WestConnex

Australian Government
BUILDING OUR FUTURE

NSW
MAKING IT HAPPEN

New M5

Environmental Impact Statement

Main Volume Chapters 8 to 15



Volume 1B

November 2015

WestConnex speaks your language

Learn more by visiting
www.westconnex.com.au/yourlanguage
to watch project videos in your language and read more about WestConnex. If you need an interpreter, call the Translating and Interpreting Service on **131 450**.

Arabic

اعرف المزيد بزيارة الموقع
www.westconnex.com.au/yourlanguage
وذلك لمشاهدة الفيديوهات الخاصة بالمشروع باللغة العربية
وقراءة المزيد عن وست كونكس. إذا كنت في حاجة إلى
مترجم، اتصل بخدمة الترجمة الخطية والشفهية على الرقم
131 450.

Chinese

了解詳情請上網
www.westconnex.com.au/yourlanguage觀看(普通話)
視頻,並 查閱有關WestConnex的更多訊息。如需要傳譯員請
。。 撥電話傳譯服務 **131 450**

Hindi

स वे बसाईट र प क ि धि अर ँ:ाए का म ा ज
www.westconnex.com.au/yourlanguage व (हन्दि ी) म इ
ा ने कजे रें। मयब दिखेंयप रवे ह्यीकॉनेक्स के रें म ब
र औक सामिग्री पेंह्ल ि द ेखद्मकाषपिया आ ए ेअिन्हवाद वच
दुभाषिया सेवा े **131 450** र फ़ोन करें।

Greek

Μάθετε περισσότερα επισκεπτόμενοι το
www.westconnex.com.au/yourlanguage για να δείτε τα βίντεο του έργου στα ελληνικά και να διαβάσετε περισσότερα για το WestConnex. Εάν χρειάζεστε διερμηνέα, καλέστε την Υπηρεσία Μετάφρασης και Διερμηνείας στο **131 450**.

Italian

Per saperne di più visiti il sito
www.westconnex.com.au/yourlanguage, dove potrà guardare i video del progetto in lingua italiana e trovare maggiori informazioni su WestConnex. Se ha bisogno di un interprete, contatti il Servizio di Traduzione ed Interpretariato (Translating and Interpreting Service) al numero **131 450**.

Korean

www.westconnex.com.au/yourlanguage 를 방문하여한국어로 된 프로젝트 비디오를 보고 WestConnex 에 관해 읽고 배우세요. 통역이 필요하시면 번역 및 통역 서비스 **131 450** (TIS) 으로 전화하십시오.

Vietnamese

Hãy tìm hiểu thêm và viếng trang mạng
www.westconnex.com.au/yourlanguage để xem phim ảnh bằng Việt ngữ về công trình này và đọc thêm về WestConnex. Nếu quý vị cần thông ngôn viên, xin vui lòng gọi Dịch Vụ Thông Ngôn Phiên Dịch số **131 450**.

Pub number: RMS 15.586
ISBN: 978-1-925421-31-6

Contents

Volume 1B

8 Overview of environmental issues 8-1

9 Traffic and transport 9-1
- 9.1 Assessment methodology 9-3
- 9.2 Existing environment 9-19
- 9.3 Assessment of potential impacts 9-52
- 9.4 Environmental management measures 9-148

10 Air quality 10-1
- 10.1 Assessment approach 10-3
- 10.2 Construction air quality assessment methodology 10-15
- 10.3 Alexandria Landfill air quality assessment methodology 10-19
- 10.4 Operational air quality assessment methodology 10-21
- 10.5 Existing environment 10-41
- 10.6 Assessment of air quality impacts during construction 10-64
- 10.7 Assessment of air quality impacts during Alexandria Landfill closure 10-64
- 10.8 Assessment of air quality impacts during operation 10-69
- 10.9 Assessment of cumulative impacts 10-179
- 10.10 Environmental management measures 10-189

11 Human health 11-1
- 11.1 Assessment methodology 11-1
- 11.2 Existing environment 11-5
- 11.3 Assessment of potential impacts 11-10
- 11.4 Environmental management measures 11-39

12 Noise and vibration 12-1
- 12.1 Assessment methodology 12-2
- 12.2 Existing environment 12-27
- 12.3 Assessment criteria 12-29
- 12.4 Assessment of potential impacts 12-46
- 12.5 Environmental management measures 12-96

13 Land use and property 13-1
- 13.1 Assessment methodology 13-2
- 13.2 Existing environment 13-2
- 13.3 Assessment of potential impacts 13-37
- 13.4 Environmental management measures 13-72

14 Visual impacts and urban design 14-1
- 14.1 Assessment methodology 14-2
- 14.2 Existing environment 14-9
- 14.3 Assessment of potential impacts 14-31
- 14.4 Environmental management measures 14-82

15 Social and economic 15-1
- 15.1 Assessment methodology 15-2
- 15.2 Existing environment 15-7
- 15.3 Assessment of potential impacts 15-31
- 15.4 Environmental management measures 15-50

8 Overview of environmental issues

The potential impacts of the project and their associated environmental, social and economic consequences have been identified through:

- A preliminary environmental assessment, carried out as part of the State significant infrastructure application report (AECOM, 2015), to allow early identification of the key environmental issues and to inform the State significant infrastructure application.
- An assessment of the key issues identified in the Secretary's Environmental Assessment Requirements (SEARs) for the project (**Appendix A** (Secretary's Environmental Assessments Requirements)).
- An environmental risk analysis (detailed in **Chapter 29** (Environmental risk analysis)).
- Development and maintenance of an environmental risk register for the project (refer to **Chapter 29**).

The potential impacts of the project, identified through this risk assessment process were grouped into issues as follows:

- Traffic and transport
- Air quality
- Human health
- Noise and vibration
- Land use and property
- Visual impacts and urban design
- Social and economic
- Soil and water quality
- Contamination
- Flooding and drainage
- Groundwater
- Non-Aboriginal heritage
- Biodiversity
- Greenhouse gas
- Aboriginal heritage
- Resource use and waste minimisation
- Climate change and risk adaptation
- Hazard and risk.

The impact assessment for each of these issues and the proposed mitigation measures are presented in **Chapters 9** to **Chapter 26**.

(blank page)

9 Traffic and transport

A technical working paper: Traffic and transport (**Appendix G**) has been prepared to assess potential traffic and transport impacts during construction and operation of the New M5 (the project). This section provides a summary of the technical working paper and details:

- The assessment methodology and approach used to undertake the traffic and transport assessment
- The existing traffic and transport environment within the traffic and transport study area
- Future traffic and transport conditions without the project
- Potential impacts of the project on the road network during construction and operation
- Recommended safeguards and management measures to avoid minimise and / or mitigate potential traffic and transport impacts.

Table 9-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to traffic and transport, and where in the environmental impact statement (EIS) these have been addressed.

Table 9-1 Secretary's Environmental Assessment Requirements – traffic and transport

Secretary's Environmental Assessment Requirement	Where addressed
Details of how the proposal meets the objectives of the overall WestConnex program.	The project objectives are detailed in **Section 3.5**. A summary of how the project meets the objectives is provided in **Table 31-2** (Project justification and conclusion).
Details of how the traffic and transport objectives of the proposal, and service and infrastructure responses, take into account: adjacent sensitive land uses; future housing and employment growth areas; existing town, employment and industrial centres; approved and proposed infrastructure proposals; and broader transport needs (including public transport, cyclist and pedestrian requirements and facilities); including with specific reference to: • The preferred alignment and design. • The proposed interchanges and connections to the surrounding road network. • Associated road and related transport infrastructure facilities.	The preferred alignment and design, including interchanges and connections to the local road network has considered how the project would provide connectivity to and support areas identified for future housing and employment growth. This is described in **Chapter 4** (Project development and alternatives). The design includes the provision of cyclist and pedestrian facilities, opportunities for bus infrastructure improvements, and maintains existing connectivity. Impacts of the project on public and active transport have been considered and are described throughout **Section 9.3**. Impacts to nearby sensitive land uses have been considered throughout the development of the project, and are discussed in **Chapter 15** (Social and economic).
An assessment and modelling of operational traffic and transport impacts on the local and regional road network (in consultation with affected councils), and the Sydney motorway network, including the consideration of planning proposals, major urban renewal and development, the potential cumulative impacts of Stage 3 – M4 South (Haberfield to St Peters), and the impacts of potential shifts of traffic movements to alternative routes outside the proposal area (including as a result of tolls);	Operational traffic modelling undertaken for the project considered impacts to the local and regional network, including the M5 East Motorway. Modelling of the future road network with the project was undertaken for three future scenarios; 2021 and 2031 with the project, and 2031 with the full WestConnex program of works and the future Southern extension. The full WestConnex program of works includes the future M4-M5 Link. Future year modelling scenarios included consideration of background traffic growth associated with urban and residential development. Potential shifts in traffic movements to alternative routes have also

Secretary's Environmental Assessment Requirement	Where addressed
	been assessed. The operational traffic impacts of the project are described in **Section 9.3.2**.
Induced traffic and operational implications for public transport (particularly with respect to strategic bus corridors and bus routes) and future public transport opportunities	Impacts of the project on existing and future public transport opportunities are described in **Section 9.3**.
Impacts on property and business access and on street parking provision, including permanent and temporary (construction) changes to access and parking, and traffic management measures such as clearways	Impacts to property access and on-street parking during construction and operation are provided in **Section 9.3**.
impacts on cyclists and pedestrian access and safety and consideration of opportunities to integrate cycleway and pedestrian elements with surrounding networks	Impacts on cyclists and pedestrian access and safety during construction and operation of the project are described in **Section 9.3.1**. Opportunities to integrate cycleway and pedestrian elements with the surrounding network are described in **Section 9.3.2**.
construction traffic and transport impacts of the proposal (including ancillary facilities) and associated management measures, in particular:	
• Impacts on the road network (including safety and level of service, parking, pedestrian and cyclist access, and disruption to public transport services and access to properties).	Impacts on the road network from construction traffic are described in **Section 9.3.1** and **Appendix G** (Technical working paper: Traffic and transport).
• Route identification and suitability for heavy vehicles, and scheduling of transport movements, particularly movements outside standard construction hours	Construction vehicle routes are discussed in **Section 9.3.1**. The construction traffic assessment has considered heavy vehicle movement during peak periods and off-peak periods, including outside standard construction hours.
• The number, frequency and size of construction related vehicles (both light and heavy vehicles).	Construction traffic volumes and patterns are described in **Section 9.3.1**. Construction vehicles are detailed in **Section 6.8** (plant and equipment).
• The nature of existing traffic on construction access routes (including consideration of peak traffic times).	The existing traffic environment within the traffic study area, which includes construction traffic vehicle routes is described in **Section 9.2**.
• The need to close, divert or otherwise reconfigure elements of the road network associated with construction of the proposal.	Temporary and permanent road closures, changes to property access, and modifications to pedestrian and cyclist pathways and infrastructure during construction of the project are described in **Section 9.3.1**.
• Having reference to the cumulative construction impacts of other infrastructure preparing for or commencing construction.	A description of potential cumulative construction traffic impacts is provided in **Section 9.3.1**. Additional detail regarding cumulative impacts is provided in **Chapter 27** (Cumulative impacts).

9.1 Assessment methodology

The Technical working paper: traffic and transport (**Appendix G**) has assessed the potential impacts of the project during construction and operation, including cumulative impacts associated with the WestConnex program of works and the future Southern extension. The existing traffic and transport environment, and the potential traffic and transport related impacts associated with the project have been described as two separate areas to reflect the key components of the project:

- The M5 East Motorway corridor (the M5 East Motorway, the main alignment tunnels between the two ends of the project and the St Peters interchange)
- The local roads around St Peters interchange and Sydney Park.

The traffic and transport impact assessment undertaken for the project consisted of three key components:

- Characterising the existing traffic and transport environment within the study area using a combination of data from the Bureau of Transport Statistics and Roads and Maritime, traffic counts and survey data, and traffic modelling applications
- The development and application of a regional strategic model; the WestConnex Road Traffic Model, to determine the anticipated future growth in traffic on the major road network and the effects of tolling on the road traffic demand
- Network modelling to determine the traffic and transport conditions within the western surface works, M5 East Motorway corridor and the local roads around St Peters interchange during construction of the project, and in future years with and without the project.

The study area for the traffic and transport assessment, as well as the methodology for undertaking these key traffic and transport assessment is discussed in **Section 9.1.1** to **Section 9.1.6**.

9.1.1 Study area

The study area for the traffic and transport assessment is shown on **Figure 9-1**. The study area encompasses the local and regional road network including the M5 East Motorway corridor and local roads around the St Peters interchange.

The extent of the traffic and transport study area was limited to roads which would potentially be affected as a result of construction and / or operation of the project, including roads which:

- Would be used as part of construction compound vehicle routes
- Would provide the main connections between the M5 East Motorway and the arterial road network during construction and operation
- Would provide the main connections between the New M5 and the arterial road network during operation.

The King Georges Road Interchange Upgrade Project is located near the western surface works. This project was approved in March 2015 and construction works have commenced. As part of the traffic and transport assessment for the project, operational traffic impacts along King Georges Road have not been re-evaluated from what was undertaken as part of the King Georges Road Interchange Upgrade project.

(blank page)

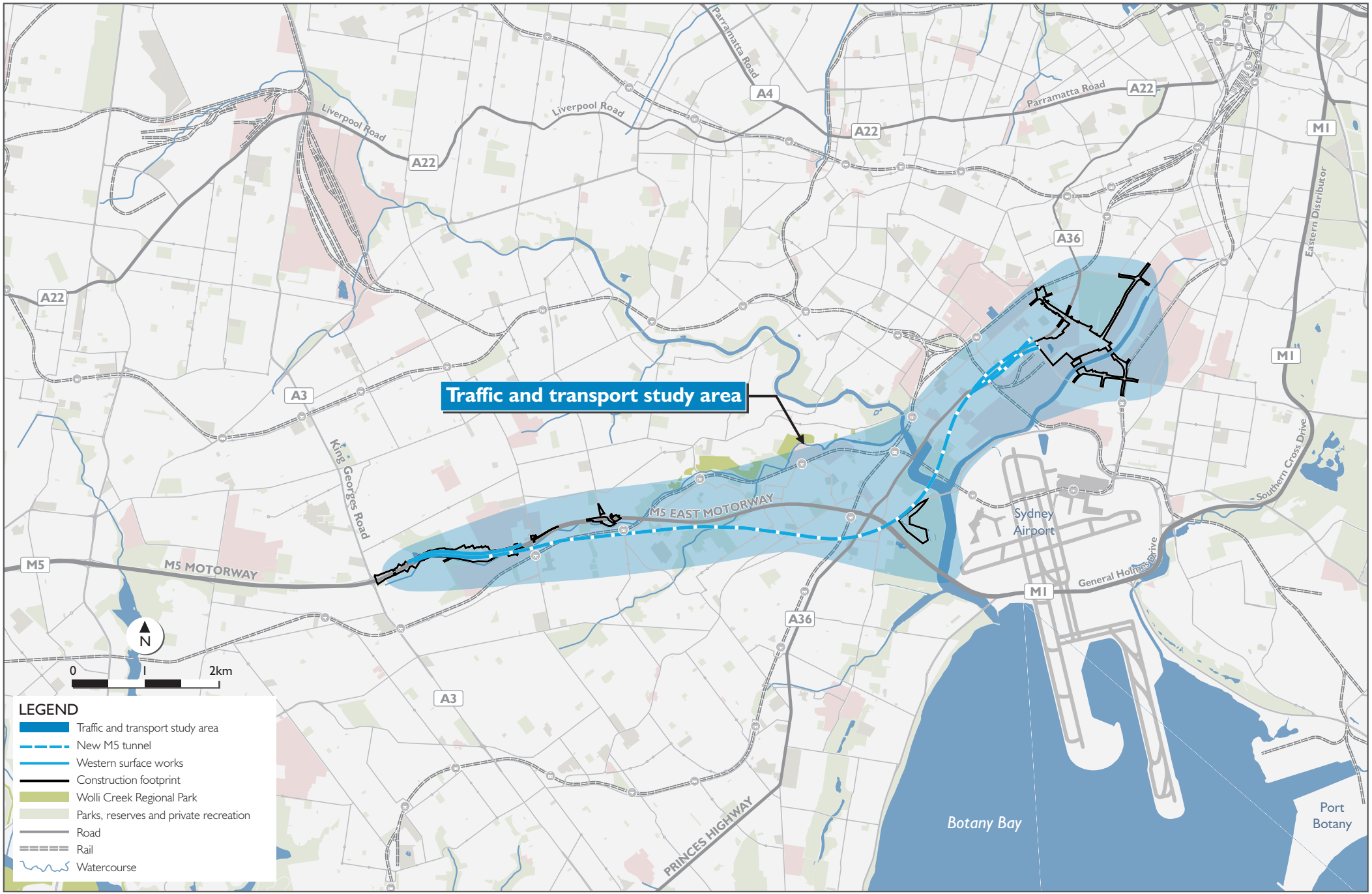


Figure 9-1 Traffic and Transport study area

(blank page)

9.1.2 Characterising the existing traffic and transport environment

The existing traffic and transport environment across the study area was characterised through:

- Data collection and review to identify the transport mode share
- Deriving traffic patterns from traffic counts.

Data collection and review

Traffic and transport-related data was collected and analysed to determine the modes of travel across the study area. Key sources of data included:

- *Household Travel Survey Report: Sydney 2012 / 2013*, (Bureau of Transport Statistics (BTS) 2014b release)
- Train Statistics 2014: Everything you need to know about Sydney Trains and NSW TrainLink, 9th Edition (BTS, December 2014c)
- Traffic volume counts and road travel time surveys collected by Roads and Maritime. Traffic surveys used to characterise the existing environment included:
  - Automatic count surveys at 13 mid-block locations and 48 intersections
  - Bicycle counts at nine locations in 2014
- Roads and Maritime crash data between 2009 and 2013.

Deriving existing traffic patterns

Automatic mid-block traffic counts were carried out at 13 locations in the study area during 2014 (refer to **Figure 9-1**). A 'mid-block' is a section of road between two intersections. In addition, traffic counts were also conducted at 48 key intersections across the study area. Locations of mid-block and intersection traffic counts were selected to provide a good representation of existing traffic conditions on roads likely to be affected by the project.

The traffic count data was used to prepare average daily and weekly traffic profiles for the study area.

Percentages of heavy vehicles were also recorded at both mid-block and intersection counts, to characterise the current distribution of heavy and light vehicles using the road network around the project.

Data collected from mid-block and intersection counts, including AM and PM peak traffic volumes, daily traffic volumes and percentages of heavy vehicles are presented in **Section 9.2**.

The traffic count data collected has been used to assess the existing operational performance of the road network in areas likely to be affected by the project, including:

- Along the M5 East Motorway corridor
- Local roads around the St Peters interchange.

In assessing the existing performance of roads and intersections, the following performance indicators have been used:

- Road safety and incidence of traffic crashes (based on Roads and Maritime Crash Data between 2009 and 2013 and Transport for NSW Centre for Road Safety Data)
- Average travel speeds and travel times
- Mid-block and intersection level of service (LoS) (refer to **Section 9.1.6** for more detail about measures of network performance).

The assessment of existing traffic performance included comparing the collected AM and PM peak period traffic data with road and intersection design capacity. This comparison has allowed an assessment of whether a particular road or intersection is operating below, at or above its design capacity, indicating the level of congestion currently experienced. Existing intersection performance level of service and average delays at key intersections have also been determined.

9.1.3 Approach to traffic modelling

Overview of traffic modelling approach

Traffic modelling for the project aimed to make the best use of existing traffic counts and traffic models to:

- Determine the existing and future conditions in the study area and key surrounding roads with and without the project
- Assess the performance of the network / corridor during construction and operation, with and without the project.

An overview of the traffic modelling approach is presented in **Figure 9-2**.

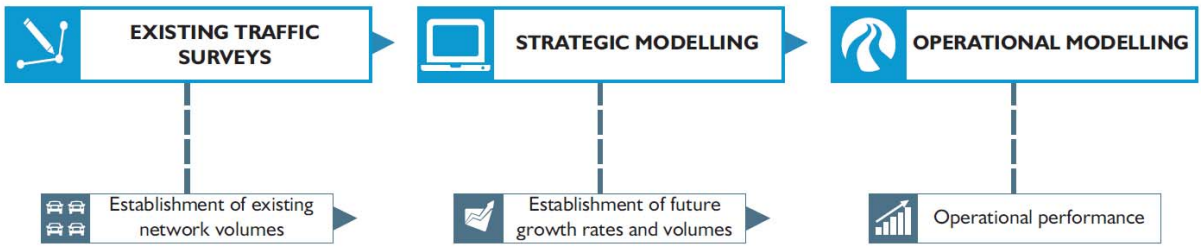


Figure 9-2 Overview of traffic modelling approach

Traffic models

Traffic modelling for the project included both regional and local scale modelling which enabled existing and future traffic and transport conditions and road network performance to be characterised, both with and without the project. This approach has been taken to include:

- Strategic modelling – changes to traffic which may occur at a regional or 'strategic' level, including as a result of the project, the broader WestConnex program of works and the future Southern extension, and factors such as major developments and changes in land use patterns
- Traffic network performance modelling – a more detailed, local analysis of changes to traffic which occur on individual roads and intersections.

These two types of models are described in more detail in **Section 9.1.4** and **Section 9.1.5** respectively.

Traffic modelling scenarios

Traffic modelling for the project assessed seven scenarios:

- Three scenarios without the project:
  - The existing road network (2012), which incorporates population and employment projections based on the September 2014 data release from the Bureau of Transport Statistics. This data has been projected from 2011 Census data and incorporates known major urban renewal and developments
  - The road network at the opening of the project (2021). While the NSW Government has committed to achieving completion of the New M5 Motorway by 2019, using 2021 allows for full ramp-up of traffic demand as travellers respond to the provision of the project.
  - The road network 10 years after opening the project (2031)

- A construction scenario (2016)
- Two scenarios with the project:
  - One at the year of opening of the New M5 (2021)
  - One 10 years after opening (2031)
- One cumulative scenario, 10 years after opening of the New M5 (2031), with all three stages of the WestConnex program of works and the future Southern extension operational.

The traffic modelling scenarios used to inform the assessment of the traffic and transport related impacts of the project are summarised in **Table 9-2**.

An additional scenario incorporating the project and the M4 East was strategically assessed to determine the potential impacts on traffic volumes and patterns within the study area (inclusive of the King Georges Road Interchange Upgrade and the M4 Widening projects). The results indicated no significant difference in volumes within the study area as a result of the M4 East. No further analysis was therefore undertaken.

Table 9-2 Traffic modelling scenarios

Model year	Without project	With project	Modelling Scenario	Description	Impact measured
2012	✓		Existing case	The existing road network with no new projects or upgrades.	NA
2016	✓		Construction	The current road network with no new projects or upgrades, with construction traffic movements for the project. This considers the worst case construction traffic generating scenario and includes traffic movements associated with spoil removal.	Construction impacts on the existing road network.
2021	✓		Base case without the project	The base case 'without project' assumes the King Georges Road Interchange upgrade and future M4 Widening projects are complete, but the remainder of the WestConnex program of works has not been built. This scenario assumes that on-going improvements will be made to the broader transport network including some new infrastructure and intersection improvements to improve capacity and to cater for traffic growth.	Consequence of not proceeding with the project on the existing network.
2021		✓	Base case with the project	The base case 'with project' assumes the New M5 is complete and open to traffic, without the future Sydney Gateway, M4 East (WestConnex Stage 1B) or the future M4-M5 Link (WestConnex Stage 3) components of the WestConnex program of works.	Operational impacts associated with the completion of the project as described in **Chapter 5** (Project description).
2031	✓		Future case without the project	The future case 'without project' assumes the King Georges Road Interchange upgrade and M4 Widening projects are complete, but the remainder of the WestConnex program of works has not been built. This scenario assumes on-going improvements will be made to the broader transport network including some new infrastructure and intersection improvements to improve capacity and to cater for traffic growth.	Consequence of not proceeding with the project on the existing network
2031		✓	Future case with the project	The future case 'with project' assumes the New M5 is complete and open to traffic without the M4 East (WestConnex Stage 1) or the future M4-M5 Link components of the WestConnex program of works.	Operational impacts associated with the completion of the project as described in **Chapter 5** (Project description).
2031		✓	Cumulative case (full WestConnex program of works and the future Southern extension)	All components of the WestConnex program of works and the future Southern extension completed. The full WestConnex program of works and the future Southern extension is considered to be a cumulative scenario.	Operational impacts associated with the operation of the three stages of the WestConnex program of works as well as the future Southern extension.

9.1.4 Strategic modelling

Strategic traffic modelling is typically undertaken for large areas and is best used for broad network evaluation and demand forecasting.

The Sydney Strategic Traffic Model

The key strategic transport model used in the Sydney greater metropolitan area is the Sydney Strategic Traffic Model (STM), managed by the Bureau of Transport Statistics. The STM provides the majority of strategic modelling for the Sydney greater metropolitan area and was developed to determine anticipated future growth in traffic on the major road network and the effect of tolling changes on this network.

The STM attempts to replicate people's travel choices and behaviour under a given scenario. It combines current understandings of travel behaviour with likely population and employment size and distribution, and likely road and public transport networks and services to estimate future travel patterns in Sydney under different strategic land use, transport and pricing scenarios. Inputs into the STM include:

- Household travel survey data
- Journey to work data
- Population and employment statistics (current and projected)
- Freight movement model data
- Parking survey data
- Road, rail, bus and ferry networks.

The WestConnex Road Traffic Model

The STM was used as the basis for developing a strategic traffic model specific to the project and the wider WestConnex program of works. The WestConnex Road Traffic Model (WRTM) was developed to determine anticipated future growth in traffic on the major road network. The model has been used to develop traffic forecasts and has been used as the basis for the traffic impact assessment for the project.

The information in the WRTM has been applied to existing traffic counts for the study area (2012) to estimate future traffic volumes as a basis for modelling and assessment of traffic impacts of the project during construction and operation.

The WRTM is not an operational model. Therefore, to assess detailed impacts of the project on the road network, further analysis using operational modelling software (traffic network performance modelling) was undertaken (refer to **Section 9.1.5** for additional detail).

The WRTM includes:

- A strategic model of the Sydney metropolitan area, including Sydney's motorway network and all major state roads in the network, taken from the STM
- Anticipated changes and upgrades to the road network up until 2031
- Anticipated future land uses as a basis for estimating future demand for travel for light and heavy vehicles
- Modelling of the effects of tolls on the road network and traffic volumes, including a toll on the New M5 and M5 East Motorways
- Accommodation of different motorist behaviours, including willingness to pay a toll to save travel time
- Induced traffic which is attracted to roads surrounding the New M5 or the main alignment tunnels from competing routes as a result of changed travel times.

Additional detail regarding induced demand and land use projections incorporated into the WRTM is provided in the following section.

Induced demand

Even with no growth in regional population and / or economic activity, a new or substantially upgraded road has the potential to induce changes in travel patterns, which appear as induced traffic. Traffic growth on new or upgraded roads is generally a result of:

- Regional growth in trips resulting from population growth and expanded economic activity
- Trips attracted from competing routes or modes as a result of improved travel times on the new or upgraded road
- Induced traffic as a result of improved travel times between homes and destinations, such as workplaces, shopping centres and education precincts, which stimulate changes to regional-wide trip patterns.

The WRTM includes changes in traffic associated with induced demand as a result of the three abovementioned sources of traffic growth.

Land use projections

Data from the STM has been extracted by the Bureau of Transport Statistics and used as a basis for developing the population and employment projections for the WRTM.

Population and employment data extracted and incorporated into the WRTM included trip generation, trip distribution and mode choice modules as well as demographic data related to land uses including population, employment and education enrolment projections.

9.1.5 Traffic network performance modelling

Traditional intersection assessment tools do not provide a whole-of-network assessment and tend to work best at evaluating individual, isolated intersections. To fully evaluate operational impacts of the project on the road network around the St Peters interchange and local road upgrades, a micro-simulation road network model using Paramics software was developed to assess localised road network effects. Modelling extents across the traffic and transport study area are shown in **Figure 9-3**.

Microsimulation or network models simulate the movement of individual vehicles within a defined area or network. Network modelling uses time-based algorithms related to vehicle-to-vehicle interactions on roads, including car-following, lane changing and gap acceptance. The vehicle-to-vehicle interactions accounted for in network modelling provide the basis for calculating delays within a defined area or network. Network modelling is used to provide a better representation of queueing, congestion and delays in at-capacity urban networks.

The major benefit of using network modelling is the ability to assess networks with closely spaced intersections, where intersection operation is likely to be influenced by adjacent intersections. This means the queue lengths and delays modelled at intersections within the modelled area reflect the impact of congestion and result in a more accurate representation in the model.

For the project's traffic and transport assessment, Paramics models were developed for the AM and PM peak periods to simulate the operation of the existing road network under present day traffic demands. The extent of the microsimulation model used for the traffic and transport impact assessment for local roads around the St Peters interchange is shown **Figure 9-4** and includes:

- A core network, comprising the intersections that would be modified as part of the local road upgrades (refer to **Section 5.7**)
- Additional intersections outside of the core modelled local road network.

Traffic data collected for the project between November 2012 and June 2014 was used to calibrate and validate the model.

Network performance modelling around the St Peters interchange and local road upgrades was undertaken to reflect the design of the project (refer to **Figure 5-29** to **Figure 5-36**). An additional two intersections were included in the network performance modelling which fall outside of the project; Sydney Park / Mitchell Road intersection and the Princes Highway / May Street intersection.

