-8.178	-8.178	-8.178	-8.178	-8.178
Population weighted Δx (µg/m^3):	-0.03586842	-0.03586842	-0.03586842	-0.03586842	-0.03586842	-0.03586842	-0.03586842	-0.03586842
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:	0.999792	0.999971	0.999985	0.999966	0.999534	0.999965	0.999932	0.999947
Attributable fraction (AF):	-2.1E-04	-2.9E-05	-1.5E-05	-3.4E-05	-4.7E-04	-3.5E-05	-6.8E-05	-5.3E-05
Increased number of cases in population:	-0.000313	-0.000102	-0.000022	-0.000036	-0.000282	-0.000010	-0.000008	-0.000027
Risk:	-2.1E-06	-2.6E-06	-5.9E-07	-1.6E-07	-1.9E-06	-4.4E-08	-3.4E-08	-6.4E-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	-496.19	-496.19	-496.19	-496.19	-496.19	-496.19	-496.19	-496.19
Population weighted Δx (µg/m^3):	-0.03872517	-0.03872517	-0.03872517	-0.03872517	-0.03872517	-0.03872517	-0.03872517	-0.03872517
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:	0.999775	0.999969	0.999984	0.999964	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:	-0.0190	-0.0062	-0.00136	-0.00216	-0.0171	-0.00061	-0.00047	-0.00165
Risk:	-2.3E-06	-2.9E-06	-6.3E-07	-1.7E-07	-2.1E-06	-4.8E-08	-3.6E-08	-6.9E-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	-18.878	-18.878	-18.878	-18.878	-18.878	-18.878	-18.878	-18.878
Population weighted Δx (µg/m^3):	-0.00185824	-0.00185824	-0.00185824	-0.00185824	-0.00185824	-0.00185824	-0.00185824	-0.00185824
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	0.999999	0.999999	0.999998	0.999976	0.999998	0.999996	0.999997
Attributable fraction (AF):	-1.1E-05	-1.5E-06	-7.6E-07	-1.7E-06	-2.4E-05	-1.8E-06	-3.5E-06	-2.8E-06
Increased number of cases in population:	-0.0007	-0.0002	-0.00005	-0.00008	-0.0007	-0.00002	-0.00002	-0.00006
Risk:	-1.1E-07	-1.4E-07	-3.0E-08	-8.1E-09	-1.0E-07	-2.3E-09	-1.7E-09	-3.3E-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	-103.31	-103.31	-103.31	-103.31	-103.31	-103.31	-103.31	-103.31
Population weighted Δx (µg/m^3):	-0.01283840	-0.01283840	-0.01283840	-0.01283840	-0.01283840	-0.01283840	-0.01283840	-0.01283840
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:	0.999926	0.999990	0.999995	0.999988	0.999833	0.999988	0.999976	0.999981
Attributable fraction (AF):	-7.4E-05	-1.0E-05	-5.3E-06	-1.2E-05	-1.7E-04	-1.2E-05	-2.4E-05	-1.9E-05
Increased number of cases in population:	-0.0040	-0.0013	-0.00028	-0.00045	-0.0036	-0.00013	-0.00010	-0.00034
Risk:	-7.6E-07	-9.5E-07	-2.1E-07	-5.6E-08	-6.9E-07	-1.6E-08	-1.2E-08	-2.3E-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	-1.0348	-1.0348	-1.0348	-1.0348	-1.0348	-1.0348	-1.0348	-1.0348
Population weighted Δx (µg/m^3):	-0.00018557	-0.00018557	-0.00018557	-0.00018557	-0.00018557	-0.00018557	-0.00018557	-0.00018557
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:	0.999999	1.000000	1.000000	1.000000	0.999998	1.000000	1.000000	1.000000
Attributable fraction (AF):	-1.1E-06	-1.5E-07	-7.6E-08	-1.7E-07	-2.4E-06	-1.8E-07	-3.5E-07	-2.7E-07
Increased number of cases in population:	-0.000040	-0.000013	-0.000003	-0.000004	-0.000036	-0.000001	-0.000001	-0.000003
Risk:	-1.1E-08	-1.4E-08	-3.0E-09	-8.1E-10	-9.9E-09	-2.3E-10	-1.7E-10	-3.3E-09
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	494.83	494.83	494.83	494.83	494.83	494.83	494.83	494.83
Population weighted Δx (µg/m^3):	0.02927963	0.02927963	0.02927963	0.02927963	0.02927963	0.02927963	0.02927963	0.02927963
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:	1.000170	1.000023	1.000012	1.000028	1.000381	1.000028	1.000056	1.000043
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.8E-05	3.8E-04	2.8E-05	5.6E-05	4.3E-05
Increased number of cases in population:	0.0189	0.0061	0.00136	0.00215	0.0170	0.00061	0.00046	0.00165

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Risk:	1.7E-06	2.2E-06	4.8E-07	1.3E-07	1.6E-06	3.6E-08	2.7E-08	5.2E-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	-437.04	-437.04	-437.04	-437.04	-437.04	-437.04	-437.04	-437.04
Population weighted Δx (μg/m^3):	-0.01357547	-0.01357547	-0.01357547	-0.01357547	-0.01357547	-0.01357547	-0.01357547	-0.01357547
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:	0.999921	0.999989	0.999994	0.999987	0.999824	0.999987	0.999974	0.999980
Attributable fraction (AF):	-7.9E-05	-1.1E-05	-5.6E-06	-1.3E-05	-1.8E-04	-1.3E-05	-2.6E-05	-2.0E-05
Increased number of cases in population:	-0.016	-0.0059	-0.0013	-0.0015	-0.015	-0.00046	-0.00041	-0.0015
Risk:	-8.1E-07	-1.0E-06	-2.2E-07	-4.7E-08	-7.3E-07	-1.4E-08	-1.3E-08	-2.4E-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	-20.051	-20.051	-20.051	-20.051	-20.051	-20.051	-20.051	-20.051
Population weighted Δx (μg/m^3):	-0.00204373	-0.00204373	-0.00204373	-0.00204373	-0.00204373	-0.00204373	-0.00204373	-0.00204373
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:	0.999988	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:	-0.000746	-0.000270	-0.000060	-0.000069	-0.000671	-0.000021	-0.000019	-0.000070
Risk:	-1.2E-07	-1.5E-07	-3.3E-08	-7.0E-09	-1.1E-07	-2.1E-09	-1.9E-09	-3.7E-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	-417.30	-417.30	-417.30	-417.30	-417.30	-417.30	-417.30	-417.30
Population weighted Δx (μg/m^3):	-0.01955221	-0.01955221	-0.01955221	-0.01955221	-0.01955221	-0.01955221	-0.01955221	-0.01955221
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:	0.999887	0.999984	0.999992	0.999982	0.999746	0.999981	0.999963	0.999971
Attributable fraction (AF):	-1.1E-04	-1.6E-05	-8.0E-06	-1.8E-05	-2.5E-04	-1.9E-05	-3.7E-05	-2.9E-05
Increased number of cases in population:	-0.0155	-0.0056	-0.00124	-0.00143	-0.0140	-0.00044	-0.00039	-0.00145
Risk:	-1.2E-06	-1.4E-06	-3.2E-07	-6.7E-08	-1.0E-06	-2.0E-08	-1.8E-08	-3.5E-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	0.31889	0.31889	0.31889	0.31889	0.31889	0.31889	0.31889	0.31889
Population weighted Δx (μg/m^3):	0.00030692	0.00030692	0.00030692	0.00030692	0.00030692	0.00030692	0.00030692	0.00030692
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:	1.000002	1.000000	1.000000	1.000000	1.000004	1.000000	1.000001	1.000000
Attributable fraction (AF):	1.8E-06	2.5E-07	1.3E-07	2.9E-07	4.0E-06	3.0E-07	5.8E-07	4.5E-07
Increased number of cases in population:	0.000012	0.000004	0.00000095	0.0000011	0.000011	0.0000003	0.0000003	0.0000011
Risk:	1.8E-08	2.3E-08	5.0E-09	1.1E-09	1.6E-08	3.2E-10	2.9E-10	5.5E-09
Total population incidence - All Suburbs	**-0.61**	**-0.16**	**-0.036**	**-0.067**	**-0.55**	**-0.019**	**-0.016**	**-0.035**