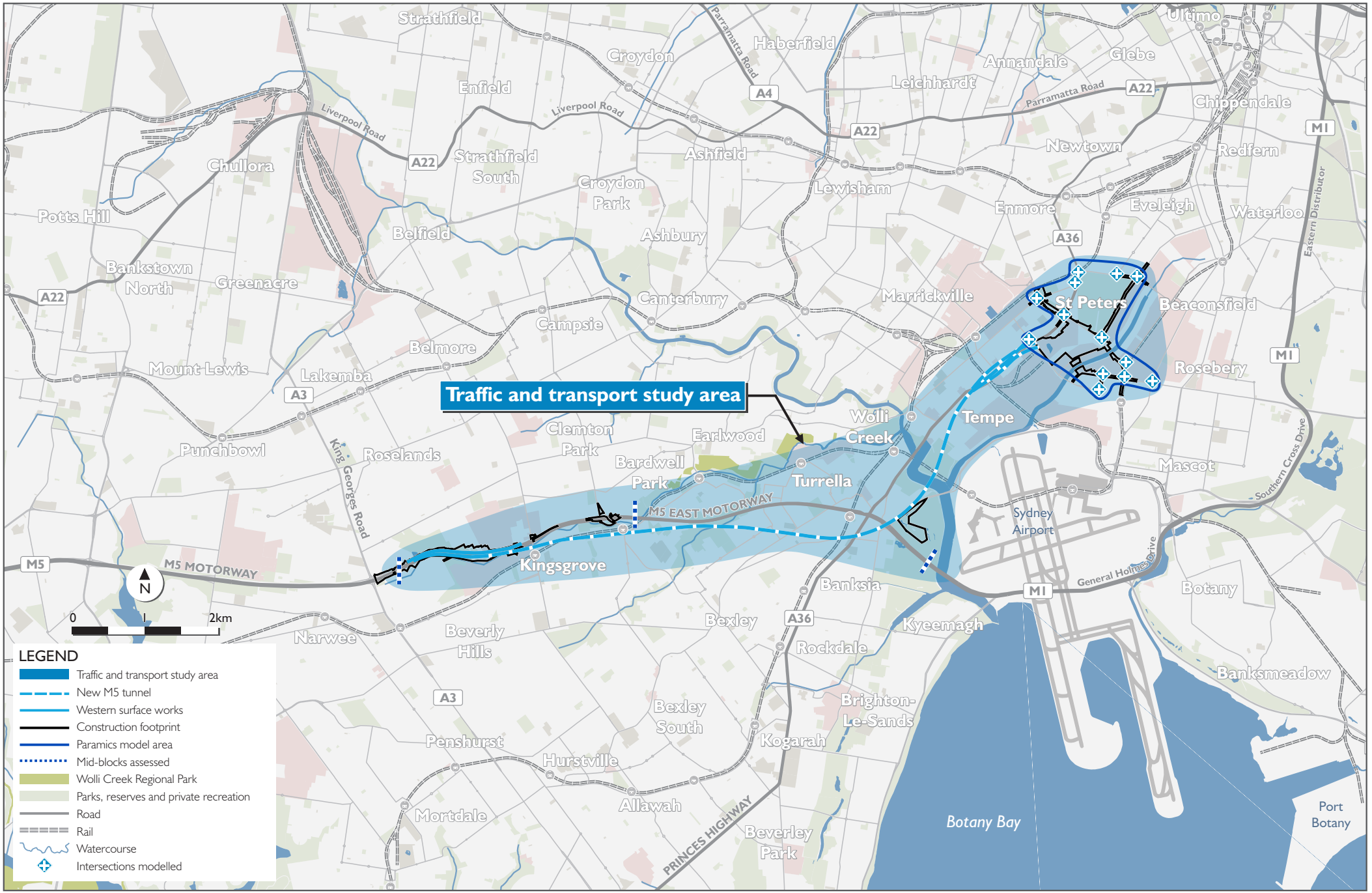


Figure 9-3 Traffic network modelling extents

(blank page)

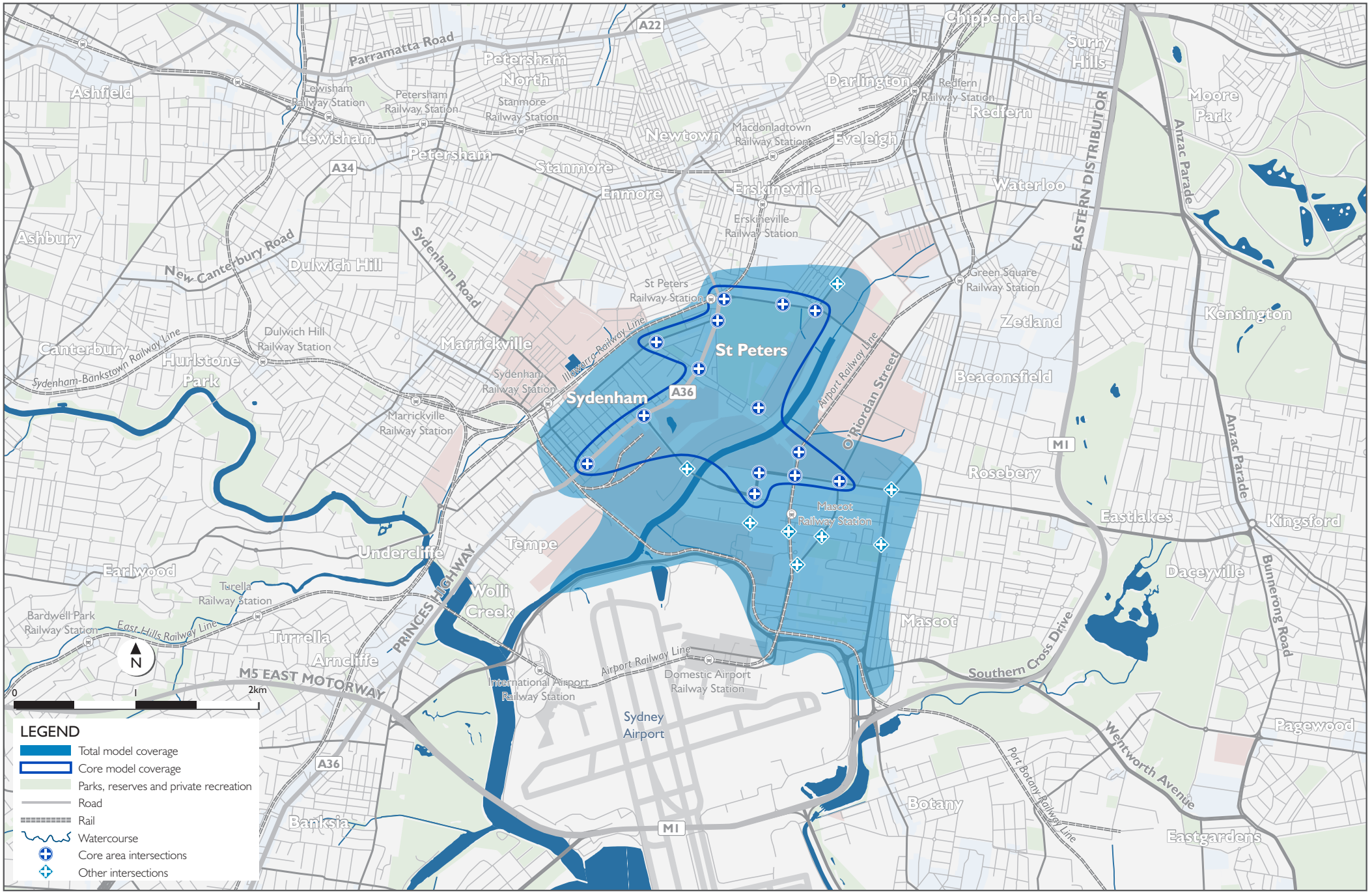


Figure 9-4 Traffic network performance modelling extent for local roads around the St Peters interchange

(blank page)

9.1.6 Measures of network performance

Level of service (LoS) is a qualitative measure used to describe the operational conditions and efficiency of a road or intersection and to assess operational performance. As a measure of performance, level of service is generally described in terms of service measures such as:

- Speed and travel time
- Freedom to manoeuvre
- Traffic interruptions
- Comfort and convenience
- Road safety.

There are six levels of service; level of service A to level of service F. A level of service A represents optimum operating conditions and a level of service F the poorest operating conditions. When the level of service of a road or intersection falls below a level of service D, investigations are generally initiated to provide suitable remediation. However, constraints in built up urban areas mean that level of service E and level of service F are regularly experienced by motorists on the Sydney road network. These conditions are generally experienced during traffic peak periods.

Intersection performance and level of service

Average delay is often used to assess the operational performance of intersections, with level of service used as an index. In other words, an intersection is first characterised based on its level of service 'band' with a more refined assessment of performance within that band carried out based on assessment of average delay times.

A description of the level of service scale for intersection performance is provided in **Table 9-3** .

Table 9-3 Level of service criteria for intersections

LoS	Average delay per vehicle (seconds)	Traffic signal / roundabouts	Give way and stop signs
A	Less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but crash study required
D	43 to 56	Operating near capacity	Near capacity and crash study required
E	57 to 70	At capacity; at signals incidents will cause excessive delays	At capacity; requires other control mode
F	More than 70	Roundabouts require other control mode	At capacity; requires other control mode

Source: Guide to Traffic Generating Developments (RTA, 2002)

Intersection performance and degree of saturation

Degree of saturation is a measure used to assess the capacity of an intersection which uses a ratio of intersection traffic volume to intersection traffic capacity (volume / capacity). In other words, the ratio of how much traffic passes through the intersection to how much traffic the intersection has been designed to accommodate.

The Degree of saturation of an intersection ranges between zero and one, with one representing the capacity of the intersection. Intersections are said to reach their practical capacity at a degree of saturation of 0.9. Beyond the practical capacity, any additional traffic would have an increasing impact on delays and the subsequent performance of the intersection.

Roadway performance and level of service

Mid-block volume / capacity (v/c) ratios provide an indication of the saturation level of a segment of road, based on the theoretical design capacity of the road. This measure for a road mid-block is equivalent to the concept of DoS for intersections described above.

Volume / capacity ratios can be used to provide a corresponding level of service for road operation, as detailed in *Guide to Traffic Management – Part 3 Traffic Studies and Analysis* (Austroads, 2013).

The range of mid-block volume / capacity ratios which correspond to each level of service vary with differing road conditions and road type classifications. The assessment of the mid-block levels of service for the M5 East Motorway and the New M5 use the volume / capacity ratios for freeways, and all other roads within the study area have been assessed using the volume / capacity ratios for multi-lane roads.

The definitions and criteria for the six levels of service for mid-blocks are provided in **Table 9-4**.

Table 9-4 Mid-block level of service definitions and criteria – multi-lane roads and freeways

LoS	Definition	Volume / capacity ratio criteria	
		Multi-lane roads[1]	Freeways[2]
A	A condition of free flowing traffic where individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high.	V / C < = 0.26	V / C < = 0.28
B	Stable traffic flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort is a little less than with level of service A.	0.26 < V / C < = 0.41	0.28 < V / C < = 0.44
C	Stable traffic flow; however, most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level	0.41 < V / C < = 0.59	0.44 < V / C < = 0.64
D	Close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems.	0.59 < V / C < = 0.81	0.64 < V / C < = 0.87
E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown.	0.81 < V / C < =1.00	0.26 < V / C < = 1.00
F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.	1.00 < V / C	1.00 < V / C

Source: Austroads Guide to Traffic Management – Part 3 Traffic Studies and Analysis, Second Edition, 2013 .

Notes [1]Where free flow speed is taken as 70 kilometres per hour. Multi-lane roads volume / capacity ratio criteria was adopted for all surveyed mid-blocks with the exception of the M5 East Motorway

[2]Where free flow speed is taken as 90 kilometres per hour. Freeway volume / capacity ratio criteria was adopted for mid-block surveys along the M5 East Motorway only.

9.2 Existing environment

The existing traffic and transport environment has been described in a regional and local context, in recognition of the key role of the M5 East Motorway as part of the State and national road freight network, as well as its role as part of the Sydney local and metropolitan road network.

The regional context of the road network within the study area has been discussed in **Section 9.2.1**, with specific focus on the role of the M5 East Motorway and the Sydney freight task.

The road network at a more local scale can be considered in two separate areas based on the local road environment and the key components of the project:

- The existing M5 East Motorway corridor
- The area around the St Peters interchange and local road upgrades.

The existing traffic and transport environment in these areas is described in the following sections with regard to:

- Modes of travel, including travel mode share, the public transport network and active transport infrastructure
- The current and future traffic conditions along the road network, including traffic volumes and patterns, travel times and speeds, network performance and road safety.

The existing environments along the M5 East Motorway corridor and around the St Peters interchange and local roads are outlined in **Section 9.2.2** and **Section 9.2.3** respectively.

9.2.1 Regional context

The role of the M5 East Motorway corridor

The M5 East Motorway corridor provides the main passenger, commercial and freight connection between South West Sydney and the Sydney CBD, Sydney Airport and Port Botany. It also connects to the Sydney orbital network and interstate transport routes. The corridor forms part of the AusLink National Land Transport Network (National Road Network) and the Sydney orbital network. The National Road Network in NSW and the Sydney orbital network are shown in **Figure 9-5** and **Figure 9-6**.

The National Road Network provides connections between all mainland states and territories of Australia. The network is based on national and inter-regional transport corridors including connections through urban areas, links to ports and airports, rail, road and intermodal connections, which together are of critical importance to national and regional economic growth, development and connectivity.

The primary objectives of the National Road Network are to facilitate overseas and interstate trade, to support regional development and to allow safe and reliable access to major population centres. The M5 East Motorway forms part of the urban roads component of the National Road Network, providing a connection between the Hume Motorway (M31) in the west and Sydney Airport and Port Botany in the east.

The Sydney orbital network comprises around 160 kilometres of motorways and other main roads which provide a ring or orbital around the Sydney metropolitan area. The network consists of nine motorways, linked with expressways, freeways and other main roads. The M5 East Motorway provides an east-west connection within the network between Port Botany and Sydney Airport in the east, and the Westlink M7 Motorway and the Hume Motorway (M31) in the west.

The Transport Master Plan identifies 46 strategic transport corridors in Sydney's greater metropolitan area. These corridors service travel demands between centres in metropolitan Sydney and are areas where high concentrations of travel demand occur during peak periods on all travel modes.

Patterns of economic and employment growth are expected to result in even greater demands along these corridors. The M5 East Motorway corridor is identified in the Transport Master Plan as a strategic transport corridor that is subject to high levels of congestion.

The M5 East Motorway corridor is very congested during peak periods with a volume / capacity ratio over 1.0 and average speeds reducing to below 40 kilometres per hour. Without any improvements to the capacity of the M5 East Motorway corridor, peak travel times between Liverpool and Sydney Airport are expected to increase by about 20 minutes to a total trip length of 90 minutes in 2031 (Infrastructure NSW, 2012).

The Transport Master Plan also notes arterial roads connecting to the M5 East Motorway, including King Georges Road, Canterbury Road, Stoney Creek Road, Princes Highway and General Holmes Drive are experiencing greater volumes of traffic than they were originally designed for, particularly heavy vehicle movements. The additional vehicles along these roads are causing underperformance of the M5 East Motorway by increasing congestion, travel time variability and a higher risk of crashes.

Freight

The NSW freight network comprises a system of railway lines, roads, ports, Sydney Airport, regional airports and intermodal terminals. Transport of freight through this system is critical to the State economy and the efficiency of the transport network contributes to the success and growth of NSW. Conversely, inefficiencies, friction and capacity constraints in the transport network add costs for manufacturers, producers and consumers (Transport for NSW, 2013e).

The M5 East Motorway forms part of the urban roads component of the National Road Network in Sydney. It is a key freight, commercial and passenger route which connects Port Botany and Sydney Airport with the Hume Motorway (M31). The Hume Motorway forms part of the National Land Transport Network; a defined national network of road and rail infrastructure links and their intermodal connections determined under the *National Land Transport Act 2014*.

The Freight and Ports Strategy states the NSW freight task is expected to almost double over the next 20 years. Capacity across the freight network varies; however, key parts of the network are already constrained. Across New South Wales in 2011:

- Of the 409 million tonnes moved on the NSW transport network in 2011, the road network carried around 256 million tonnes (63 per cent)
- About 33 per cent of the total freight task was carried by the rail network, dominated by the movement of coal in the Hunter Valley.
- Excluding the coal freight task, the road-share of the freight task was 90 per cent (Transport for NSW, 2013e).
- The road network also accounted for 92 per cent of the mode share for the total interstate freight task.

There is limited available freight capacity on the shared rail network in the metropolitan area, and priority for passenger trains in the rail timetables further constrains freight movements. A dedicated freight railway line exists to the north of the M5 East Motorway corridor and is used by freight trains travelling between the Illawarra / Port Botany and the Main Southern Railway. As described in **Chapter 4** (Project development and alternatives), improvements to the freight rail network, including shifting additional freight for transport from road to rail, would not satisfy future growth in transport demand and the diverse travel demands along the M5 East Motorway corridor.

The volumes of all commodities are expected to grow as population and economic activity increases. The increase in transport demand has implications for the capacity of the road network, including the M4, M5 and M7 motorways in the Sydney greater metropolitan area. Without additional motorway capacity, it is estimated the M5 East Motorway will not be able to accommodate the additional traffic by 2031 (Transport for NSW, 2012a).

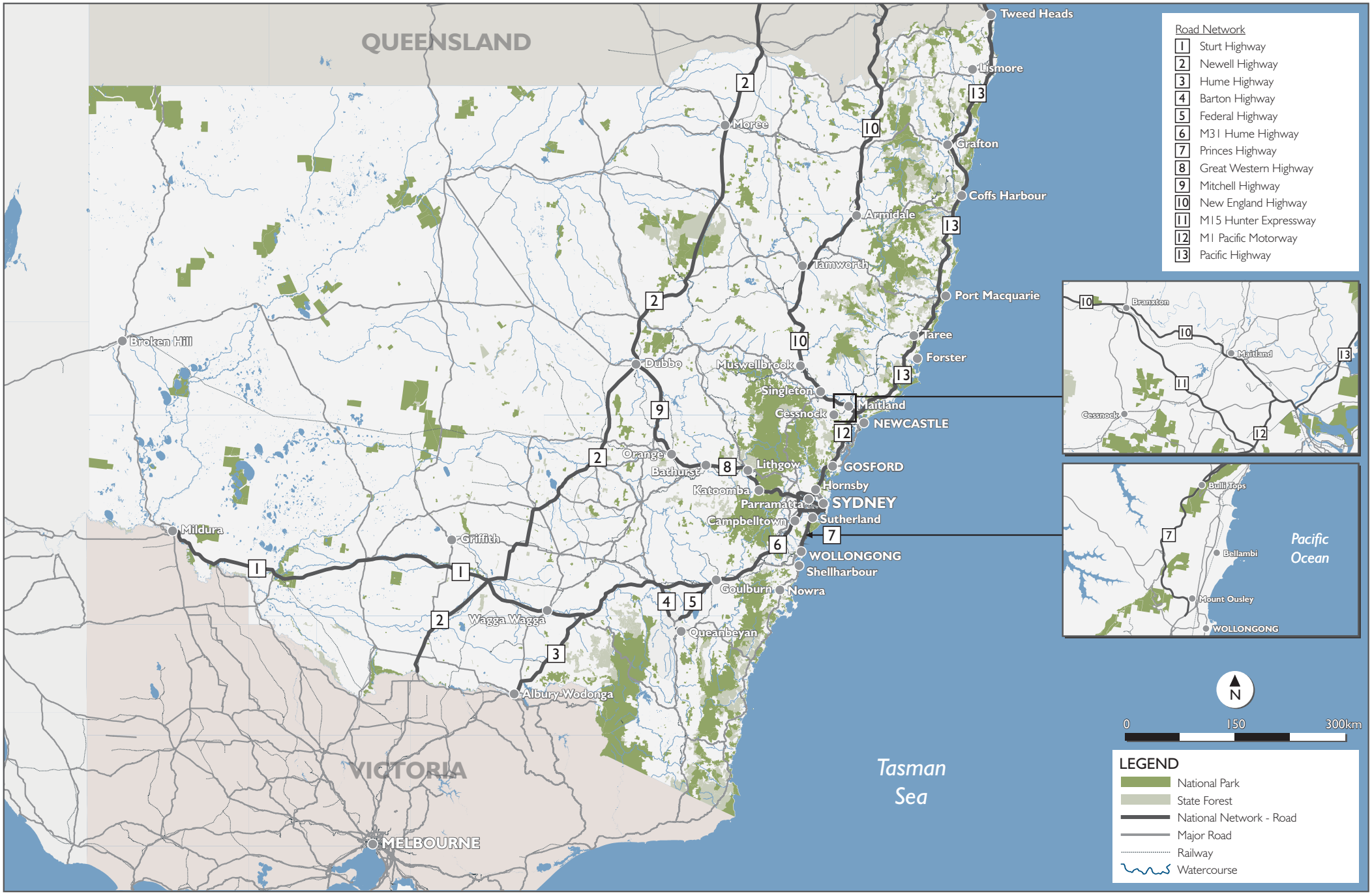


Figure 9-5 The National Road Network in NSW

(blank page)

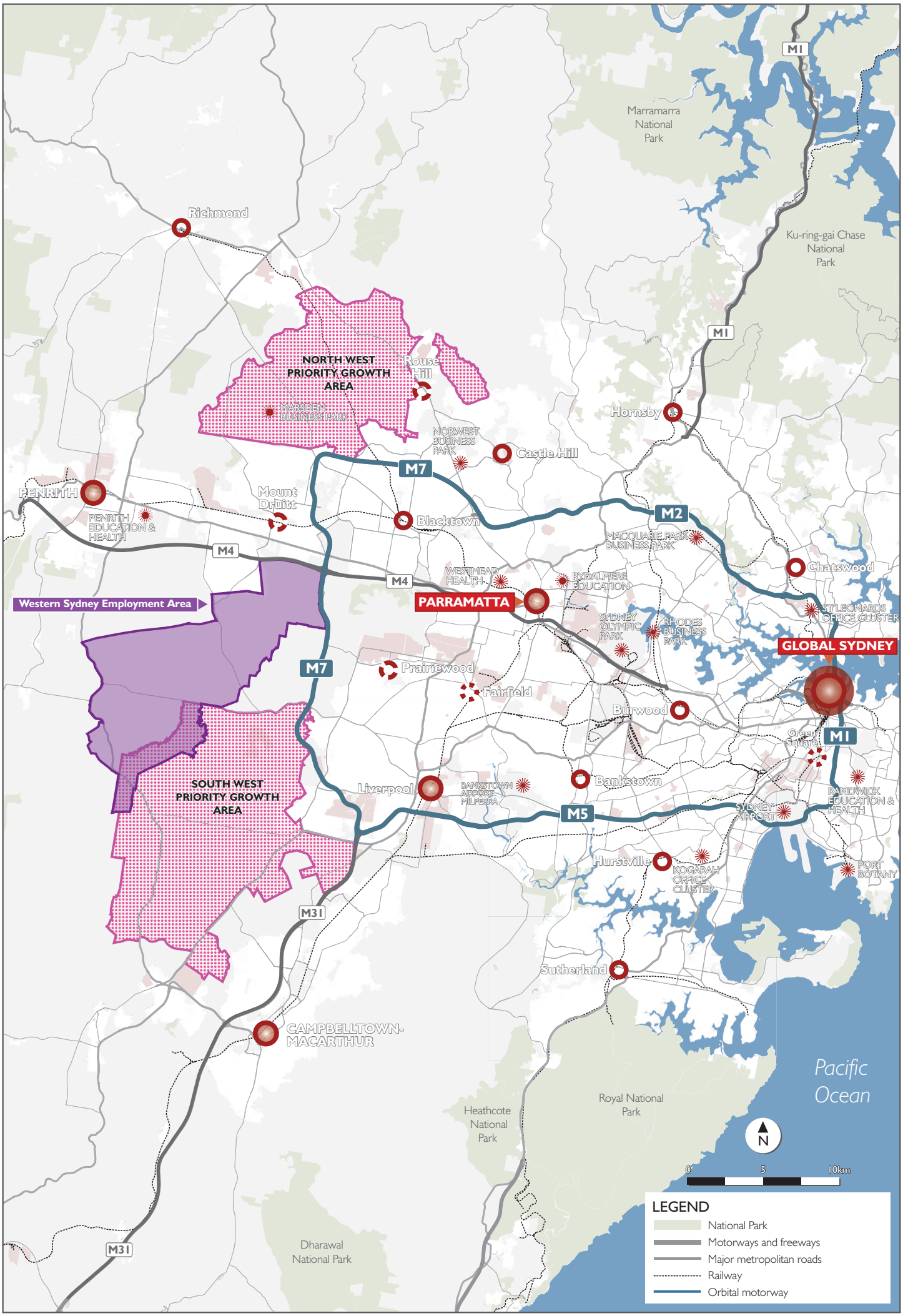


Figure 9-6 Sydney orbital network

(blank page)

9.2.2 The M5 East Motorway corridor

The M5 East Motorway corridor provides a motorway connection between south-west Sydney in the west and the Sydney CBD, Sydney Airport and Port Botany in the east. It is the main east-west freight, commercial and passenger vehicle corridor in southern Sydney, and is of local and regional transport importance in terms of its function. The regional context of the M5 East Motorway corridor, including its role in wider road networks and the State and national freight network is provided in **Section 9.2.1**.

Overview of the existing traffic and transport environment

No pedestrians or regular bus services use the existing M5 East Motorway corridor. Cyclists are able to use the shoulder lane of the M5 East Motorway along the surface road sections. However, cyclist use of the corridor is limited, likely due to the off-street shared path facilities between King Georges Road and Bexley Road.

The AWDT traffic volumes along the corridor are similar for both the eastbound and westbound carriageways. A high percentage of heavy vehicles were recorded during traffic surveys, indicating the importance of the M5 East Motorway corridor as a key regional and local freight transport route.

The eastbound carriageway of the M5 East Motorway in the AM peak and the westbound direction in the PM peak are the most congested, with the longest recorded travel times, and slowest speeds. The speed limit of the motorway varies between 80 and 90 kilometres per hour along its length. However, average speeds along the M5 East Motorway corridor during peak periods vary between around 31 kilometres per hour and 68 kilometres per hour.

The motorway operates between a level of service B and C in both directions during the AM and PM peak, which is considered to be an acceptable level of service. However, it should be noted the surveyed demand could be representative of a suppressed demand due to congestion along the M5 East Motorway within the tunnels.

The total number of crashes, and the number of crashes which resulted in fatalities and injuries per million vehicle kilometres travelled (MVKT) along the M5 East Motorway is considerably lower than average records for the Sydney metropolitan area, likely due to the limited number of opposing turning movements along the motorway and separation of traffic travelling in opposing directions.

The traffic conditions along the M5 East Motorway under the 'without project' scenarios for 2021 and 2031 (refer to **Section 9.1.3** for additional detail on scenarios) would continue to deteriorate with additional growth in light and heavy vehicle movements along the road. This would result in a reduction in the performance of the motorway between King Georges Road and Foreshore Road. The motorway would approach capacity near the Cooks River along the westbound carriageway during the AM peak and along the eastbound carriageway during the PM peak.

Modes of travel

Travel mode share

The M5 East Motorway corridor traverses the Local Government Areas (LGAs) of Canterbury, Hurstville and, Botany Bay. The NSW Bureau of Transport Statistics (BTS), Household Travel Survey Report: Sydney 2012/13, November 2014 Release provides details of the mode share of average weekday travel demand made from each LGA in NSW.

A comparison of the average weekday travel mode shares of LGAs traversed by the M5 East Motorway in comparison with the Sydney Greater Metropolitan Area (GMA) is shown in **Table 9-5**.

Modes of travel within LGAs which traverse the M5 East Motorway are generally comparable to the Sydney greater metropolitan region, with the exception of trips made using the passenger railway network.

Private vehicles are the predominant mode of transport along the M5 East Motorway corridor. On a typical weekday, an average of about 70 per cent of trips are made by private vehicle across the Canterbury, Hurstville and Rockdale LGAs, which is comparable to the general trips made by all residents within the Sydney greater metropolitan area (about 69 per cent).

Table 9-5 Comparison of the average weekday travel mode shares of LGAs which are traversed by the M5 East Motorway with the Sydney Greater Metropolitan Area

Local government area	Private vehicles			Rail	Bus	Walk only	Other modes
	Driver	Passenger	Total				
Canterbury	46%	25%	71%	8%	5%	14%	1%
Hurstville	52%	22%	74%	9%	4%	12%	1%
Rockdale	44%	20%	64%	13%	5%	16%	2%
Sydney Greater Metropolitan Area	47%	22%	69%	5%	6%	18%	2%

Source: NSW Bureau of Transport Statistics (BTS), Household Travel Survey Report: Sydney 2012/13, Nov 2014 Release

Public transport

Intercity and regional bus services which depart from the Sydney CBD use the M5 East Motorway and the M5 South West Motorway; however there are no operational bus stops along the M5 East Motorway. There are a number of bus services which operate through the M5 East Motorway interchanges at King Georges Road, Kingsgrove Road, Bexley Road and Marsh Street (refer to **Section 9.3.1** for additional detail).

Active transport

No pedestrian facilities are provided along the M5 East Motorway due to road safety considerations.

Bicycle counts were conducted along the M5 East Motorway and Beverly Grove Park in 2014. The average daily bicycle count along the eastbound and westbound carriageways of the M5 East Motorway were five and nine per day respectively. The low number of cyclists using the M5 East Motorway is likely due to the availability of off-street shared path facilities within Beverly Grove Park between King Georges Road and Bexley Road. Bicycle trips recorded during the survey periods are summarised in **Table 9-6**.The existing cycle network around the M5 Motorway corridor is shown on **Figure 9-7**.

Table 9-6 Bicycle survey counts within Beverly Grove Park (12 May to 18 May 2014)

Location	AM peak period (three hours)	PM peak period (three hours)	Average weekday (24 hours)
King Georges Road / M5	6	8	32
South-west of Rosebank Ave	3	17	51
North of The Crescent	5	14	37
Tallawalla St entry / exit prior to split	7	20	52
North-east of Kirrang St	2	5	20
South-west of Elouera St	3	9	28
South of Shorter Ave (eastern side of Rd)	0	0	3
South-West of Allambee Crescent (north of M5)	1	2	7
West of Allambee Crescent (south of M5)	5	5	23
West of Rosetta Ln	1	2	9
West of Penshurst Rd (north of Windarra St, south of M5)	1	1	34

Source: Jacobs (2014), WestConnex M5 – King Georges Road Interchange Upgrade: Traffic and Transport Assessment

Shared paths are located adjacent to the M5 East Motorway within Beverly Grove Park, providing a continuous pedestrian and cyclist connection between King Georges Road and Bexley Road. Pedestrians and cyclists are able to cross the M5 East Motorway via:

- Four underpasses, located at Beverly Grove Park, Karingal Street, Arinya Street and Lundy Street
- Four at-grade signalised crossing points, located at King Georges Road, Cooloongatta Road, Kingsgrove Road and Bexley Road.