Assessment of Increased Incidence - $PM_{2.5}$
Beaches Link: 2027 Cumulative

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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
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	69.33	69.33	69.33	69.33	69.33	69.33	69.33	69.33
Population weighted Δx (µg/m^3):	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231
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:	1.000172	1.000024	1.000012	1.000028	1.000386	1.000029	1.000056	1.000044
Attributable fraction (AF):	1.7E-04	2.4E-05	1.2E-05	2.8E-05	3.9E-04	2.9E-05	5.6E-05	4.4E-05
Increased number of cases in population:	0.0026	0.00075	0.00017	0.00026	0.0023	0.000076	0.000065	0.00018
Risk:	1.8E-06	2.2E-06	4.8E-07	1.1E-07	1.6E-06	3.3E-08	2.8E-08	5.3E-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	69.33	69.33	69.33	69.33	69.33	69.33	69.33	69.33
Population weighted Δx (µg/m^3):	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231	0.02970231
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:	1.000172	1.000024	1.000012	1.000028	1.000386	1.000029	1.000056	1.000044
Attributable fraction (AF):	1.7E-04	2.4E-05	1.2E-05	2.8E-05	3.9E-04	2.9E-05	5.6E-05	4.4E-05
Increased number of cases in population:	0.0026	0.00075	0.000166	0.00026	0.0023	0.000076	0.000065	0.00018
Risk:	1.8E-06	2.2E-06	4.8E-07	1.1E-07	1.6E-06	3.3E-08	2.8E-08	5.3E-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	-9117.0	-9117.0	-9117.0	-9117.0	-9117.0	-9117.0	-9117.0	-9117.0
Population weighted Δx (µg/m^3):	-0.09683557	-0.09683557	-0.09683557	-0.09683557	-0.09683557	-0.09683557	-0.09683557	-0.09683557
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:	0.999439	0.999923	0.999960	0.999909	0.998742	0.999906	0.999816	0.999857
Attributable fraction (AF):	-5.6E-04	-7.7E-05	-4.0E-05	-9.1E-05	-1.3E-03	-9.4E-05	-1.8E-04	-1.4E-04
Increased number of cases in population:	-0.36	-0.13	-0.028	-0.029	-0.33	-0.0087	-0.0086	-0.027
Risk:	-5.8E-06	-7.2E-06	-1.6E-06	-3.0E-07	-5.2E-06	-9.3E-08	-9.1E-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	-1466.0	-1466.0	-1466.0	-1466.0	-1466.0	-1466.0	-1466.0	-1466.0
Population weighted Δx (µg/m^3):	-0.07697656	-0.07697656	-0.07697656	-0.07697656	-0.07697656	-0.07697656	-0.07697656	-0.07697656
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:	0.999554	0.999938	0.999968	0.999928	0.999000	0.999925	0.999854	0.999886
Attributable fraction (AF):	-4.5E-04	-6.2E-05	-3.2E-05	-7.2E-05	-1.0E-03	-7.5E-05	-1.5E-04	-1.1E-04
Increased number of cases in population:	-0.0586	-0.0207	-0.0046	-0.0046	-0.0527	-0.0014	-0.0014	-0.0044
Risk:	-4.6E-06	-5.7E-06	-1.3E-06	-2.4E-07	-4.1E-06	-7.4E-08	-7.2E-08	-1.4E-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	22.214	22.214	22.214	22.214	22.214	22.214	22.214	22.214
Population weighted Δx (µg/m^3):	0.00122981	0.00122981	0.00122981	0.00122981	0.00122981	0.00122981	0.00122981	0.00122981
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:	1.000007	1.000001	1.000001	1.000001	1.000016	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.1E-06	9.8E-07	5.0E-07	1.2E-06	1.6E-05	1.2E-06	2.3E-06	1.8E-06
Increased number of cases in population:	0.00090	0.00024	0.000052	0.000070	0.00081	0.000021	0.000021	0.000045
Risk:	7.3E-08	9.1E-08	2.0E-08	3.9E-09	6.6E-08	1.2E-09	1.2E-09	2.2E-08
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	-2342.8	-2342.8	-2342.8	-2342.8	-2342.8	-2342.8	-2342.8	-2342.8
Population weighted Δx (µg/m^3):	-0.08231251	-0.08231251	-0.08231251	-0.08231251	-0.08231251	-0.08231251	-0.08231251	-0.08231251
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:	0.999523	0.999934	0.999966	0.999923	0.998931	0.999920	0.999844	0.999878
Attributable fraction (AF):	-4.8E-04	-6.6E-05	-3.4E-05	-7.7E-05	-1.1E-03	-8.0E-05	-1.6E-04	-1.2E-04
Increased number of cases in population:	-0.0936	-0.0331	-0.0073	-0.0074	-0.0842	-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	-4016.2	-4016.2	-4016.2	-4016.2	-4016.2	-4016.2	-4016.2	-4016.2
Population weighted Δx (µg/m^3):	-0.22437956	-0.22437956	-0.22437956	-0.22437956	-0.22437956	-0.22437956	-0.22437956	-0.22437956
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:	0.998699	0.999821	0.999908	0.999789	0.997087	0.999782	0.999574	0.999668
Attributable fraction (AF):	-1.3E-03	-1.8E-04	-9.2E-05	-2.1E-04	-2.9E-03	-2.2E-04	-4.3E-04	-3.3E-04
Increased number of cases in population:	-0.1636	-0.0427	-0.0094	-0.0126	-0.1473	-0.0038	-0.0038	-0.0080
Risk:	-1.3E-05	-1.7E-05	-3.7E-06	-7.1E-07	-1.2E-05	-2.1E-07	-2.1E-07	-4.0E-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	-1314.2	-1314.2	-1314.2	-1314.2	-1314.2	-1314.2	-1314.2	-1314.2
Population weighted Δx (µg/m^3):	-0.12305427	-0.12305427	-0.12305427	-0.12305427	-0.12305427	-0.12305427	-0.12305427	-0.12305427
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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:	0.999287	0.999902	0.999950	0.999884	0.998402	0.999881	0.999766	0.999818
Attributable fraction (AF):	-7.1E-04	-9.8E-05	-5.0E-05	-1.2E-04	-1.6E-03	-1.2E-04	-2.3E-04	-1.8E-04
Increased number of cases in population:	-0.0535	-0.0140	-0.0031	-0.0041	-0.0482	-0.0013	-0.0012	-0.0026
Risk:	-7.3E-06	-9.1E-06	-2.0E-06	-3.9E-07	-6.6E-06	-1.2E-07	-1.2E-07	-2.2E-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	463.14	463.14	463.14	463.14	463.14	463.14	463.14	463.14
Population weighted Δx (μg/m^3):	0.00958817	0.00958817	0.00958817	0.00958817	0.00958817	0.00958817	0.00958817	0.00958817
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:	1.000056	1.000008	1.000004	1.000009	1.000125	1.000009	1.000018	1.000014
Attributable fraction (AF):	5.6E-05	7.7E-06	3.9E-06	9.0E-06	1.2E-04	9.3E-06	1.8E-05	1.4E-05
Increased number of cases in population:	0.018	0.0042	0.00092	0.0023	0.016	0.00066	0.00043	0.0012
Risk:	5.7E-07	7.1E-07	1.6E-07	4.8E-08	5.1E-07	1.4E-08	9.0E-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	-110.26	-110.26	-110.26	-110.26	-110.26	-110.26	-110.26	-110.26
Population weighted Δx (μg/m^3):	-0.00702619	-0.00702619	-0.00702619	-0.00702619	-0.00702619	-0.00702619	-0.00702619	-0.00702619
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:	0.999959	0.999994	0.999997	0.999993	0.999909	0.999993	0.999987	0.999990
Attributable fraction (AF):	-4.1E-05	-5.6E-06	-2.9E-06	-6.6E-06	-9.1E-05	-6.8E-06	-1.3E-05	-1.0E-05
Increased number of cases in population:	-0.0042	-0.00099	-0.000219	-0.00055	-0.0038	-0.000157	-0.000103	-0.000278
Risk:	-4.2E-07	-5.2E-07	-1.1E-07	-3.5E-08	-3.8E-07	-1.0E-08	-6.6E-09	-1.3E-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	326.68	326.68	326.68	326.68	326.68	326.68	326.68	326.68
Population weighted Δx (μg/m^3):	0.01862377	0.01862377	0.01862377	0.01862377	0.01862377	0.01862377	0.01862377	0.01862377
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:	1.000108	1.000015	1.000008	1.000018	1.000242	1.000018	1.000035	1.000028
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:	0.012	0.003	0.0007	0.002	0.011	0.0005	0.0003	0.0008
Risk:	1.1E-06	1.4E-06	3.0E-07	9.4E-08	1.0E-06	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	246.72	246.72	246.72	246.72	246.72	246.72	246.72	246.72
Population weighted Δx (μg/m^3):	0.01966051	0.01966051	0.01966051	0.01966051	0.01966051	0.01966051	0.01966051	0.01966051
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:	1.000114	1.000016	1.000008	1.000018	1.000256	1.000019	1.000037	1.000029
Attributable fraction (AF):	1.1E-04	1.6E-05	8.1E-06	1.8E-05	2.6E-04	1.9E-05	3.7E-05	2.9E-05
Increased number of cases in population:	0.009	0.002	0.0005	0.0012	0.008	0.0004	0.0002	0.0006
Risk:	1.2E-06	1.5E-06	3.2E-07	9.9E-08	1.1E-06	2.8E-08	1.8E-08	3.5E-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	-65.337	-65.337	-65.337	-65.337	-65.337	-65.337	-65.337	-65.337
Population weighted Δx (μg/m^3):	-0.02592750	-0.02592750	-0.02592750	-0.02592750	-0.02592750	-0.02592750	-0.02592750	-0.02592750
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:	0.999850	0.999979	0.999989	0.999976	0.999663	0.999975	0.999951	0.999962
Attributable fraction (AF):	-1.5E-04	-2.1E-05	-1.1E-05	-2.4E-05	-3.4E-04	-2.5E-05	-4.9E-05	-3.8E-05
Increased number of cases in population:	-0.002481	-0.000589	-0.000130	-0.000328	-0.002233	-0.000093	-0.000061	-0.000165
Risk:	-1.5E-06	-1.9E-06	-4.2E-07	-1.3E-07	-1.4E-06	-3.7E-08	-2.4E-08	-4.6E-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	-21428	-21428	-21428	-21428	-21428	-21428	-21428	-21428
Population weighted Δx (μg/m^3):	-0.16241906	-0.16241906	-0.16241906	-0.16241906	-0.16241906	-0.16241906	-0.16241906	-0.16241906
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:	0.999058	0.999870	0.999933	0.999847	0.997891	0.999842	0.999691	0.999760
Attributable fraction (AF):	-9.4E-04	-1.3E-04	-6.7E-05	-1.5E-04	-2.1E-03	-1.6E-04	-3.1E-04	-2.4E-04
Increased number of cases in population:	-0.73	-0.13	-0.029	-0.10	-0.66	-0.029	-0.020	-0.023
Risk:	-9.7E-06	-1.2E-05	-2.6E-06	-7.8E-07	-8.7E-06	-2.2E-07	-1.5E-07	-2.9E-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	-1610.8	-1610.8	-1610.8	-1610.8	-1610.8	-1610.8	-1610.8	-1610.8
Population weighted Δx (μg/m^3):	-0.14187435	-0.14187435	-0.14187435	-0.14187435	-0.14187435	-0.14187435	-0.14187435	-0.14187435
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:	0.999177	0.999887	0.999942	0.999867	0.998157	0.999862	0.999730	0.999790
Attributable fraction (AF):	-8.2E-04	-1.1E-04	-5.8E-05	-1.3E-04	-1.8E-03	-1.4E-04	-2.7E-04	-2.1E-04
Increased number of cases in population:	-0.055	-0.0098	-0.00215	-0.0077	-0.050	-0.00217	-0.00151	-0.00170
Risk:	-8.4E-06	-1.0E-05	-2.3E-06	-6.8E-07	-7.6E-06	-1.9E-07	-1.3E-07	-2.5E-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	-929.81	-929.81	-929.81	-929.81	-929.81	-929.81	-929.81	-929.81
Population weighted Δx (μg/m^3):	-0.04745626	-0.04745626	-0.04745626	-0.04745626	-0.04745626	-0.04745626	-0.04745626	-0.04745626
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999725	0.999962	0.999981	0.999955	0.999383	0.999954	0.999910	0.999930
Attributable fraction (AF):	-2.8E-04	-3.8E-05	-1.9E-05	-4.5E-05	-6.2E-04	-4.6E-05	-9.0E-05	-7.0E-05
Increased number of cases in population:	-0.031875	-0.005633	-0.001244	-0.004440	-0.028694	-0.001253	-0.000873	-0.000982
Risk:	-2.8E-06	-3.5E-06	-7.7E-07	-2.3E-07	-2.5E-06	-6.4E-08	-4.5E-08	-8.5E-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	-278.37	-278.37	-278.37	-278.37	-278.37	-278.37	-278.37	-278.37
Population weighted Δx (µg/m^3):	-0.05400991	-0.05400991	-0.05400991	-0.05400991	-0.05400991	-0.05400991	-0.05400991	-0.05400991
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:	0.999687	0.999957	0.999978	0.999949	0.999298	0.999948	0.999897	0.999920
Attributable fraction (AF):	-3.1E-04	-4.3E-05	-2.2E-05	-5.1E-05	-7.0E-04	-5.2E-05	-1.0E-04	-8.0E-05
Increased number of cases in population:	-0.010	-0.0017	-0.0004	-0.0013	-0.009	-0.0004	-0.00026	-0.00029
Risk:	-3.2E-06	-4.0E-06	-8.8E-07	-2.6E-07	-2.9E-06	-7.3E-08	-5.1E-08	-9.7E-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	-10402	-10402	-10402	-10402	-10402	-10402	-10402	-10402
Population weighted Δx (µg/m^3):	-0.49064638	-0.49064638	-0.49064638	-0.49064638	-0.49064638	-0.49064638	-0.49064638	-0.49064638
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:	0.997158	0.999608	0.999799	0.999539	0.993642	0.999524	0.999068	0.999274
Attributable fraction (AF):	-2.8E-03	-3.9E-04	-2.0E-04	-4.6E-04	-6.4E-03	-4.8E-04	-9.3E-04	-7.3E-04
Increased number of cases in population:	-0.357	-0.063	-0.0139	-0.050	-0.322	-0.0140	-0.0098	-0.0110
Risk:	-2.9E-05	-3.6E-05	-8.0E-06	-2.3E-06	-2.6E-05	-6.6E-07	-4.6E-07	-8.8E-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	-2082.8	-2082.8	-2082.8	-2082.8	-2082.8	-2082.8	-2082.8	-2082.8
Population weighted Δx (µg/m^3):	-0.09613506	-0.09613506	-0.09613506	-0.09613506	-0.09613506	-0.09613506	-0.09613506	-0.09613506
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:	0.999443	0.999923	0.999961	0.999910	0.998751	0.999907	0.999817	0.999858
Attributable fraction (AF):	-5.6E-04	-7.7E-05	-3.9E-05	-9.0E-05	-1.3E-03	-9.3E-05	-1.8E-04	-1.4E-04
Increased number of cases in population:	-0.071	-0.0126	-0.0028	-0.0099	-0.064	-0.0028	-0.00196	-0.00220
Risk:	-5.7E-06	-7.1E-06	-1.6E-06	-4.6E-07	-5.1E-06	-1.3E-07	-9.0E-08	-1.7E-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	-730.14	-730.14	-730.14	-730.14	-730.14	-730.14	-730.14	-730.14
Population weighted Δx (µg/m^3):	-0.07404369	-0.07404369	-0.07404369	-0.07404369	-0.07404369	-0.07404369	-0.07404369	-0.07404369
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:	0.999571	0.999941	0.999970	0.999930	0.999038	0.999928	0.999859	0.999890
Attributable fraction (AF):	-4.3E-04	-5.9E-05	-3.0E-05	-7.0E-05	-9.6E-04	-7.2E-05	-1.4E-04	-1.1E-04
Increased number of cases in population:	-0.02503	-0.004423	-0.000977	-0.003487	-0.02254	-0.000984	-0.000685	-0.000771
Risk:	-4.4E-06	-5.5E-06	-1.2E-06	-3.5E-07	-4.0E-06	-1.0E-07	-6.9E-08	-1.3E-06
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	-2278.5	-2278.5	-2278.5	-2278.5	-2278.5	-2278.5	-2278.5	-2278.5
Population weighted Δx (µg/m^3):	-0.14513725	-0.14513725	-0.14513725	-0.14513725	-0.14513725	-0.14513725	-0.14513725	-0.14513725
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:	0.999159	0.999884	0.999940	0.999864	0.998115	0.999859	0.999724	0.999785
Attributable fraction (AF):	-8.4E-04	-1.2E-04	-6.0E-05	-1.4E-04	-1.9E-03	-1.4E-04	-2.8E-04	-2.1E-04
Increased number of cases in population:	-0.078	-0.0138	-0.00305	-0.0109	-0.070	-0.00307	-0.00214	-0.00241
Risk:	-8.6E-06	-1.1E-05	-2.4E-06	-6.9E-07	-7.8E-06	-2.0E-07	-1.4E-07	-2.6E-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	-3116.3	-3116.3	-3116.3	-3116.3	-3116.3	-3116.3	-3116.3	-3116.3
Population weighted Δx (µg/m^3):	-0.11370418	-0.11370418	-0.11370418	-0.11370418	-0.11370418	-0.11370418	-0.11370418	-0.11370418
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:	0.999341	0.999909	0.999953	0.999893	0.998523	0.999890	0.999784	0.999832
Attributable fraction (AF):	-6.6E-04	-9.1E-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:	-0.1069	-0.0189	-0.00417	-0.0149	-0.0962	-0.00420	-0.00293	-0.00329
Risk:	-6.8E-06	-8.4E-06	-1.9E-06	-5.4E-07	-6.1E-06	-1.5E-07	-1.1E-07	-2.0E-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	-2686.6	-2686.6	-2686.6	-2686.6	-2686.6	-2686.6	-2686.6	-2686.6
Population weighted Δx (µg/m^3):	-0.02599348	-0.02599348	-0.02599348	-0.02599348	-0.02599348	-0.02599348	-0.02599348	-0.02599348
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:	0.999849	0.999979	0.999989	0.999976	0.999662	0.999975	0.999951	0.999962
Attributable fraction (AF):	-1.5E-04	-2.1E-05	-1.1E-05	-2.4E-05	-3.4E-04	-2.5E-05	-4.9E-05	-3.8E-05
Increased number of cases in population:	-0.10	-0.027	-0.0060	-0.010	-0.090	-0.0030	-0.0025	-0.0082
Risk:	-1.5E-06	-1.9E-06	-4.2E-07	-9.8E-08	-1.4E-06	-2.9E-08	-2.4E-08	-4.7E-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	-1040.3	-1040.3	-1040.3	-1040.3	-1040.3	-1040.3	-1040.3	-1040.3
Population weighted Δx (µg/m^3):	-0.03633381	-0.03633381	-0.03633381	-0.03633381	-0.03633381	-0.03633381	-0.03633381	-0.03633381
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999789	0.999971	0.999985	0.999966	0.999528	0.999965	0.999931	0.999946
Attributable fraction (AF):	-2.1E-04	-2.9E-05	-1.5E-05	-3.4E-05	-4.7E-04	-3.5E-05	-6.9E-05	-5.4E-05
Increased number of cases in population:	-0.0387	-0.0105	-0.0023	-0.0039	-0.0348	-0.0011	-0.0010	-0.0032
Risk:	-2.2E-06	-2.7E-06	-5.9E-07	-1.4E-07	-1.9E-06	-4.0E-08	-3.4E-08	-6.5E-07
Chatswood West - Lane Cove North								
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	-436.49	-436.49	-436.49	-436.49	-436.49	-436.49	-436.49	-436.49
Population weighted Δx ($\mu g/m^3$):	-0.02373131	-0.02373131	-0.02373131	-0.02373131	-0.02373131	-0.02373131	-0.02373131	-0.02373131
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	0.999692	0.999977	0.999955	0.999965
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:	-0.0162	-0.0044	-0.0010	-0.0016	-0.0146	-0.0005	-0.0004	-0.0013
Risk:	-1.4E-06	-1.8E-06	-3.9E-07	-9.0E-08	-1.3E-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	-151.68	-151.68	-151.68	-151.68	-151.68	-151.68	-151.68	-151.68
Population weighted Δx ($\mu g/m^3$):	-0.00743478	-0.00743478	-0.00743478	-0.00743478	-0.00743478	-0.00743478	-0.00743478	-0.00743478
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:	0.999957	0.999994	0.999997	0.999993	0.999903	0.999993	0.999986	0.999989
Attributable fraction (AF):	-4.3E-05	-5.9E-06	-3.0E-06	-7.0E-06	-9.7E-05	-7.2E-06	-1.4E-05	-1.1E-05
Increased number of cases in population:	-0.0056	-0.0015	-0.0003	-0.0006	-0.0051	-0.00017	-0.00014	-0.0005
Risk:	-4.4E-07	-5.5E-07	-1.2E-07	-2.8E-08	-4.0E-07	-8.2E-09	-7.0E-09	-1.3E-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	-328.82	-328.82	-328.82	-328.82	-328.82	-328.82	-328.82	-328.82
Population weighted Δx ($\mu g/m^3$):	-0.03138168	-0.03138168	-0.03138168	-0.03138168	-0.03138168	-0.03138168	-0.03138168	-0.03138168
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:	0.999818	0.999975	0.999987	0.999971	0.999592	0.999970	0.999940	0.999954
Attributable fraction (AF):	-1.8E-04	-2.5E-05	-1.3E-05	-2.9E-05	-4.1E-04	-3.0E-05	-6.0E-05	-4.6E-05
Increased number of cases in population:	-0.0122	-0.0033	-0.00073	-0.00124	-0.0110	-0.00036	-0.00031	-0.00101
Risk:	-1.9E-06	-2.3E-06	-5.1E-07	-1.2E-07	-1.7E-06	-3.4E-08	-2.9E-08	-5.6E-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	-729.30	-729.30	-729.30	-729.30	-729.30	-729.30	-729.30	-729.30
Population weighted Δx ($\mu g/m^3$):	-0.02865391	-0.02865391	-0.02865391	-0.02865391	-0.02865391	-0.02865391	-0.02865391	-0.02865391
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:	0.999834	0.999977	0.999988	0.999973	0.999628	0.999972	0.999946	0.999958
Attributable fraction (AF):	-1.7E-04	-2.3E-05	-1.2E-05	-2.7E-05	-3.7E-04	-2.8E-05	-5.4E-05	-4.2E-05
Increased number of cases in population:	-0.0271	-0.0074	-0.0016	-0.0028	-0.0244	-0.0008	-0.0007	-0.0022
Risk:	-1.7E-06	-2.1E-06	-4.7E-07	-1.1E-07	-1.5E-06	-3.1E-08	-2.7E-08	-5.1E-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	17.229	17.229	17.229	17.229	17.229	17.229	17.229	17.229
Population weighted Δx ($\mu g/m^3$):	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998
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:	1.000044	1.000006	1.000003	1.000007	1.000099	1.000007	1.000014	1.000011
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	7.2E-09	1.4E-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	17.229	17.229	17.229	17.229	17.229	17.229	17.229	17.229
Population weighted Δx ($\mu g/m^3$):	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998	0.00762998
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:	1.000044	1.000006	1.000003	1.000007	1.000099	1.000007	1.000014	1.000011
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	7.2E-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	-1296.6	-1296.6	-1296.6	-1296.6	-1296.6	-1296.6	-1296.6	-1296.6
Population weighted Δx ($\mu g/m^3$):	-0.01804873	-0.01804873	-0.01804873	-0.01804873	-0.01804873	-0.01804873	-0.01804873	-0.01804873
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:	0.999895	0.999986	0.999993	0.999983	0.999765	0.999982	0.999966	0.999973
Attributable fraction (AF):	-1.0E-04	-1.4E-05	-7.4E-06	-1.7E-05	-2.3E-04	-1.8E-05	-3.4E-05	-2.7E-05
Increased number of cases in population:	-0.051	-0.018	-0.0039	-0.0048	-0.046	-0.0014	-0.0012	-0.0034
Risk:	-1.1E-06	-1.3E-06	-2.9E-07	-6.7E-08	-9.7E-07	-1.9E-08	-1.7E-08	-3.2E-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	4.1047	4.1047	4.1047	4.1047	4.1047	4.1047	4.1047	4.1047
Population weighted Δx ($\mu g/m^3$):	0.00187942	0.00187942	0.00187942	0.00187942	0.00187942	0.00187942	0.00187942	0.00187942
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00396	0.00412	0.00111	0.00049	0.01209
Relative Risk:	1.000011	1.000002	1.000001	1.000002	1.000024	1.000002	1.000004	1.000003
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:	0.00016	0.000056	0.000012	0.000015	0.00014	0.0000044	0.0000039	0.000011
Risk:	1.1E-07	1.4E-07	3.1E-08	7.0E-09	1.0E-07	2.0E-09	1.8E-09	3.4E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-141.43	-141.43	-141.43	-141.43	-141.43	-141.43	-141.43	-141.43
Population weighted Δx (µg/m^3):	-0.01196655	-0.01196655	-0.01196655	-0.01196655	-0.01196655	-0.01196655	-0.01196655	-0.01196655
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:	0.999931	0.999990	0.999995	0.999989	0.999844	0.999988	0.999977	0.999982
Attributable fraction (AF):	-6.9E-05	-9.6E-06	-4.9E-06	-1.1E-05	-1.6E-04	-1.2E-05	-2.3E-05	-1.8E-05
Increased number of cases in population:	-0.0055	-0.0019	-0.00043	-0.00053	-0.0050	-0.000152	-0.000133	-0.00037
Risk:	-7.1E-07	-8.8E-07	-2.0E-07	-4.5E-08	-6.4E-07	-1.3E-08	-1.1E-08	-2.1E-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	14.008	14.008	14.008	14.008	14.008	14.008	14.008	14.008
Population weighted Δx (µg/m^3):	0.00736084	0.00736084	0.00736084	0.00736084	0.00736084	0.00736084	0.00736084	0.00736084
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:	1.000043	1.000006	1.000003	1.000007	1.000096	1.000007	1.000014	1.000011
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:	0.0005	0.00019	0.00004	0.00005	0.0005	0.000015	0.000013	0.00004
Risk:	4.4E-07	5.4E-07	1.2E-07	2.7E-08	3.9E-07	7.9E-09	6.9E-09	1.3E-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	-229.61	-229.61	-229.61	-229.61	-229.61	-229.61	-229.61	-229.61
Population weighted Δx (µg/m^3):	-0.00925918	-0.00925918	-0.00925918	-0.00925918	-0.00925918	-0.00925918	-0.00925918	-0.00925918
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:	0.999946	0.999993	0.999996	0.999991	0.999880	0.999991	0.999982	0.999986
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:	-0.0090	-0.00316	-0.00070	-0.00085	-0.0081	-0.000246	-0.000216	-0.000596
Risk:	-5.5E-07	-6.8E-07	-1.5E-07	-3.4E-08	-5.0E-07	-9.9E-09	-8.7E-09	-1.7E-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	-46.944	-46.944	-46.944	-46.944	-46.944	-46.944	-46.944	-46.944
Population weighted Δx (µg/m^3):	-0.01476694	-0.01476694	-0.01476694	-0.01476694	-0.01476694	-0.01476694	-0.01476694	-0.01476694
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:	0.999914	0.999988	0.999994	0.999986	0.999808	0.999986	0.999972	0.999978
Attributable fraction (AF):	-8.6E-05	-1.2E-05	-6.1E-06	-1.4E-05	-1.9E-04	-1.4E-05	-2.8E-05	-2.2E-05
Increased number of cases in population:	-0.0018	-0.00065	-0.00014	-0.00017	-0.0016	-0.000050	-0.000044	-0.00012
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
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	-684.72	-684.72	-684.72	-684.72	-684.72	-684.72	-684.72	-684.72
Population weighted Δx (µg/m^3):	-0.05144023	-0.05144023	-0.05144023	-0.05144023	-0.05144023	-0.05144023	-0.05144023	-0.05144023
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:	0.999702	0.999959	0.999979	0.999952	0.999332	0.999950	0.999902	0.999924
Attributable fraction (AF):	-3.0E-04	-4.1E-05	-2.1E-05	-4.8E-05	-6.7E-04	-5.0E-05	-9.8E-05	-7.6E-05
Increased number of cases in population:	-0.02673	-0.00941	-0.002077	-0.002549	-0.02407	-0.000734	-0.000643	-0.001777
Risk:	-3.1E-06	-3.8E-06	-8.4E-07	-1.9E-07	-2.8E-06	-5.5E-08	-4.8E-08	-9.2E-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	-85.866	-85.866	-85.866	-85.866	-85.866	-85.866	-85.866	-85.866
Population weighted Δx (µg/m^3):	-0.01229461	-0.01229461	-0.01229461	-0.01229461	-0.01229461	-0.01229461	-0.01229461	-0.01229461
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:	0.999929	0.999990	0.999995	0.999988	0.999840	0.999988	0.999977	0.999982
Attributable fraction (AF):	-7.1E-05	-9.8E-06	-5.0E-06	-1.2E-05	-1.6E-04	-1.2E-05	-2.3E-05	-1.8E-05
Increased number of cases in population:	-0.00335	-0.00118	-0.000260	-0.000320	-0.00302	-0.000092	-0.000081	-0.000223
Risk:	-7.3E-07	-9.1E-07	-2.0E-07	-4.6E-08	-6.6E-07	-1.3E-08	-1.2E-08	-2.2E-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	-126.18	-126.18	-126.18	-126.18	-126.18	-126.18	-126.18	-126.18
Population weighted Δx (µg/m^3):	-0.01646594	-0.01646594	-0.01646594	-0.01646594	-0.01646594	-0.01646594	-0.01646594	-0.01646594
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:	0.999905	0.999987	0.999993	0.999985	0.999786	0.999984	0.999969	0.999976
Attributable fraction (AF):	-9.6E-05	-1.3E-05	-6.8E-06	-1.5E-05	-2.1E-04	-1.6E-05	-3.1E-05	-2.4E-05
Increased number of cases in population:	-0.00493	-0.00173	-0.000383	-0.000470	-0.00443	-0.000135	-0.000118	-0.000327
Risk:	-9.8E-07	-1.2E-06	-2.7E-07	-6.1E-08	-8.8E-07	-1.8E-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	-293.92	-293.92	-293.92	-293.92	-293.92	-293.92	-293.92	-293.92
Population weighted Δx (µg/m^3):	-0.00339030	-0.00339030	-0.00339030	-0.00339030	-0.00339030	-0.00339030	-0.00339030	-0.00339030
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:	0.999980	0.999997	0.999999	0.999997	0.999956	0.999997	0.999994	0.999995