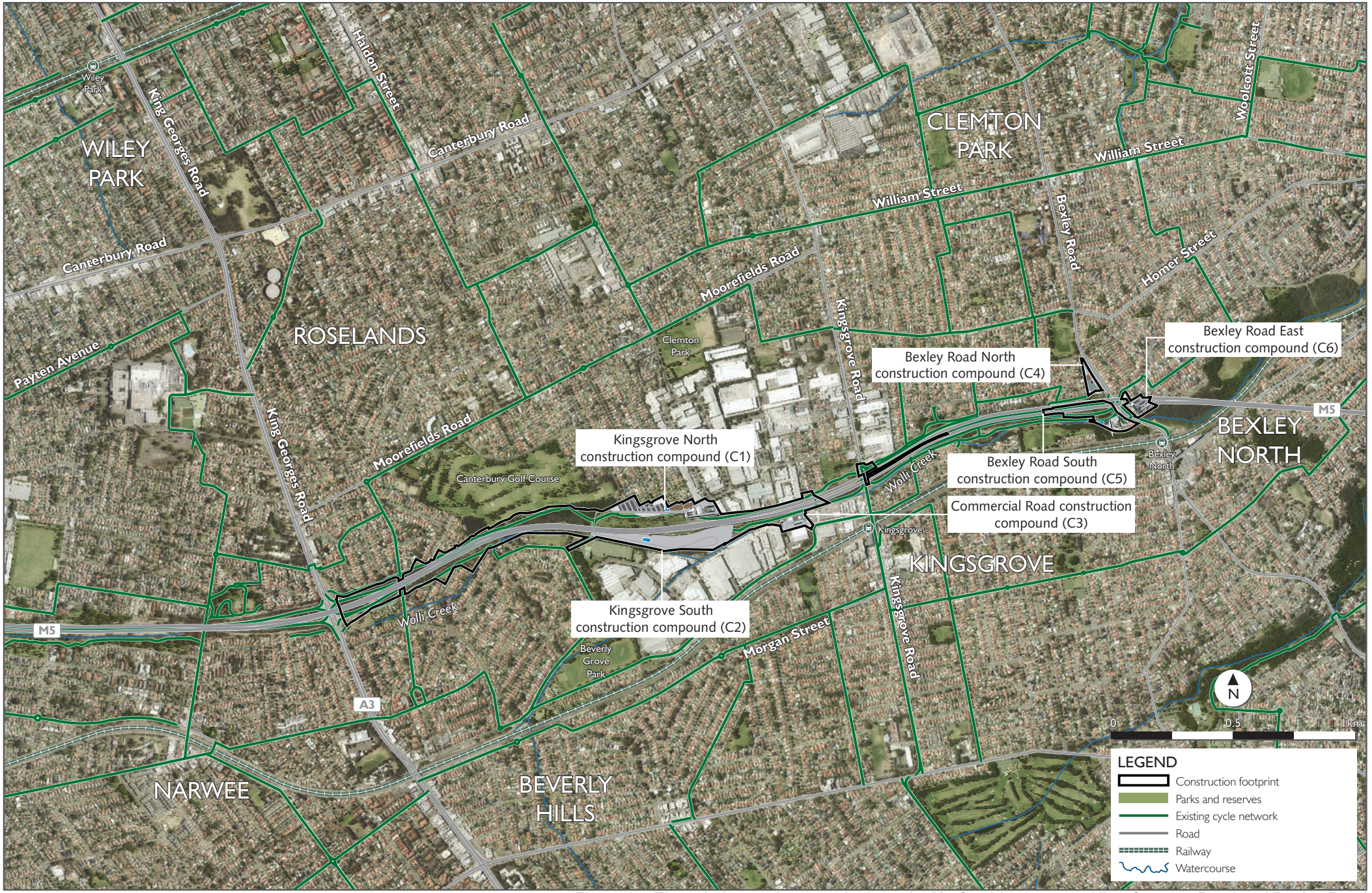


Figure 9-7 The existing cycle network along the M5 Corridor between King Georges Road and Bexley Road

(blank page)

Current conditions (2014 / 2015)

Traffic volumes and patterns

Table 9-7 presents the results of traffic surveys carried out in late 2014 / early 2015 along the M5 East Motorway at three locations. These results include the percentage of average weekday daily traffic (AWDT) observed to be heavy vehicles.

The results of the survey show the AWDT volumes for the M5 East Motorway are similar for both the eastbound and westbound carriageways, with eastbound traffic generally having slightly higher flows. The percentage of heavy vehicles indicates the importance of the M5 East Motorway corridor as a key freight and commercial route between the Sydney CBD, Sydney Airport, Port Botany and south-western Sydney.

Table 9-7 Average mid-block counts on the M5 East Motorway

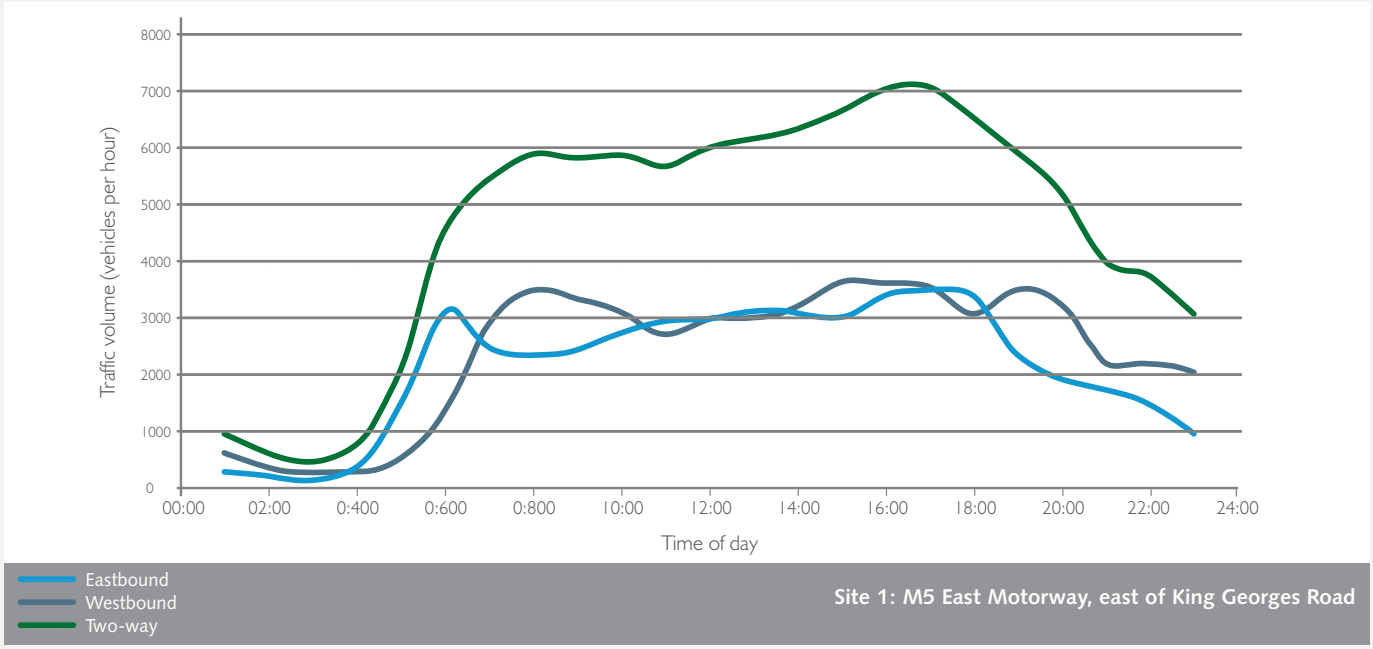
Location	Direction of traffic flow	Vehicles per hour		AWDT flow (vehicles/ day)	Percentage of heavy vehicles
		AM peak	PM peak		
M5 East Motorway east of King Georges Road	Eastbound	2380	3499	50,769	11%
	Westbound	3505	3564	57,359	10%
M5 East Motorway east of Bexley Road (in tunnel)	Eastbound	3539	3500	58,806	12%
	Westbound	2856	2937	50,327	13%
M5 East Motorway at the Cooks River	Eastbound	2773	2518	40,115	13%
	Westbound	2566	2439	38,946	13%

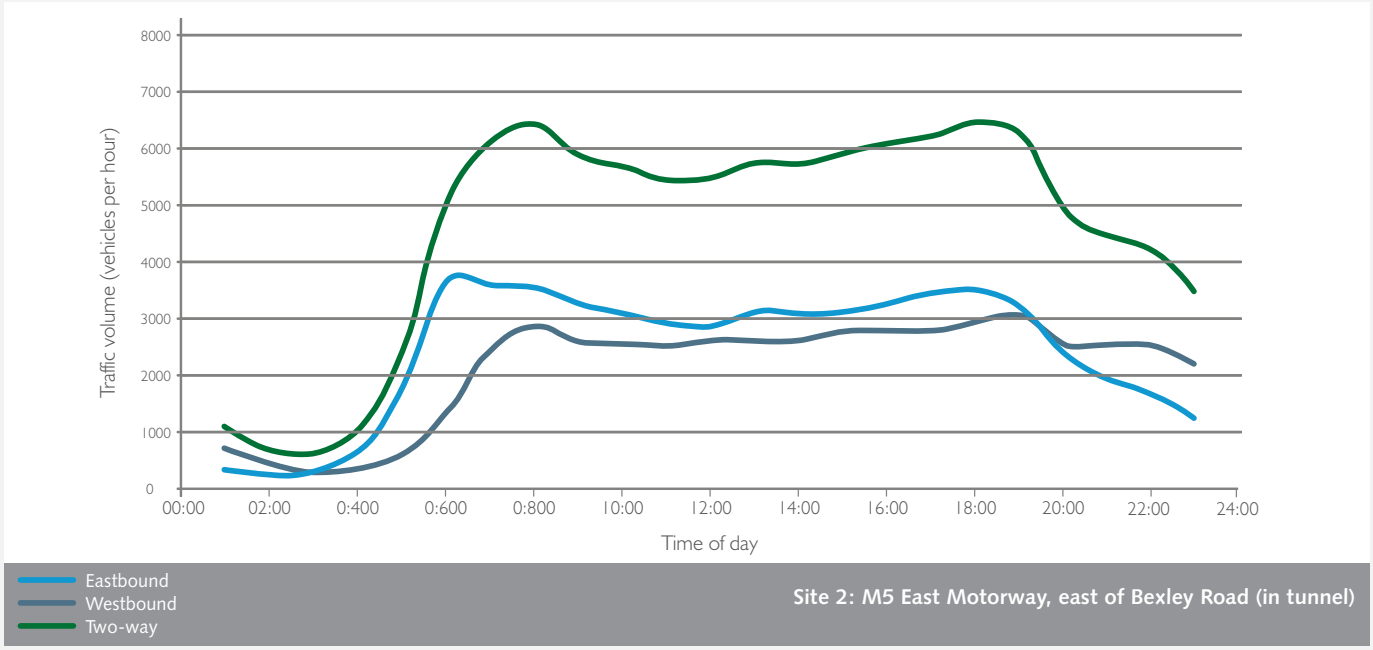
Traffic profile

The daily traffic flows along the M5 East Motorway at the three mid-block locations are shown on **Figure 9-8**. The daily traffic profile at this location demonstrates fairly consistent traffic flows between about 5am and 7pm along the eastbound and westbound carriageways. During the AM peak, the peak flow direction is westbound (away from the Sydney CBD, Sydney Airport and Port Botany) and during the PM peak, the peak flow direction is eastbound (towards the Sydney CBD, Sydney Airport and Port Botany).

During the AM peak, there is a drop in traffic flows along the eastbound and westbound carriageways. This is due to congestion along the M5 East Motorway, which restricts more traffic from entering the carriageways and reduces the average traffic speeds along the motorway.

(blank page)





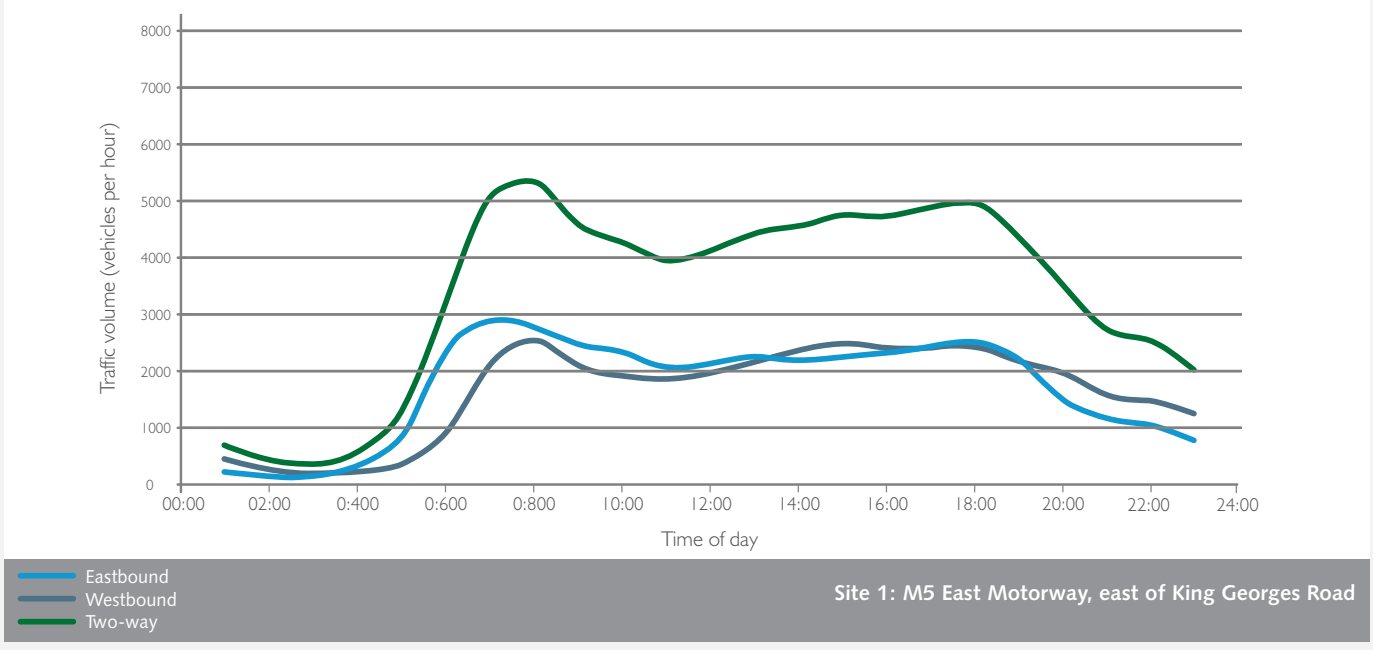


Figure 9-8 Average weekday traffic profiles along the M5 East Motorway (26/11/2014 - 11/02/2015)

(blank page)

Travel times and speeds

Travel times and speeds along the M5 East Motorway between King Georges Road and Foreshore Road were surveyed in 2015. The M5 East Motorway has a posted speed limit of 90 kilometres per hour along the surface road section of the M5 East Motorway between King Georges Road and the motorway tunnels at Bexley, and 80 kilometres per hour along the remaining section of the motorway.

Average speeds along the M5 East Motorway corridor during peak periods varies between around 31 kilometres per hour and 68 kilometres per hour. The eastbound carriageway of the M5 East Motorway in the AM peak and the westbound direction in the PM peak are the most congested, with the longest recorded travel times, and slowest speeds. A summary of the travel times and speeds recorded along the M5 East Motorway are summarised in **Table 9-8**.

Table 9-8 Travel speed and travel time on the M5 East Motorway between King Georges Road and Foreshore Road (2015)

Direction	Distance (kilometres)	Average travel times (min:sec)	Range of surveyed travel times (min:sec)	Average speeds (kilometres per hour)
AM Peak period (5 am to 8 pm)				
Eastbound	10.8	15:20	09:31 – 18:55	42.4
Westbound	10.8	09:31	08:36 – 11:31	68.3
PM peak period (4 pm to 7 pm)				
Eastbound	10.8	11:52	09:37 – 16:32	54.8
Westbound	10.7	20:53	15:12 – 24:00	31.1

Source: AECOM (2015), based on Skyhigh survey data (2015)

Network performance

Mid-block volume / capacity ratios on the M5 East Motorway east of King Georges Road, within the existing M5 East Motorway tunnels, east of Bexley Road and at near the Cooks River under existing conditions in the AM and PM peak are provided in **Table 9-9**.

The volume / capacity ratios show the motorway operates at or close to capacity during the AM and PM peak. The level of service presented in **Table 9-9** represents the operational performance of the M5 East Motorway based on the surveyed demand. It is recognised that the actual level of service may be lower than the surveyed level of service, which could be supressed as a result of congestion at other sections of the M5 Motorway corridor, causing variations to travel times and speeds. The level of service and volume/ capacity rations should therefore be used as a comparison, or indication of change between scenarios, rather than absolute values.

Table 9-9 M5 East Motorway mid-block traffic and volumes and level of service (2014)

Location	Direction	Mid-block capacity*	Light vehicles	Heavy vehicles	v/c	LoS
AM peak						
M5 East Motorway, east of King Georges Road	Eastbound	4300	2979	333	0.86	D
	Westbound	4300	2972	335	0.86	D
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	4300	3380	406	0.99	E
	Westbound	4300	2506	363	0.77	D
M5 East Motorway, at Cooks River	Eastbound	4300	2435	338	0.74	D
	Westbound	4300	2289	277	0.67	D
PM peak						
M5 East Motorway, east of King Georges Road	Eastbound	4300	3288	194	0.86	D
	Westbound	4300	3377	350	0.96	E
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	4300	3316	192	0.87	D
	Westbound	4300	2824	241	0.78	D
M5 East Motorway, at Cooks River	Eastbound	4300	2365	137	0.62	C
	Westbound	4300	2242	232	0.64	C

Source: AECOM (2015)
*the mid-block capacity adopted for the M5 East Motorway is 2,250 PCU per hour per lane based on a freeway speed of 90 kilometres per hour (Austroads Guide to Traffic Management Part 3: Traffic Studies and Analysis, second edition (2013).

Road safety

An analysis of crash statistics collected along the M5 East Motorway between King Georges Road and General Holmes Drive between 2009 and 2013 found a total of 478 crashes occurred from 2009 and 2013. Of these crashes, there were no fatalities and 188 crashes resulted in injuries.

The total number of crashes, and the number of crashes that resulted in fatalities and injuries per million vehicle kilometres travelled (MVKT) along the M5 East Motorway is considerably lower than averages for the Sydney metropolitan area, but higher than other Sydney motorway tunnels..

A summary of the crash statistics along the M5 East Motorway per MVKT between King Georges Road and General Holmes Drive in comparison to the Sydney greater metropolitan area and other Sydney motorway tunnels is provided in **Table 9-10**.

Between 2009 and 2013, crashes on the M5 East Motorway between King Georges Road and General Holmes Drive are estimated to have cost about $79.4 million (about $15.9 million per year), with the cost of crashes per 1000MVKT estimated to be about $5.9 million.

Table 9-10 Crash rates per 100 MVKT along the M5 East between King Georges Road and General Holmes Drive

Route / location	Crash severity index	Crash rate per 100 MVKT		
		Total	Fatal	Injury
M5 East Motorway between King Georges Road and General Holmes Drive	1.20	35.4	0	13.9
Existing Sydney motorway tunnels (Lane Cove, Eastern Distributor, Cross City and Sydney Harbour tunnels)	1.16	11.6	0	4.2
Total – Sydney metropolitan area	1.22	68.8	0.2	29.4

*Cost per MVKT has been calculated based on crash costs over the years 2009 to 2013.

Future conditions without the project (2021 and 2031)

The traffic conditions along the M5 East Motorway under the 'without project' scenarios for 2021 and 2031 would continue to deteriorate with additional growth in vehicle movements along the motorway.

This would result in a reduction in the performance of the motorway, with the road approaching capacity along the westbound carriageway during the AM peak and along the eastbound carriageway during the PM peak. The future condition of the M5 East Motorway corridor under the 2021 and 2031 'without project' scenarios in comparison to the current conditions is discussed in the following sections.

Modes of travel

As no regular bus services operate along the M5 East Motorway or the M5 South West Motorway, increases in travel times and speeds would not have a direct impact on the performance of bus services under the 2021 and 2031 without project scenarios.

Increases in congestion along roads which run perpendicular to the M5 Motorway corridor (ie north-south) and intersect the M5 East Motorway at grade separated interchanges (eg Kingsgrove Road, Bexley Road and Marsh Street) may cause delays to bus services operating on these roads.

Public transport services operate along other routes adjacent to the M5 Motorway corridor. *Sydney's Bus Future* (Transport for NSW, 2013) was developed to complement the Transport Master Plan by redesigning the city's bus network to meet current and future customer needs through identifying short and longer term priorities for bus services across Sydney.

Transport for NSW has identified a planned rapid bus route, which has target average speeds of 25 to 30 kilometres per hour between Hurstville and Macquarie Park via Burwood (current route M41). There is a commitment to deliver bus priority along the M5 Motorway corridor, including on Stoney Creek Road and Bexley Road (Transport for NSW, 2013a).

From the commencement of construction of the King Georges Road Interchange Upgrade project, cyclists would be diverted off the M5 East Motorway and onto parallel paths, namely the pedestrian and shared paths through Beverly Grove Park. It is expected that cyclist movements along the shared path within Beverly Grove Park would increase under the 2021 and 2031 without project scenarios.

Traffic volumes and patterns

Light and heavy vehicle AM and PM peak hour volumes along the M5 East Motorway have been forecast for 2021 and 2031 under 'without project' scenarios.

These volumes have been analysed and compared to existing (2014) volumes, in order to identify and assess relative changes in road network performance. A comparison of mid-block traffic counts on the M5 East Motorway between the existing case (2014) and 2021 and 2031 without the project is provided in **Table 9-11**.

Traffic volumes (vehicles per hour) would increase under the without project scenario between the existing case (2012) and 2021, and again between 2021 and 2031 (refer to **Table 9-11**). Between the existing case (2012) and 2021, the proportion of traffic using the M5 East Motorway comprising heavy vehicles would generally remain the same during the AM peak.

While the total number of heavy vehicles using the M5 East Motorway would increase during the PM peak in both directions, there would be a reduction in the proportion of heavy vehicles. This is expected to be a result of a larger increase in light vehicles.

Under the without project scenario, the proportion of heavy vehicles using the M5 East Motorway is expected to increase between 2021 and 2031 during the AM peak and reduce in the PM peak in both directions.

Table 9-11 Comparison of mid-block traffic counts on the M5 East Motorway between the existing case (2012) and 2021 and 2031 without the project (do minimum)

Location	Direction	2012 (existing case)		2021 (without project)*		2031 (without project)**	
		Vehicles per hour	Percentage heavy vehicles	Vehicles per hour	Percentage heavy vehicles	Vehicles per hour	Percentage heavy vehicles
AM peak							
M5 East Motorway, at King Georges Road	Eastbound	2380	11	3330	11	3190	15
	Westbound	3505	10	3750	10	3950	9
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	3539	12	3810	11	3750	15
	Westbound	2856	13	3290	13	3390	14
M5 East Motorway, at Cooks River	Eastbound	2773	13	2890	13	2860	18
	Westbound	2566	13	3160	10	3440	13
PM peak							
M5 East Motorway, at King Georges Road	Eastbound	3499	11	3620	6	3830	5
	Westbound	3564	10	3850	12	3800	15
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	3500	12	3670	7	3720	9
	Westbound	2937	13	3460	10	3410	13
M5 East Motorway, at Cooks River	Eastbound	2518	13	2900	6	3370	9
	Westbound	2439	13	2710	12	2770	16

*2021 without project assumes that the King Georges Road Interchange upgrade and M4 Widening projects are complete, but the remainder of the WestConnex program of works have not been built.

**2031 without project represents the future road network, assumed to include the King Georges Road Interchange upgrade and the M4 Widening projects as well as some upgrades to the broader transport network over time to improve capacity and cater for traffic growth.

Travel times and speeds

Surveyed travel times and speeds along the M5 East Motorway have been compared to the forecast average travel times and speeds for the 2021 and 2031 scenarios without the project. The forecast travel times have been provided from the WRTM and have been presented for comparison with the existing surveyed travel times and speeds in **Table 9-12**.

The WRTM results indicate that the M5 East Motorway will experience an increase in travel times and a reduction in speeds under the without project scenario in 2021 and 2031. Under the 2021 'without project' scenario, the average travel time would be the greatest during the AM peak in the eastbound direction and the westbound AM peak would experience the greatest reduction in average speed, slowing by about 16 kilometres per hour to 49 kilometres per hour. Under the 2031 without project scenario, traffic travelling westbound during the PM peak would experience the longest average travel time (27 minutes) and the slowest average speed (31 minutes).

Table 9-12 Comparison of average travel times along the M5 East Motorway between King Georges Road and Foreshore Road between the existing (2012) case and 2021 and 2031 under the without project scenario

Direction	Existing (2012)		2021 (without project)		2031 (without project)	
	Average travel time (minutes)	Average speed (kilometres per hour)	Average travel time (minutes)	Average speed (kilometres per hour)	Average travel time (minutes)	Average speed (kilometres per hour)
AM peak						
Eastbound	17	49	20	42	26	32
Westbound	13	65	17	49	23	37
PM peak						
Eastbound	12	70	18	47	26	32
Westbound	14	60	19	44	27	31

Source: WestConnex Delivery Authority Road Traffic Model, 2015

Network performance

Results of mid-block performance analysis as presented in **Table 9-13** demonstrates that under the without project scenarios for the years 2021 and 2031, growth in background traffic would result in decreased levels of mid-block performance in 2021. Under forecast 2031 without traffic volumes, the roadway performance of the M5 East Motorway is expected to further decrease.

Under the without project scenario in 2031, the M5 East Motorway at the Cooks River would operate at a level of service E in the westbound direction during the AM peak and in the eastbound direction during the PM peak. The Motorway at this location would be susceptible to decreases in performance with increases in demand if additional capacity is not provided.

Table 9-13 Comparison of M5 East Motorway mid-block traffic and volumes and level of service in 2012 (existing case) and without the project ('do minimum' scenario) in 2021 and 2031

Location	Direction	Mid-block capacity[1]	2012 (existing case)				2021 'without project'				2031 'without project'			
			LV[2]	HV[3]	v/c	LoS	LV	HV	v/c	LoS	LV	HV	v/c	LoS
AM peak														
M5 East Motorway, east of King Georges Road	Eastbound	4300	2979	333	0.86	D	2970	360	0.87	E	2710	480	0.87	E
	Westbound	4300	2972	335	0.86	D	3390	360	0.97	E	3560	350	1.01	F
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	4300	3380	406	0.99	E	3370	440	1.01	F	3200	550	1.02	F
	Westbound	4300	2506	363	0.77	D	2860	430	0.88	E	2910	480	0.92	E
M5 East Motorway, at Cooks River	Eastbound	4300	2435	338	0.74	D	2510	380	0.78	D	2360	500	0.80	D
	Westbound	4300	2289	277	0.67	D	2830	330	0.82	D	3000	440	0.92	E
PM peak														
M5 East Motorway, east of King Georges Road	Eastbound	4300	3288	194	0.86	D	3390	230	0.90	E	3630	200	0.94	E
	Westbound	4300	3377	350	0.96	E	3390	460	1.02	F	3220	580	1.03	F
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	4300	3316	192	0.87	D	3430	240	0.92	E	3390	330	0.95	E
	Westbound	4300	2824	241	0.78	D	3100	360	0.90	E	2950	460	0.91	E
M5 East Motorway, at Cooks River	Eastbound	4300	2365	137	0.62	C	2720	180	0.72	D	3060	310	0.87	D
	Westbound	4300	2242	232	0.64	C	2390	320	0.71	D	2340	430	0.76	D

[1] the mid-block capacity adopted for the M5 East Motorway is 2,250 PCU per hour per lane based on a freeway speed of 90 kilometres per hour (Austroads Guide to Traffic Management Part 3: Traffic Studies and Analysis, second edition (2013).
[2] LV – Light vehicle
[3] HV – Heavy vehicle

Road safety

Forecast crash statistics along the M5 East Motorway under the 'without project' scenario in 2021 and 2031 have been prepared assuming the future frequency, type and severity of crashes on these roads would be consistent with historic trends.

It is expected the frequency of crashes on roads along the M5 East Motorway would increase in proportion to the forecast future traffic growth. The crash rate per vehicle kilometre under the 'without project' scenario in 2021 and 2031 would remain the same as the existing (2012) conditions.

By 2031, the growth in traffic volumes along the M5 East Motorway corridor is expected to result in:

- An increase in the number of crashes from an average of 96 per year to 117 per year
- An increase in the annual cost of crashed from $15.9 million to $19.5 million.

9.2.3 Area around the St Peters interchange and local road upgrades

The area around the St Peters interchange and local road upgrades spans the Sydney, Marrickville and Botany LGAs. The key roads at this location include the Princes Highway, Campbell Street, Campbell Road, Euston Road, Bourke Road and Gardeners Road. The St Peters interchange would provide a connection to the local road network at the intersection of Campbell Road and Euston Road, St Peters. Additional detail regarding the St Peters interchange and upgrades to the local road network are provided in **Section 5.6** and **Section 5.7**.

Overview of existing traffic and transport environment

The mode share in the Sydney and Marrickville LGAs is markedly different to the Sydney greater metropolitan area, given the proximity of these areas to the Sydney CBD (refer to **Table 9-14**). The extensive public transport network and diverse land use mix where residential development is located relatively close to employment areas reduces the need for travel by private vehicles. The Sydney and Marrickville LGAs are serviced by four railway lines, with the closest railway stations located at St Peters and Mascot. The St Peters and Mascot area also has a comprehensive bus network which provides access to the surrounding activity and employment centres as well as the Sydney CBD.

The Botany Bay LGA is situated further to the east and closer to industrial and commercial land uses, including Sydney Airport and Port Botany. Mode share within the Botany Bay LGA is similar to the Sydney greater metropolitan area, with the exception of travel by rail and bus (refer to **Table 9-14**). This is reflective of the lack of rail coverage within the area, with public transport instead provided by a relatively large bus network.

High traffic volumes around the St Peters interchange and local road upgrades generally flow eastbound and northbound towards the Sydney CBD and Sydney Airport / Port Botany in the AM peak and in the opposite direction during the PM peak.