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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):	-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:	-0.011	-0.0036	-0.00081	-0.0013	-0.010	-0.00036	-0.00028	-0.00098
Risk:	-2.0E-07	-2.5E-07	-5.5E-08	-1.5E-08	-1.8E-07	-4.2E-09	-3.2E-09	-6.1E-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	-171.82	-171.82	-171.82	-171.82	-171.82	-171.82	-171.82	-171.82
Population weighted Δx (μg/m^3):	-0.00849998	-0.00849998	-0.00849998	-0.00849998	-0.00849998	-0.00849998	-0.00849998	-0.00849998
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:	-0.0066	-0.0021	-0.00047	-0.00075	-0.0059	-0.00021	-0.00016	-0.00057
Risk:	-5.1E-07	-6.3E-07	-1.4E-07	-3.7E-08	-4.6E-07	-1.1E-08	-8.0E-09	-1.5E-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	-72.288	-72.288	-72.288	-72.288	-72.288	-72.288	-72.288	-72.288
Population weighted Δx (μg/m^3):	-0.00566652	-0.00566652	-0.00566652	-0.00566652	-0.00566652	-0.00566652	-0.00566652	-0.00566652
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:	0.999967	0.999995	0.999998	0.999995	0.999926	0.999995	0.999989	0.999992
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:	-0.0028	-0.0009	-0.00020	-0.00031	-0.0025	-0.00009	-0.00007	-0.00024
Risk:	-3.4E-07	-4.2E-07	-9.2E-08	-2.5E-08	-3.0E-07	-7.0E-09	-5.3E-09	-1.0E-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	0.26148	0.26148	0.26148	0.26148	0.26148	0.26148	0.26148	0.26148
Population weighted Δx (μg/m^3):	0.00114684	0.00114684	0.00114684	0.00114684	0.00114684	0.00114684	0.00114684	0.00114684
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:	1.000007	1.000001	1.000000	1.000001	1.000015	1.000001	1.000002	1.000002
Attributable fraction (AF):	6.7E-06	9.2E-07	4.7E-07	1.1E-06	1.5E-05	1.1E-06	2.2E-06	1.7E-06
Increased number of cases in population:	0.000010	0.000003	0.00000072	0.0000011	0.0000090	0.00000032	0.00000025	0.00000087
Risk:	6.8E-08	8.5E-08	1.9E-08	5.0E-09	6.1E-08	1.4E-09	1.1E-09	2.1E-08
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	-504.07	-504.07	-504.07	-504.07	-504.07	-504.07	-504.07	-504.07
Population weighted Δx (μg/m^3):	-0.03934033	-0.03934033	-0.03934033	-0.03934033	-0.03934033	-0.03934033	-0.03934033	-0.03934033
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:	0.999772	0.999969	0.999984	0.999963	0.999489	0.999962	0.999925	0.999942
Attributable fraction (AF):	-2.3E-04	-3.1E-05	-1.6E-05	-3.7E-05	-5.1E-04	-3.8E-05	-7.5E-05	-5.8E-05
Increased number of cases in population:	-0.0193	-0.0063	-0.00138	-0.00219	-0.0174	-0.00062	-0.00047	-0.00168
Risk:	-2.3E-06	-2.9E-06	-6.4E-07	-1.7E-07	-2.1E-06	-4.9E-08	-3.7E-08	-7.0E-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	8.4834	8.4834	8.4834	8.4834	8.4834	8.4834	8.4834	8.4834
Population weighted Δx (μg/m^3):	0.00083506	0.00083506	0.00083506	0.00083506	0.00083506	0.00083506	0.00083506	0.00083506
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	1.000011	1.000001	1.000002	1.000001
Attributable fraction (AF):	4.8E-06	6.7E-07	3.4E-07	7.8E-07	1.1E-05	8.1E-07	1.6E-06	1.2E-06
Increased number of cases in population:	0.00032	0.00011	0.000023	0.000037	0.00029	0.000010	0.0000080	0.000028
Risk:	5.0E-08	6.2E-08	1.4E-08	3.6E-09	4.5E-08	1.0E-09	7.8E-10	1.5E-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	-15.061	-15.061	-15.061	-15.061	-15.061	-15.061	-15.061	-15.061
Population weighted Δx (μg/m^3):	-0.00187161	-0.00187161	-0.00187161	-0.00187161	-0.00187161	-0.00187161	-0.00187161	-0.00187161
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	0.999999	0.999999	0.999998	0.999976	0.999998	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:	-0.0006	-0.0002	-0.00004	-0.00007	-0.0005	-0.00002	-0.000014	-0.00005
Risk:	-1.1E-07	-1.4E-07	-3.1E-08	-8.1E-09	-1.0E-07	-2.3E-09	-1.8E-09	-3.3E-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	-30.637	-30.637	-30.637	-30.637	-30.637	-30.637	-30.637	-30.637
Population weighted Δx (μg/m^3):	-0.00549442	-0.00549442	-0.00549442	-0.00549442	-0.00549442	-0.00549442	-0.00549442	-0.00549442
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:	0.999968	0.999996	0.999998	0.999995	0.999929	0.999995	0.999990	0.999992
Attributable fraction (AF):	-3.2E-05	-4.4E-06	-2.3E-06	-5.2E-06	-7.1E-05	-5.3E-06	-1.0E-05	-8.1E-06
Increased number of cases in population:	-0.001172	-0.000380	-0.000084	-0.000133	-0.001055	-0.000038	-0.000029	-0.000102
Risk:	-3.3E-07	-4.1E-07	-9.0E-08	-2.4E-08	-2.9E-07	-6.8E-09	-5.2E-09	-9.8E-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	491.21	491.21	491.21	491.21	491.21	491.21	491.21	491.21
Population weighted Δx (μg/m^3):	0.02906559	0.02906559	0.02906559	0.02906559	0.02906559	0.02906559	0.02906559	0.02906559
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:	1.000169	1.000023	1.000012	1.000027	1.000378	1.000028	1.000055	1.000043
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.5E-05	4.3E-05
Increased number of cases in population:	0.0188	0.0061	0.00135	0.00213	0.0169	0.00061	0.00046	0.00163

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Risk:	1.7E-06	2.1E-06	4.7E-07	1.3E-07	1.6E-06	3.6E-08	2.7E-08	5.2E-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	-540.72	-540.72	-540.72	-540.72	-540.72	-540.72	-540.72	-540.72
Population weighted Δx (μg/m^3):	-0.01679631	-0.01679631	-0.01679631	-0.01679631	-0.01679631	-0.01679631	-0.01679631	-0.01679631
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:	0.999903	0.999987	0.999993	0.999984	0.999782	0.999984	0.999968	0.999975
Attributable fraction (AF):	-9.7E-05	-1.3E-05	-6.9E-06	-1.6E-05	-2.2E-04	-1.6E-05	-3.2E-05	-2.5E-05
Increased number of cases in population:	-0.020	-0.0073	-0.0016	-0.0019	-0.018	-0.00056	-0.00051	-0.0019
Risk:	-1.0E-06	-1.2E-06	-2.7E-07	-5.8E-08	-9.0E-07	-1.8E-08	-1.6E-08	-3.0E-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	-52.408	-52.408	-52.408	-52.408	-52.408	-52.408	-52.408	-52.408
Population weighted Δx (μg/m^3):	-0.00534179	-0.00534179	-0.00534179	-0.00534179	-0.00534179	-0.00534179	-0.00534179	-0.00534179
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:	0.999969	0.999996	0.999998	0.999995	0.999931	0.999995	0.999990	0.999992
Attributable fraction (AF):	-3.1E-05	-4.3E-06	-2.2E-06	-5.0E-06	-6.9E-05	-5.2E-06	-1.0E-05	-7.9E-06
Increased number of cases in population:	-0.0019	-0.0007	-0.00016	-0.00018	-0.0018	-0.00005	-0.00005	-0.00018
Risk:	-3.2E-07	-3.9E-07	-8.7E-08	-1.8E-08	-2.9E-07	-5.6E-09	-5.0E-09	-9.6E-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	-481.76	-481.76	-481.76	-481.76	-481.76	-481.76	-481.76	-481.76
Population weighted Δx (μg/m^3):	-0.02257210	-0.02257210	-0.02257210	-0.02257210	-0.02257210	-0.02257210	-0.02257210	-0.02257210
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:	0.999869	0.999982	0.999991	0.999979	0.999707	0.999978	0.999957	0.999967
Attributable fraction (AF):	-1.3E-04	-1.8E-05	-9.3E-06	-2.1E-05	-2.9E-04	-2.2E-05	-4.3E-05	-3.3E-05
Increased number of cases in population:	-0.0179	-0.0065	-0.00143	-0.00165	-0.0161	-0.00050	-0.00045	-0.00167
Risk:	-1.3E-06	-1.7E-06	-3.7E-07	-7.7E-08	-1.2E-06	-2.4E-08	-2.1E-08	-4.0E-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	-6.5591	-6.5591	-6.5591	-6.5591	-6.5591	-6.5591	-6.5591	-6.5591
Population weighted Δx (μg/m^3):	-0.00631286	-0.00631286	-0.00631286	-0.00631286	-0.00631286	-0.00631286	-0.00631286	-0.00631286
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:	0.999963	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:	-0.000244	-0.000088	-0.000019	-0.000022	-0.000220	-0.000007	-0.000006	-0.000023
Risk:	-3.8E-07	-4.7E-07	-1.0E-07	-2.2E-08	-3.4E-07	-6.6E-09	-5.9E-09	-1.1E-07
Total population incidence - All Suburbs	**-1.3**	**-0.31**	**-0.068**	**-0.15**	**-1.1**	**-0.042**	**-0.033**	**-0.063**

Assessment of Increased Incidence - $PM_{2.5}$
Beaches Link: 2037 Cumulative

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
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	23.62	23.62	23.62	23.62	23.62	23.62	23.62	23.62
Population weighted Δx (µg/m³):	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200
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:	1.000059	1.000008	1.000004	1.000010	1.000132	1.000010	1.000019	1.000015
Attributable fraction (AF):	5.9E-05	8.1E-06	4.2E-06	9.5E-06	1.3E-04	9.8E-06	1.9E-05	1.5E-05
Increased number of cases in population:	0.00088	0.00026	0.000057	0.000090	0.00079	0.000026	0.000022	0.000063
Risk:	6.0E-07	7.5E-07	1.7E-07	3.8E-08	5.4E-07	1.1E-08	9.5E-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	23.62	23.62	23.62	23.62	23.62	23.62	23.62	23.62
Population weighted Δx (µg/m³):	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200	0.01012200
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:	1.000059	1.000008	1.000004	1.000010	1.000132	1.000010	1.000019	1.000015
Attributable fraction (AF):	5.9E-05	8.1E-06	4.2E-06	9.5E-06	1.3E-04	9.8E-06	1.9E-05	1.5E-05
Increased number of cases in population:	0.0009	0.00026	0.000057	0.00009	0.0008	0.000026	0.000022	0.00006
Risk:	6.0E-07	7.5E-07	1.7E-07	3.8E-08	5.4E-07	1.1E-08	9.5E-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	-8783.3	-8783.3	-8783.3	-8783.3	-8783.3	-8783.3	-8783.3	-8783.3
Population weighted Δx (µg/m³):	-0.09329173	-0.09329173	-0.09329173	-0.09329173	-0.09329173	-0.09329173	-0.09329173	-0.09329173
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:	0.999459	0.999925	0.999962	0.999912	0.998788	0.999910	0.999823	0.999862
Attributable fraction (AF):	-5.4E-04	-7.5E-05	-3.8E-05	-8.8E-05	-1.2E-03	-9.0E-05	-1.8E-04	-1.4E-04
Increased number of cases in population:	-0.35	-0.12	-0.027	-0.028	-0.32	-0.0084	-0.0082	-0.026
Risk:	-5.6E-06	-6.9E-06	-1.5E-06	-2.9E-07	-5.0E-06	-8.9E-08	-8.8E-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	-1232.4	-1232.4	-1232.4	-1232.4	-1232.4	-1232.4	-1232.4	-1232.4
Population weighted Δx (µg/m³):	-0.06470784	-0.06470784	-0.06470784	-0.06470784	-0.06470784	-0.06470784	-0.06470784	-0.06470784
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:	0.999625	0.999948	0.999973	0.999939	0.999159	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:	-0.0492	-0.0174	-0.0038	-0.0039	-0.0443	-0.0012	-0.0012	-0.0037
Risk:	-3.9E-06	-4.8E-06	-1.1E-06	-2.0E-07	-3.5E-06	-6.2E-08	-6.1E-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	30.811	30.811	30.811	30.811	30.811	30.811	30.811	30.811
Population weighted Δx (µg/m³):	0.00170574	0.00170574	0.00170574	0.00170574	0.00170574	0.00170574	0.00170574	0.00170574
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:	1.000010	1.000001	1.000001	1.000002	1.000022	1.000002	1.000003	1.000003
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:	0.0013	0.0003	0.000072	0.00010	0.0011	0.000029	0.000029	0.000062
Risk:	1.0E-07	1.3E-07	2.8E-08	5.4E-09	9.1E-08	1.6E-09	1.6E-09	3.1E-08
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	-2358.9	-2358.9	-2358.9	-2358.9	-2358.9	-2358.9	-2358.9	-2358.9
Population weighted Δx (µg/m³):	-0.08287952	-0.08287952	-0.08287952	-0.08287952	-0.08287952	-0.08287952	-0.08287952	-0.08287952
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:	0.999519	0.999934	0.999966	0.999922	0.998923	0.999920	0.999843	0.999877
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:	-0.0942	-0.0333	-0.0073	-0.0074	-0.0848	-0.0023	-0.0022	-0.0070
Risk:	-4.9E-06	-6.1E-06	-1.4E-06	-2.6E-07	-4.4E-06	-7.9E-08	-7.8E-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	-3845.9	-3845.9	-3845.9	-3845.9	-3845.9	-3845.9	-3845.9	-3845.9
Population weighted Δx (µg/m³):	-0.21486409	-0.21486409	-0.21486409	-0.21486409	-0.21486409	-0.21486409	-0.21486409	-0.21486409
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:	0.998755	0.999828	0.999912	0.999798	0.997211	0.999792	0.999592	0.999682
Attributable fraction (AF):	-1.2E-03	-1.7E-04	-8.8E-05	-2.0E-04	-2.8E-03	-2.1E-04	-4.1E-04	-3.2E-04
Increased number of cases in population:	-0.1566	-0.0409	-0.0090	-0.0121	-0.1411	-0.0037	-0.0036	-0.0077
Risk:	-1.3E-05	-1.6E-05	-3.5E-06	-6.8E-07	-1.2E-05	-2.1E-07	-2.0E-07	-3.8E-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	-1377.0	-1377.0	-1377.0	-1377.0	-1377.0	-1377.0	-1377.0	-1377.0
Population weighted Δx (µg/m³):	-0.12893295	-0.12893295	-0.12893295	-0.12893295	-0.12893295	-0.12893295	-0.12893295	-0.12893295
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999252	0.999897	0.999947	0.999879	0.998325	0.999875	0.999755	0.999809
Attributable fraction (AF):	-7.5E-04	-1.0E-04	-5.3E-05	-1.2E-04	-1.7E-03	-1.3E-04	-2.5E-04	-1.9E-04
Increased number of cases in population:	-0.0561	-0.0147	-0.0032	-0.0043	-0.0505	-0.0013	-0.0013	-0.0028
Risk:	-7.7E-06	-9.5E-06	-2.1E-06	-4.1E-07	-6.9E-06	-1.2E-07	-1.2E-07	-2.3E-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	450.35	450.35	450.35	450.35	450.35	450.35	450.35	450.35
Population weighted Δx (µg/m^3):	0.00932344	0.00932344	0.00932344	0.00932344	0.00932344	0.00932344	0.00932344	0.00932344
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	7.5E-06	3.8E-06	8.8E-06	1.2E-04	9.0E-06	1.8E-05	1.4E-05
Increased number of cases in population:	0.017	0.0041	0.00090	0.0023	0.015	0.00064	0.00042	0.0011
Risk:	5.5E-07	6.9E-07	1.5E-07	4.7E-08	5.0E-07	1.3E-08	8.8E-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	-263.24	-263.24	-263.24	-263.24	-263.24	-263.24	-263.24	-263.24
Population weighted Δx (µg/m^3):	-0.01677411	-0.01677411	-0.01677411	-0.01677411	-0.01677411	-0.01677411	-0.01677411	-0.01677411
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:	0.999903	0.999987	0.999993	0.999984	0.999782	0.999984	0.999968	0.999975
Attributable fraction (AF):	-9.7E-05	-1.3E-05	-6.9E-06	-1.6E-05	-2.2E-04	-1.6E-05	-3.2E-05	-2.5E-05
Increased number of cases in population:	-0.0100	-0.00237	-0.000524	-0.00132	-0.0090	-0.000374	-0.000247	-0.000664
Risk:	-1.0E-06	-1.2E-06	-2.7E-07	-8.4E-08	-9.0E-07	-2.4E-08	-1.6E-08	-3.0E-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	535.01	535.01	535.01	535.01	535.01	535.01	535.01	535.01
Population weighted Δx (µg/m^3):	0.03050037	0.03050037	0.03050037	0.03050037	0.03050037	0.03050037	0.03050037	0.03050037
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:	1.000177	1.000024	1.000013	1.000029	1.000397	1.000030	1.000058	1.000045
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:	0.020	0.005	0.0011	0.003	0.018	0.0008	0.0005	0.0013
Risk:	1.8E-06	2.3E-06	5.0E-07	1.5E-07	1.6E-06	4.3E-08	2.9E-08	5.5E-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	178.58	178.58	178.58	178.58	178.58	178.58	178.58	178.58
Population weighted Δx (µg/m^3):	0.01423056	0.01423056	0.01423056	0.01423056	0.01423056	0.01423056	0.01423056	0.01423056
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:	1.000083	1.000011	1.000006	1.000013	1.000185	1.000014	1.000027	1.000021
Attributable fraction (AF):	8.3E-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:	0.007	0.002	0.0004	0.0009	0.006	0.0003	0.0002	0.0005
Risk:	8.5E-07	1.1E-06	2.3E-07	7.1E-08	7.6E-07	2.0E-08	1.3E-08	2.5E-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	31.107	31.107	31.107	31.107	31.107	31.107	31.107	31.107
Population weighted Δx (µg/m^3):	0.01234389	0.01234389	0.01234389	0.01234389	0.01234389	0.01234389	0.01234389	0.01234389
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:	1.000072	1.000010	1.000005	1.000012	1.000160	1.000012	1.000023	1.000018
Attributable fraction (AF):	7.2E-05	9.9E-06	5.1E-06	1.2E-05	1.6E-04	1.2E-05	2.3E-05	1.8E-05
Increased number of cases in population:	0.001181	0.000280	0.000062	0.000156	0.001063	0.000044	0.000029	0.000078
Risk:	7.3E-07	9.1E-07	2.0E-07	6.2E-08	6.6E-07	1.8E-08	1.2E-08	2.2E-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	-17249	-17249	-17249	-17249	-17249	-17249	-17249	-17249
Population weighted Δx (µg/m^3):	-0.13073870	-0.13073870	-0.13073870	-0.13073870	-0.13073870	-0.13073870	-0.13073870	-0.13073870
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:	0.999242	0.999895	0.999946	0.999877	0.998302	0.999873	0.999752	0.999807
Attributable fraction (AF):	-7.6E-04	-1.0E-04	-5.4E-05	-1.2E-04	-1.7E-03	-1.3E-04	-2.5E-04	-1.9E-04
Increased number of cases in population:	-0.59	-0.10	-0.023	-0.082	-0.53	-0.023	-0.016	-0.018
Risk:	-7.8E-06	-9.7E-06	-2.1E-06	-6.2E-07	-7.0E-06	-1.8E-07	-1.2E-07	-2.3E-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	-1284.7	-1284.7	-1284.7	-1284.7	-1284.7	-1284.7	-1284.7	-1284.7
Population weighted Δx (µg/m^3):	-0.11315334	-0.11315334	-0.11315334	-0.11315334	-0.11315334	-0.11315334	-0.11315334	-0.11315334
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:	0.999344	0.999909	0.999954	0.999894	0.998530	0.999890	0.999785	0.999833
Attributable fraction (AF):	-6.6E-04	-9.1E-05	-4.6E-05	-1.1E-04	-1.5E-03	-1.1E-04	-2.2E-04	-1.7E-04
Increased number of cases in population:	-0.044	-0.0078	-0.00172	-0.0061	-0.040	-0.00173	-0.00121	-0.00136
Risk:	-6.7E-06	-8.4E-06	-1.8E-06	-5.4E-07	-6.1E-06	-1.5E-07	-1.1E-07	-2.0E-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	-638.12	-638.12	-638.12	-638.12	-638.12	-638.12	-638.12	-638.12
Population weighted Δx (µg/m^3):	-0.03256898	-0.03256898	-0.03256898	-0.03256898	-0.03256898	-0.03256898	-0.03256898	-0.03256898
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	508.0	412.0	138.9	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Baseline Incidence (per person)	0.01026	0.09235	0.03978	0.00508	0.00412	0.00139	0.00049	0.01209
Relative Risk:	0.999811	0.999974	0.999987	0.999969	0.999577	0.999968	0.999938	0.999952
Attributable fraction (AF):	-1.9E-04	-2.6E-05	-1.3E-05	-3.1E-05	-4.2E-04	-3.2E-05	-6.2E-05	-4.8E-05
Increased number of cases in population:	-0.022	-0.0039	-0.00085	-0.0030	-0.020	-0.00086	-0.00060	-0.00067
Risk:	-1.9E-06	-2.4E-06	-5.3E-07	-1.6E-07	-1.7E-06	-4.4E-08	-3.1E-08	-5.8E-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	-25.486	-25.486	-25.486	-25.486	-25.486	-25.486	-25.486	-25.486
Population weighted Δx (µg/m^3):	-0.00494495	-0.00494495	-0.00494495	-0.00494495	-0.00494495	-0.00494495	-0.00494495	-0.00494495
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:	0.999971	0.999996	0.999998	0.999995	0.999936	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.9E-05	-4.0E-06	-2.0E-06	-4.6E-06	-6.4E-05	-4.8E-06	-9.4E-06	-7.3E-06
Increased number of cases in population:	-0.00087	-0.00015	-0.000034	-0.00012	-0.00079	-0.000034	-0.000024	-0.000027
Risk:	-2.9E-07	-3.7E-07	-8.1E-08	-2.4E-08	-2.6E-07	-6.7E-09	-4.6E-09	-8.8E-08
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	-6623.4	-6623.4	-6623.4	-6623.4	-6623.4	-6623.4	-6623.4	-6623.4
Population weighted Δx (µg/m^3):	-0.31242395	-0.31242395	-0.31242395	-0.31242395	-0.31242395	-0.31242395	-0.31242395	-0.31242395
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:	0.998190	0.999750	0.999872	0.999706	0.995947	0.999697	0.999407	0.999538
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	-0.0089	-0.032	-0.205	-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	-2716.4	-2716.4	-2716.4	-2716.4	-2716.4	-2716.4	-2716.4	-2716.4
Population weighted Δx (µg/m^3):	-0.12538171	-0.12538171	-0.12538171	-0.12538171	-0.12538171	-0.12538171	-0.12538171	-0.12538171
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:	0.999273	0.999900	0.999949	0.999882	0.998371	0.999878	0.999762	0.999814
Attributable fraction (AF):	-7.3E-04	-1.0E-04	-5.1E-05	-1.2E-04	-1.6E-03	-1.2E-04	-2.4E-04	-1.9E-04
Increased number of cases in population:	-0.093	-0.0165	-0.0036	-0.0130	-0.084	-0.0037	-0.00255	-0.00287
Risk:	-7.5E-06	-9.3E-06	-2.0E-06	-6.0E-07	-6.7E-06	-1.7E-07	-1.2E-07	-2.2E-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	-271.71	-271.71	-271.71	-271.71	-271.71	-271.71	-271.71	-271.71
Population weighted Δx (µg/m^3):	-0.02755378	-0.02755378	-0.02755378	-0.02755378	-0.02755378	-0.02755378	-0.02755378	-0.02755378
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:	0.999840	0.999978	0.999989	0.999974	0.999642	0.999973	0.999948	0.999959
Attributable fraction (AF):	-1.6E-04	-2.2E-05	-1.1E-05	-2.6E-05	-3.6E-04	-2.7E-05	-5.2E-05	-4.1E-05
Increased number of cases in population:	-0.00931	-0.001646	-0.000363	-0.001297	-0.00838	-0.000366	-0.000255	-0.000287
Risk:	-1.6E-06	-2.0E-06	-4.5E-07	-1.3E-07	-1.5E-06	-3.7E-08	-2.6E-08	-4.9E-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	-1982.7	-1982.7	-1982.7	-1982.7	-1982.7	-1982.7	-1982.7	-1982.7
Population weighted Δx (µg/m^3):	-0.12629161	-0.12629161	-0.12629161	-0.12629161	-0.12629161	-0.12629161	-0.12629161	-0.12629161
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:	0.999268	0.999899	0.999948	0.999881	0.998360	0.999878	0.999760	0.999813
Attributable fraction (AF):	-7.3E-04	-1.0E-04	-5.2E-05	-1.2E-04	-1.6E-03	-1.2E-04	-2.4E-04	-1.9E-04
Increased number of cases in population:	-0.068	-0.0120	-0.00265	-0.0095	-0.061	-0.00267	-0.00186	-0.00209
Risk:	-7.5E-06	-9.3E-06	-2.1E-06	-6.0E-07	-6.8E-06	-1.7E-07	-1.2E-07	-2.3E-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	-3706.3	-3706.3	-3706.3	-3706.3	-3706.3	-3706.3	-3706.3	-3706.3
Population weighted Δx (µg/m^3):	-0.13523016	-0.13523016	-0.13523016	-0.13523016	-0.13523016	-0.13523016	-0.13523016	-0.13523016
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:	0.999216	0.999892	0.999945	0.999873	0.998244	0.999869	0.999743	0.999800
Attributable fraction (AF):	-7.8E-04	-1.1E-04	-5.5E-05	-1.3E-04	-1.8E-03	-1.3E-04	-2.6E-04	-2.0E-04
Increased number of cases in population:	-0.1271	-0.0225	-0.00496	-0.0177	-0.1144	-0.00499	-0.00348	-0.00391
Risk:	-8.0E-06	-1.0E-05	-2.2E-06	-6.5E-07	-7.2E-06	-1.8E-07	-1.3E-07	-2.4E-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	-1633.0	-1633.0	-1633.0	-1633.0	-1633.0	-1633.0	-1633.0	-1633.0
Population weighted Δx (µg/m^3):	-0.01579969	-0.01579969	-0.01579969	-0.01579969	-0.01579969	-0.01579969	-0.01579969	-0.01579969
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:	0.999908	0.999987	0.999994	0.999985	0.999795	0.999985	0.999970	0.999977
Attributable fraction (AF):	-9.2E-05	-1.3E-05	-6.5E-06	-1.5E-05	-2.1E-04	-1.5E-05	-3.0E-05	-2.3E-05
Increased number of cases in population:	-0.061	-0.017	-0.0036	-0.0062	-0.055	-0.0018	-0.0015	-0.0050
Risk:	-9.4E-07	-1.2E-06	-2.6E-07	-6.0E-08	-8.5E-07	-1.7E-08	-1.5E-08	-2.8E-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	-676.51	-676.51	-676.51	-676.51	-676.51	-676.51	-676.51	-676.51
Population weighted Δx (µg/m^3):	-0.02362850	-0.02362850	-0.02362850	-0.02362850	-0.02362850	-0.02362850	-0.02362850	-0.02362850
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