Intersections along main roads in the area were recorded as having high traffic volumes, particularly along the Princes Highway, King Street, Canal Road, Botany Road and Gardeners Road. High percentages of heavy vehicles were recorded for intersections along Burrows Road and Coward Street which provide connections and access to the industrial areas east of Alexandra Canal.

The performance of roads surveyed is generally better during the PM peak than the AM peak, although congestion is experienced in both peak periods. Sections of Campbell Street, the Princes Highway and Ricketty Street operate at or near capacity during the AM and / or PM peak. Four intersections within the core modelled network operate at or near capacity during the AM and/ or PM peak. These intersections are susceptible to further decreases in performance with an increase in demand, if improvements to intersection layout or optimisation of signal timing are not undertaken.

The total number of crashes, and the number of crashes that resulted in fatalities and injuries per million vehicle kilometres travelled (MKVT) has historically been higher along all roads analysed around the St Peters interchange and local roads area when compared to the greater Sydney metropolitan area. Higher than average statistics in this area can be attributed to:

- High traffic volumes, comprising relatively high proportions of heavy vehicles
- High levels of congestion and poor network performance along key roads and at key intersections
- A large number of intersections with more opposing movements, resulting in a greater risk of crashes.

Modes of travel

Travel mode share

The mode share in the Sydney and Marrickville LGAs is markedly different to the Sydney greater metropolitan area and the Botany Bay LGA, given the proximity of these areas to the Sydney CBD. The extensive public transport network and better land use mix where residential development are located close to employment areas reduces the need for travel by private vehicles. The Sydney and Marrickville LGAs have a much lower mode share for private vehicles and a high mode share for walking compared to the Sydney greater metropolitan area. Travel by rail and bus in these two LGAs is also above the mode share for the Sydney greater metropolitan area.

The Botany Bay LGA is situated further to the east and closer to industrial and commercial land uses, including Sydney Airport and Port Botany. Mode share within the Botany Bay LGA is similar to the Sydney greater metropolitan area, with the exception of travel by rail and bus. Only two per cent of residents in the Botany Bay LGA travel using the passenger rail network, which is reflective of the lack of rail coverage at this location. There are additional bus services and routes within the Botany Bay LGA to provide connection to the rail network and Sydney CBD. This is reflected in the proportion of mode share by bus in this LGA being almost double the use across the Sydney greater metropolitan area.

The travel mode shares for the Sydney, Marrickville and Botany Bay LGAs in comparison with the Sydney greater metropolitan area are shown in **Table 9-14**.

Table 9-14 Average weekday travel mode share for LGAs around the St Peters interchange and local road upgrades

Area	Private vehicles			Rail	Bus	Walk only	Other modes
	Driver	Passenger	Total				
Sydney LGA	21%	9%	30%	8%	9%	49%	4%
Marrickville LGA	37%	12%	49%	10%	7%	30%	4%
Botany Bay LGA	46%	21%	67%	2%	11%	19%	1%
Sydney greater metropolitan area	47%	22%	69%	5%	6%	18%	2%

Source: NSW Bureau of Transport Statistics Household Travel Survey Report: Sydney 2012/2013

Public transport

The Sydney and Marrickville LGAs are serviced by four railway lines:

- T1 North Shore, Northern and Western Line
- T2 Airport, Inner West and South Line
- T3 Bankstown Line
- T4 Eastern Suburbs and Illawarra Line.

The Botany Bay LGA has limited rail coverage by the T4 Eastern Suburbs and Illawarra Line.

The closest railway stations to the St Peters interchange and the local road upgrades are the St Peters and Mascot railway stations. St Peters railway station is located on the T3 Bankstown Line, about 750 metres north of the St Peters interchange, and Mascot railway station is about one kilometre south of the St Peters interchange on the T2 Airport, Inner West and South Line.

From St Peters railway station there are 14 train services travelling towards the Sydney CBD during the AM peak (between 7 am and 9 am) at a frequency between six and 15 minutes. In the PM peak, there are 18 services from the Sydney CBD to St Peters, occurring at a frequency of between seven and 15 minutes.

From Mascot railway station there are 18 train services travelling towards the Sydney CBD during the AM peak at a frequency of between six and nine minutes. In the PM peak there are 16 train services from the Sydney CBD to Mascot railway station, occurring at a frequency of between six and nine minutes. Bureau of Travel Statistics NSW station entry and exit statistics (BTS, 2015) show Mascot railway station handles almost double the passenger throughput of St Peters railway station during peak periods.

The area around the St Peters interchange and local road upgrades has a comprehensive bus network providing access to surrounding activity and employment centres and the Sydney CBD. Key roads which provide for bus routes around the St Peters interchange include the Princes Highway, King Street, Canal Road, Ricketty Street, Kent Road, Gardeners Road, Euston Road, Bourke Road and Bourke Street. Three bus services provide access to the Sydney CBD at frequencies of between seven and 20 minutes during the AM and PM peak periods. Another six bus routes operate more local services around the St Peters interchange and local road upgrades, providing access to suburbs and centres, including Wolli Creek, Bondi Junction, Marrickville and Burwood. These services are less frequent than bus services to the Sydney CBD.

The public transport services along local roads around the St Peters interchange are summarised in **Table 9-15** below.

Table 9-15 Public transport services around St Peters interchange and local road upgrades

Railway station / bus route	AM Peak services	AM Peak frequency	PM Peak services	PM Peak frequency
Passenger rail				
St Peters (T3 Bankstown Line)	14	6-15 minutes	18	7-15 minutes
Mascot (T2 Airport, Inner West and South Line)	18	6-9 minutes	16	6-9 minutes
Bus services				
305 – Stamford Plaza Hotel to Railway Square	5	20 minutes	5	20 minutes
308 – Marrickville to City	8	20 minutes	4	30 minutes
310 / X10 Eastgardens to City	10	4 – 14 minutes	12	5 – 15 minutes
348 – Wolli Creek to Bondi Junction	4	30 minutes	4	30 minutes
352 – Marrickville to Bondi Junction	4	30 minutes	6	20 minutes
370 – Leichardt to Coogee	14	8-9 minutes	11	10-11 minutes
400 – Burwood to Bondi Junction	7	17-18 minutes	8	15 minutes
410 – Burwood to Bondi Junction	4	30 minutes	7	17-18 minutes
418 – Burwood to Bondi Junction	6	20 minutes	8	20 minutes
422 – Kogarah to City	9	13-14 minutes	9	13-14 minutes
M20 – Gore Hill to Botany Shops via City	12-17	7-10 minutes	12-17	7-10 minutes

Active transport

There is a network of cycle paths in the area, comprising a mixture of separated cycleways and on-road paths in areas of low to medium traffic. The major cycle path in the area is the Bourke Road cycleway, which provides a separated cycle path along Bourke Road between Gardeners Road and the Green Square railway station. Additional separated cycleways are located in Sydney Park, and these connect to on-road cycle paths on surrounding roads. The existing cycling network in the vicinity of St Peters and Mascot is shown in **Figure 9-9**.

A cyclist survey was undertaken in 2014 at eight locations around the St Peters interchange and local road upgrades area. The survey results indicated that the highest volumes of cyclists during peak periods (AM and PM) were located at the following intersections:

- Gardeners Road / Bourke Road
- Mitchell Road / Coulson Street
- King Street / Princes Highway / Concord Street / Lord Street
- Bourke Road / Maddox Street.

An analysis of historic bicycle count data from 2010 to 2014 indicates the number of bicycle trips around the area has increased at all surveyed locations except the intersection of Euston Road and Campbell Road. The average growth rate of cycling in the area at the surveyed locations over the five years between 2010 and 2014 is about nine per cent per annum. A summary of the bicycle trips recorded during the cyclist survey in 2014 and historical growth of bicycle trips in the St Peters and Mascot area is provided in **Table 9-16**.

Table 9-16 Bicycle counts around the St Peters and Mascot area during peak periods (2014)

Location	Bicycle count data (2014)		Historical bicycle count					growth per annum (per cent)
	AM peak	PM peak	2010	2011	2012	2013	2014	
Burrows Road / Canal Road / Ricketty Street*	40	39	-	-	-	-	-	-
Euston Road / Campbell Road	13	19	55	88	23	42	32	-13%
Gardeners Road / Bourke Road	219	253	272	339	320	420	472	15%
King Street / Princes Highway / May Street / Sydney Park pedestrian entrance	58	81	118	146	162	149	139	4%
Mitchell Road / Coulson Street	103	109	168	187	162	228	212	6%
O'Riordan Street / Doody Street	39	30	70	80	62	104	69	0%
King Street / Princes Highway / Concord Street / Lord Street	164	150	276	209	261	260	314	3%
Bourke Road / Maddox Street	205	225	244	277	338	490	430	15%
Total	841	906	1,203	1,326	1,328	1,693	1,668	9%

Source: City of Sydney (2015)
*No historical data

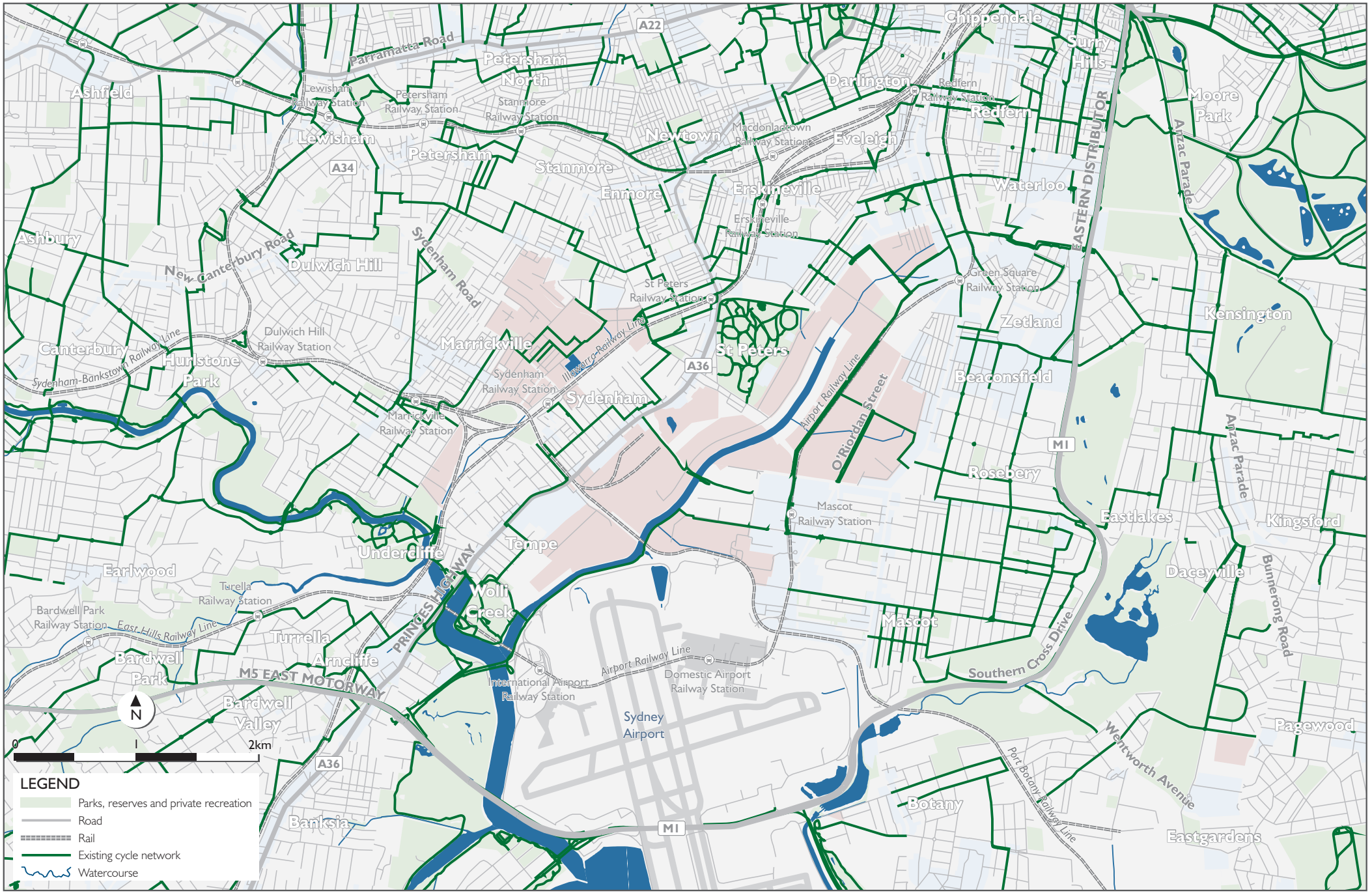


Figure 9-9 The existing cycle network around the St Peters interchange and local road upgrades

(blank page)

Current conditions (2014 / 2015)

Traffic volumes and patterns

Table 9-17 presents results of traffic surveys that were carried out at various locations around the St Peters interchange and local road upgrades in 2014, including percentages of average weekday daily traffic (AWDT) observed to be heavy vehicles.

The results indicate that high AM peak traffic flows are generally in the eastbound and northbound directions along surveyed routes, towards the Sydney CBD and Sydney Airport / Port Botany areas. High percentages of heavy vehicles were recorded in some parts of at least one point along all roads surveyed.

Table 9-17 Mid-block traffic volumes on local roads around the St Peters interchange

Location	Direction of traffic flow	Vehicles per hour		AWDT flow (vehicles / day)	Percentage of heavy vehicles
		AM peak	PM peak		
King Street, south of Alice Street	Northbound	1019	953	-	-
	Southbound	781	941	-	-
Princes Highway, north of Campbell Street	Northbound	1661	981	18,818	6%
	Southbound	558	1601	17,371	7%
Princes Highway, south of Campbell Street	Northbound	1715	1043	19,681	9%
	Southbound	612	1553	17,798	10%
Railway Road, west of Princes Highway	Eastbound	626	638	-	-
	Westbound	389	550	-	-
Princes Highway, south of Railway Road	Northbound	3368	1595	26,902	15%
	Southbound	784	2607	25,443	17%
Euston Road, north of Campbell Road	Northbound	411	185	3117	13%
	Southbound	199	188	2559	16%
Euston Road, north of Sydney Park Road	Northbound	1220	597	-	-
	Southbound	503	1334	-	-
Campbell Road, west of Euston Road	Eastbound	864	407	7533	11%
	Westbound	161	320	3555	14%
Campbell Street, east of May Street	Eastbound	358	318	4988	8%
	Westbound	142	275	2994	12%
Edgeware Road, west of Edinburgh Road	Northbound	670	814	-	-
	Southbound	730	777	-	-
Ricketty Street	Eastbound	2285	1162	22,159	11%
	Westbound	963	1,830	20,614	12%
Gardeners Road, west of O'Riordan Street	Eastbound	1090	920	14,237	14%
	Westbound	1001	1121	15,235	11%

Network performance

Table 9-18 presents the performance of the modelled road network around the St Peters interchange and local road upgrades during the AM and PM peak periods.

The results of the network performance modelling show the AM and PM peak periods have similar levels of total traffic demand. During the AM peak travel times are longer with lower travel speeds and more stops, indicating there is more congestion during the AM peak when compared to the PM peak.

Table 9-18 Current network performance around the St Peters interchange and local road upgrades (2014)

Road network measure	AM peak hour	PM peak hour
All vehicles		
Total traffic demand (vehicles)	22,000	21,300
Total vehicle kilometres travelled in network (kilometres)	59,100	56,500
Total time travelled in network (hours)	2,310	2,070
Total number of stops	102,700	102,000
Average per vehicle		
Average vehicle kilometres travelled in network (kilometres)	2.7	2.7
Average time travelled in network (minutes)	6.3	5.8
Average number of stops	4.7	4.8
Average speed (kilometres per hour)	25.6	27.3
Unreleased vehicles		
Unreleased demand (vehicles)	0	0
Per cent of total traffic demand	0	0

Intersection counts were also obtained during 2014 from the area around the St Peters interchange and local road upgrades, and the performance of these intersections was modelled. The results of the intersection performance modelling are summarised in **Table 9-19**. The results indicate there are several intersections experiencing significant congestion during the AM and PM peak and are operating at a poor level of service. Any small increases to demand would further reduce the performance of intersections at this location without upgrades and improvements. Intersections which currently operate at or near capacity, ie a level of service E or level of service F include:

- Princes Highway / May Street during the AM peak
- Princes Highway / Canal Road during the AM and PM peak
- Princes Highway / Railway Road during the AM and PM peak
- Gardeners Road / O'Riordan Street during the AM peak.

Table 9-19 Overview of existing (2014) intersection performance around the St Peters interchange and local road upgrades during the AM and PM peak

Intersection	Level of service	
	AM peak	PM peak
Princes Highway / Sydney Park Road	C	D
Princes Highway / May Street	E	D
Princes Highway / Campbell Street	D	D
Princes Highway / Canal Road	E	F
Princes Highway / Railway Road	F	E
Sydney Park Road / Mitchell Road	C	D
Euston Road / Sydney Park Road / Huntley Street	A	D
Unwins Bridge Road / Campbell Street	C	C
Campbell Road / Euston Road	A	A
Gardeners Road / Bourke Road	C	C
Gardeners Road / O'Riordan Street	E	D

Road safety

An analysis of crash statistics collected between 2009 and 2013 showed 745 crashes occurred around the St Peters interchange and local road upgrades area. Of these crashes, three resulted in fatalities and 3337 resulted in injuries. The crash history of the area analysed is provided in **Table 9-20**.

Table 9-20 Crash statistics around the St Peters interchange and local road upgrades (2009-2013)

Road	Crashes			
	Total	Fatal	Injury	Tow-away
Princes Highway between Enmore Road and Gannon Street	407	2	189	216
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	248	1	100	147
Euston Road between Sydney Park Road and Campbell Road	21	0	13	12
Bourke Road between Wyndham Street and Gardeners Road	69	0	35	34
Total	745	3	337	409

Source: Summarised from crash reports provided by Road and Maritime Services (2015)

The total number of crashes, and the number of crashes which resulted in fatalities and injuries per million vehicle kilometres travelled (MKVT) has historically been higher along all roads analysed when compared to the greater Sydney greater metropolitan area (refer to **Table 9-21**). Higher than average statistics in this area can be attributed to:

- High traffic volumes, comprising relatively high proportions of heavy vehicles
- High levels of congestion and poor network performance along key roads and at key intersections
- A large number of intersections, with more opposing movements, resulting in a greater risk of crashes.

Table 9-21 Crash rates per 100 MVKT (2014) on local roads around the St Peters interchange

Road / location	Crash severity index	Crash rate per 100 MVKT			Cost per 100 MVKT (AUD)
		Total	Fatal	Injury	
Princes Highway between Enmore Road and Gannon Street	1.24	115.1	0.6	53.5	$25,573,070
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	1.21	143.0	0.6	57.7	$27,547,890
Euston Road between Sydney Park Road and Campbell Road	1.50	265.8	0	164.5	$68,702,630
Bourke Road between Wyndham Street and Gardeners Road	1.25	157.5	0	79.9	$33,391,030
Total – Sydney metropolitan area	1.22	68.8	0.2	29.4	-

Source: AECOM (2015), calculated based on the crash reports provided by Road and Maritime Services (2015)

Future conditions without the project (2021 and 2031)

Travel times and speeds

The average travel times and speeds for the Princes Highway near the St Peters interchange and local road upgrades during the AM and PM peak under existing conditions and under the 'without project' scenario in 2021 and 2031 are shown in **Table 9-22**. The results indicate that without the project, travel times would considerably increase, particularly between 2021 and 2031.

Table 9-22 Comparison of average peak travel times along the Princes Highway and the New M5 in 2021 with and without the project and in 2031 without the project and with the Full WestConnex program of works and Southern extension during the AM and PM peak

From	To	Average travel time (minutes)		
		Existing (2012)	2021 'without project'	2031 'without project'
AM peak				
Princes Highway (south of Railway Road)	North of Euston Rd	10:30	22:00	25:30
Princes Highway North (King St)	Sydney Airport Domestic Terminal	13:00	14:00	44:30
PM peak				
Princes Highway (south of Railway Road)	North of Euston Rd	8:00	14:00	38:00
Princes Highway North (King St)	Sydney Airport Domestic Terminal	15:30	17:30	45:00

*Taken from an equivalent distance to the Princes Highway (south of Railway Road)

Network performance

Road network performance

Modelling of the road network under the 'without project' scenario around the St Peters interchange and local road upgrades incorporated the following changes due to occur before 2021:

- As part of the Sydney Airport Master Plan 2033 (Sydney Airport Corporation Limited, 2014)
  - A new access and egress arrangement to Sydney Airport Domestic Terminal
  - A new one-way pairing arrangement for Robey Street, O'Riordan Street and Qantas Drive which would mean traffic would be able to travel northbound only along Robey Street between Qantas Drive and southbound only along O'Riordan Street between Robey Street and Qantas Drive
- The closure of General Holmes Drive between Joyce Drive and Botany Road.

A comparison of the road network performance for the existing case (2012) with 2021 and 2031 under the 'without project' scenario within the area around the St Peters interchange and local road upgrades is provided in **Table 9-23**.

By 2021, without construction of the project, about four per cent of vehicles in the AM peak and two per cent in the PM peak would be unable to enter the modelled road network around the St Peters interchange and local road upgrades as a result of high levels of congestion and queue lengths at intersections. This indicates that the road network does not have sufficient capacity to handle the forecast demand. The road network as a whole is restricted in 2021 under the 'without project' scenario, reflected in the increased travel times and reduced average speeds.

In 2031 under the 'without project' scenario, there would be a 13 per cent increase in traffic demand around the St Peters interchange and local road upgrades when compared to 2021. This would result in nine per cent of the total traffic demand in the AM peak and eight per cent in the PM peak being unable to enter the modelled road network due to congestion and queue lengths at intersections.

Table 9-23 Comparison of the road network performance for the existing case (2012) with 2021 and 2031 under the 'without project' scenarios within the area around the St Peters interchange and local road upgrades

Network measure	Existing (2012)	2021 (without project)	Per cent change (2012-2021)	2031 (without project)	Per cent change (2021-2031)
AM peak					
All vehicles					
Total traffic demand (vehicles)	22,000	23,800	+8	27,000	+13
Total vehicle kilometres travelled in network (kilometres)	59,100	66,400	+12	72,500	+9
Total time travelled in network (hours)	2,310	3,510	+52	3,840	+9
Total number of stops	102,700	170,600	+66	160,600	-6
Average per vehicle					
Average vehicle kilometres travelled in network (kilometres)	2.7	2.8	+4	2.7	-4
Average time travelled in network (minutes)	6.3	8.8	+40	8.5	-3
Average number of stops	4.7	7.2	+53	5.9	-18
Average speed (kilometres)	25.6	18.9	-26	18.9	0
Unreleased vehicles					
Unreleased demand (vehicles)	0	980	-	2,530	158
Per cent of total traffic demand	0	4	-	9	-
PM peak					
All vehicles					
Total traffic demand (vehicles)	21,300	24,800	+16	27,600	+11
Total vehicle kilometres travelled in network (kilometres)	56,500	67,000	+19	72,800	+9
Total time travelled in network (hours)	2,070	2,900	+40	4,470	+54
Total number of stops	102,000	124,100	+22	172,700	+39
Average per vehicle					
Average vehicle kilometres travelled in network (kilometres)	2.7	2.7	0	2.6	-4
Average time travelled in network (minutes)	5.8	7	+21	9.7	+39
Average number of stops	4.8	5	+4	6.3	+26
Average speed (kilometres per hour)	27.3	23.1	-15	16.3	-29
Unreleased vehicles					
Unreleased demand (vehicles)	0	520	-	2,200	323
Per cent of total traffic demand	0	2	-	8	-

Intersection performance

A comparison of intersection performance (level of service) for 2012 (the existing case) with forecasts for 2021 and 2031 under the 'without project' scenarios is summarised in **Table 9-24**.

Under the 'without project' scenario, a number of intersections would be close to or at capacity during the AM and PM peak in 2021 and 2031.

The number of intersection at or near capacity would continue to increase over time with the increase in traffic demand around the St Peters interchange and local road upgrades.

Intersections operating at a level of service F in 2012 and/ or 2021 would continue to deteriorate, with the average delay increasing.

The performance of some intersections in the modelled area around the St Peters interchange and local road upgrades area would improve between the existing (2012) and 2021 under the 'without project' scenario. This is likely a result of:

- A redistribution of green time at the Princes Highway / Railway Road intersection to accommodate the increased demand for southbound turning movements. As a result of this modification, the amount of time that the signal remains green for northbound movements along the Princes Highway at this intersection is reduced, thereby reducing the amount of traffic reaching the modelled road network around the St Peters interchange and local road upgrades. This leads to an improved level of service at intersections of Canal Road, Campbell Street, May Street and Sydney Park Road with the Princes Highway (refer to **Table 9-24**)
- Traffic that is unable to enter the modelled area around the St Peters interchange and local road upgrades from other traffic routes as a result of congestion.

Table 9-24 Summary of intersection level of service under existing (2012) traffic conditions and under the 'without project' scenario in 2021 and 2031

Intersection	Existing (2012)		2021 'without project'		2031 'without project'	
	AM peak	PM peak	AM peak	PM peak	AM peak	PM peak
Princes Highway / Sydney Park Road	C	D	B	F	F	F
Princes Highway / May Street	E	D	B	D	C	D
Princes Highway / Campbell Street	D	D	C	C	D	F
Princes Highway / Canal Road	E	F	C	E	F	F
Princes Highway / Railway Road	F	E	F	F	F	F
Sydney Park Road / Mitchell Road	C	D	B	B	B	D
Euston Road / Sydney Park Road / Huntley Street	A	D	A	A	A	E
Unwins Bridge Road / Campbell Street	C	C	B	C	B	F
Campbell Road / Euston Road	A	A	A	A	A	F
Gardeners Road / Bourke Road	C	C	C	C	D	E
Gardeners Road / O'Riordan Street	E	D	F	D	F	F

Road safety

Forecast crash statistics on roads around the St Peters interchange and local road upgrades area under the 'without project' scenario in 2021 and 2031 have been prepared assuming that the future frequency, type and severity of crashes on these roads would be consistent with historic trends.

It is expected that the frequency of crashes on roads around area would increase in proportion to the forecast traffic growth. The crash rate per vehicle kilometre under the 'without project' scenario in 2021 and 2031 would remain the same as the existing (2012) conditions.

By 2031, the growth in traffic volumes would create a relative rise in crash frequencies and costs along the following road sections:

- Princes Highway (Enmore Road to Gannon Street):
  - Crashes would be expected to increase from an average of 81 to 112 per annum
  - The corresponding annual cost of crashes would rise from $18.1 million to $24.8 million per annum
- Canal Road / Ricketty Street / Gardeners Road (Princes Highway to Botany Road):
  - Crashes would be expected to increase from an average of 50 to 69 per annum
  - The corresponding annual cost of crashes would rise from $9.6 million to $13.3 million per annum
- Euston Road (Sydney Park Road to Campbell Road):
  - Crashes would be expected to increase from an average of four to six per annum
  - The corresponding annual cost of crashes would rise from $1.1 million to $1.6 million per annum
- Bourke Road (Wyndham Street to Gardeners Road):
  - Crashes would be expected to increase from an average of 14 to 21 per annum
  - The corresponding annual cost of crashes would rise from $2.9 million to $4.4 million per annum

9.3 Assessment of potential impacts

9.3.1 Construction

During construction, the project may affect the surrounding road network as a result of:

- The introduction of construction vehicles, especially heavy vehicles transporting spoil
- Surface road works, requiring temporary traffic cyclist and / or pedestrian diversions, road occupation and temporary road closures
- Changes to speed limits.

There would be 14 construction compounds used during construction of the project, as shown in **Figure 6-5** and in detail in **Figure 6-6** to **Figure 6-15**. The establishment and use of construction compounds may result in

- Impacts to local traffic
- Alterations to property access, pedestrian and cyclist movements
- Changes to the bus stop locations.

A detailed description of key traffic activities at each construction compound is provided in the Technical working paper: Traffic and transport (**Appendix G**).

Overview of construction traffic and vehicle routes

Construction of the project would result in the generation of additional heavy and light vehicle movements on the road network in three broad categories:

- Removal of spoil generated by construction activities
- Heavy vehicle deliveries and other heavy vehicles involved in construction activities
- Light vehicle movements associated with construction of the project.

Construction traffic routes for the project would use the existing motorway and arterial road network as much as possible, reducing traffic related impacts on local roads.

Spoil would be transported from construction compounds to spoil management locations, generally along the M5 East Motorway and M5 South West Motorway.

Western surface works, Kingsgrove Road surface works and Bexley Road surface works

Construction traffic volumes and patterns

Table 9-25 presents construction compound access points and construction traffic volumes around the western surface works, Kingsgrove Road surface works and the Bexley Road surface works.

The construction traffic volumes are the two-way volumes (inbound and outbound) associated with the peak construction period at each construction compound for each route.

Construction haulage routes for the Kingsgrove North (C1), Kingsgrove South (C2), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5) and Bexley Road East (C6) construction compounds are shown in **Figure 9-10** to **Figure 9-12**.

Table 9-25 Construction compound access points and traffic volumes around the western surface works

Construction compound	Construction route number	Vehicle type	Access point	Daily vehicles^	AM peak (vehicles per hour)	PM peak (vehicles per hour)
Kingsgrove North (C1)*	Route 1	Light	Garema Circuit (left in, left out)	452	14	12
		Heavy		672	21	19
	Route 2	Light	Garema Circuit (left in, left out)	452	14	12
		Heavy		672	21	19
	Route 3	Light	M5 East Motorway (left in, left out)	86	3	2
		Heavy		631	20	18
	Total (Route 1, 2 and 3)	Light	Garema Circuit and M5 East Motorway	989	31	26
		Heavy		1975	62	56
Kingsgrove South (C2)	Route 3**	Light	M5 East Motorway (left in, left out)	24	1	1
		Heavy		72	3	3
Commercial Road (C3)	N/A	Light	Commercial Road (right in, left out)	133	7	7
		Heavy		192	8	8
Bexley Road North (C4)	N/A	Light	Bexley Road (left in, left out)	96	4	4
		Heavy		432	18	18
Bexley Road South (C5)	N/A	Light	Bexley Road (left in, left out)	96	4	4
		Heavy		432	18	18
Bexley Road East (C6)	N/A	Light	Wolli Avenue (left in, right and left out)	418	32	32
		Heavy		0	0	0
Total construction vehicles around the western surface works, Kingsgrove Road surface works and Bexley Road surface works		Light		1,756	79	74
		Heavy		3,103	109	103

*Construction traffic from the Kingsgrove North construction compound (C1) onto Garema Circuit (construction route 1 and route 2) comprises heavy and light vehicle movements from the Kingsgrove South construction compound (C2) which are not entering and exiting the construction compound directly via the M5 East Motorway (westbound).
**The Kingsgrove South construction compound (C2) construction routes 1 and 2 are included as part of the Kingsgrove North construction compound (C1) construction route 1 and 2. Construction traffic would travel to the Kingsgrove North construction compound (C1) via the Kindilan underpass.
^Daily vehicles accounts for traffic movements across a 24-hour period, including movements outside of standard construction hours

Construction vehicles would use the existing arterial road network to access construction compounds as much as practically possible. At locations where direct access to and from construction compounds via arterial roads is not feasible, or these roads cannot be used as a standalone access point for a construction compound, construction vehicles would use local roads. Impacts to the local road network from construction vehicle movements around the western surface works would be minimised where reasonable and feasible, in accordance with the Construction Traffic and Safety Management Plan.