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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:	0.999863	0.999981	0.999990	0.999978	0.999693	0.999977	0.999955	0.999965
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:	-0.0252	-0.0068	-0.0015	-0.0026	-0.0226	-0.0007	-0.0006	-0.0021
Risk:	-1.4E-06	-1.7E-06	-3.9E-07	-8.9E-08	-1.3E-06	-2.6E-08	-2.2E-08	-4.2E-07
Chatswood West - Lane Cove North								
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	-369.14	-369.14	-369.14	-369.14	-369.14	-369.14	-369.14	-369.14
Population weighted Δx (μg/m^3):	-0.02006938	-0.02006938	-0.02006938	-0.02006938	-0.02006938	-0.02006938	-0.02006938	-0.02006938
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:	0.999884	0.999984	0.999992	0.999981	0.999739	0.999981	0.999962	0.999970
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:	-0.0137	-0.0037	-0.0008	-0.0014	-0.0124	-0.0004	-0.0003	-0.0011
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
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	-14.445	-14.445	-14.445	-14.445	-14.445	-14.445	-14.445	-14.445
Population weighted Δx (μg/m^3):	-0.00070807	-0.00070807	-0.00070807	-0.00070807	-0.00070807	-0.00070807	-0.00070807	-0.00070807
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:	0.999996	0.999999	1.000000	0.999999	0.999991	0.999999	0.999999	0.999999
Attributable fraction (AF):	-4.1E-06	-5.7E-07	-2.9E-07	-6.7E-07	-9.2E-06	-6.9E-07	-1.3E-06	-1.0E-06
Increased number of cases in population:	-0.0005	-0.00015	-0.000032	-0.000055	-0.00048	-0.000016	-0.000014	-0.000044
Risk:	-4.2E-08	-5.2E-08	-1.2E-08	-2.7E-09	-3.8E-08	-7.8E-10	-6.6E-10	-1.3E-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	34.655	34.655	34.655	34.655	34.655	34.655	34.655	34.655
Population weighted Δx (μg/m^3):	0.00330742	0.00330742	0.00330742	0.00330742	0.00330742	0.00330742	0.00330742	0.00330742
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:	1.000019	1.000003	1.000001	1.000003	1.000043	1.000003	1.000006	1.000005
Attributable fraction (AF):	1.9E-05	2.6E-06	1.4E-06	3.1E-06	4.3E-05	3.2E-06	6.3E-06	4.9E-06
Increased number of cases in population:	0.0013	0.0004	0.00008	0.00013	0.0012	0.00004	0.00003	0.00011
Risk:	2.0E-07	2.4E-07	5.4E-08	1.2E-08	1.8E-07	3.6E-09	3.1E-09	5.9E-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	-607.54	-607.54	-607.54	-607.54	-607.54	-607.54	-607.54	-607.54
Population weighted Δx (μg/m^3):	-0.02387016	-0.02387016	-0.02387016	-0.02387016	-0.02387016	-0.02387016	-0.02387016	-0.02387016
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:	-0.0226	-0.0061	-0.0014	-0.0023	-0.0203	-0.0007	-0.0006	-0.0019
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
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	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786
Population weighted Δx (μg/m^3):	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484
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:	1.000007	1.000001	1.000001	1.000001	1.000017	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.4E-06	1.0E-06	5.2E-07	1.2E-06	1.7E-05	1.2E-06	2.4E-06	1.9E-06
Increased number of cases in population:	0.00011	0.000046	0.000010	0.000014	0.000099	0.0000037	0.0000027	0.0000093
Risk:	7.6E-08	9.4E-08	2.1E-08	6.0E-09	6.8E-08	1.7E-09	1.2E-09	2.3E-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	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786	2.8786
Population weighted Δx (μg/m^3):	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484	0.00127484
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:	1.000007	1.000001	1.000001	1.000001	1.000017	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.4E-06	1.0E-06	5.2E-07	1.2E-06	1.7E-05	1.2E-06	2.4E-06	1.9E-06
Increased number of cases in population:	0.00011	0.00005	0.000010	0.000014	0.00010	0.0000037	0.0000027	0.0000093
Risk:	7.6E-08	9.4E-08	2.1E-08	6.0E-09	6.8E-08	1.7E-09	1.2E-09	2.3E-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	-1012.7	-1012.7	-1012.7	-1012.7	-1012.7	-1012.7	-1012.7	-1012.7
Population weighted Δx (μg/m^3):	-0.01409637	-0.01409637	-0.01409637	-0.01409637	-0.01409637	-0.01409637	-0.01409637	-0.01409637
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:	0.999918	0.999989	0.999994	0.999987	0.999817	0.999986	0.999973	0.999979
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	-5.2E-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	6.4228	6.4228	6.4228	6.4228	6.4228	6.4228	6.4228	6.4228
Population weighted Δx (μg/m^3):	0.00294083	0.00294083	0.00294083	0.00294083	0.00294083	0.00294083	0.00294083	0.00294083
Baseline Incidence (per 100,000) (as per Table 3-5)	1026	9235	3978	396.0	412.0	110.5	49.4	1209.0

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
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	2.4E-06	1.2E-06	2.8E-06	3.8E-05	2.9E-06	5.6E-06	4.4E-06
Increased number of cases in population:	0.0003	0.00009	0.00002	0.00002	0.0002	0.000007	0.000006	0.00002
Risk:	1.8E-07	2.2E-07	4.8E-08	1.1E-08	1.6E-07	3.2E-09	2.8E-09	5.3E-08
Bondi Beach - North Bondi								
Total Population in study area:	11819	11819	11819	11819	11819	11819	11819	11819
% population in assessment age-group:	66%	19%	19%	100%	66%	100%	100%	15%
total change	-45.251	-45.251	-45.251	-45.251	-45.251	-45.251	-45.251	-45.251
Population weighted Δx (µg/m^3):	-0.00382870	-0.00382870	-0.00382870	-0.00382870	-0.00382870	-0.00382870	-0.00382870	-0.00382870
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:	0.999978	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:	-0.0018	-0.0006	-0.00014	-0.00017	-0.0016	-0.000049	-0.000042	-0.00012
Risk:	-2.3E-07	-2.8E-07	-6.2E-08	-1.4E-08	-2.1E-07	-4.1E-09	-3.6E-09	-6.9E-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	-34.279	-34.279	-34.279	-34.279	-34.279	-34.279	-34.279	-34.279
Population weighted Δx (µg/m^3):	-0.01801326	-0.01801326	-0.01801326	-0.01801326	-0.01801326	-0.01801326	-0.01801326	-0.01801326
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:	0.999896	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:	-0.0013	-0.00047	-0.00010	-0.00013	-0.0012	-0.000037	-0.000032	-0.00009
Risk:	-1.1E-06	-1.3E-06	-2.9E-07	-6.7E-08	-9.6E-07	-1.9E-08	-1.7E-08	-3.2E-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	-115.32	-115.32	-115.32	-115.32	-115.32	-115.32	-115.32	-115.32
Population weighted Δx (µg/m^3):	-0.00465025	-0.00465025	-0.00465025	-0.00465025	-0.00465025	-0.00465025	-0.00465025	-0.00465025
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	0.999940	0.999995	0.999991	0.999993
Attributable fraction (AF):	-2.7E-05	-3.7E-06	-1.9E-06	-4.4E-06	-6.0E-05	-4.5E-06	-8.8E-06	-6.9E-06
Increased number of cases in population:	-0.0045	-0.00158	-0.00035	-0.00043	-0.0041	-0.000124	-0.000108	-0.000299
Risk:	-2.8E-07	-3.4E-07	-7.6E-08	-1.7E-08	-2.5E-07	-5.0E-09	-4.4E-09	-8.3E-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	-26.325	-26.325	-26.325	-26.325	-26.325	-26.325	-26.325	-26.325
Population weighted Δx (µg/m^3):	-0.00828086	-0.00828086	-0.00828086	-0.00828086	-0.00828086	-0.00828086	-0.00828086	-0.00828086
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:	0.999952	0.999993	0.999997	0.999992	0.999892	0.999992	0.999984	0.999988
Attributable fraction (AF):	-4.8E-05	-6.6E-06	-3.4E-06	-7.8E-06	-1.1E-04	-8.0E-06	-1.6E-05	-1.2E-05
Increased number of cases in population:	-0.0010	-0.00036	-0.00008	-0.00010	-0.0009	-0.000028	-0.000025	-0.00007
Risk:	-4.9E-07	-6.1E-07	-1.4E-07	-3.1E-08	-4.4E-07	-8.9E-09	-7.8E-09	-1.5E-07
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	-637.40	-637.40	-637.40	-637.40	-637.40	-637.40	-637.40	-637.40
Population weighted Δx (µg/m^3):	-0.04788547	-0.04788547	-0.04788547	-0.04788547	-0.04788547	-0.04788547	-0.04788547	-0.04788547
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:	0.999722	0.999962	0.999980	0.999955	0.999378	0.999954	0.999909	0.999929
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:	-0.02489	-0.00876	-0.001934	-0.002373	-0.02240	-0.000683	-0.000598	-0.001654
Risk:	-2.8E-06	-3.5E-06	-7.8E-07	-1.8E-07	-2.6E-06	-5.1E-08	-4.5E-08	-8.6E-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	-73.756	-73.756	-73.756	-73.756	-73.756	-73.756	-73.756	-73.756
Population weighted Δx (µg/m^3):	-0.01056066	-0.01056066	-0.01056066	-0.01056066	-0.01056066	-0.01056066	-0.01056066	-0.01056066
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:	0.999939	0.999992	0.999996	0.999990	0.999863	0.999990	0.999980	0.999984
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:	-0.00288	-0.00101	-0.000224	-0.000275	-0.00259	-0.000079	-0.000069	-0.000191
Risk:	-6.3E-07	-7.8E-07	-1.7E-07	-3.9E-08	-5.7E-07	-1.1E-08	-9.9E-09	-1.9E-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	-86.789	-86.789	-86.789	-86.789	-86.789	-86.789	-86.789	-86.789
Population weighted Δx (µg/m^3):	-0.01132566	-0.01132566	-0.01132566	-0.01132566	-0.01132566	-0.01132566	-0.01132566	-0.01132566
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	0.999978	0.999983
Attributable fraction (AF):	-6.6E-05	-9.1E-06	-4.6E-06	-1.1E-05	-1.5E-04	-1.1E-05	-2.2E-05	-1.7E-05
Increased number of cases in population:	-0.00339	-0.00119	-0.000263	-0.000323	-0.00305	-0.000093	-0.000081	-0.000225
Risk:	-6.7E-07	-8.4E-07	-1.8E-07	-4.2E-08	-6.1E-07	-1.2E-08	-1.1E-08	-2.0E-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	-455.04	-455.04	-455.04	-455.04	-455.04	-455.04	-455.04	-455.04
Population weighted Δx (µg/m^3):	-0.00524879	-0.00524879	-0.00524879	-0.00524879	-0.00524879	-0.00524879	-0.00524879	-0.00524879
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:	0.999970	0.999996	0.999998	0.999995	0.999932	0.999995	0.999990	0.999992

	Primary Indicators			Secondary Indicators				
Health Endpoint:	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):	-3.0E-05	-4.2E-06	-2.2E-06	-4.9E-06	-6.8E-05	-5.1E-06	-1.0E-05	-7.8E-06
Increased number of cases in population:	-0.017	-0.0056	-0.0012	-0.0020	-0.016	-0.00056	-0.00043	-0.0015
Risk:	-3.1E-07	-3.9E-07	-8.6E-08	-2.3E-08	-2.8E-07	-6.5E-09	-4.9E-09	-9.4E-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	-190.29	-190.29	-190.29	-190.29	-190.29	-190.29	-190.29	-190.29
Population weighted Δx (µg/m^3):	-0.00941396	-0.00941396	-0.00941396	-0.00941396	-0.00941396	-0.00941396	-0.00941396	-0.00941396
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:	0.999945	0.999992	0.999996	0.999991	0.999878	0.999991	0.999982	0.999986
Attributable fraction (AF):	-5.5E-05	-7.5E-06	-3.9E-06	-8.8E-06	-1.2E-04	-9.1E-06	-1.8E-05	-1.4E-05
Increased number of cases in population:	-0.0073	-0.0024	-0.00052	-0.00083	-0.0066	-0.00024	-0.00018	-0.00063
Risk:	-5.6E-07	-7.0E-07	-1.5E-07	-4.1E-08	-5.0E-07	-1.2E-08	-8.8E-09	-1.7E-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	-79.693	-79.693	-79.693	-79.693	-79.693	-79.693	-79.693	-79.693
Population weighted Δx (µg/m^3):	-0.00624702	-0.00624702	-0.00624702	-0.00624702	-0.00624702	-0.00624702	-0.00624702	-0.00624702
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:	0.999964	0.999995	0.999997	0.999994	0.999919	0.999994	0.999988	0.999991
Attributable fraction (AF):	-3.6E-05	-5.0E-06	-2.6E-06	-5.9E-06	-8.1E-05	-6.1E-06	-1.2E-05	-9.2E-06
Increased number of cases in population:	-0.0030	-0.0010	-0.00022	-0.00035	-0.0027	-0.00010	-0.00007	-0.00027
Risk:	-3.7E-07	-4.6E-07	-1.0E-07	-2.7E-08	-3.3E-07	-7.7E-09	-5.9E-09	-1.1E-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	-4.2487	-4.2487	-4.2487	-4.2487	-4.2487	-4.2487	-4.2487	-4.2487
Population weighted Δx (µg/m^3):	-0.01863474	-0.01863474	-0.01863474	-0.01863474	-0.01863474	-0.01863474	-0.01863474	-0.01863474
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:	0.999892	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:	-0.000163	-0.000053	-0.000012	-0.000018	-0.000146	-0.000005	-0.000004	-0.000014
Risk:	-1.1E-06	-1.4E-06	-3.0E-07	-8.1E-08	-1.0E-06	-2.3E-08	-1.7E-08	-3.3E-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	-490.28	-490.28	-490.28	-490.28	-490.28	-490.28	-490.28	-490.28
Population weighted Δx (µg/m^3):	-0.03826415	-0.03826415	-0.03826415	-0.03826415	-0.03826415	-0.03826415	-0.03826415	-0.03826415
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:	0.999778	0.999969	0.999984	0.999964	0.999503	0.999963	0.999927	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:	-0.0188	-0.0061	-0.00134	-0.00213	-0.0169	-0.00061	-0.00046	-0.00163
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	-58.628	-58.628	-58.628	-58.628	-58.628	-58.628	-58.628	-58.628
Population weighted Δx (µg/m^3):	-0.00577108	-0.00577108	-0.00577108	-0.00577108	-0.00577108	-0.00577108	-0.00577108	-0.00577108
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:	0.999967	0.999995	0.999998	0.999995	0.999925	0.999994	0.999989	0.999991
Attributable fraction (AF):	-3.3E-05	-4.6E-06	-2.4E-06	-5.4E-06	-7.5E-05	-5.6E-06	-1.1E-05	-8.5E-06
Increased number of cases in population:	-0.0022	-0.0007	-0.00016	-0.00025	-0.0020	-0.00007	-0.00006	-0.00020
Risk:	-3.4E-07	-4.3E-07	-9.4E-08	-2.5E-08	-3.1E-07	-7.1E-09	-5.4E-09	-1.0E-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	-101.26	-101.26	-101.26	-101.26	-101.26	-101.26	-101.26	-101.26
Population weighted Δx (µg/m^3):	-0.01258402	-0.01258402	-0.01258402	-0.01258402	-0.01258402	-0.01258402	-0.01258402	-0.01258402
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:	0.999927	0.999990	0.999995	0.999988	0.999836	0.999988	0.999976	0.999981
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:	-0.0039	-0.0013	-0.00028	-0.00044	-0.0035	-0.00013	-0.00010	-0.00034
Risk:	-7.5E-07	-9.3E-07	-2.1E-07	-5.5E-08	-6.7E-07	-1.6E-08	-1.2E-08	-2.3E-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	-20.841	-20.841	-20.841	-20.841	-20.841	-20.841	-20.841	-20.841
Population weighted Δx (µg/m^3):	-0.00373764	-0.00373764	-0.00373764	-0.00373764	-0.00373764	-0.00373764	-0.00373764	-0.00373764
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:	-0.000797	-0.000259	-0.000057	-0.000091	-0.000718	-0.000026	-0.000020	-0.000069
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
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	490.21	490.21	490.21	490.21	490.21	490.21	490.21	490.21
Population weighted Δx (µg/m^3):	0.02900644	0.02900644	0.02900644	0.02900644	0.02900644	0.02900644	0.02900644	0.02900644
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:	1.000168	1.000023	1.000012	1.000027	1.000377	1.000028	1.000055	1.000043
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.5E-05	4.3E-05
Increased number of cases in population:	0.0188	0.0061	0.00134	0.00213	0.0169	0.00061	0.00046	0.00163

	Primary Indicators			Secondary Indicators				
Health Endpoint:	**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
Risk:	1.7E-06	2.1E-06	4.7E-07	1.3E-07	1.6E-06	3.6E-08	2.7E-08	5.2E-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	-378.80	-378.80	-378.80	-378.80	-378.80	-378.80	-378.80	-378.80
Population weighted Δx (μg/m^3):	-0.01176664	-0.01176664	-0.01176664	-0.01176664	-0.01176664	-0.01176664	-0.01176664	-0.01176664
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:	0.999932	0.999991	0.999995	0.999989	0.999847	0.999989	0.999978	0.999983
Attributable fraction (AF):	-6.8E-05	-9.4E-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:	-0.014	-0.0051	-0.0011	-0.0013	-0.013	-0.00040	-0.00036	-0.0013
Risk:	-7.0E-07	-8.7E-07	-1.9E-07	-4.0E-08	-6.3E-07	-1.2E-08	-1.1E-08	-2.1E-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	-26.626	-26.626	-26.626	-26.626	-26.626	-26.626	-26.626	-26.626
Population weighted Δx (μg/m^3):	-0.00271390	-0.00271390	-0.00271390	-0.00271390	-0.00271390	-0.00271390	-0.00271390	-0.00271390
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:	0.999984	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	-2.6E-06	-3.5E-05	-2.6E-06	-5.2E-06	-4.0E-06
Increased number of cases in population:	-0.0010	-0.0004	-0.00008	-0.00009	-0.0009	-0.00003	-0.00002	-0.00009
Risk:	-1.6E-07	-2.0E-07	-4.4E-08	-9.3E-09	-1.5E-07	-2.8E-09	-2.5E-09	-4.9E-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	-353.67	-353.67	-353.67	-353.67	-353.67	-353.67	-353.67	-353.67
Population weighted Δx (μg/m^3):	-0.01657080	-0.01657080	-0.01657080	-0.01657080	-0.01657080	-0.01657080	-0.01657080	-0.01657080
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:	0.999904	0.999987	0.999993	0.999984	0.999785	0.999984	0.999969	0.999975
Attributable fraction (AF):	-9.6E-05	-1.3E-05	-6.8E-06	-1.6E-05	-2.2E-04	-1.6E-05	-3.1E-05	-2.5E-05
Increased number of cases in population:	-0.0132	-0.0048	-0.00105	-0.00121	-0.0118	-0.00037	-0.00033	-0.00123
Risk:	-9.9E-07	-1.2E-06	-2.7E-07	-5.7E-08	-8.9E-07	-1.7E-08	-1.6E-08	-3.0E-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	1.4932	1.4932	1.4932	1.4932	1.4932	1.4932	1.4932	1.4932
Population weighted Δx (μg/m^3):	0.00143716	0.00143716	0.00143716	0.00143716	0.00143716	0.00143716	0.00143716	0.00143716
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:	1.000008	1.000001	1.000001	1.000001	1.000019	1.000001	1.000003	1.000002
Attributable fraction (AF):	8.3E-06	1.1E-06	5.9E-07	1.4E-06	1.9E-05	1.4E-06	2.7E-06	2.1E-06
Increased number of cases in population:	0.000056	0.000020	0.000004	0.000005	0.000050	0.000002	0.000001	0.000005
Risk:	8.6E-08	1.1E-07	2.3E-08	4.9E-09	7.7E-08	1.5E-09	1.3E-09	2.6E-08
Total population incidence - All Suburbs	**-1.1**	**-0.27**	**-0.059**	**-0.12**	**-0.95**	**-0.035**	**-0.027**	**-0.054**

Annexure H – Risk calculations: Elevated receptors

Introduction

This annexure provides further detail in relation to the assessment of potential exposures to changes in VOCs, NO_2 and $PM_{2.5}$ at elevated receptors, focusing on receptors in the 300 metres at heights of 10 metres, 20 metres, 30 metres and 45 metres surrounding the project's ventilation outlets to address multi-storey buildings that may be constructed near the proposed ventilation outlets.

Potential impacts at elevated receptors have been further assessed by the air quality specialists. The analysis addressed emission related to expected traffic as well as the regulatory worst case scenario for 2037 (cumulative scenario) where impacts related to all the pollutants considered in the assessment have been included.

The analysis has been reviewed further in terms of impacts on human health, utilising the methodology and assumptions outlined and presented in the Health Impact Assessment (HIA).

The modelling has evaluated the maximum concentrations at the modelled heights relevant to existing buildings, as well as future buildings where buildings may be any height up to 45 metres.

Volatile organic compounds and polycyclic aromatic hydrocarbons

Impacts related to emissions to air of volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) at elevated receptors has been assessed on the basis of the maximum incremental change in air concentration at various heights relevant to existing and future buildings. The air modelling has provided data on the basis of a one hour average, which is relevant to the assessment of acute inhalation exposures, however the assessment of health impacts also needs to address chronic exposures. For many VOCs and PAHs the key health effects related to chronic inhalation exposures. As an annual average concentration as not been predicted, a conversion factor of 0.08 has been adopted[16] (ie annual average = one hour average x 0.08). The predicted maximum one hour average and annual average concentrations for VOCs and PAHs have been compared with the health based guidelines presented in the HIA. In addition, incremental carcinogenic risks have been calculated for carcinogens (benzene, 1,3-butadiene and benzo(a)pyrene). The chronic assessment undertaken assumes that exposures occur at the heights evaluated all day, every day for a lifetime.

Tables H1 to H3 present a summary of the calculated total Hazard Index (HI) calculated for acute exposures (Table H1), chronic exposures (Table H2) and the calculated incremental carcinogenic risk (Table H3), relevant to exposures to the VOCs and PAHs assessed at the elevated receptors.

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[16] Conversion factor of 0.08 from 1 hour to an annual average based on the upper end of the range relevant to modelled VOCs for 2037 Do something cumulative scenario for all receptors evaluated in the EIS. It is also consistent with the conversion factor identified in review of averaging time conversions by Ontario Ontario MfE 2004, Air Dispersion Modelling Guideline for Ontario (2004).

Table H1 Assessment of acute exposures to VOCs – elevated receptors (2037-DSC)

Scenario	Calculated HI relevant to maximum concentrations predicted at elevated receptors			
	10 m	20 m	30 m	45 m
Expected traffic				
Outlet H – Warringah Freeway				
Existing elevated receptors	0.0024	0.0037	0.0069	--
Future elevated receptors	0.0035	0.0052	0.012	0.023
Outlet I – Gore Hill Freeway				
Existing elevated receptors	0.0007	--	--	--
Future elevated receptors	0.0010	0.0020	0.016	0.043
Outlet J – Wakehurst Parkway				
Existing elevated receptors	0.0007	--	--	--
Future elevated receptors	0.0013	0.0014	0.0021	0.003
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	0.0015	--	--	--
Future elevated receptors	0.0020	0.0037	0.006	0.009
Regulatory worst case				
Outlet H – Warringah Freeway				
Existing elevated receptors	0.038	0.050	0.11	--
Future elevated receptors	0.041	0.060	0.16	0.38
Outlet I – Gore Hill Freeway				
Existing elevated receptors	0.013	--	--	--
Future elevated receptors	0.028	0.039	0.20	0.82
Outlet J – Wakehurst Parkway				
Existing elevated receptors	0.014	--	--	--
Future elevated receptors	0.016	0.020	0.028	0.052
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	0.030	--	--	--
Future elevated receptors	0.037	0.073	0.10	0.14
Acceptable HI	**≤1**	**≤1**	**≤1**	**≤1**

Table H2 Assessment of chronic exposures to VOCs – elevated receptors (2037-DSC)

Scenario	Calculated HI relevant to maximum concentrations predicted at elevated receptors			
	10 m	20 m	30 m	45 m
Expected traffic				
Outlet H – Warringah Freeway				
Existing elevated receptors	0.0029	0.0045	0.0084	--
Future elevated receptors	0.0042	0.0063	0.015	0.028
Outlet I – Gore Hill Freeway				
Existing elevated receptors	0.00084	--	--	--
Future elevated receptors	0.0012	0.0024	0.019	0.052
Outlet J – Wakehurst Parkway				
Existing elevated receptors	0.00086	--	--	--
Future elevated receptors	0.0015	0.0016	0.0025	0.0043
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	0.0019	--	--	--
Future elevated receptors	0.0024	0.0044	0.0075	0.011
Regulatory worst case				
Outlet H – Warringah Freeway				
Existing elevated receptors	0.046	0.060	0.13	--
Future elevated receptors	0.050	0.073	0.19	0.46
Outlet I – Gore Hill Freeway				
Existing elevated receptors	0.016	--	--	--
Future elevated receptors	0.034	0.047	0.25	0.99
Outlet J – Wakehurst Parkway				
Existing elevated receptors	0.017	--	--	--
Future elevated receptors	0.019	0.025	0.034	0.063
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	0.037	--	--	--
Future elevated receptors	0.044	0.089	0.13	0.18
Acceptable HI	**≤1**	**≤1**	**≤1**	**≤1**

Table H3 **Assessment of incremental lifetime carcinogenic risk – elevated receptors (2037-DSC)**

Scenario	Calculated HI relevant to maximum concentrations predicted at elevated receptors			
	10 m	20 m	30 m	45 m
Expected traffic				
Outlet H – Warringah Freeway				
Existing elevated receptors	$4x10^{-8}$	$7x10^{-8}$	$1x10^{-7}$	--
Future elevated receptors	$7x10^{-8}$	$1x10^{-7}$	$2x10^{-7}$	$4x10^{-7}$
Outlet I – Gore Hill Freeway				
Existing elevated receptors	$1x10^{-8}$	--	--	--
Future elevated receptors	$2x10^{-8}$	$3x10^{-8}$	$3x10^{-7}$	$7x10^{-7}$
Outlet J – Wakehurst Parkway				
Existing elevated receptors	$1x10^{-8}$	--	--	--
Future elevated receptors	$2x10^{-8}$	$2x10^{-8}$	$5x10^{-8}$	$1x10^{-7}$
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	$3x10^{-8}$	--	--	--
Future elevated receptors	$3x10^{-8}$	$6x10^{-8}$	$1x10^{-7}$	$2x10^{-7}$
Regulatory worst case				
Outlet H – Warringah Freeway				
Existing elevated receptors	$7x10^{-7}$	$9x10^{-7}$	$2x10^{-6}$	--
Future elevated receptors	$7x10^{-7}$	$1x10^{-6}$	$3x10^{-6}$	$7x10^{-6}$
Outlet I – Gore Hill Freeway				
Existing elevated receptors	$2x10^{-7}$	--	--	--
Future elevated receptors	$5x10^{-7}$	$7x10^{-6}$	$4x10^{-6}$	$1x10^{-5}$
Outlet J – Wakehurst Parkway				
Existing elevated receptors	$2x10^{-7}$	--	--	--
Future elevated receptors	$3x10^{-7}$	$4x10^{-7}$	$5x10^{-7}$	$9x10^{-7}$
Outlet K – Burnt Bridge Creek Deviation				
Existing elevated receptors	$5x10^{-7}$	--	--	--
Future elevated receptors	$6x10^{-7}$	$1x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$

Tables 1 and 2 show that the maximum calculated HIs at all elevated receptors related to acute and chronic exposures to VOCs, for both the expected traffic and regulatory worst case emissions scenarios are less than 1.

Table 3 show that the maximum calculated incremental lifetime carcinogenic risk at all elevated receptors is less than $1x10^{-5}$. These exposures would be expected to be considered low and acceptable.

Nitrogen dioxide

The assessment of potential health effects related to exposures to NO_2 involves consideration of total exposures (ie background + project) as well as calculated risks related to incremental exposures, or changes in NO_2 exposures.

Cumulative exposures

Assessment of cumulative exposures involves comparing the total predicted air concentration, representative acute (one hour average) and chronic (annual average) exposures with the health based guidelines ambient air guidelines available from the NEPC (NEPC 2016). This assessment, including comparison against the NEPC air guidelines was undertaken by the air quality specialist. The assessment undertaken identified the following:

- Acute exposures:
  - Expected traffic scenario: All predicted maximum total 1-hour average concentrations of NO_2, for all elevated receptors, are below the NEPC air guideline of 246 μg/m^3
  - Regulatory worst case: All predicted maximum total 1-hour average concentrations of NO_2, for all elevated receptors, are below the NEPC air guideline of 246 μg/m^3

- Chronic exposures:
  - Expected traffic scenario: All predicted maximum total annual average concentration of NO_2, for all elevated receptors are below the NEPC air guideline of 62 µg/m^3
  - Regulatory worst case: All predicted maximum total annual average concentration of NO_2, for all elevated receptors are below the NEPC air guideline of 62 µg/m^3.

Incremental exposures

Assessment of changes in NO_2 exposure concentrations has been undertaken on the basis of the predicted increase in NO_2 concentrations at the elevated receptors and consideration of published dose-response relationships relevant to the assessment of individual risks to health for the key health endpoints (mortality all causes and respiratory as Asthma emergency department admissions for children). While the effects evaluated related to changes in short-term concentrations, where exposures are long-term (such as for residents living in apartments), long-term annual risks can be calculated on the basis of changes in annual average air concentrations. Based on the maximum incremental changes in NO_2 modelled at the elevated receptors (adopting assumptions on the conversion of NOx to NO_2 consistent with the Air Quality Assessment), changes in individual risk have been calculated, and are summarised in Tables H4 to H7.