Vehicle access to the Kingsgrove North (C1), Kingsgrove South (C2), Commercial Road (C3) and Bexley Road East (C6) construction compounds would require the use of some local roads.

The construction compound access requirements from local roads around the western surface works, Kingsgrove Road surface works and Bexley Road surface works are presented in **Table 9-26**.

Table 9-26 Construction compound access requirements from local roads around the western surface works, Kingsgrove Road surface works and Bexley Road surface works

Construction compound	Access point	Local road access requirements
Kingsgrove North (C1) Kingsgrove South (C2)	Primary access: Garema circuit (left in, left out) Secondary access: M5 East Motorway (left in, left out)	The roads used to travel to the principal construction compound access point would be Kingsgrove Road, Moorefields Avenue, Wirega Avenue and Garema Circuit. These roads are located adjacent to a mixture of mostly industrial and residential land uses. Construction of the project would generate around 40 vehicles per hour in both directions along Moorefields Avenue, Wirega Avenue and Garema Circuit.
Commercial Road (C3)	Commercial Road (right in, left out)	Commercial Road is a local road which travels through a light industrial precinct to the south of the M5 East Motorway. Construction of the project would generate around eight vehicles per hour in both directions along Commercial Road between the Commercial Road construction compound (C3) access point and Kingsgrove Road.
Bexley Road East (C6)	Wolli Avenue (left in, right and left out)	Wolli Avenue is a local road which passes through a primarily residential area. The Bexley Road East compound (C6) is located at the intersection of Wolli Avenue and Bexley Road and would generally not require heavy vehicles to travel along this road, apart from heavy vehicle movements required for site establishment and demobilisation. Construction of the project would generate around 16 additional light vehicle movements per hour in both directions on Wolli Avenue, Frost Street, Douglas Street and Homer Street.

(blank page)

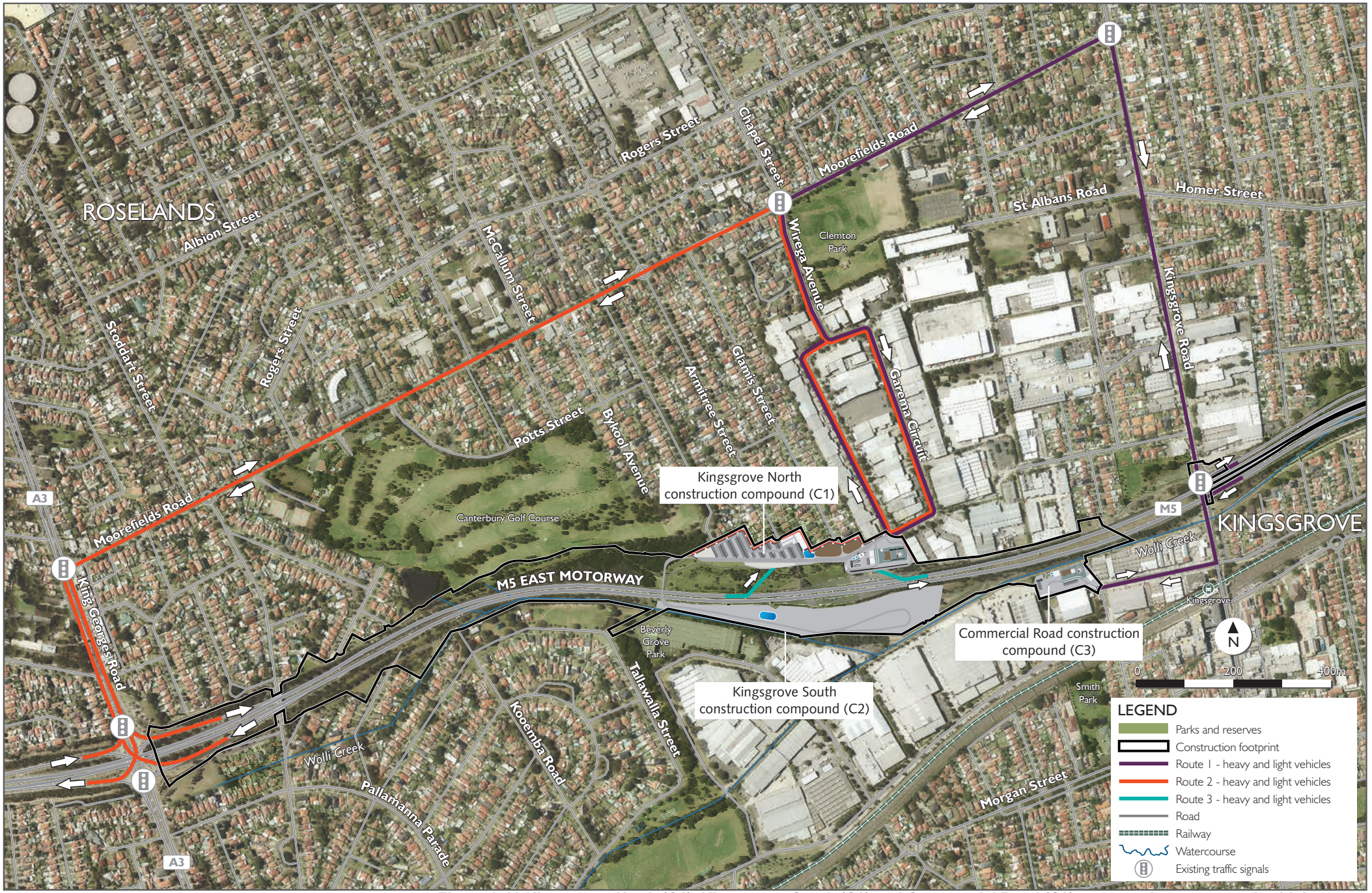


Figure 9-10 Kingsgrove North (C1), Kingsgrove South (C2) and Commercial Road (C3) construction compound vehicle routes

(blank page)



Figure 9-11 Bexley Road North construction compound (C4) vehicle routes

(blank page)

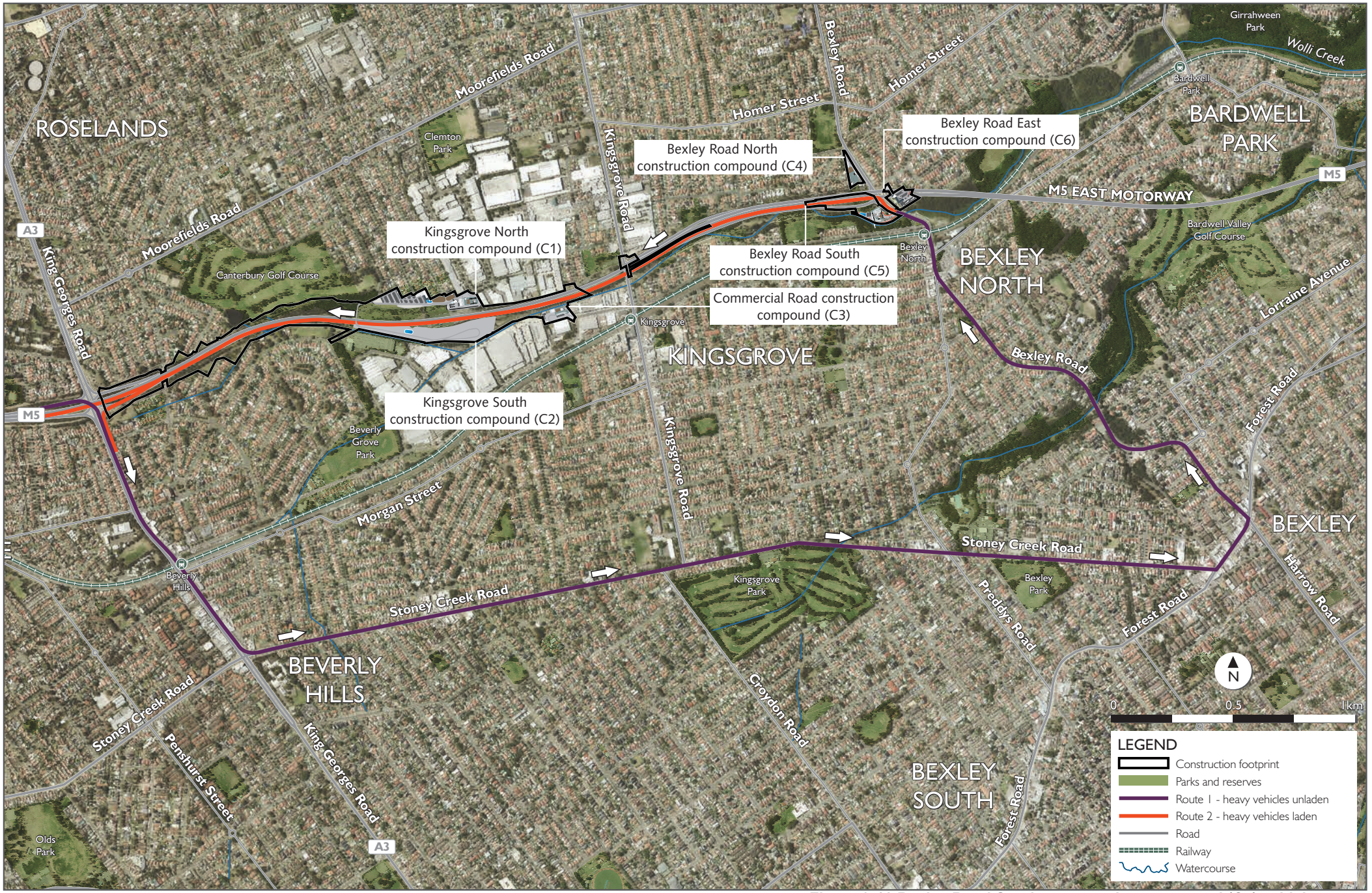


Figure 9-12 Bexley Road South construction compound (C5) vehicle routes

(blank page)

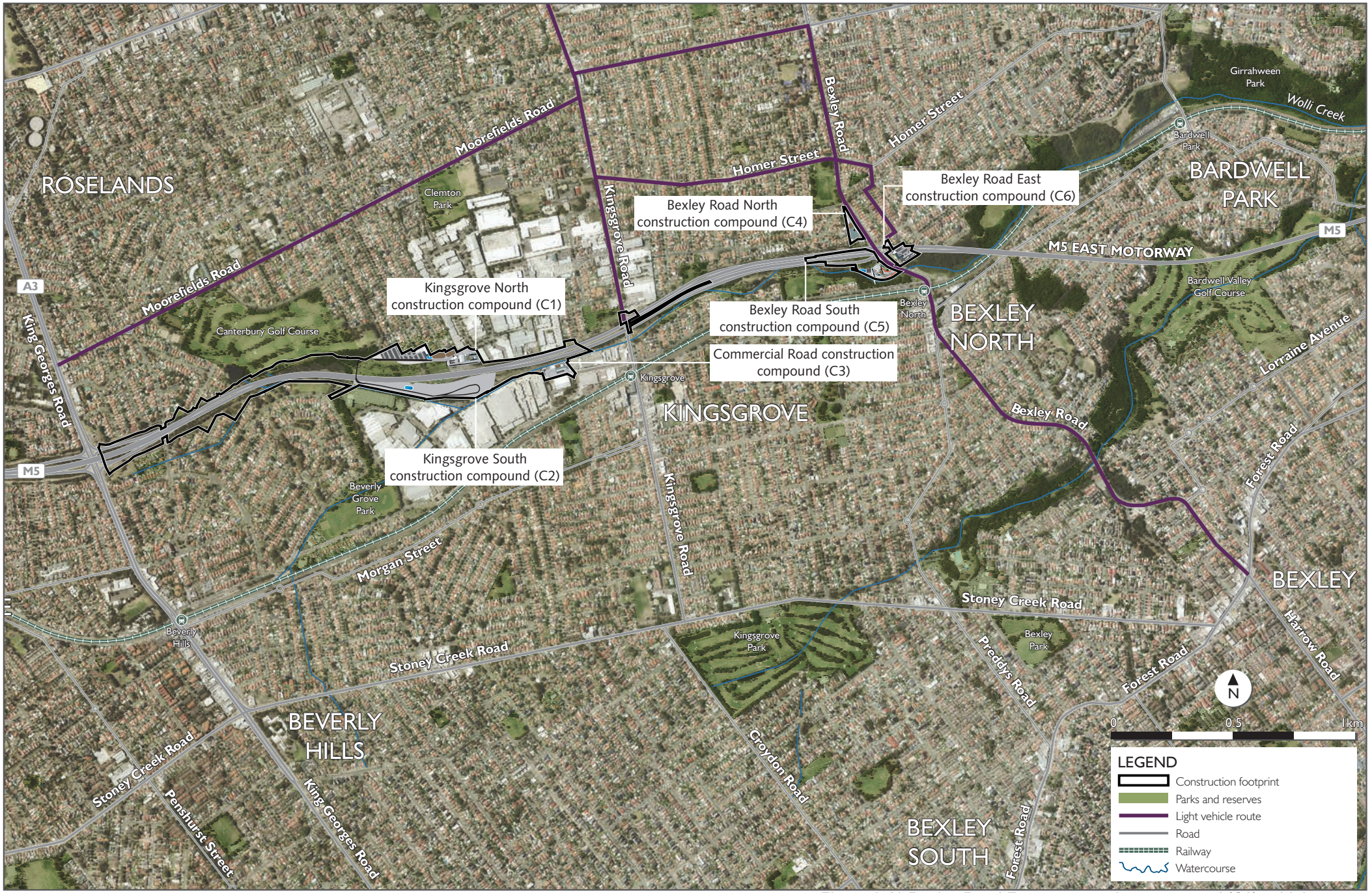


Figure 9-13 Bexley Road East construction compound (C6) vehicle routes

(blank page)

Network performance

Mid-block traffic volumes and level of service

Mid-block volume / capacity ratios around the western surface works, Kingsgrove Road surface works and Bexley Road surface works in 2016 with and without construction of the project are presented in **Table 9-27**.

The volume / capacity ratios show the operation of the road network would be similar with and without construction of the project. This is mainly due to the small volume of total construction traffic relative to expected background traffic volumes in 2016.

During construction, road performance is generally expected to operate at a level of service D or better during the AM and PM peak periods, with the exception of the following roads which would operate at a level of service E during periods of peak construction:

- The M5 East Motorway (surface lanes) between King Georges Road and Bexley Road during the AM peak in both directions
- The M5 East Motorway tunnel (eastbound), east of Bexley Road during the AM peak
- King Georges Road (northbound) between the M5 East Motorway and Moorefields Road during the AM peak
- Moorefields Road (eastbound), east of Chapel Street during the AM and PM peak
- Moorefields Road (westbound), east of Chapel Street during the PM peak.

Only one road (the M5 East Motorway tunnel eastbound from Bexley Road) would deteriorate from a level of service E to a level of service F in 2016 (AM peak) with the addition of project construction traffic. This road is already anticipated to be very close to capacity in 2016, even without the addition of project construction traffic.

Total construction traffic during peak construction activities along major roads around the western surface works area, Kingsgrove Road surface works area and Bexley Road surface works area would be:

- Less than four per cent of the total existing traffic (2016) on the M5 East Motorway
- Less than three per cent of the total existing traffic (2016) on Kingsgrove Road
- Less than four per cent of the total existing traffic (2016) on Bexley Road.

As a result, construction of the project would have a minor, temporary impact on the mid-block performance of the road network around the western surface works area, Kingsgrove Road surface works area and the Bexley Road surface works area.

Table 9-27 Mid-block traffic and volumes and level of service (2016) with construction and without construction around the western surface works, Kingsgrove Road surface works and Bexley Road surface works

Location	Traffic direction	Mid-block capacity	2016 'without construction' LV	HV	v/c	LoS	2016 'with construction' LV	LV increase* (per cent)	HV	HV increase* (per cent)	v/c	LoS
AM peak												
M5 East Motorway, east of King Georges Road	East	4300	2979	333	0.86	D	2995	1%	372	12%	0.88	E
	West	4300	2972	335	0.86	D	2982	0.3%	356	6%	0.87	E
M5 East Motorway, east of Bexley Road (tunnel)	East	4300	3380	406	0.99	E	3404	1%	450	11%	1.02	F
	West	4300	2506	363	0.77	D	2527	1%	390	7%	0.78	D
Bexley Road, (M5 East Motorway-Kingsgrove Avenue)	North	2400	1674	58	0.75	D	1679	0.3%	67	15%	0.76	D
	South	2400	1196	46	0.54	C	1199	0.3%	46	0%	0.54	C
Kingsgrove Road, south of Homer Street	North	2400	1027	79	0.50	C	1037	1%	90	14%	0.51	C
	South	2400	1213	78	0.58	C	1223	1%	89	14%	0.59	D
Commercial Road, west of Kingsgrove Road	East	900	554	22	0.67	D	558	1%	26	18%	0.68	D
	West	900	423	21	0.52	C	427	1%	25	19%	0.53	C
King Georges Road (between the M5 East Motorway-and Moorefields Road)	North	3600	2,506	306	0.88	E	2513	0.3%	317	4%	0.89	E
	South	3600	1678	234	0.61	D	1687	1%	239	2%	0.61	D
Moorefields Road, east of Chapel Street	East	900	675	50	0.87	E	682	1%	61	22%	0.90	E
	West	900	553	45	0.72	D	560	1%	56	25%	0.76	D
Wirega Avenue, south of Moorefields Road	North	900	101	17	0.15	A	115	14%	39	129%	0.22	A
	South	900	252	18	0.32	B	266	6%	40	122%	0.39	B
PM peak												
M5 East Motorway, east of King Georges Road	East	4300	3288	194	0.86	D	3302	0.4%	231	19%	0.88	E
	West	4300	3377	350	0.96	E	3386	0.3%	370	6%	0.97	E
M5 East Motorway, east of Bexley Road (tunnel)	East	4300	3316	192	0.87	D	3338	1%	233	21%	0.89	E
	West	4300	2824	241	0.78	D	2843	1%	266	10%	0.79	D
Bexley Road, (M5 East Motorway-Kingsgrove Avenue)	North	2400	1492	33	0.65	D	1497	0.3%	42	27%	0.66	D
	South	2400	1499	47	0.67	D	1502	0.2%	47	0%	0.67	D

Location	Traffic direction	Mid-block capacity	2016 'without construction' LV	HV	v/c	LoS	2016 'with construction' LV	LV increase* (per cent)	HV	HV increase* (per cent)	v/c	LoS
Kingsgrove Road, south of Homer Street	North	2400	1089	43	0.49	C	1098	1%	53	23%	0.50	C
	South	2400	1341	59	0.61	D	1350	1%	69	17%	0.62	D
Commercial Road, west of Kingsgrove Road	East	900	498	14	0.59	C	502	1%	18	29%	0.60	D
	West	900	540	10	0.62	D	544	1%	14	39%	0.64	D
King Georges Road (between the M5 East Motorway-and Moorefields Road)	North	3600	2078	241	0.72	D	2084	0.3%	251	4%	0.73	D
	South	3600	2218	251	0.76	D	2226	0.4%	255	2%	0.77	D
Moorefields Road, east of Chapel Street	East	900	690	22	0.82	E	696	1%	32	45%	0.85	E
	West	900	815	23	0.96	E	821	1%	33	44%	0.99	E
Wirega Avenue, south of Moorefields Road	North	900	233	5	0.27	B	245	5%	25	400%	0.33	B
	South	900	106	4	0.13	A	118	11%	24	500%	0.19	A

*increase in number of vehicles between 2016 'without construction traffic' scenario and 2016 'with construction traffic' scenario
LV – light vehicles, HV – heavy vehicles and LOS – level of service

Intersection performance with and without construction of the project

Table 9-28 provides a summary of the intersection performance level of service at key locations along construction traffic routes around the western surface works area, Kingsgrove Road surface works area and Bexley Road surface works area in 2016 with and without construction of the project. The analysis provides the average intersection delays and level of service for the worst performing movement at each intersection.

During construction of the project, the performance of intersections along construction traffic routes are expected to generally operate at a level of service similar to the operation of these intersections without construction in 2016. Without construction of the project, all intersections would operate at a level of service D or better during the AM and PM peak, except:

- Moorefields Road / Wirega Avenue / Chapel Street, which would operate at a level of service E during the AM peak
- Kingsgrove Road / Homer Street, which would operate at a level of service F during the AM peak and level of service E during the PM peak
- Bexley Road / Homer Street, which would operate at a level of service F during the PM peak.

The Moorefields Road / Wirega Avenue / Chapel Street, Kingsgrove Road / Homer Street and Bexley Road / Homer Street intersections would continue to operate at a level of service E during construction; however, the average delay would increase. Construction of the project would result in a reduction in the performance of the Kingsgrove Road / Homer Street intersection during the PM peak from a level of service D to a level of service E.

Table 9-28 **Intersection performance (2016) with construction and without construction (including spoil disposal) around the western surface works, Kingsgrove Road surface works and Bexley Road surface works**

Intersection / Peak	2016 – without construction				2016 – with construction			
	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service
Kingsgrove Road / Homer Street								
AM Peak	2789	191	>100	F	2815	213	>100	F
PM Peak	2993	522	52.2	D	3017	138	56.9	E
Kingsgrove Road / Moorefields Road								
AM Peak	3016	221	32.4	C	3036	243	31.3	C
PM Peak	3253	126	26.0	B	3271	146	30.0	C
Moorefields Road / Wirega Avenue / Chapel Street								
AM Peak	1652	128	56.8	E	1680	172	70.1	E
PM Peak	1925	52	34.9	C	1949	92	40.4	C
Kingsgrove Road / M5 East Motorway interchange								
AM Peak	3119	170	31.7	C	3147	200	37.9	C
PM Peak	3049	74	20.3	B	3075	102	21.1	B
Kingsgrove Road / Commercial Road / Kingsgrove Avenue								
AM Peak	2787	118	28.4	B	2795	126	29.4	C
PM Peak	3079	74	22.4	B	3087	82	22.9	B
Bexley Road / M5 East Motorway interchange								
AM Peak	3499	143	20.6	B	3515	161	21.2	B
PM Peak	4066	139	25.9	B	4082	157	26.0	B
Bexley Road / Kingsgrove Avenue								
AM Peak	3059	118	7.9	A	3067	127	7.8	A
PM Peak	3201	69	8.8	A	3209	78	8.8	A

Intersection / Peak	2016 – without construction				2016 – with construction			
	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service
Bexley Road / Homer Street								
AM Peak	3430	135	46.2	D	3459	144	48.9	D
PM Peak	3485	92	77.5	F	3514	101	83.0	F

Temporary road closures and changes to property access and on-street parking provisions

Increases in traffic volumes around construction compounds and along construction traffic vehicle routes at the western surface works, Kingsgrove Road surface works and Bexley Road surface works would be relatively low when compared with background traffic volumes in 2016. The increase in traffic volumes due to construction traffic is not expected to affect the ability for road users to enter or exit properties along construction traffic routes; however, minor delays due to the increase in traffic volumes may be experienced in some areas.

The use of construction compounds would not require any temporary road closures during construction of the project. Some temporary road closures would be required along the M5 East Motorway at night to facilitate the installation, relocation and removal of traffic barriers, the installation of tolling infrastructure and for works associated with the M5 Motorway corridor integration works.

Light vehicle parking for about 200 vehicles would be provided at the Kingsgrove North construction compound (C1) and about 112 light vehicle parking spaces would be provided at the Bexley Road East construction compound (C6). Off-street parking within construction compounds would minimise impacts on the availability of on-street parking (refer to **Section 6.5.3**).

Construction works around the western surface works, Kingsgrove Road surface works and the Bexley Road surface works areas are not expected to impact property access and/ or existing on-street parking provisions.

Travel times and speeds

There may be some short-term periods during construction where the speed limits around the western surface works, Kingsgrove Road surface works and Bexley Road surface works are reduced to provide a safe road working environment. This would include:

- Lowering the speed limit on some local roads to 40 kilometres per hour
- Lowering the speed limit on sections of the M5 South West and M5 East Motorways to 80 kilometres per hour

Speed limits along local roads would be reduced where:

- There is a large volume of construction traffic, particularly heavy vehicles
- The relocation of pedestrian pathways requires a reduction in the speed limit
- Construction of the project generates additional opposing turning movements or conflict points on the local road network
- Construction of the project presents a risk to the safety of construction workers
- Construction of the project creates additional road hazards, such as uneven road surfaces.

A reduction in the speed limit along local roads would not significantly impact on travel times.

Any reductions to speed limits along local roads, the M5 South West Motorway and M5 East Motorway would be undertaken in accordance with a Construction Traffic Management and Safety Plan(s) which would be developed and implemented for the project.

Impacts to public and active transport facilities and infrastructure

Public transport

During construction, increases in traffic flows on the existing road network around the western surface works, Kingsgrove Road surface works and Bexley Road surface works areas, particularly increases in heavy vehicle movements would result in increased delays at intersections along the construction vehicle routes identified in **Table 9-25**.

Buses would experience the same delays as general traffic at these intersections, as well as delays as a result of reduced speed limits and manual traffic control. Bus services around the western surface works area, Kingsgrove Road surface works area and Bexley Road surface works area that would potentially experience some minor delays in line with that experienced by general traffic on the existing road network are shown in **Figure 9-14** and include:

- Route 400 (Bondi Junction to Burwood), which travels along Bexley Road every 10 to 20 minutes during the AM and PM peak
- Route 446 (St George Hospital to Roselands), which travels along Homer Street, Bexley Road and Moorefields Road every 30 minutes during the AM and PM peak
- Route 450 (Hurstville to Burwood) and Route 452 (Bankstown to Canterbury), which travel along King Georges Road every 20 minutes during the AM and PM peak
- Route 490 (Drummoyne to Hurstville) and Route 492 (Drummoyne to Roselands), which travel along Kingsgrove Road every 30 minutes during the AM and PM peak
- Route 491 (Five Dock to Hurstville), which travels along Bexley Road once an hour during the AM and PM peak
- Route 493 (Rockdale to Roselands), which travels along Bexley Road and Kingsgrove Road outside of the AM and PM peak once an hour
- Route 495 (Williams Landing to Point Cook South), which travels along Kingsgrove Road every 20 minutes during the AM and PM peak
- Route M41 (Hurstville to Macquarie Park), which travels along Bexley Road every ten minutes during the AM and PM peak
- Route 946 (Hurstville to Bankstown) and Route 942 (Lugarno to Campsie), which travel along King Georges Road every 30 minutes during the AM and PM peak.

School bus services operating on these roads would also be impacted.

Construction of the project would not impact on the operation of passenger rail services on the Sydney metropolitan rail network.



Figure 9-14 Bus services along construction compound vehicle routes around the Western, Kingsgrove Road and Bexley Road surface work areas

(blank page)

Active transport

Construction of the project would require modifications to pedestrian and cycling facilities around the western surface works, Kingsgrove Road surface works and Bexley Road surface works. These modifications are shown in **Figure 9-15** and include:

- Realignment of the shared path within Beverly Grove Park, north of the M5 East Motorway. The shared path would be relocated outside of the Kingsgrove North (C1) construction compound so it would remain accessible during construction of the project. The path would be permanently realigned within Beverly Grove Park at the end of construction (refer to **Figure 5-1** to **Figure 5-3**)
- Temporary closure of the shared path within Beverly Grove Park, south of the M5 East Motorway between the Kindilan underpass and the Karingal Street underpass. Pedestrians and cyclists would be diverted onto the shared path within Beverly Grove Park on the northern side of the M5 East Motorway between these two underpasses. The path would be reinstated at the end of construction
- Permanent removal of cyclist provisions along the M5 East Motorway from the start of construction between King Georges Road and Bexley Road as part of the King Georges Road Interchange Upgrade project. Cyclists would be diverted onto the shared path within Beverly Grove Park and / or surrounding roads
- Changes to pedestrian and cyclist use of the Kindilan underpass. Kindilan underpass would be used for off-road vehicle access between the Kingsgrove North (C1) and Kingsgrove South (C2) construction compounds. Cyclists and pedestrian access would be temporarily separated from vehicles using the underpass with a hoarding to ensure safe access is maintained
- Temporary closure of the Kindilan underpass for four weeks during construction to facilitate the extension of the underpass as part of the western surface works (refer to **Section 5.4**). Additional intermittent closures may also be required during the construction period. In instances where the Kindilan underpass is closed, pedestrians and cyclists would be able to cross the M5 East Motorway via the underpasses at Karingal Street and/ or Coolangatta Road.

In addition, the pedestrian walkway along Bexley Road (northbound) adjacent to the Bexley Road South (C5) construction compound would be temporarily realigned to accommodate construction activities and maintain pedestrian accessibility. The path would be reinstated at the end of construction.

On-road cyclists may experience delays at intersections due to an increase in traffic volumes around the western surface works, Kingsgrove Road surface works and Bexley Road surface works areas. Additionally, journey times and distances for cyclists may be longer due to detours and changes in cycling routes.

A strategy for the maintenance of pedestrian and cyclist access during construction would be provided as part of the Construction Traffic Management and Safety Plan(s) for the project. The strategy would be prepared during the detailed design phase of the project and would incorporate management measures for pedestrian and cyclist access around the western surface works, Kingsgrove Road surface works and Bexley Road surface works.