Table H4 Assessment of incremental risks for changes in NO_2 at elevated receptors (2037-DSC) – Outlet H (Warringah Freeway)

Health endpoint	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (all ages)	$5x10^{-6}$	$6x10^{-6}$	$1x10^{-5}$	--	$6x10^{-6}$	$9x10^{-6}$	$2x10^{-5}$	$4x10^{-5}$
Mortality, respiratory (all ages)	$9x10^{-7}$	$1x10^{-6}$	$2x10^{-6}$	--	$1x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$	$7x10^{-6}$
Asthma emergency department admissions (1–14 years)	$9x10^{-6}$	$1x10^{-5}$	$2x10^{-5}$	--	$1x10^{-5}$	$2x10^{-5}$	$3x10^{-5}$	$7x10^{-5}$
Regulatory worst case								
Mortality all causes (all ages)	$3x10^{-5}$	$3x10^{-5}$	$6x10^{-5}$	--	$3x10^{-5}$	$5x10^{-5}$	$8x10^{-5}$	$1x10^{-4}$
Mortality, respiratory (all ages)	$6x10^{-6}$	$5x10^{-6}$	$9x10^{-6}$	--	$6x10^{-6}$	$8x10^{-6}$	$1x10^{-5}$	$2x10^{-5}$
Asthma emergency department admissions (1–14 years)	$6x10^{-5}$	$5x10^{-5}$	$1x10^{-4}$	--	$6x10^{-5}$	$8x10^{-5}$	$1x10^{-4}$	$2x10^{-4}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Table H5 **Assessment of incremental risks for changes in NO_2 at elevated receptors (2037-DSC) – Outlet I (Gore Hill Freeway)**

Health endpoint	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (all ages)	$2x10^{-6}$	--	--	--	$3x10^{-6}$	$5x10^{-6}$	$2x10^{-5}$	$6x10^{-5}$
Mortality, respiratory (all ages)	$4x10^{-7}$	--	--	--	$5x10^{-7}$	$8x10^{-7}$	$3x10^{-6}$	$1x10^{-5}$
Asthma emergency department admissions (1–14 years)	$4x10^{-6}$	--	--	--	$6x10^{-6}$	$8x10^{-6}$	$3x10^{-5}$	$1x10^{-4}$
Regulatory worst case								
Mortality all causes (all ages)	$2x10^{-5}$	--	--	--	$3x10^{-5}$	$3x10^{-5}$	$8x10^{-5}$	$2x10^{-4}$
Mortality, respiratory (all ages)	$3x10^{-6}$	--	--	--	$4x10^{-6}$	$6x10^{-6}$	$1x10^{-5}$	$4x10^{-5}$
Asthma emergency department admissions (1–14 years)	$3x10^{-5}$	--	--	--	$4x10^{-5}$	$6x10^{-5}$	$1x10^{-4}$	$4x10^{-4}$
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

Table H6 **Assessment of incremental risks for changes in NO_2 at elevated receptors (2037-DSC) – Outlet J (Wakehurst Parkway)**

Health endpoint	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (all ages)	$1x10^{-6}$	--	--	--	$2x10^{-6}$	$2x10^{-6}$	$3x10^{-5}$	$5x10^{-5}$
Mortality, respiratory (all ages)	$2x10^{-7}$	--	--	--	$4x10^{-7}$	$4x10^{-7}$	$5x10^{-7}$	$8x10^{-7}$
Asthma emergency department admissions (1–14 years)	$3x10^{-6}$	--	--	--	$4x10^{-6}$	$4x10^{-6}$	$5x10^{-6}$	$8x10^{-6}$
Regulatory worst case								
Mortality all causes (all ages)	$1x10^{-5}$	--	--	--	$1x10^{-5}$	$2x10^{-5}$	$2x10^{-5}$	$3x10^{-5}$
Mortality, respiratory (all ages)	$2x10^{-6}$	--	--	--	$2x10^{-6}$	$3x10^{-6}$	$3x10^{-6}$	$5x10^{-6}$
Asthma emergency department admissions (1–14 years)	$2x10^{-5}$	--	--	--	$2x10^{-5}$	$3x10^{-5}$	$3x10^{-4}$	$5x10^{-5}$
Negligible risks	<1x10^{-6}							
Tolerable/acceptable risks	≥1x10^{-6} and ≤1x10^{-4}							
Unacceptable risks	>1x10^{-4}							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Table H7 Assessment of incremental risks for changes in NO_2 at elevated receptors (2037-DSC) – Outlet K (Burnt Bridge Creek Deviation)

Health endpoint	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (all ages)	$2x10^{-6}$	--	--	--	$4x10^{-6}$	$6x10^{-6}$	$9x10^{-5}$	$1x10^{-5}$
Mortality, respiratory (all ages)	$4x10^{-7}$	--	--	--	$7x10^{-7}$	$1x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$
Asthma emergency department admissions (1–14 years)	$4x10^{-6}$	--	--	--	$7x10^{-6}$	$1x10^{-5}$	$2x10^{-5}$	$2x10^{-5}$
Regulatory worst case								
Mortality all causes (all ages)	$2x10^{-5}$	--	--	--	$3x10^{-5}$	$5x10^{-5}$	$6x10^{-5}$	$8x10^{-5}$
Mortality, respiratory (all ages)	$3x10^{-6}$	--	--	--	$5x10^{-6}$	$8x10^{-6}$	$1x10^{-5}$	$1x10^{-5}$
Asthma emergency department admissions (1–14 years)	$3x10^{-5}$	--	--	--	$5x10^{-5}$	$8x10^{-5}$	$1x10^{-4}$	$1x10^{-4}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Review of Tables H4 to H7 indicate the following:

- Outlets H (Warringah Freeway) and I (Gore Hill Freeway)
  - Potential risks associated with exposure to NO_2 at all elevated receptors relevant to expected traffic emissions are in the range considered tolerable/acceptable
  - Potential risks associated with exposure to NO_2 for the regulatory worst case scenario are considered to be elevated and unacceptable at for maximum concentrations predicted at 45 m height and higher for future buildings
- Outlet J (Wakehurst Parkway) and K (Burnt Bridge Creek Deviation)
  - Potential risks associated with exposure to NO_2 at all elevated receptors relevant to expected traffic emissions are in the range considered tolerable/acceptable
  - Potential risks associated with exposure to NO_2 for the regulatory worst case scenario are in the range considered tolerable/acceptable.

Particulate matter

The assessment of potential health effects related to exposures to PM_{10} and $PM_{2.5}$ involves consideration of total exposures (ie background + project) as well as calculated risks related to incremental exposures, or changes in $PM_{2.5}$ exposures (which is the key focus in terms of health impacts).

Cumulative exposures

Assessment of cumulative exposures involves comparing the total predicted air concentration, representative short-term (24 hour average) and chronic (annual average) exposures with the health based guidelines ambient air guidelines available from the NEPC (NEPC 2016). This assessment, including comparison against the NEPC air guidelines was undertaken by the air quality specialist. The assessment undertaken identified the following:

- Short-term (24 hour average) exposures:
  - Expected traffic scenario: With the exception of concentrations predicted at 45 metre height surrounding ventilation Outlet I (Gore Hill Freeway), the predicted maximum total 24 hour average concentration of PM_{10} and $PM_{2.5}$ for all elevated receptors are below the NEPC air guidelines of 50 µg/m^3 and 25 µg/m^3 respectively

- Regulatory worst case:
  - The maximum 24-hour average concentrations of PM_{10} exceeds the NEPC air guideline of 50 µg/m^3 at elevated receptors at 20 metres and higher for Outlet J (Wakehurst Parkway) and 30 metres and higher for Outlets H (Warringah Freeway) and I (Gore Hill Freeway). The maximum concentrations of PM_{10} predicted at 10 metres height are below the NEPC guideline
  - The maximum 24-hour average concentrations of $PM_{2.5}$ exceeds the NEPC air guideline of 25 µg/m^3 at elevated receptors at 20 metres and higher (both Outlets H (Warringah Freeway), I (Gore Hill Freeway) and K (Burnt Bridge Creek Deviation)). The maximum concentrations of $PM_{2.5}$ predicted at 10 metres height are below the NEPC guideline
  - The exceedance reported are primarily due to the increased contribution from the ventilation outlets

- Chronic exposures:
  - Expected traffic scenario:
    - All predicted maximum total 24 hour average concentration of PM_{10} and $PM_{2.5}$ for all elevated receptor heights are below the NEPC air guidelines of 25 µg/m^3 and eight µg/m^3 respectively
  - Regulatory worst case:
    - All predicted maximum total annual average concentrations of PM_{10}, for all elevated receptor heights are below the NEPC air guideline of 25 µg/m^3
    - With the exception of predicted concentrations at all heights surrounding Outlets H (Warringah Freeway) and K (Gore Hill Freeway), the predicted maximum total annual average concentrations of $PM_{2.5}$, for all elevated receptor heights exceed the NEPC air guideline of eight µg/m^3. The exceedances reported are primarily due to elevated background levels of $PM_{2.5}$.

Incremental exposures

Assessment of changes in particulate matter concentrations has focused on changes in $PM_{2.5}$, which is the size fraction that is of most importance in terms of potential health effects. This assessment has considered the predicted increase in $PM_{2.5}$ concentrations at the elevated receptors and the published dose-response relationships relevant to the assessment of individual risks to health for the key health endpoints (specifically mortality all causes, respiratory and cardiovascular and morbidity [hospitalisations] for respirator and cardiovascular disease).

These effects have been assessed on the basis of changes in annual average air concentrations. Based on the maximum incremental changes in $PM_{2.5}$ modelled at the elevated receptors, changes in individual risk have been calculated, and are summarised in Tables H8 to H11.

Table H8 Assessment of incremental risks for changes in $PM_{2.5}$ at elevated receptors (2037-DSC) – Outlet H (Warringah Freeway)

Primary health endpoints	Maximum from existing receptors 10 m	20 m	30 m	45 m	Maximum from all (future) receptors 10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (long term effects, ages 30+)	$4x10^{-6}$	$5x10^{-6}$	$9x10^{-6}$	--	$5x10^{-6}$	$7x10^{-6}$	$1x10^{-5}$	$3x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$5x10^{-6}$	$6x10^{-6}$	$1x10^{-5}$	--	$6x10^{-6}$	$8x10^{-6}$	$1x10^{-5}$	$4x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$1x10^{-6}$	$1x10^{-6}$	$2x10^{-6}$	--	$1x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$	$8x10^{-6}$
Regulatory worst case								
Mortality all causes (long term effects, ages 30+)	$1x10^{-5}$	$3x10^{-5}$	$51x10^{-5}$	--	$1x10^{-5}$	$5x10^{-5}$	$8x10^{-5}$	$2x10^{-4}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$2x10^{-5}$	$4x10^{-5}$	$6x10^{-5}$	--	$2x10^{-5}$	$6x10^{-5}$	$1x10^{-4}$	$2x10^{-4}$
Respiratory hospitalisations (short term effects, ages 65+)	$4x10^{-6}$	$8x10^{-6}$	$1x10^{-5}$	--	$3x10^{-6}$	$1x10^{-5}$	$2x10^{-5}$	$4x10^{-5}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Table H9 Assessment of incremental risks for changes in $PM_{2.5}$ at elevated receptors (2037-DSC) – Outlet I (Gore Hill Freeway)

Primary health endpoints	Maximum from existing receptors 10 m	20 m	30 m	45 m	Maximum from all (future) receptors 10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (long term effects, ages 30+)	$2x10^{-6}$	--	--	--	$3x10^{-6}$	$4x10^{-6}$	$1x10^{-5}$	$5x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$3x10^{-6}$	--	--	--	$3x10^{-6}$	$4x10^{-6}$	$2x10^{-5}$	$6x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$6x10^{-7}$	--	--	--	$7x10^{-7}$	$1x10^{-6}$	$4x10^{-6}$	$1x10^{-5}$
Regulatory worst case								
Mortality all causes (long term effects, ages 30+)	$2x10^{-5}$	--	--	--	$2x10^{-5}$	$3x10^{-5}$	$8x10^{-5}$	$4x10^{-4}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$2x10^{-5}$	--	--	--	$3x10^{-5}$	$4x10^{-5}$	$1x10^{-4}$	$5x10^{-4}$
Respiratory hospitalisations (short term effects, ages 65+)	$5x10^{-6}$	--	--	--	$6x10^{-6}$	$8x10^{-6}$	$2x10^{-5}$	$1x10^{-4}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Table H10 Assessment of incremental risks for changes in $PM_{2.5}$ at elevated receptors (2037-DSC) – Outlet J (Wakehurst Parkway)

Primary health endpoints	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (long term effects, ages 30+)	$1x10^{-6}$	--	--	--	$2x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$1x10^{-6}$	--	--	--	$2x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$
Respiratory hospitalisations (short term effects, ages 65+)	$3x10^{-7}$	--	--	--	$4x10^{-7}$	$5x10^{-7}$	$5x10^{-7}$	$8x10^{-7}$
Regulatory worst case								
Mortality all causes (long term effects, ages 30+)	$8x10^{-6}$	--	--	--	$1x10^{-5}$	$1x10^{-5}$	$1x10^{-5}$	$2x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$1x10^{-5}$	--	--	--	$1x10^{-5}$	$2x10^{-5}$	$2x10^{-5}$	$2x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$2x10^{-6}$	--	--	--	$3x10^{-6}$	$3x10^{-6}$	$4x10^{-6}$	$5x10^{-6}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Table H11 Assessment of incremental risks for changes in $PM_{2.5}$ at elevated receptors (2037-DSC) – Outlet K (Burnt Bridge Creek Deviation)

Primary health endpoints	Maximum from existing receptors				Maximum from all (future) receptors			
	10 m	20 m	30 m	45 m	10 m	20 m	30 m	45 m
Expected traffic								
Mortality all causes (long term effects, ages 30+)	$2x10^{-6}$	--	--	--	$3x10^{-6}$	$5x10^{-6}$	$6x10^{-6}$	$8x10^{-6}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$2x10^{-6}$	--	--	--	$4x10^{-6}$	$6x10^{-6}$	$8x10^{-6}$	$1x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$5x10^{-7}$	--	--	--	$8x10^{-7}$	$1x10^{-6}$	$2x10^{-6}$	$2x10^{-6}$
Regulatory worst case								
Mortality all causes (long term effects, ages 30+)	$1x10^{-5}$	--	--	--	$3x10^{-5}$	$4x10^{-5}$	$5x10^{-5}$	$6x10^{-5}$
Cardiovascular hospitalisations (short term effects, ages 65+)	$2x10^{-5}$	--	--	--	$3x10^{-5}$	$5x10^{-5}$	$7x10^{-5}$	$8x10^{-5}$
Respiratory hospitalisations (short term effects, ages 65+)	$4x10^{-6}$	--	--	--	$7x10^{-6}$	$1x10^{-5}$	$1x10^{-5}$	$2x10^{-5}$
Negligible risks	$<1x10^{-6}$							
Tolerable/acceptable risks	$\geq 1x10^{-6}$ and $\leq 1x10^{-4}$							
Unacceptable risks	$>1x10^{-4}$							

Note: Shaded cells indicate calculated risks that are considered unacceptable

Review of Tables H8 to H11 indicate that there are no exposures to $PM_{2.5}$ at any of the elevated receptors, associated with the expected traffic emissions that would be considered unacceptable (ie > 1×10^{-4}).

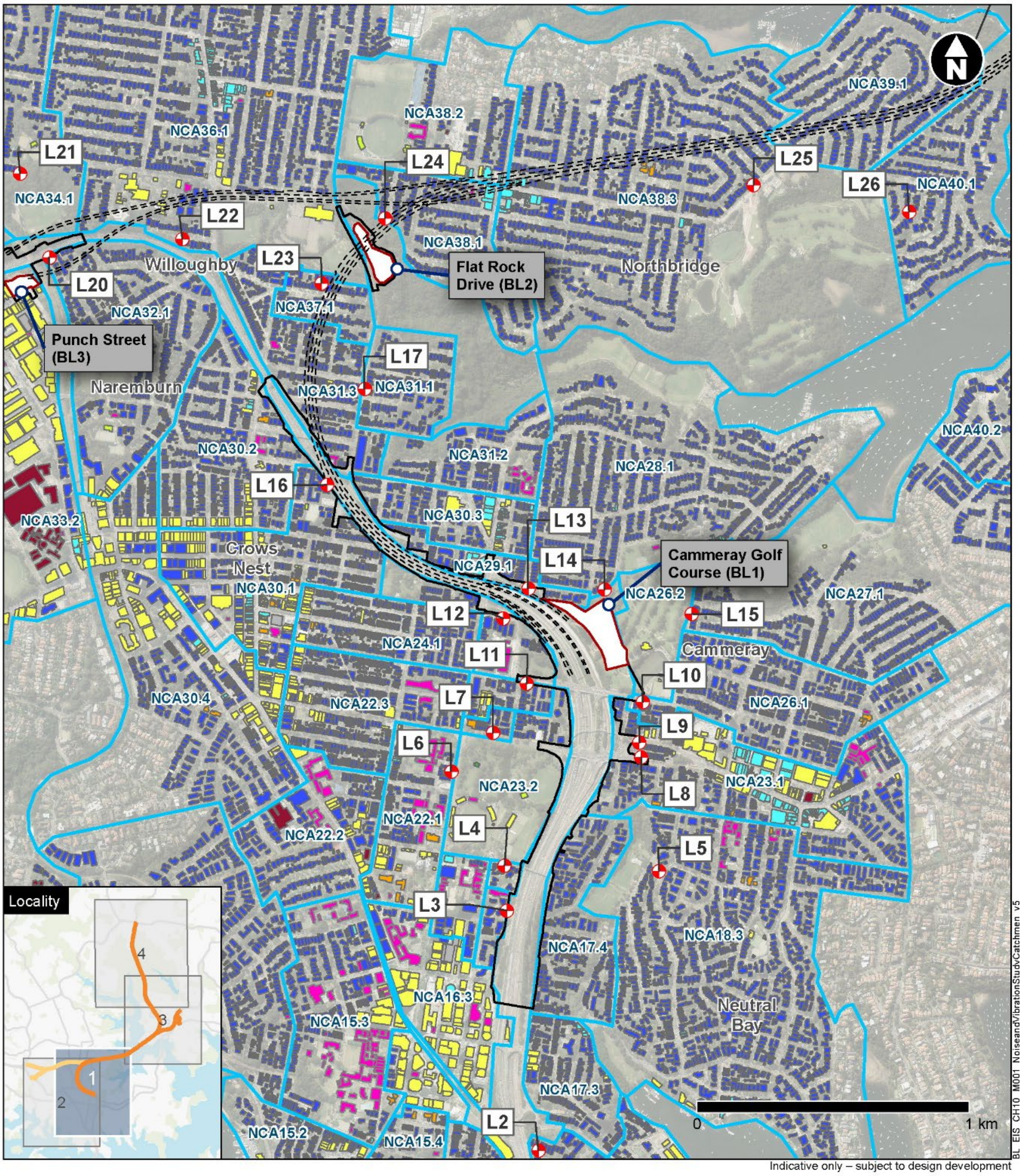
In relation to regulatory worst case emissions exposures to $PM_{2.5}$ at receptors (future buildings, not current buildings) at 45 metres height are considered to be unacceptable.

Overall

The additional analysis undertaken has identified the following:

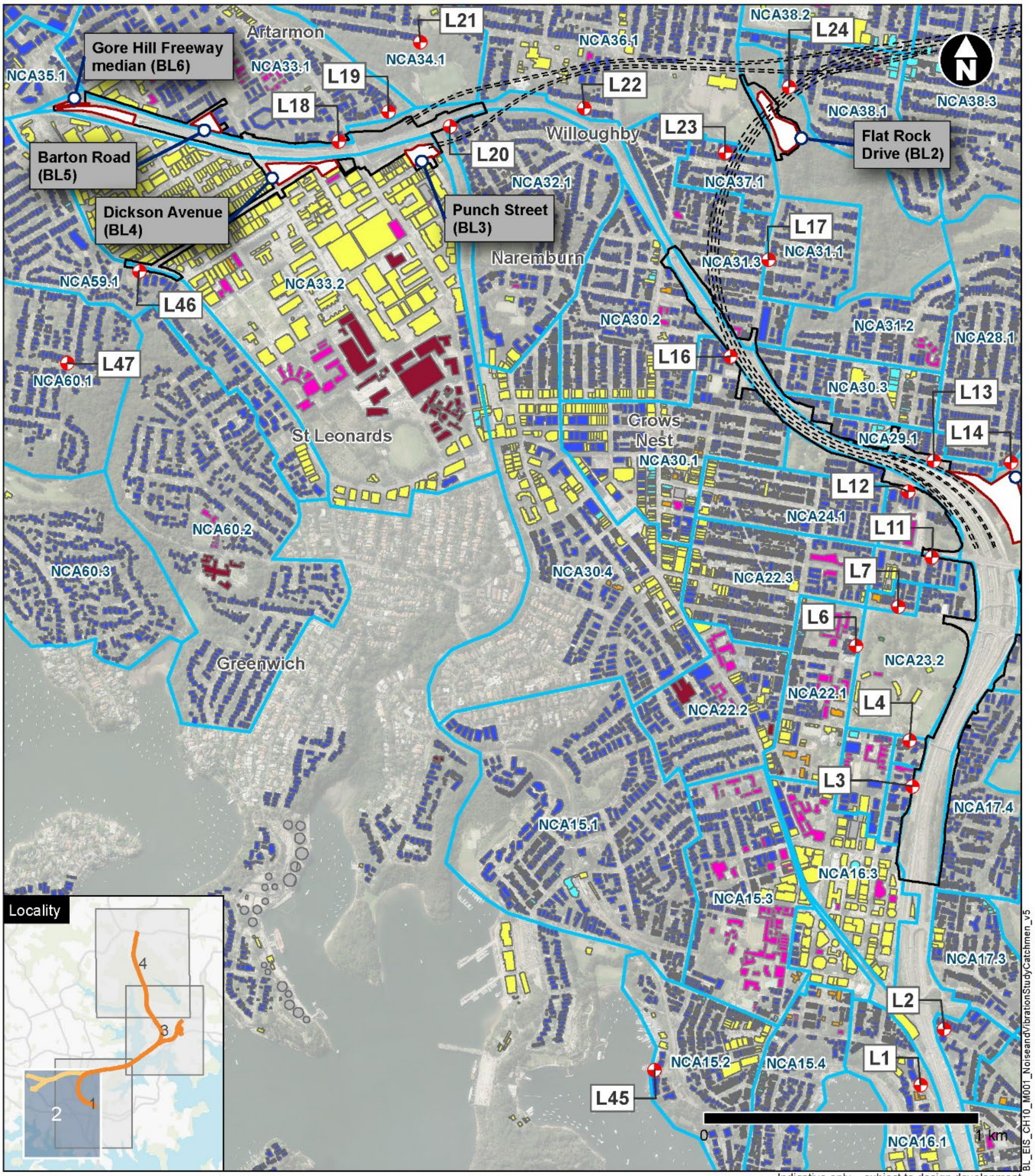
- The assessment of potential health risks for elevated receptors is dominated by the assessment of individual risks relevant to changes in NO_2 and $PM_{2.5}$.
- **Existing and expected traffic emissions**: No unacceptable risks have been identified in the 300m adjacent to Outlets H (Warringah Freeway), I (Gore Hill Freeway) and K (Burnt Bridge Creek Deviation) for elevated receptors to 45 m height.
- **Regulatory worst case emissions**: Unacceptable risks have been identified for elevated receptors in the 300m adjacent to Outlets H (Warringah Freeway), I (Gore Hill Freeway) and K (Burnt Bridge Creek Deviation) for elevated receptors that may be present at 45 m height.

Annexure I – Noise catchment areas



Legend

Construction footprint	**Receiver type**	Medical
Construction support site boundary	Commercial/industrial	Place of worship
Tunnel section	Mixed use	Recreational - active
Noise assessment features	Non receiver building	Recreational - passive
Noise monitoring location	Educational/childcare	Residential
Noise catchment area (NCA)		



Indicative only – subject to design development

Legend

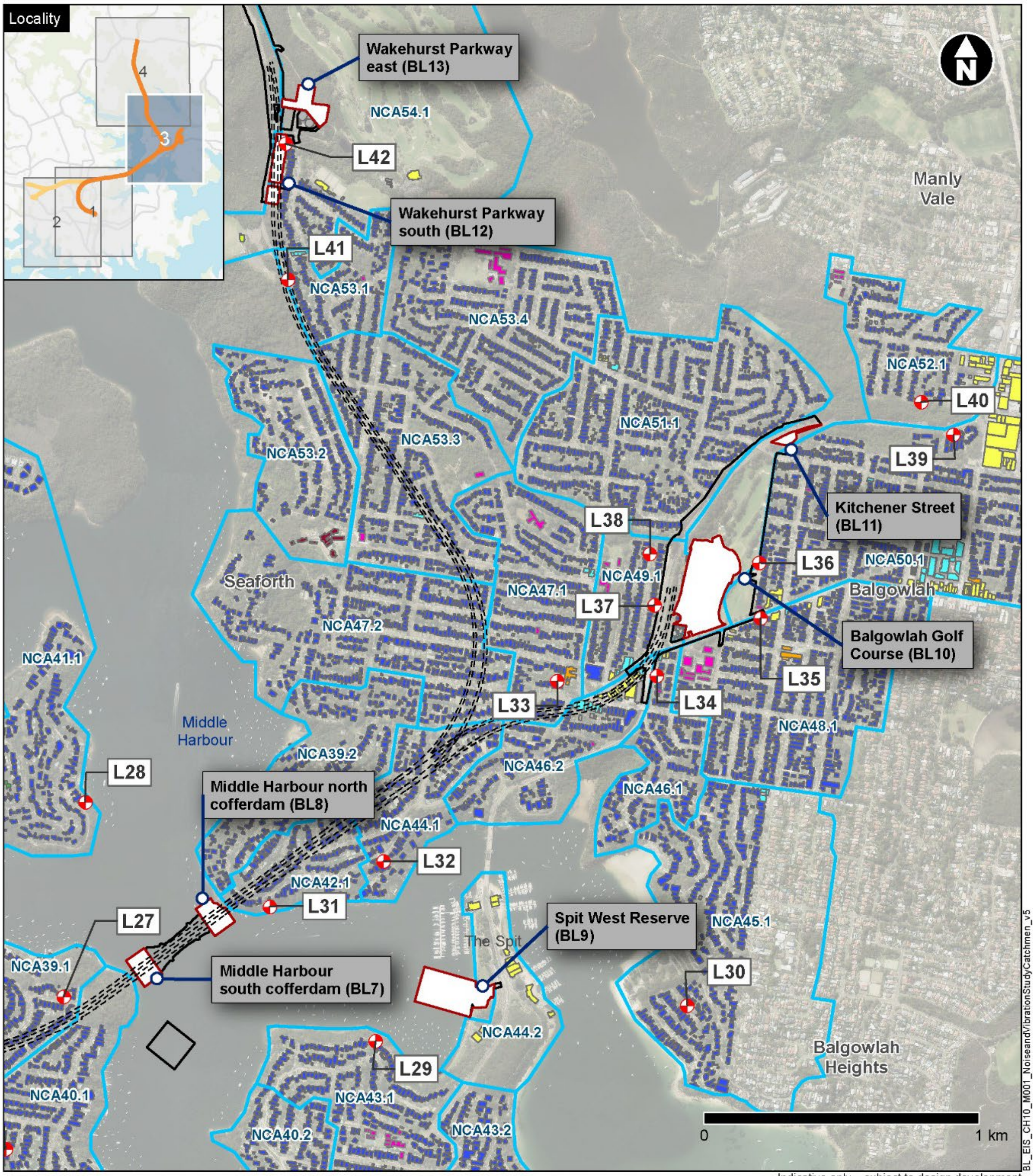
- Construction footprint
- Construction support site boundary
- Tunnel section

Noise assessment features

- Noise monitoring location
- Noise catchment area (NCA)

Receiver type

- Commercial/industrial
- Mixed use
- Non receiver building
- Educational/childcare
- Medical
- Place of worship
- Recreational - active
- Recreational - passive
- Residential



Indicative only – subject to design development

Legend

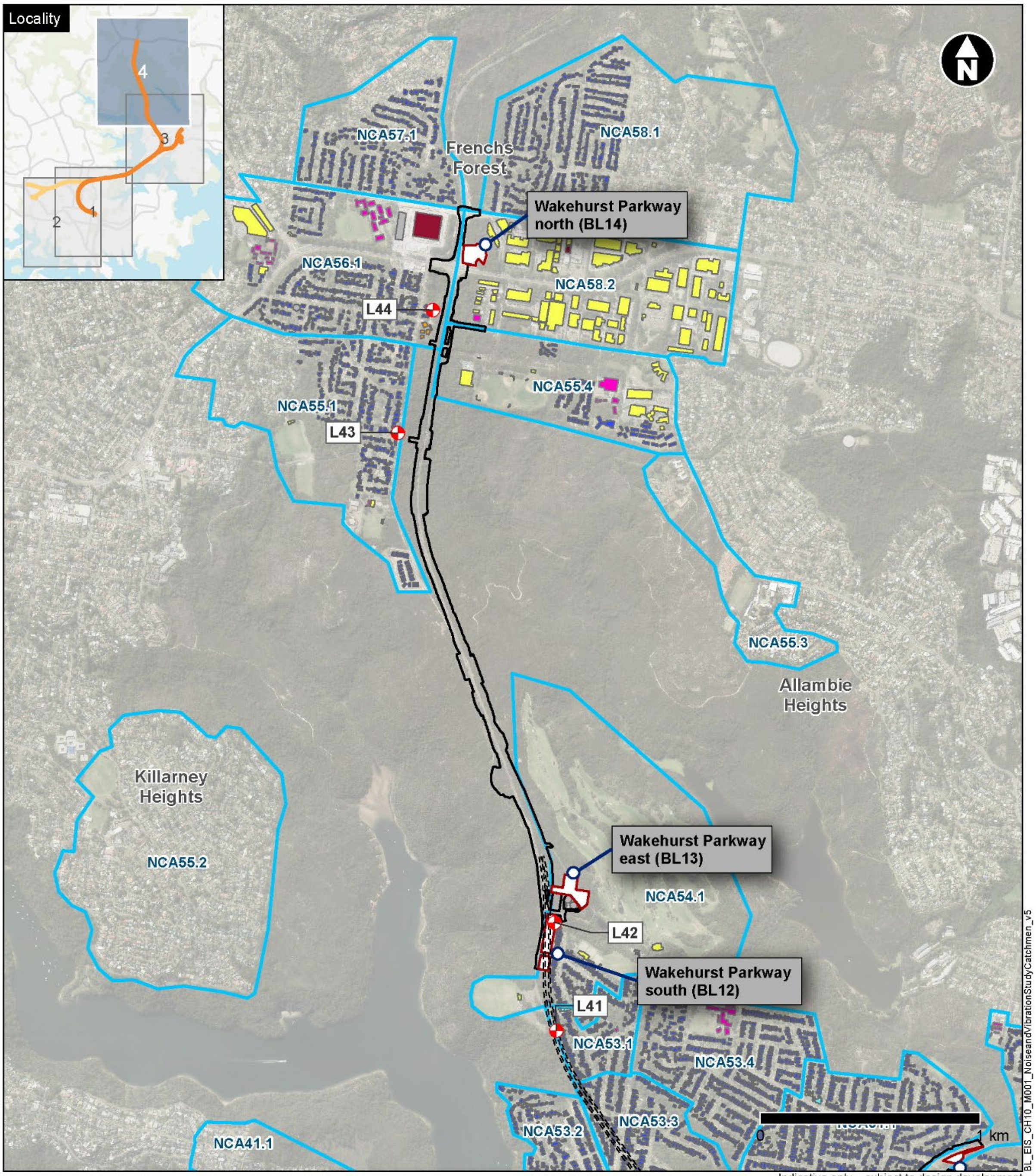
- Construction footprint
- Construction support site boundary
- Tunnel section

Noise assessment features

- Noise monitoring location
- Noise catchment area (NCA)

Receiver type

- Commercial/industrial
- Mixed use
- Non receiver building
- Educational/childcare
- Medical
- Place of worship
- Recreational - active
- Recreational - passive
- Residential



Indicative only – subject to design development

Legend

Construction footprint
Construction support site boundary
Tunnel section

Noise assessment features

Noise monitoring location
Noise catchment area (NCA)

Receiver type

Commercial/industrial
Mixed use
Non receiver building
Educational/childcare
Medical
Place of worship
Recreational - active
Recreational - passive
Residential