Road safety

Construction traffic volumes are expected to be relatively low when compared with background traffic volumes in 2016 during peak construction activities along major roads around the western surface works, Kingsgrove Road surface works and Bexley Road surface works, making up:

- Less than four per cent of the total existing traffic on the M5 East Motorway
- Less than three per cent of the total existing traffic on Kingsgrove Road
- Less than four per cent of the total existing traffic on Bexley Road.

Increases in traffic along these roads due to construction of the project would be for the duration of construction only and are not expected to significantly impact on road safety around the western surface works area, Kingsgrove Road surface works area and / or Bexley Road surface works area.

(blank page)

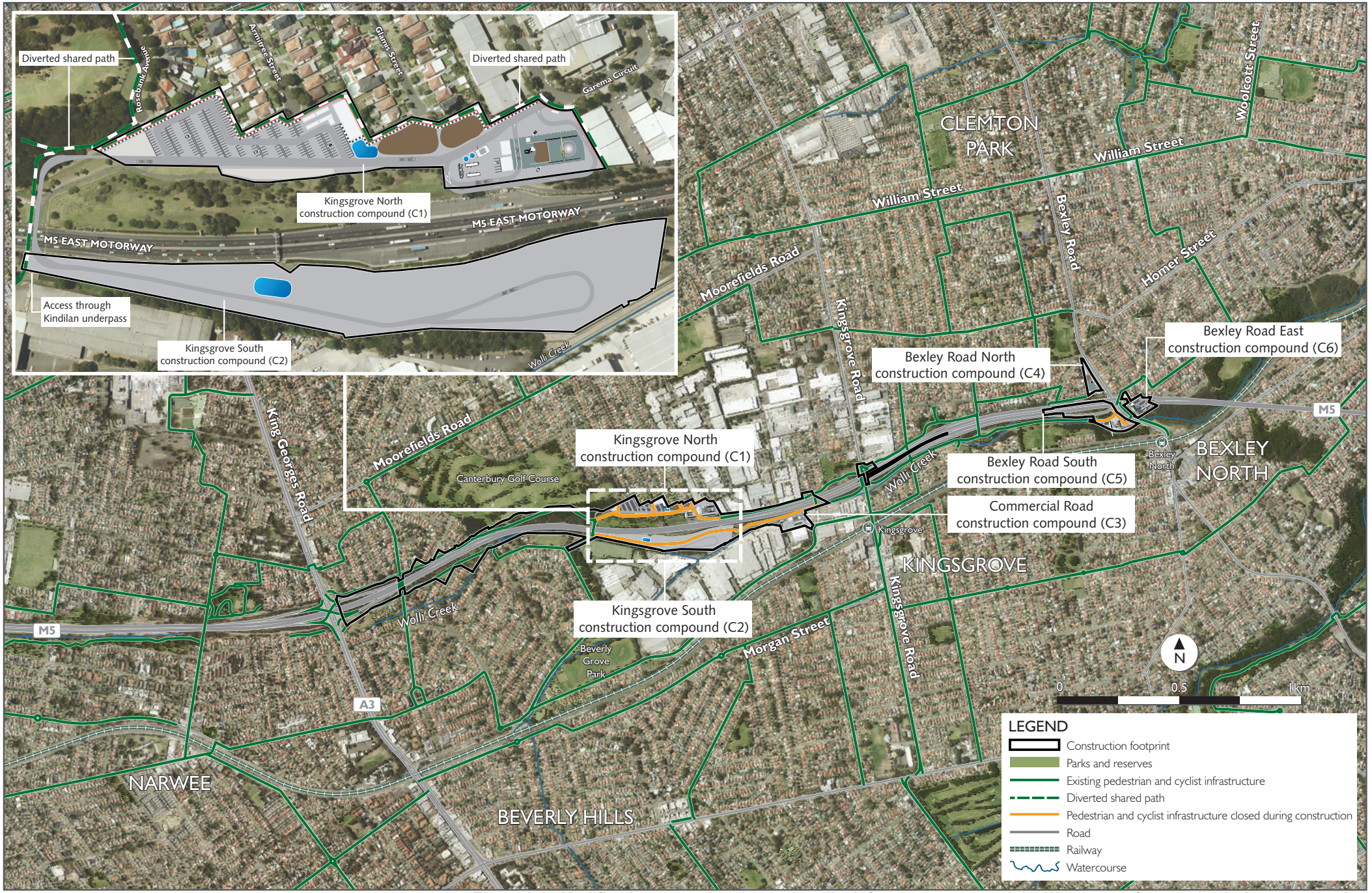


Figure 9-15 Modifications to pedestrian and cyclist infrastructure around the Western surface works during construction

(blank page)

Arncliffe surface works

Construction traffic volumes and patterns

Table 9-29 presents construction compound access points and construction traffic volumes around the Arncliffe surface works.

The construction traffic volumes are the two-way volumes (inbound and outbound) associated with the peak construction period for each route. Construction haulage routes for the Arncliffe (C7) construction compound are shown in **Figure 9-16**.

Vehicle access to the Arncliffe (C7) construction compound would require the use of Marsh Street to connect to the wider arterial road and motorway networks.

A modification to the layout and traffic signals at the Marsh Street/ Flora Street intersection would be required to accommodate the proposed vehicle access to the Arncliffe construction compound. The current Airport West Precinct project being undertaken by Roads and Maritime would include the provision of a temporary right-hand turn storage lane of about 25 metres on Marsh Street, eastbound and a 20 metre taper on Marsh Street (westbound) to accommodate access for the construction of the Airport West Precinct project.

Further to planning approval of the Airport West Precinct project, access to the Arncliffe construction compound from the Marsh Street/ Flora Street intersection would be maintained for project construction traffic to enter the Arncliffe construction compound, subject to the Contractors Traffic Management and Safety Plan(s). The right turn bay on Marsh Street (eastbound) would also be required for permanent access to the Arncliffe motorway operations complex (MOC3) (refer to **Section 5.8**). Accordingly, the right turn bay would become part of the permanent WestConnex project. The Airport West Precinct project also includes the widening of Marsh Street to three westbound lanes between Giovanni Brunetti Bridge and the M5 East Motorway interchange. The intersection is anticipated to operate within its capacity at a level of service B and level of service A in the AM and PM peak hours respectively.

Table 9-29 Construction traffic routes, access points and volumes around the Arncliffe surface works

Construction traffic route	Vehicle type	Access point	Daily vehicles	AM peak (vehicles per hour)	PM peak (vehicles per hour)
Route 1	Light	Marsh Street / Flora Street signalised intersection	151	7	7
	Heavy		443	25	25
Route 2	Light	Marsh Street / Flora Street signalised intersection	48	2	2
	Heavy		116	7	7
Route 3	Light	Marsh Street / Flora Street signalised intersection	151	7	7
	Heavy		443	25	25
Route 4	Light	Marsh Street / Flora Street signalised intersection	24	1	1
	Heavy		55	3	3
Total	Light	Marsh Street / Flora Street signalised intersection	374	17	17
	Heavy		1055	60	60

(blank page)

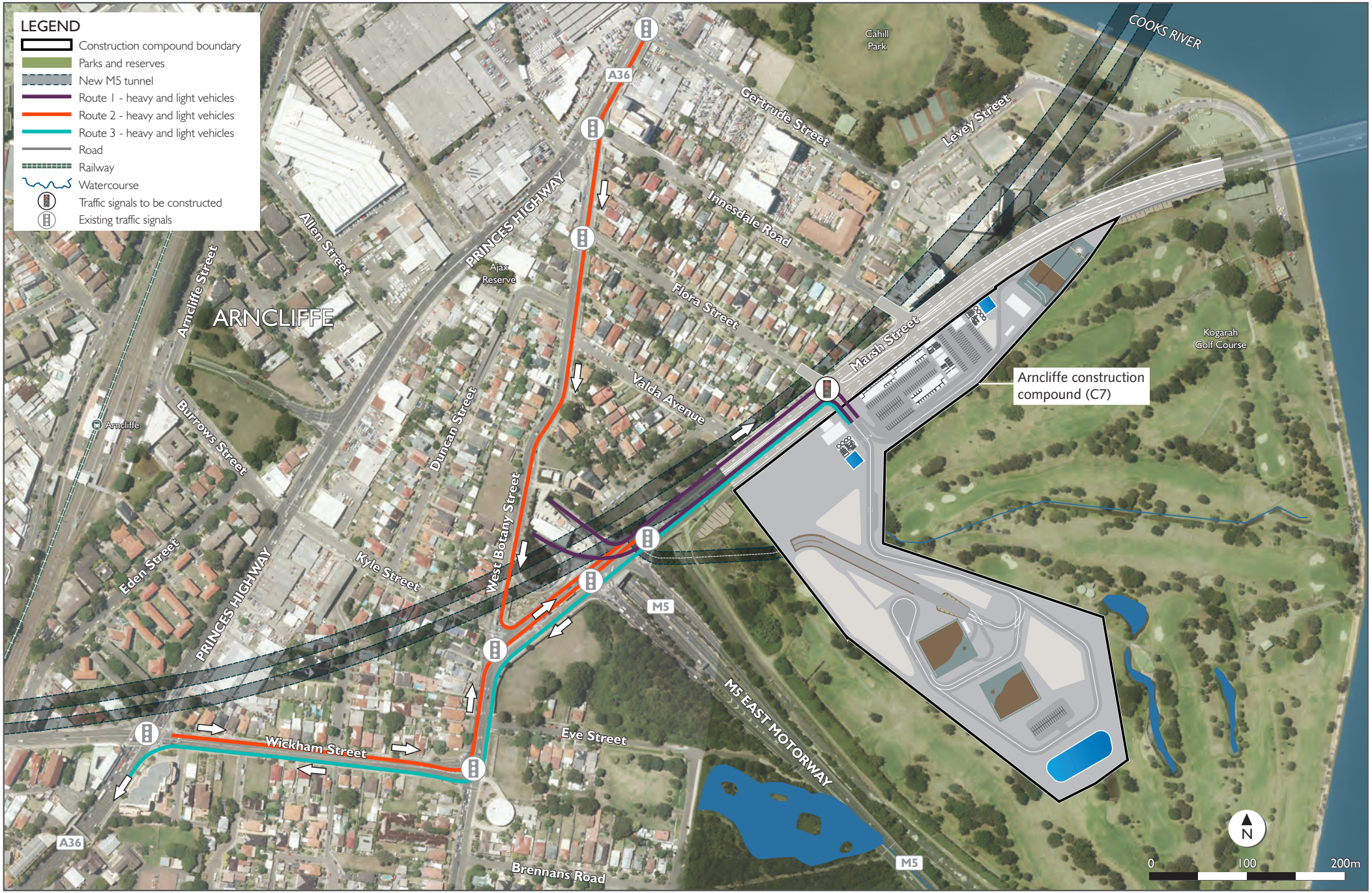


Figure 9-16 Arncliffe construction compound (C7) vehicle routes

(blank page)

Network performance

Mid-block traffic volumes and level of service

Mid-block volume / capacity ratios around the Arncliffe surface works in 2016 with and without construction of the project are presented in **Table 9-30**.

The volume / capacity ratios show the mid-block level of service on the road network around the Arncliffe surface works area would remain the same with and without construction of the project. This is mainly due to the small volume of construction traffic relative to expected background traffic volumes in 2016.

Without construction, the performance of roads around the Arncliffe surface works area are generally expected to operate at a level of service D or better during the AM and PM peak, except:

- West Botany Street (northbound) between Marsh Street and Wickham Street, which would operate at a level of service F during the AM peak
- West Botany Street (eastbound) between the M5 East Motorway and Flora Street, which would operate at a level of service E during the AM peak.

Construction of the project would not change the level of service along key roads around the Arncliffe (C7) construction compound; however, a minor increase in the volume / capacity ratios along these roads would be experienced.

Intersection performance with and without construction of the project

Table 9-31 provides a summary of the intersection performance at key locations along construction traffic routes around the Arncliffe surface works area in 2016 with and without construction of the project. The analysis provides the average intersection delays and level of service for the worst performing movement at each intersection.

Without construction of the project, all intersections would operate at a level of service D or better during the AM and PM peak, with the exception of the Princes Highway / Wickham Street intersection, which would operate at a level of service F in the AM peak.

During construction, the performance of intersections along construction traffic routes to and from the Arncliffe (C7) construction compound are expected to generally operate at the same level of service expected without construction in 2016. The performance of the Marsh Street / Flora Street intersection would be reduced to a level of service B during the AM peak; indicating the intersection would still operate effectively.

(blank page)

Table 9-30 Mid-block traffic and volumes and level of service (2016) with construction and without construction around the Arncliffe surface works

Location	Traffic direction	Mid-block capacity	2016 'without construction traffic'				2016 'with construction traffic'					
			LV	HV	v/c	LoS	LV	LV increase** (per cent)	HV	HV increase** (per cent)	v/c	LoS
AM peak												
Wickham Street (Princes Highway - West Botany St)	East	2400	1696	70	0.78	D	1703	<1%	95	135%	0.81	E
	West	2400	488	50	0.26	A	489	<1%	54	108%	0.26	B
West Botany Street (Marsh St -Wickham St)	North	2400	2310	92	1.06	F	2317	<1%	117	127%	1.09	F
	South	3600	734	72	0.26	A	735	<1%	76	105%	0.26	A
Marsh Street (M5 East Motorway-Flora Street)	East	3600	3047	96	0.92	E	3059	<1%	138	144%	0.95	E
	West	3600	1115	79	0.37	B	1120	<1%	96	121%	0.38	B
Princes Highway, south of Wickham St	North	3600	2645	56	0.77	D	2652	<1%	81	145%	0.79	D
	South	3600	903	55	0.29	B	904	<1%	59	107%	0.29	B
PM peak												
Wickham Street (Princes Highway - West Botany St)	East	2400	618	32	0.29	B	625	1%	57	178%	0.32	B
	West	2400	948	30	0.43	B	949	<1%	34	113%	0.43	C
West Botany Street (Marsh St -Wickham St)	North	2400	988	44	0.46	C	995	<1%	69	156%	0.49	C
	South	3600	2729	49	0.79	D	2730	<1%	53	8%	0.79	D
Marsh Street (M5 East Motorway-Flora Street)	East	3600	1265	63	0.39	B	1277	<1%	105	166%	0.43	C
	West	3600	2214	64	0.66	D	2219	<1%	80	125%	0.67	D
Princes Highway, south of Wickham St	North	3600	1223	30	0.36	B	1230	<1%	55	183%	0.38	B
	South	3600	2318	33	0.67	D	2319	<1%	37	112%	0.67	D

*increase in number of vehicles between 2016 'without construction traffic' scenario and 2016 'with construction traffic' scenario
LV – light vehicles HV – heavy vehicles LOS – level of service

Table 9-31 Intersection performance (2016) with construction and without construction (including spoil disposal) around the Arncliffe surface works

Intersection / peak	2016 – without construction				2016 – with construction			
	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service
Princes Highway / Wickham Street								
AM Peak	5685	225	>100	F	5693	254	>100	F
PM Peak	5779	137	49.8	D	5787	166	52.5	D
Wickham Street / West Botany Street								
AM Peak	2893	157	23	B	2901	186	23.3	B
PM Peak	4175	82	11.9	A	4183	111	12.0	A
Marsh Street / West Botany Street								
AM Peak	3359	203	7.1	A	3368	236	7.2	A
PM Peak	3500	111	10.8	A	3509	144	10.8	A
Marsh Street / M5 East Motorway interchange								
AM Peak	4986	253	27.7	B	5003	312	27.9	B
PM Peak	4528	148	32.4	C	4545	207	32.5	C
Marsh Street / Flora Street								
AM Peak	4561	182	14.4	A	4580	243	16.6	B
PM Peak	3571	153	6.6	A	3590	214	11.4	A

Temporary road closures and changes to property access and on-street parking provisions

Construction traffic volumes around the Arncliffe surface works would be relatively low when compared to background traffic volumes in 2016. The increase in traffic volumes around the Arncliffe surface works due to construction traffic is not expected to affect the ability for road users to access existing properties along construction traffic routes. Motorists entering or exiting properties from roads along construction traffic routes may experience minor delays due to the increase in traffic volumes.

The use of the Arncliffe construction compound (C7) would require some minor, temporary road closures to allow the Marsh Street / Flora Street intersection to be modified. These works would require some lane closures at night-time, in accordance with a road occupancy licence and Construction Traffic Management and Safety Plan(s) to be prepared for the project.

Light vehicle parking for 220 vehicles would be provided at the Arncliffe construction compound (C7), minimising potential impacts to on-street parking (refer to **Section 6.5.3**). The use of the construction compound would not require the modification of existing on-street parking provisions.

Travel times and speeds

The speed limit on roads around the Arncliffe surface works may be temporarily reduced to 40 kilometres per hour to provide a safe road and working environment. Speed limits along local roads would be reduced where:

- There is a large volume of construction traffic, particularly heavy vehicles
- Construction of the project generates additional opposing turning movements or conflict points on the local road network
- Construction of the project creates additional road hazards, such as uneven road surfaces.

A reduction in the speed limit along roads around the Arncliffe surface works would not significantly impact on travel times along local and State roads.

Any reductions to speed limits along roads around the Arncliffe surface works would be undertaken in accordance with a Construction Traffic Management and Safety Plan(s) for the project.

Impacts to public and active transport facilities and infrastructure

Public transport

Increases in traffic flow on the existing road network around the Arncliffe surface works, particularly increases in heavy vehicle movements during construction would result in increased delays at intersections along the construction vehicle routes.

Buses would experience the same delays as general traffic at these intersections, as well as delays resulting from lower speed limits and/ or manual traffic control. Bus services around the Arncliffe surface works area would potentially experience some minor delays in line with that experienced by general traffic on the existing road network. Bus services that would experience some minor delays during construction of the project include:

- Route 400 (Bondi Junction to Burwood), which travels along Marsh Street and Wickham Street every 10 to 20 minutes during the weekday AM and PM peak periods
- Route 410 (Bondi Junction to Rockdale), which travels along Marsh Street and Wickham Street every 20 to 30 minutes during the weekday AM and PM peak periods
- Route 422 (Tempe/Kogarah to Sydney), which travels along the Princes Highway and West Botany Street every 10 to 15 minutes during the weekday AM and PM peak periods.

School buses operating on these roads would also be impacted

Construction of the project would not impact on the operation of passenger rail services on the Sydney metropolitan rail network.

Bus services along construction compound routes around the Arncliffe surface works are shown on **Figure 9-17**.

(blank page)

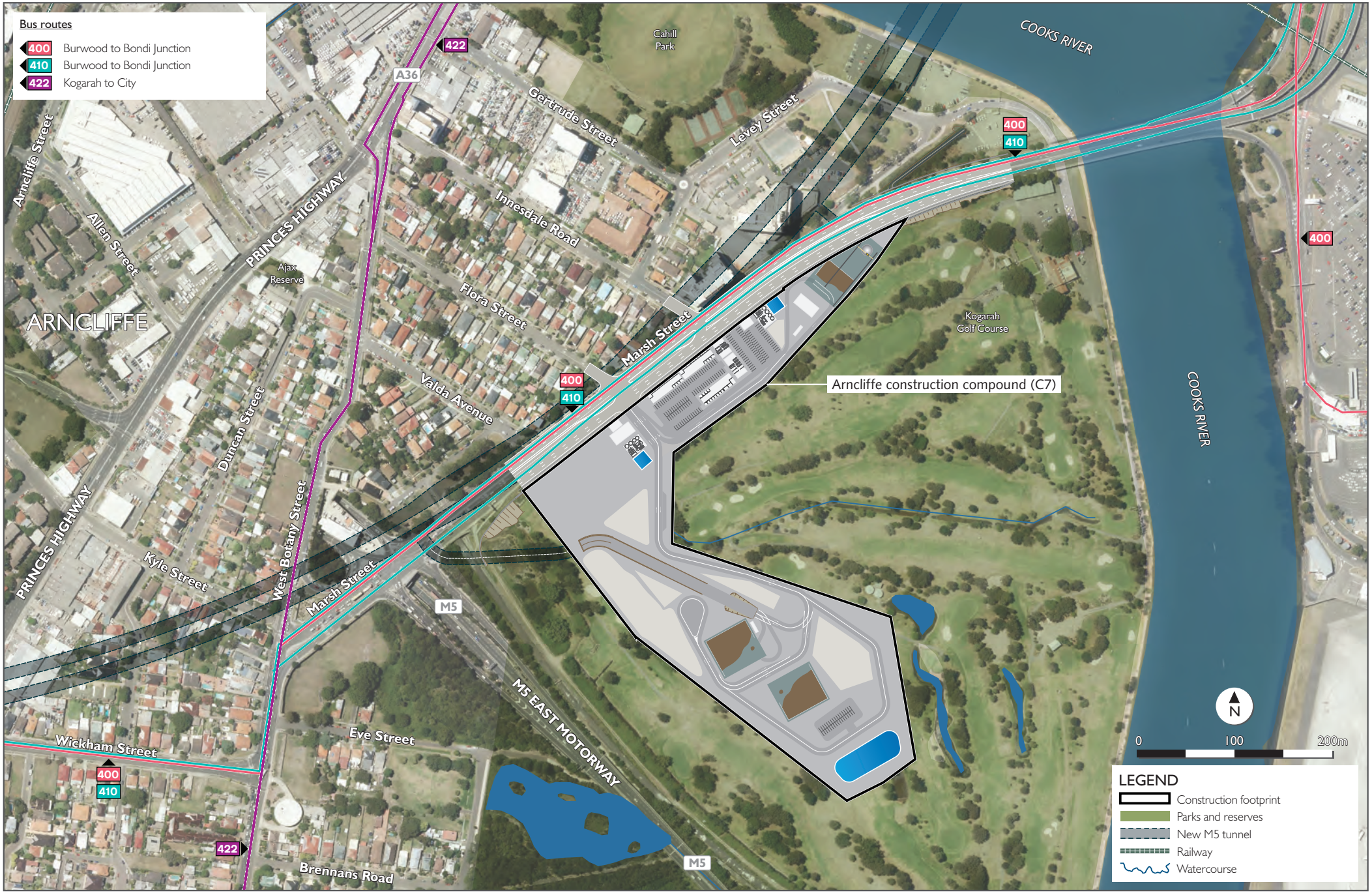


Figure 9-17 Bus services along construction compound routes around the Arncliffe surface works

(blank page)

Active transport

Roads and Maritime is proposing to widen Marsh Street to three lanes in each direction as part of the Airport West Precinct component of the WestConnex enabling works around Sydney Airport. As part of these works, a dedicated cycleway would be constructed along the westbound carriageway of Marsh Street. Signalised pedestrian crossing facilities are also proposed at the Flora Street / Marsh Street intersection as part of the Airport West Precinct works. Modifications to the Flora Street / Marsh Street intersection would integrate with the Airport West Precinct, and would be constructed in consultation with Roads and Maritime.

A strategy for the maintenance of pedestrian and cyclist access during construction would be provided as part of the Construction Traffic Management and Safety Plan(s) for the project. The strategy would be prepared during the detailed design of the project and would incorporate management measures for pedestrian and cyclist access around the Arncliffe construction compound (C7).

Road safety

Construction traffic volumes are expected to be relatively low when compared with background traffic volumes on the roads around the Arncliffe surface works area.

Construction traffic during peak construction along Marsh Street would comprise less than two per cent of total expected traffic along Marsh Street in 2016.

Increases in traffic along Marsh Street as a result of construction of the project would be for the duration of construction only and are not expected to significantly impact on road safety around the Arncliffe surface works area.

St Peters interchange and local road upgrades surface works

The following compounds around the St Peters interchange and local road upgrades would generate construction traffic:

- Canal Road (C8) construction compound
- Campbell Road (C9) construction compound
- Landfill Closure (C10) construction compound
- Burrows Road (C11) construction compound
- Campbell Road bridge (C12) construction compound
- Gardeners Road bridge (C13) construction compound
- Sydney Park (C14) construction compound

These construction compounds would be used from around June 2016 to late 2019 to support:

- Closure of the former Alexandria Landfill (refer to **Section 6.5**)
- Construction of the local road upgrades (refer to **Section 6.5**)
- Construction of the main alignment tunnels (refer to **Section 6.5**)
- Construction of the St Peters interchange (refer to **Section 6.5**).

Additional detail on the construction compound layouts, construction activities and construction programs are provided in **Section 6.5.3** of this environmental impact statement.

Construction traffic volumes and patterns

Table 9-32 presents construction compound access points and construction traffic volumes around the St Peters interchange and local road upgrades. The construction traffic volumes are the two-way volumes (inbound and outbound) during the peak construction period for each route. Construction haulage routes for the seven construction compounds around the St Peters interchange and local road upgrades are shown in **Figure 9-18** to **Figure 9-20**.

(blank page)



Figure 9-18 Canal Road construction compound (C8) vehicle routes

(blank page)

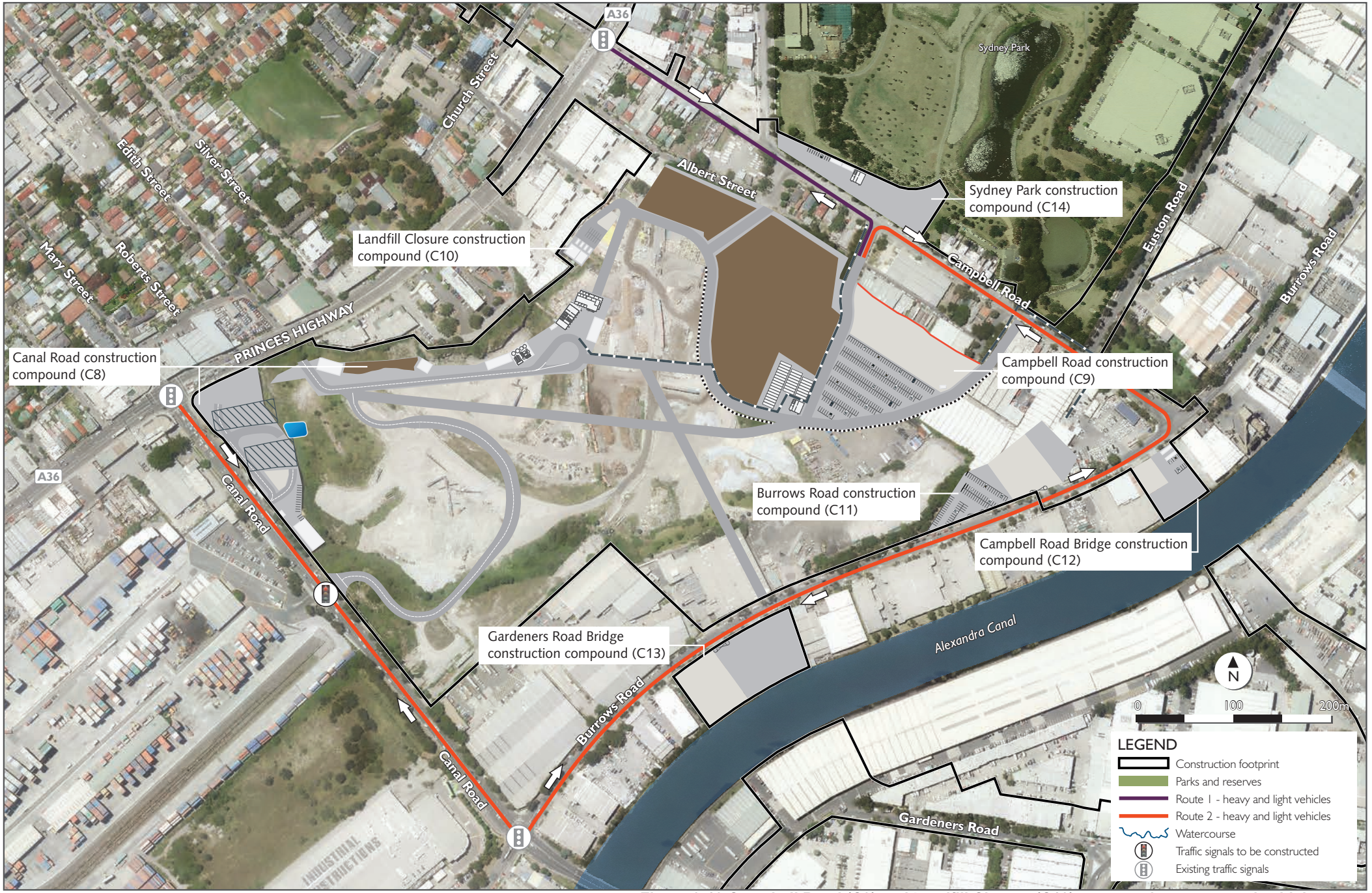


Figure 9-19 Campbell Road (C9) and Landfill Closure (C10) construction compound vehicle routes

(blank page)

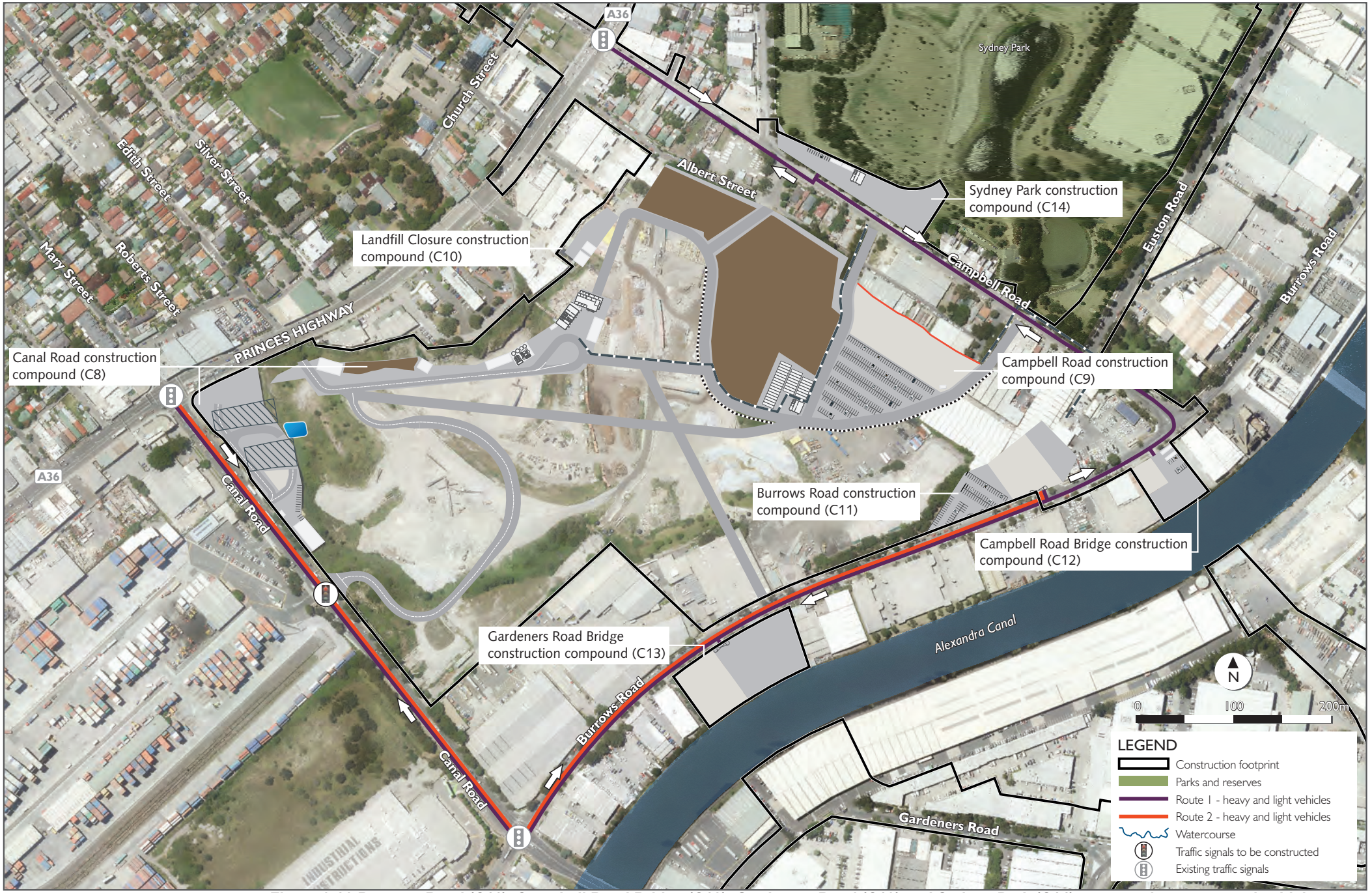


Figure 9-20 Burrows Road (C11), Campbell Road Bridge (C12), Gardeners Road (C13) and Sydney Park (C14) construction compound vehicle routes

(blank page)

Table 9-32 Construction traffic routes, access points and volumes around the St Peters interchange and local road upgrades

Construction compound	Construction traffic route	Vehicle type	Access point	Daily vehicles	AM peak (vehicles per hour)	PM peak (vehicles per hour)
Canal Road (C8)	N/A	Light	Canal Road (left in right out from signalised intersection)	1132	40	54
		Heavy		710	50	50
Campbell Road (C9)	Route 1	Light	Campbell Road (left and right in, left and right out)	519	26	26
		Heavy		358	13	16
	Route 2	Light		519	26	26
		Heavy		358	13	16
Landfill Closure (C10)	N/A	Light	Campbell Road (left and right in, left and right out)	170	10	10
		Heavy		218	12	12
Burrows Road (C11)	Route 1	Light	Burrows Road (left and right in, left and right out)	130	6	7
		Heavy		100	4	5
	Route 2	Light		130	6	7
		Heavy		100	4	5
Campbell Road bridge (C12)	N/A	Light	Burrows Road (right in, left out)	79	4	4
		Heavy		117	5	4
Gardeners Road bridge (C13)	Route 1	Light	Burrows Road (left and right in, left and right out)	130	6	7
		Heavy		100	4	5
	Route 2	Light		130	6	7
		Heavy		96	4	4
Sydney Park (C14)	N/A	Light	Campbell Road (left and right in, left and right out)	96	4	4
		Heavy		61	4	4
Total	N/A	Light	As above	3035	134	152
		Heavy		2,218	113	121

Construction vehicles would use the existing arterial road network to access construction compounds as much as practically possible.

At locations where direct access to and from construction compounds via arterial roads is not feasible, or these roads cannot be used as a standalone access point for a construction compound, construction vehicles would use local roads. Impacts to the local road network from construction vehicle movements around the St Peters interchange would be minimised where reasonable and feasible, in accordance with a Construction Traffic and Safety Management Plan.

Vehicle access to the seven construction compounds around St Peters interchange and local road upgrades would require the use of some local roads, including Campbell Road, Canal Road and Burrows Road. The construction compound access requirements from local roads to these construction compounds are presented in **Table 9-33**.

Table 9-33 Local road access requirements around the St Peters interchange and local road upgrades

Local roads	Construction compound access from local roads						
	Canal Road (C8)	Campbell Road (C9)	Landfill Closure (C10)	Burrows Road (C11)	Campbell Road Bridge (C12)	Gardeners Road bridge (C13)	Sydney Park (C14)
Canal Road	✓						
Campbell Road		✓	✓				✓
Burrows Road				✓	✓	✓	

Network performance

Mid-block traffic volumes and level of service

Mid-block volume / capacity ratios around the St Peters interchange and local road upgrades in 2016 with and without construction of the project are presented in **Table 9-34**. The volume / capacity ratios show the operation of the road network would be similar with and without construction of the project.

The following roads would be operating at (or close to) design capacity in 2016 without construction traffic, largely as a result of background traffic growth:

- The Princes Highway (northbound), south of Canal Road, which would operate at a level of service F during the AM peak
- The Princes Highway (southbound), south of Canal Road, which would operate at a level of service E during the PM peak
- Campbell Road, (eastbound), east of the Princes Highway, which would operate at a level of service E during the AM peak.

With construction, road performance is generally expected to operate at a similar level of performance to the road network without constriction traffic. Road performance would generally operate a level of service D or better during the AM and PM peak, except:

- Campbell Road (eastbound), east of the Princes Highway, which would continue to operate at a level of service F during the AM peak
- The Princes Highway (northbound), south of Canal Road, which would operate at a level of service F during the AM peak
- The Princes Highway (southbound), which would continue to operate at a level of service E during the PM peak.
- Canal Road (westbound), between the Princes Highway and Burrows Road which would operate at a level of service E during the PM peak. Construction traffic would comprise less than four per cent of traffic along Canal Road at this location; however, the additional traffic would reduce the operation of the road network at this location, reducing the road performance from a level of service D without construction traffic to a level of service E.

When compared with background traffic volumes in 2016, total construction traffic during peak construction along roads around the St Peters interchange and local road upgrades would comprise a small proportion of total existing traffic on Canal Road, the Princes Highway, Burrows Road and Campbell Road.

As a result, construction of the project would have a minor, temporary impact on the mid-block performance of the road network around the St Peters interchange and local road upgrades.

Table 9-34 Mid-block traffic and volumes and level of service (2016) with construction and without construction around the St Peters interchange and local road upgrades

Location	Traffic direction	Mid-block capacity	2016 'without construction' LV	HV	v/c	LoS	2016 'with construction' LV	LV increase* (per cent)	HV	HV increase* (per cent)	v/c	LoS
AM peak												
Princes Highway, south of Canal Road	North	3600	3329	137	1.01	F	3396	2%	194	41%	1.06	F
	South	3600	1018	49	0.31	B	1085	6%	106	116%	0.36	B
Canal Road (Princes Highway - Burrows Road)	East	2400	1590	65	0.73	D	1621	2%	91	40%	0.76	D
	West	2400	1034	60	0.49	C	1065	3%	85	42%	0.53	C
Burrows Road, north of Canal Road	North	900	202	8	0.24	A	223	10%	21	163%	0.30	B
	South	900	520	19	0.62	C	541	4%	32	68%	0.68	D
Campbell Road, east of Princes Highway	East	900	822	34	1.00	E	848	3%	53	55%	1.07	F
	West	900	105	9	0.14	A	131	24%	28	211%	0.21	A
PM peak Hour												
Princes Highway, south of Canal Road	North	3600	1634	69	0.49	C	1710	4%	130	88%	0.55	C
	South	3600	2815	114	0.85	E	2891	3%	175	53%	0.90	E
Canal Road (Princes Highway - Burrows Road)	East	2400	862	39	0.40	B	897	4%	66	69%	0.44	C
	West	2400	1680	79	0.78	D	1716	2%	107	35%	0.83	E
Burrows Road, north of Canal Road	North	900	210	6	0.25	A	232	10%	21	250%	0.31	B
	South	900	537	21	0.64	D	559	4%	36	71%	0.70	D
Campbell Road, east of Princes Highway	East	900	373	17	0.45	C	400	7%	38	124%	0.53	C
	West	900	441	16	0.53	C	468	6%	37	131%	0.61	D

*increase in number of vehicles between 2016 'without construction traffic' scenario and 2016 'with construction traffic' scenario
LV – light vehicles HV – heavy vehicles LOS – level of service

Intersection performance with and without construction of the project

Table 9-35 summarises the intersection performance at key locations along construction traffic routes around the St Peters interchange and local road upgrades in 2016 with and without construction of the project. The analysis provides the average intersection delays and level of service for the worst performing movement at each intersection.

During construction of the project, intersections along construction traffic routes are expected to generally operate at a level of service similar to the operation of these intersections without construction in 2016. Although the level of service of these intersections around the St Peters interchange and local road upgrades would remain the same, the average delay may increase. The following intersections would operate at or above capacity both with and without construction:

- Princes Highway / Railway Road, which would operate at a level of service F during the AM and PM peak
- Princes Highway / Canal Road, which would operate at a level of service F during the AM and PM peak
- Canal Road / Burrows Road, which would operate at a level of service F during the PM peak.

Table 9-35 Intersection performance (2016) with construction and without construction (including spoil disposal) around the St Peters interchange and local road upgrades

Intersection / peak	2016 – without construction				2016 – with construction			
	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service	Light vehicles (vehicles per hour)	Heavy vehicles (vehicles per hour)	Average delay (seconds)	Level of service
Princes Highway / Railway Road								
AM Peak	4857	211	>100	F	4991	325	>100	F
PM Peak	5103	206	70.6	F	5255	328	88.8	F
Princes Highway / Canal Road								
AM Peak	5036	212	>100	F	5170	326	>100	F
PM Peak	5326	225	>100	F	5478	347	>100	F
Canal Road / Burrows Road								
AM Peak	3276	152	29.1	C	3318	178	49.6	D
PM Peak	2975	137	>100	F	3019	167	>100	F
Princes Highway / Campbell Road								
AM Peak	3146	121	28.9	C	3198	159	31.1	C
PM Peak	3437	148	26.7	C	3491	190	32.8	C
Campbell Road / Euston Road								
AM Peak	1014	157	17.9	B	1052	179	19.8	B
PM Peak	989	61	10.3	A	1029	87	11.5	A
Campbell Road / Burrows Road								
AM Peak	668	199	9.3	A	706	221	10.1	A
PM Peak	996	171	15.4	B	1036	197	18.4	B
Canal Road compound signalised access								
AM Peak	2625	325	N/A	N/A	2707	401	9.6	A
PM Peak	2542	318	N/A	N/A	2640	398	9.5	A

Road closures and changes to property access and parking provisions

Road closures

The project would require permanent and temporary road closures to enable construction of the local road upgrades (refer to **Section 5.7**). Road closures around the St Peters interchange and local road upgrades are summarised in **Table 9-36**.

Roads requiring permanent closure would be located within the footprint of the St Peters interchange. Prior to the commencement of construction, all properties along these roads would be acquired by Roads and Maritime in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (refer to **Chapter 13** for additional detail).

Campbell Lane and Harber, Holland and Woodley Streets would be permanently closed as part of the project.

During construction, Brown Street and Florence Street would be partially closed at their intersections with Campbell Street to facilitate tie-in works to the upgraded Campbell Street. Alternative access to and from these streets would continue to be provided via Unwins Bridge Road. Temporary closures to Brown Street and Florence Street would be undertaken in accordance with a road occupancy licence, as required under the *Roads Act 1993*.

Minor, temporary partial closures may be required to roads around the St Peters interchange and local road upgrades to accommodate the installation of new barriers and road realignments, as well as to temporary and / or permanent traffic switches.

Partial closures would be intermittent and access to these roads and properties would be maintained. Roads potentially affected by these closures are summarised in **Table 9-36** below.

A Construction Traffic Management and Safety Plan(s) would be prepared for the project, detailing temporary road closures and including traffic control procedures, signage requirements, construction traffic management requirements of the relevant Roads and Maritime manuals and procedures and Australian Standards.

Lane closures

Temporary lane closures may be required to roads around the St Peters and local road upgrades to accommodate:

- The installation of traffic signals, new barriers and road realignments
- Temporary and / or permanent traffic switches.

These lane closures would be temporary and would be undertaken at night within approved times in accordance with a Road Occupancy Licence under the *Roads Act 1993*. Roads temporarily affected by temporary lane closures are summarised in **Table 9-36**.

A Construction Traffic Management and Safety Plan would be prepared for the project, detailing temporary lane closures and including traffic control procedures, signage requirements, construction traffic management requirements of the relevant Roads and Maritime manuals and procedures and Australian Standards.

Table 9-36 Road and lane closures around the St Peters interchange and local road upgrades

Road	Extent of road closure			Duration of closure		Temporary lane closures required
	Partial	Full	Temporary (short –term)	Temporary (medium to long term)	Permanent	
Bedwin Road	✓		✓			✓
Bourke Road / Bourke Street	✓		✓			✓
Brown Street	✓	✓*		✓		✓
Burrows Road	✓		✓			✓
Campbell Lane		✓			✓	
Canal Road						✓
Campbell Road / Campbell Street	✓		✓			✓
Church Street	✓		✓			✓
Euston Road	✓		✓			✓
Florence Street	✓	✓*		✓		✓
Gardeners Road	✓		✓			✓
Harber Street		✓			✓	
Holland Street		✓			✓	
Huntley Street	✓		✓			✓
Princes Highway	✓		✓			✓
St Peters Street	✓		✓			✓
Sydney Park Road	✓		✓			✓
Unwins Bridge Road	✓		✓			✓
Woodley Street		✓			✓	

*Road closures would be for a short period in accordance with a road occupancy licence

Property access

Construction of the St Peters interchange and local road upgrades may result in increases in traffic volumes around construction compounds and along construction traffic vehicle routes, as detailed above.

The increase in traffic volumes around the St Peters interchange and local road upgrades as a result of construction traffic is not expected to affect access to existing properties along construction traffic routes.

Motorists entering or exiting properties from roads along construction traffic routes may experience minor delays due to the increase in traffic volumes. Some commercial and industrial properties along Euston Road, Bourke Road, Burrows Road and Gardeners Road would require temporary modifications to driveways as part of the local road upgrades.

Parking provisions

Parking provisions in St Peters and Mascot would be temporarily reduced to allow safe access to construction compounds and to accommodate construction of the local road upgrades. The indicative temporary changes to on-street parking availability is summarised in **Table 9-37**. The final number of on-street parking spaces to be affected by construction of the project would be finalised during detailed design. The demand for parking is likely to reduce around St Peters interchange and the local road upgrades with the changes to land use.

Table 9-37 Indicative temporary impacts to parking during construction around St Peters interchange and the local road upgrades

Road	Indicative impact
Albert Street	Loss of 44 on-street spaces along both sides
Campbell Road, between Barwon Park Road and Burrows Road	Loss of 111 spaces along both sides
Euston Road, between Campbell Road and Sydney Park Road	Loss of 112 spaces along both sides
Burrows Road, south-west of Campbell Road	Loss of 38 spaces along both sides
Burrows Road, north-east of Campbell Road	Loss of 23 spaces along both sides
Euston Road, north of Sydney Park Road intersection	Loss of 24 spaces along both sides
Huntley Street, east of Euston Road	Loss of 32 spaces along both sides
Barwon Park Road, north of Campbell Road	Loss of 6 spaces
Princess Highway	Loss of 30 spaces along both sides
May Street	Loss of 50 spaces along both sides
Unwins Bridge Road	Loss of 39 spaces along both sides
Brown Street	Possible loss of up to 16 spaces during integration / tie-in works
Florence Street	Possible loss of up to 16 spaces during integration / tie-in works
St Peters Street	Possible loss of up to 12 spaces during integration / tie-in works
Hutchison Street	Possible loss of up to 10 spaces during integration / tie-in works
Gardeners Road, west of Bourke Street	Loss of 10 spaces
Gardeners Road, between Kent Road and cul-de-sac of Gardeners Road	Loss of 47 on-street spaces and 20 off-street spaces
Bunnings Mascot	Loss of 25 off-street spaces
Bourke Road, north of Bourke Street / Gardeners Road intersection	Loss of 26 off-street spaces

Light vehicle parking would be provided at construction compounds around the St Peters interchange and local road upgrades, minimising impacts on on-street parking.

Travel times and speeds

During construction, the speed limit on local roads may be reduced to 40 kilometres per hour to provide a safe road and working environment. Speed limits along local roads would be reduced where:

- There is a large volume of construction traffic, particularly heavy vehicles
- The relocation of pedestrian pathways requires a reduction in the speed limit
- Construction of the project generates additional opposing turning movements or conflict points on the local road network
- Construction of the project creates additional road hazards, such as uneven road surfaces.

A reduction in the speed limit along local roads would not significantly impact on travel times.

Any reductions to speed limits along local roads would be undertaken in accordance with a Construction Traffic Management and Safety Plan for the project.

Impacts to public and active transport facilities and infrastructure

Public transport

Some intersections along the construction vehicle routes identified in **Table 9-32** would experience increased delays during construction as a result of increased traffic on the road network, particularly heavy vehicles.

Buses would experience the same delays as general traffic at these intersections, and delays as a result of lower speed limits and/ or manual traffic control. Additionally, users of bus services may experience:

- Longer travel times to and from bus stops by supplementary travel modes, such as by car and walking
- A reduction in amenity for bus users waiting at bus stops and potential reductions to pedestrian roadside safety.

Bus services around the St Peters interchange surface works and local road upgrade area would potentially experience some minor delays including:

- Route 348 (Wolli Creek to Bondi Junction), which travels along Princes Highway every 30 minutes during the AM and PM peak periods
- Route 418 route (Bondi Junction to Burwood), which travels along Canal Road, every 15 to 20 minutes during the AM and PM peak periods
- Route 422 (Kogarah to Sydney City), which travel along a section of the Princes Highway, south of Canal Road, every 10 – 15 minutes the AM and PM peak periods.

School buses operating along these roads would also be impacted.

Bus services along construction compound routes around the St Peters interchange and local road upgrades are shown in **Figure 9-21**.

The existing bus stop on Euston Road northbound, south of the intersection with Maddox Street, would be temporarily relocated during the local road upgrades. The bus stop would be reinstated at the completion of construction.

The bus stop on the southbound side of Canal Road along route 418 (Burwood to Bondi Junction) near the intersection of the Princes Highway would be permanently relocated further south along Canal Road to accommodate construction vehicles accessing the Canal Road construction compound (C8) (refer to **Section 6.9** for additional detail). The final location of this bus stop would be determined during detailed design and in consultation with Transport for NSW.

Due to their location, the following bus stops would be temporarily removed at the start of construction and reinstated in a similar location at the earliest possible time during construction:

- Princes Highway (southbound) outside 136 Princes Highway, St Peters
- Bourke Road (northbound) outside 81A to 83 Bourke Road, Mascot
- Bourke Road (southbound) outside 520-530 Gardeners Road, Mascot
- Gardeners Road (eastbound) outside 538 to 540 Gardeners Road. Mascot.

Customers would be informed of the changes through a TfNSW-approved program of communication. The following impacts to bus services would also potentially be experienced during construction:

- Longer travel times to and from bus stops by supplementary travel modes (e.g. car passenger, walking to/from bus stop, etc) due to an increase in traffic volumes, slower travel speeds and increased intersection delays
- Reduced amenity for bus users waiting at stops; an increase in traffic would result in impacts including a reduction in pedestrian roadside safety.

Construction of the project would not impact on the operation of passenger rail services on the Sydney metropolitan rail network.

Bus stops requiring closure or relocation around the St Peters interchange and local road upgrades are shown on **Figure 9-22**.

Active transport

Construction of the project would require modifications to pedestrian and cycling facilities around the St Peters interchange and local road upgrades, including:

- Temporary diversion of the Bourke Road bicycle path around construction zones
- Relocation of existing and/ or provision of temporary access paths around construction zones
- Temporary diversions to alternative footpaths/ routes along Campbell Street/ Campbell Road, Bourke Road/ Bourke Street, Euston Road, Gardeners Road and the Princes Highway.

The project's Construction Traffic Management and Safety Plan would include a strategy to ensure the maintenance of pedestrian and cyclist access during construction. The strategy would be prepared during detailed design of the project and would incorporate management measures for pedestrian and cyclist access around the St Peters interchange and local road upgrades. This would include the installation of concrete barriers along construction traffic vehicle routes to provide a safe environment for pedestrians, cyclists and the general public.

On-road cyclists may experience delays at intersections due to an increase in traffic volumes around the St Peters interchange and local road upgrades. Additionally, journey times and distances for cyclists may be longer due to detours and changes in cycling routes.

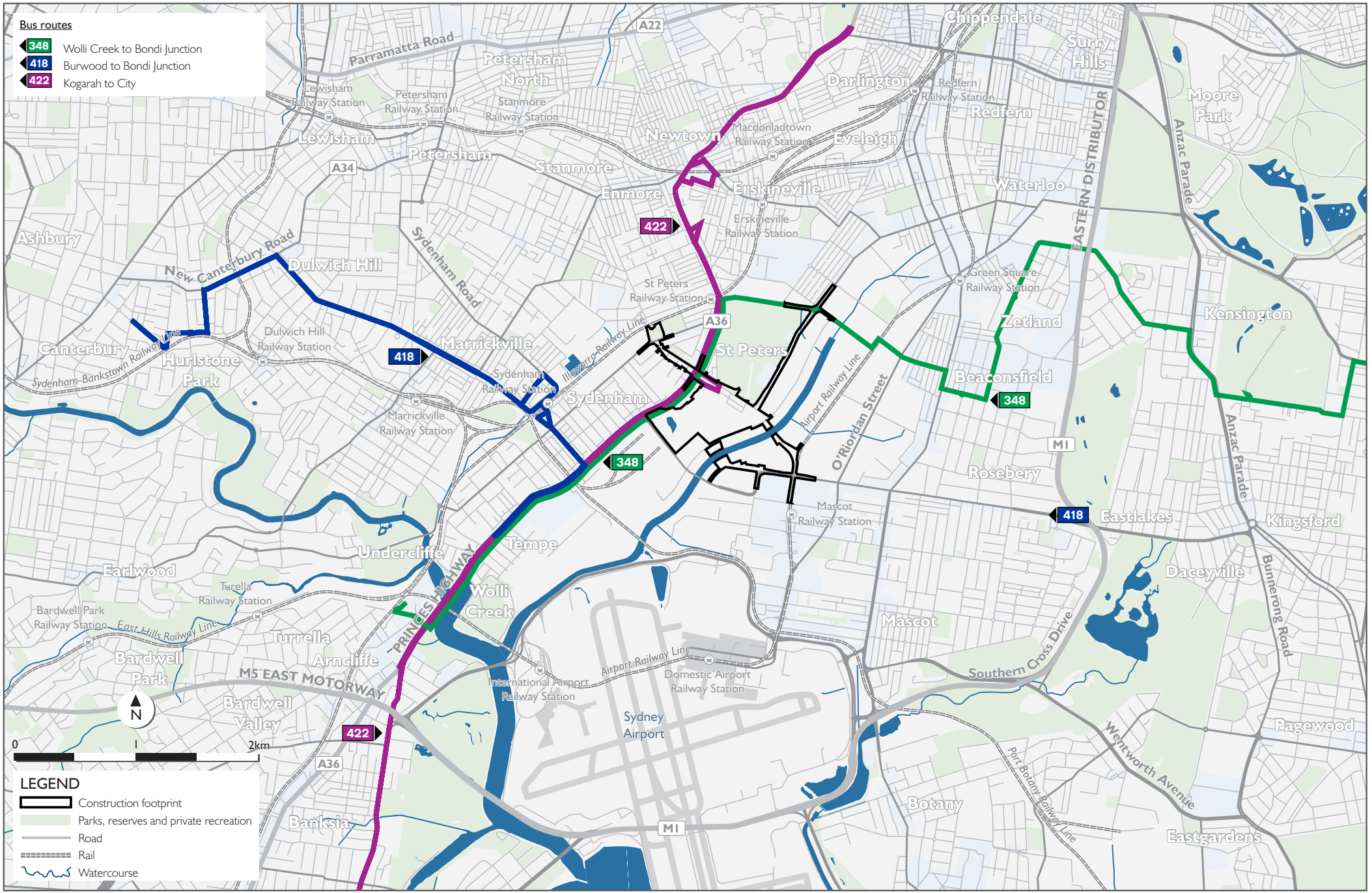


Figure 9-21 Bus services along construction compound routes around the St Peters interchange and local road upgrades

(blank page)



Figure 9-22 Bus stops requiring closure or relocation during construction

(blank page)

Road safety

Construction traffic along Campbell Road would comprise about 14 per cent of the total existing traffic. There is the potential that additional traffic incidents and crashes may occur as a result of this additional traffic. Construction traffic volumes along other local roads around the St Peters interchange and local road upgrades are generally expected to be low when compared to background traffic volumes. Increases in traffic as a result of construction of the project would be for the duration of construction only and are not expected to significantly impact on road safety around the St Peters interchange and local road upgrades.

Management measures to minimise traffic incidents would be implemented as part of a Construction Traffic Management and Safety Plan, with specific measure relating to road safety around the St Peters interchange and local road upgrades.

Spoil haulage

The project is expected to generate about 2.7 million cubic metres of surplus spoil, mostly from the excavation of the main alignment tunnels. Other spoil-generating construction activities would include the excavation of dive structures and ventilation shafts, as well as cut and fill activities for surface construction works around the western surface works and local road upgrades. The anticipated spoil generation is detailed in **Table 6.28** of **Chapter 6** (Construction works).

The assessment of impacts associated with construction traffic has taken into account heavy vehicle movements associated with spoil disposal. **Table 9-38** provides a summary of heavy vehicle movements at each construction compound, including spoil-related haulage and non-spoil related haulage.

Heavy vehicle movements from the construction compounds around the St Peters interchange would be required for the movement of spoil from tunnelling and the construction of the local road upgrades. Construction works as part of the closure of the former Alexandria Landfill are expected to have a cut/ fill balance. Should this change during detailed design, construction traffic impacts, including heavy vehicle movements would be revised.

It is expected that spoil haulage would comprise about 80 per cent of all heavy vehicle movements. Other heavy vehicle movements would be required for the delivery of materials, plant and equipment to construction compounds.

Table 9-38 Summary of heavy vehicle movements at construction compounds for the project

Construction compound	Heavy vehicle movements (spoil)			Heavy vehicle movements (other)		
	Daily vehicles	AM peak (vehicles per hour)	PM peak (vehicles per hour)	Daily vehicles	AM peak (vehicles per hour)	PM peak (vehicles per hour)
Kingsgrove North (C1)	1582	50	44	393	12	6
Kingsgrove South (C2)	48	2	2	24	1	1
Commercial Road (C3)	144	6	6	48	2	2
Bexley Road North (C4)	336	14	14	96	4	4
Bexley Road South (C5)	336	14	14	96	4	4
Bexley Road East (C6)	0	0	0	0	0	0
Arncliffe (C7)	726	47	27	469	13	13
Canal Road (C8)	575	40	40	135	10	10
Campbell Road (C9)	564	20	24	151	6	12
Landfill Closure (C10)	170	10	10	48	2	2
Burrows Road (C11)	151	6	8	48	2	4
Alexandra Canal bridge (C12)	93	4	3	24	1	0
Gardeners Road bridge (C13)	124	5	6	72	3	4
Sydney Park (C14)	24	1	1	37	3	3

Spoil disposal sites

Spoil would be reused on site where possible; however, excess spoil that cannot be re-used would require off-site management, including re-use and/ or disposal. Six potential spoil disposal sites have been identified for receiving excess spoil from the project, as summarised in **Table 9-39**. The feasibility of disposing of excess spoil at these locations is currently under investigation and final spoil disposal locations would be determined during detailed design. A final decision on a spoil management location(s) may include one or several of the potential spoil management sites that have been identified, or another suitable site(s) that may be identified during detailed design.

Sites identified as potential spoil disposal locations that do not currently have the necessary environmental planning approval to accept the materials would be subject to separate assessment and approval in accordance with the requirements of the EP&A Act and disposal of spoil from the project to particular locations would be undertaken in accordance with those other approvals.

Table 9-39 Potential spoil management sites

Spoil receiver site	Location	Distance from project* (kilometres)	Approximate capacity for spoil disposal (cubic metres)
CSR PGH Brick Pit	75 Townson Road, Schofields.	55	550,000
DHA Schofields	49 Manorhouse Boulevard, Quakers Hill	60	500,000
Austral Plant 2 or 3 clay shale pit	738-780 Wallgrove Road, Horsley Park	40	3,000,000
Riverstone West Sakkara Development	Land west of Riverstone	60	3,500,000
Sandy Point Quarry	Heathcote Road, Sandy Point	25	5,000,000
Kurnell Landfill Company	330 Captain Cook Drive, Kurnell	15	7,000,000

*Taken as Bardwell Valley Golf Course, about halfway along the tunnelling works to be undertaken as part of the project.

Spoil haulage routes

Spoil haulage routes to and from construction compounds have been identified with the aim of minimising impacts to local residential streets and maximising movements along State and regional roads.

The assessment of construction traffic impacts has taken into account heavy vehicle movements for spoil disposal. It is expected that spoil haulage would generally be undertaken using B-Doubles and super B-doubles.

B-Doubles are considered Restricted Access Vehicles (RAVs) under the Heavy Vehicle (Mass, Dimension and Loading) National Regulation, due to the restricted road network that can safely accommodate these vehicles. Spoil haulage using B-doubles would follow Roads and Maritimes' approved RAV routes. Super B-doubles are considered Higher Mass Limit (HML) vehicles, due to their longer length and would follow Roads and Maritime approved HML routes.

Restricted access vehicle routes around the project approved for B Double use are shown on **Figure 9-23** and higher mass limit vehicle routes around the project are shown on **Figure 9-24**.

It is expected that spoil would be transported from six construction compounds providing the main tunnel support functions during construction:

- Kingsgrove North (C1) construction compound
- Commercial Road (C3) construction compound
- Bexley Road North (C4) construction compound
- Bexley Road South (C5) construction compound
- Arncliffe (C7) construction compound
- Canal Road (C8) construction compound.

These construction compounds would have direct access to roads which form part of Roads and Maritime approved RAV and HML routes on the State and National road network as follows:

- Kingsgrove North construction compound (C1) via the M5 East Motorway
- Commercial Road construction compound (C3) via Commercial Road and Kingsgrove Road
- Bexley Road North (C4) and Bexley Road South (C5) via Bexley Road
- Arncliffe construction compound (C7) via Marsh Street, Wickham Street, West Botany Street and the Princes Highway
- Canal Road construction compound (C8) via Canal Road and the Princes Highway.

Spoil handling at construction compounds which provide tunnelling support would be undertaken 24 hours per day, seven days a week. Where practical, spoil would be moved during the day, outside of peak periods. Heavy vehicle movements outside of standard construction hours for the purpose of spoil haulage would be required. Construction road traffic noise impacts associated with works conducted outside of standard construction hours are described in **Section 12.3**.

A Spoil Management Strategy would be prepared and implemented for the project prior to the commencement of tunnelling activities, which would include procedures relating to spoil haulage and spoil management sites.

(blank page)

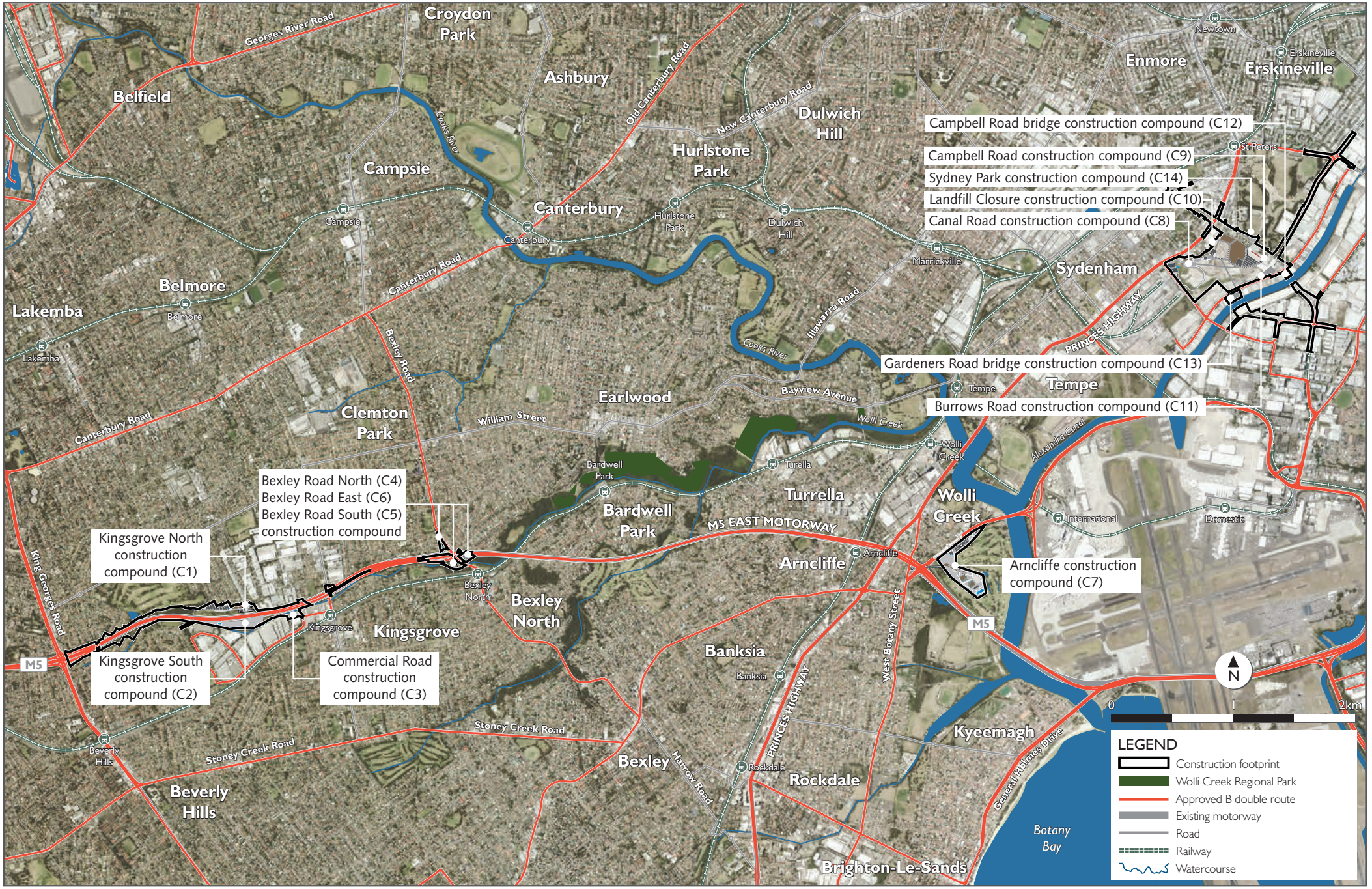


Figure 9-23 Restricted access vehicle routes approved for B double use around the project

(blank page)

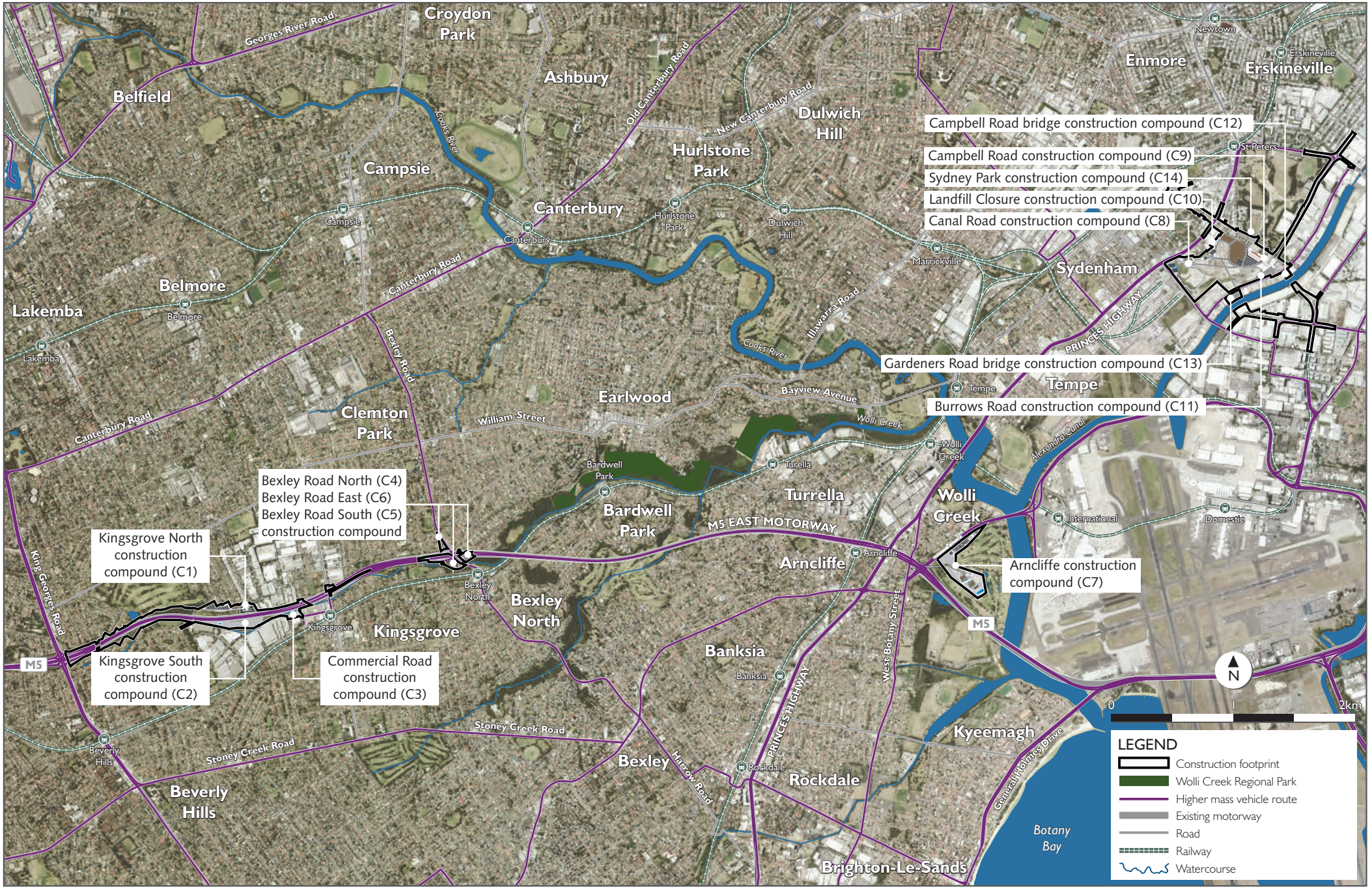


Figure 9-24 Higher mass limit vehicle routes around the project

(blank page)

Emergency vehicles

The M5 East Motorway, 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.

The Construction Traffic Management Plan(s) for the project would be developed in consultation with relevant emergency services, ensuring that procedures are in place to maintain safe, priority access for emergency vehicles through construction zones. Additionally, local emergency services would be periodically updated on the staging and progress of construction works.

Cumulative construction impacts

Construction of the project is expected to take place between 2016 and 2019. Based on the proposed construction program (refer to **Section 6.4** (Construction program) for more detail), there is the potential for construction of the project to occur at the same time as construction of other components of the WestConnex program of works, and other major developments near the project.

WestConnex program of works

There is the potential for construction of the project to occur at the same time as construction of the King Georges Road Interchange upgrade, the M4 East and future M4-M5 Link projects, all of which form part of the WestConnex program of works. A summary of the timing of these projects is provided in **Table 9-40**.

Table 9-40 Timing of projects that form part of the WestConnex program of works

WestConnex project	Commencement of construction	Commencement of operation
New M5	Mid 2016	Late 2019
King Georges Road Interchange Upgrade Project	Commenced July 2015	Late 2016/ early 2017
M4 East	Mid 2016	Early 2019
M4-M5 Link	2019	2023

King Georges Road Interchange Upgrade Project

Construction of the King Georges Road Interchange Upgrade project would potentially overlap with construction of the project for about three to six months in 2016 / 2017.

However, the project would not align with the peak construction period of the King Georges Road Interchange Upgrade project.

Construction vehicles from both projects would likely use common roads, such as King Georges Road and while there is likely to be some cumulative construction traffic impacts, these are likely to be short term and minor, due to the relatively low vehicle numbers predicted for the King Georges Road Interchange Upgrade project at this late stage of construction.

M4 East Project

Subject to environmental planning approval, the M4 East project has a projected construction program commencing in mid-2016 and continuing until early 2019. It is therefore likely that construction of the project would be undertaken concurrently with the M4 East.

It is expected that haulage and construction routes associated with the M4 East would include the M4 Motorway and adjacent arterial roads, and there is limited potential for cumulative construction traffic impacts with the project.

M4-M5 Link

Subject to environmental planning approval, there is the potential for construction of the future M4-M5 Link to commence in 2019 while the project is under construction.

It is expected that peak construction of the project would be complete, and the construction activities for the project at this time would largely comprise mechanical and electrical fit-out and landscaping and rehabilitation works.

There is the potential for localised cumulative construction works around the St Peters interchange, as a portion of the site may be used as a construction compound for the future M4-M5 Link.

There is likely to be some cumulative construction traffic impacts, these are likely to be short term. As both projects would be outside of peak construction periods, and the local road upgrades would be complete, it is expected the road network would have the capacity to accommodate construction vehicles from both projects at this location.

Should the M4-M5 Link project proceed, the environmental assessment of the project would include a traffic and transport impact assessment which would consider potential cumulative impacts of the project.

During construction, consultation would continue with local communities potentially affected by concurrent construction of projects that form part of the WestConnex program of works. Additionally, consultation would be undertaken with proponents of other (unrelated) nearby projects to increase the overall awareness of project timeframes and impact.

Additional information about consultation and cumulative impacts is provided in **Chapter 7** (Consultation) and **Chapter 27** (Cumulative impacts).

Other nearby major projects

The construction of nearby projects has the potential to result in additional construction traffic on the surrounding road network. Other major developments near the project include:

- Extension of the Marrickville Metro Shopping Centre
- Green Square development
- Mascot Station Town Centre precinct
- Wolli Creek redevelopment.

Extension of the Marrickville Metro Shopping Centre received approval from DP&E in April 2015. Although the construction program has not been confirmed, it is assumed construction would likely take place during the same period as construction of the project. Traffic from the construction of the extension of the Marrickville Metro Shopping Centre, north-west of Camdenville Park, may contribute to cumulative impacts, most notably during the construction of the St Peters interchange and local road upgrades.

The number of construction vehicles required for the construction of the extension of the Marrickville Metro Shopping Centre is not currently available, and as such, a quantitative assessment of potential cumulative traffic impacts has not been undertaken. While the Marrickville Metro Shopping Centre project would likely result in a localised increase in the number of vehicles, it is likely that the number associated with this development would not significantly contribute to overall traffic numbers.

Construction traffic for the extension of the Marrickville Metro shopping centre would largely use Edinburgh Road, Victoria Road, Enmore Road and Belmore Road. These roads would not be used as major routes for construction traffic for construction of the New M5. Intersections around the Marrickville Metro Shopping Centre would operate at a satisfactory level of service, provided the Marrickville Metro Shopping Centre incorporates the recommended improvements to Unwins Bridge Road, Bedwin Road, May and Campbell Street intersection, as well as providing a new roundabout to Edinburgh and Sydney Steel Road, as stated in the Environmental Assessment Report (July 2010) for the Marrickville Metro Shopping Centre Concept Plan Application (refer to http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=3734).

The Green Square Development, Mascot Station Town Centre Precinct Masterplan and Wolli Creek redevelopment area would all be developed progressively in a staged manner, and would generally be located away from areas potentially affected by construction of the project. Traffic from these developments is therefore unlikely to contribute substantially to cumulative traffic impacts near the project during construction.

Construction traffic management

Appropriate controls would be implemented to reduce and manage traffic-related impacts associated with construction of the project. This would include:

- Scheduling of works and traffic movements outside of peak traffic periods where feasible and reasonable
- Minimising road closure, especially during peak traffic periods
- Maintaining property access or providing an alternative access in consultation with property owners.

A Construction Traffic Management and Safety Plan(s) and traffic control plans would be developed in order to detail the site specific construction vehicle arrangements as well as the safe movement of motorists, cyclists and pedestrians around construction compounds and surface construction works.

Additional construction traffic management measures which would be considered during the development of the Construction Traffic Management and Safety Plan(s) and traffic control plans include:

- The use of temporary traffic signals at heavy vehicle access and egress points
- Siting heavy vehicle egress points where there are downhill grades, where feasible and reasonable
- Stipulating certain emission standards from heavy vehicles used as part of the project
- The use of larger trucks, with greater capacity to reduce the overall number of heavy vehicle movements.

Additional construction traffic management and mitigation measures are provided in **Section 9.4**.

9.3.2 Operation

The M5 Motorway corridor

Travel times and speeds

M5 East Motorway

Travel times and speeds along the M5 East Motorway under the 'with project' scenario in 2021 and 2031, and in 2031 with the complete WestConnex program of works and the future Southern extension have been provided from the WRTM and are presented in **Table 9-41**. Travel times and speeds would improve in 2021 and 2031 under the 'with project' scenario during the AM and PM peak in both directions when compared to the existing (2012) traffic conditions and forecast traffic conditions under the 'without project' scenario for the years 2021 and 2031.

Between 2021 and 2031 under the 'with project' scenario, average travel times on the M5 East Motorway would generally be halved and average travel speeds would generally double during the AM and PM peak in both directions. With the completion of the complete WestConnex program of works and the future Southern extension, average travel times and speeds would improve in both directions during the AM and PM peaks.

The New M5

Estimated average travel times and speeds along the New M5 between King Georges Road and St Peters interchange in 2021 and 2031, and in 2031 with the complete WestConnex program of works and the future Southern extension is presented in **Table 9-42**.

The New M5 would have a posted speed limit of 80 kilometres per hour. With the exception of westbound traffic during the PM peak in 2031 (without the full WestConnex program of works), travel times along the eastbound and westbound carriageways during the AM and PM peak would be about nine minutes at an average speed of about 68 kilometres per hour.

In 2031 westbound traffic during the PM peak would experience a slightly lower average travel speed of 62 kilometres per hour and average travel times of 10 minutes.

Table 9-41 Comparison of average travel times and speeds along the M5 East Motorway between the existing (2012) case, and 2021 and 2031 under the 'without project' and 'with project' scenarios

Direction	Existing (2012)		2021 (without project)		2021 (with project)		2031 (without project)		2031 (with project)		2031 (with full WestConnex program of works and the future Southern extension)	
	Average travel time (min)	Average speed (km)	Average travel time (min)	Average speed (km)	Average travel time (min)	Average speed (km)	Average travel time (min)	Average speed (km)	Average travel time (min)	Average speed (km)	Average travel time (min)	Average speed (km)
AM peak												
Eastbound	15	42	20	42	11	76	26	32	12	70	11	76
Westbound	10	68	17	49	11	76	23	37	12	70	11	76
PM peak												
Eastbound	12	55	18	47	10	84	26	32	13	65	10	84
Westbound	21	31	19	44	12	70	27	31	15	56	11	76

Source: WDA strategic transport model, 2015

Table 9-42 Comparison of average travel times and speeds along the New M5 in 2021 and 2031 (Kingsgrove to St Peters)

Direction	2021 (with project)		2031 (with project)		2031 (with full WestConnex program of works and the future Southern extension)	
	Average travel time (minutes)	Average speed (kilometres)	Average travel time (minutes)	Average speed (kilometres)	Average travel time (minutes)	Average speed (kilometres)
AM peak						
Eastbound	9	68	9	68	9	68
Westbound	9	68	9	68	9	68
PM peak						
Eastbound	9	68	9	68	9	68
Westbound	9	68	10	62	9	68

Source: WDA strategic transport model, 2015

Network performance

M5 East Motorway

Table 9-43 presents peak hour mid-block traffic volumes and levels of service under the 'with project' scenario for 2021 and 2031 and with the full WestConnex program of works and the future Southern extension. When compared to the mid-block performance in 2021 and 2031 under the 'without project' scenario, performance of the M5 East Motorway is generally shown to improve with the operation of the New M5. The improved level of service during the AM and PM peak in both directions corresponds to a reduction in traffic on the M5 East Motorway as a result of some traffic switching onto the New M5.

With the project, the M5 East Motorway would operate at a level of service D or greater, with the exception of the section between King Georges Road and Bexley Road, which would operate at a level of service E in the westbound direction during the AM peak and in the eastbound direction during the PM peak. This would be an improvement on the 'without project' scenario in 2031, as the M5 East Motorway is anticipated to be a level of service F without the New M5.

With the complete WestConnex program of works and the future Southern extension, the reduction in traffic volumes, and improved level of service along the M5 East Motorway is more apparent. With the full WestConnex program of works and the future Southern extension, the M5 East Motorway would operate at a level of service D or better in both directions during the AM and PM peak.

The traffic volumes presented in **Table 9-43** have been based on surveyed traffic flows under existing traffic conditions. It is recognised that the actual level of service may be lower than what has been predicted based on the surveyed traffic flows, as the level of service only represents the satisfied demand (capacity). As a result of congestion on other sections of the road network downstream of the surveyed locations, the actual demand may be underestimated. The level of service and volume/ capacity ratios should therefore be used as a comparison, or indication of change between scenarios, rather than absolute values.

Table 9-43 Mid-block traffic volumes and level of service along the M5 East Motorway in 2021 with the project and 2031 with the full WestConnex program of works

Location	Direction	2021 (without project)			2021 (with project)			2031 (without project)			2031 (with project)			2031 (with full WestConnex program of works and the future Southern extension)		
		LV	HV	LoS	LV	HV	LoS	LV	HV	LoS	LV	HV	LoS	LV	HV	LoS
AM peak																
M5 East Motorway, east of King Georges Road	Eastbound	2970	360	E	2110	180	C	2710	480	E	2110	300	C	1910	130	C
	Westbound	3390	360	E	2400	140	C	3560	350	F	3150	380	E	1990	50	C
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	3370	440	F	2720	250	D	3200	550	F	2850	380	D	2500	200	D
	Westbound	2860	430	E	1790	170	C	2910	480	E	2360	400	D	1220	70	B
M5 East Motorway, at Cooks River	Eastbound	2510	380	D	2010	260	C	2360	500	D	2080	400	D	2580	480	D
	Westbound	2830	330	D	2320	150	C	3000	440	E	2740	340	D	2690	450	D
PM peak																
M5 East Motorway, east of King Georges Road	Eastbound	3390	230	E	2670	60	D	3630	200	E	3260	270	E	2980	30	D
	Westbound	3390	460	F	2730	240	D	3220	580	F	2780	400	D	2380	170	C
M5 East Motorway, east of Bexley Road (in tunnel)	Eastbound	3430	240	E	2300	40	C	3390	330	E	3110	260	D	2610	20	C
	Westbound	3100	360	E	2100	130	C	2950	460	E	2390	290	D	1620	50	B
M5 East Motorway, at Cooks River	Eastbound	2720	180	D	2450	110	C	3060	310	D	2940	310	D	3190	80	D
	Westbound	2390	320	D	1830	180	C	2340	430	D	2050	340	D	1520	140	B

LV-light vehicles, HV-heavy vehicles, LoS-Level of Service

The New M5

As the New M5 would be a new motorway, the theoretical mid-block capacity for a single lane of a freeway of 2250 passenger car units per hour per lane has been adopted.

The mid-block traffic volumes and levels of service under the 2021 'with project' and 2031 'with project' scenarios are presented in **Table 9-44** and show that the New M5 is forecast to operate at an acceptable level of service with spare capacity during the AM and PM peak in 2021 and 2031.

The mid-block traffic volumes and levels of service under the 2031 'with full WestConnex program of works and the future Southern extension' scenario are presented in **Table 9-45**.

With the introduction of a future Southern extension, traffic on the New M5 to the west of the future Southern extension is forecast to decrease with a corresponding improvement to the level of service.

Despite increases in traffic volumes on the section of the New M5 between the future Southern extension and the St Peters interchange are forecast to increase compared to the 2031 'with project' scenario, the New M5 is still expected to operate at a good level of service with spare capacity during the peak hours in 2031.

Table 9-44 Mid-block traffic volumes and level of service for the New M5 in 2021 and 2031

Location and direction		Theoretical mid-block capacity	2021				2031			
			LV	HV	v/c	LoS	LV	HV	v/c	LoS
AM peak										
New M5	Eastbound	4500	1260	160	0.36	B	1440	230	0.43	B
	Westbound	4500	490	80	0.15	A	640	120	0.20	A
PM peak										
New M5	Eastbound	4500	680	110	0.20	A	950	150	0.28	B
	Westbound	4500	1300	150	0.36	B	1590	230	0.46	C

LV – light vehicles, HV – heavy vehicles. LoS – level of service

Table 9-45 Mid-block traffic volumes and level of service for the New M5 in 2031 with the full WestConnex program of works and the future Southern extension

Location	Direction	Theoretical capacity	Light vehicles	Heavy vehicles	v/c	LoS
AM peak						
New M5, west of the future Southern extension	Eastbound	4500	850	120	0.25	A
	Westbound	4500	1160	140	0.32	B
New M5, between the future Southern extension and St Peters interchange	Eastbound	9000	3290	250	0.43	B
	Westbound	9000	1850	160	0.25	A
PM peak						
New M5, west of the future Southern extension	Eastbound	4500	750	90	0.21	A
	Westbound	4500	1440	220	0.42	B
New M5, between the future Southern extension and St Peters interchange	Eastbound	9000	1840	160	0.24	A
	Westbound	9000	4830	310	0.61	C

Impacts to the performance of the King Georges Road Interchange

The King Georges Road Interchange Upgrade project includes the provision of on ramps to, and off ramps from the New M5. The King Georges Road Interchange is expected to operate at a level of service F, irrespective of whether the New M5 is constructed or not.

The results of the traffic and transport assessment undertaken for the King Georges Road Interchange Upgrade project (Jacobs, 2014) indicated in 2027 (10 years after opening), the interchange would operate at a level of service F in the AM and PM peak without the upgrade and with all components of the WestConnex program of works completed, as well and the future Southern extension. With the completion of the WestConnex program of works and the future Southern extension, average traffic delays at the interchange would be reduced, despite it continuing to operate at a level of service F.

The New South Wales Government has committed funding to fix pinch points along key Sydney road corridors to improve road network performance. The pinch points program includes funding for works along King Georges Road at its intersection with Broadarrow Road and Stoney Creek Road. Details of potential upgrade works at these intersections have yet to be finalised, however it is expected any improvements to the operation of these intersections would likely contribute to improved performance of the King Georges Road Interchange.

Impacts to public and active transport infrastructure and facilities

As discussed in **Section 9.2.2**, there is a planned rapid bus route between Hurstville and Macquarie Park via Burwood (current route M41), with a commitment to deliver bus priority along the corridor, including on Stoney Creek Road and Bexley Road. The forecast increase in traffic volumes along these roads will be reviewed as part of an operational traffic review undertaken on the surrounding arterial roads and major intersections about 12 months after the commencement of operation of the project. Roads and Maritime and TfNSW will continue to work together to deliver Sydney's Bus Future, with the surface road network being adapted to include bus priority measures already identified, as well as those identified at a future date.

The configuration of carriageways within the M5 Motorway corridor would be modified to accommodate the western surface works and would involve reducing the width of the shoulders. As a result, cyclists would be unable to use the M5 Motorway corridor east of King Georges Road due to safety considerations. Cyclists would be diverted onto parallel off-road shared path facilities within Beverly Grove Park.

The shared path within Beverly Grove Park would be permanently realigned to the north and south to accommodate the western surface works and the Kingsgrove motorway operations complex (MOC1). The realignment of this shared path would not restrict its use. Modifications to pedestrian and cycling facilities around the western surface works as part of the project is described in more detail in **Section 5.4**.

Road safety

Forecast crash statistics along the M5 East Motorway corridor under the 'with project' and 'without project' scenarios in 2021 and 2031 are presented in **Table 9-46**. These forecasts have been prepared assuming that the future frequency, type and severity of crashes on the M5 East Motorway and the New M5 would be consistent with historic trends.

In the 2031 under the 'full WestConnex program of works and the future Southern extension' scenario, the total number and cost of crashes is roughly the same as under the 2031 'with project' scenario. While there is more traffic on the section of the New M5 between the St Peters interchange and the future Southern extension, this is balanced out by the reduction on the section between the western portals and the future Southern extension.

Forecast crash statistics show the number and cost of crashes would continue to increase, which is a result of general traffic growth. Given the forecast reduction in daily traffic on the M5 East Motorway with the implementation of the New M5, the number and cost of crashes would reduce. Operation of the project is not expected to have a significant impact on road safety

.

Table 9-46 Forecast crash statistics along the M5 East Motorway corridor

Road	Section from	Section to	Section length (kilometres)	Average daily Traffic (vehicles)	Average annual crashes	Average annual cost ($AUD)
2021 'without project'						
M5 East Motorway	King Georges Road	General Holmes Drive	9.5	87,640	108	$17,880,031
2021 'with project'						
M5 East Motorway	King Georges Road	General Holmes Drive	9.5	67,170	82	$13,704,111
New M5	Western portal	St Peters interchange	8.8	28,900	11	$1,646,199
Total					93	$15,350,310
2031 'without project'						
M5 East Motorway	King Georges Road	General Holmes Drive	9.5	95,600	117	$19,503,875
2031 'with project'						
M5 East Motorway	King Georges Road	General Holmes Drive	9.5	81,390	100	$16,604,778
New M5	Western portal	St Peters interchange	8.8	34,230	39	$1,949,778
Total					139	$18,554,459
2031 'full WestConnex and the future Southern extension'						
M5 East Motorway	King Georges Road	General Holmes Drive	9.5	73,070	90	$14,907,512
New M5	Western portal	The future Southern extension	5.8	29,290	22	$1,095,741
New M5	The future Southern extension	St Peters interchange	2.9	80,520	30	$1,540,474
Total					142	$17,543,727

Impacts to the arterial road network

In 2021 and 2031 under the 'with project' scenario, changes to localised traffic volumes are expected within the traffic and transport study area. The project may result in some changes to daily traffic volumes and performance of the regional road network.

A screenline analysis has been undertaken to examine how traffic patterns along the adjacent arterial road network may change as a result of the operation of the project in 2021 and 2031, and with the operation of the full WestConnex program of works and the future Southern extension. Two screenlines, which represent theoretical boundaries specifically designed to collectively analyse directional and two-way traffic volume outputs from the different modelling scenarios have been established:

- The western screenline, which captures east-west traffic volumes on the M5 East Motorway corridor west of the New M5 tunnels and three parallel roads: Canterbury Road, Stoney Creek Road and Forest Road / Queens Road. The M5 East Motorway corridor location includes traffic using the New M5 in the 'with project' scenarios
- The eastern screenline, which captures traffic on the New M5 (east of the future Southern extension stub tunnels) and four parallel roads: the Princes Highway, Marsh Street, the M5 East Motorway and General Holmes Drive (all in the vicinity of the Cooks River).

A comparison of the two-way traffic volumes and traffic share in 2021 and 2031 with the project and full WestConnex program of works and the future Southern extension is provided in **Table 9-47**.

Impacts to the broader transport network in 2021 and 2031 under the 'with project' scenario

The project would result in changes to localised traffic volumes within the M5 East Motorway corridor under the 'with project' scenario in 2021 and 2031. These changes would be due to traffic switching to the New M5 and other parallel arterial roads, such as King Georges Road, Stoney Creek Road, Forest Road and Canterbury Road. It is expected that traffic switching to parallel arterial roads may be partly a result of the introduction of tolls onto the M5 East Motorway. This is likely to occur outside of peak traffic periods to avoid the proposed toll. This is not expected to have an impact from a traffic perspective in terms of congestion, as there is generally spare capacity across the network in off-peak periods.

Along the western screenline:

- The total two-way daily traffic volumes would reduce by about two per cent in 2021 and increase by about six per cent with the project in 2031
- The share of two-way daily traffic on the M5 East Motorway corridor would reduce by seven per cent in 2021 and a three per cent in 2031. This traffic is expected to shift to parallel arterial roads, mainly Stoney Creek Road and Canterbury Road. The increase in traffic on Stoney Creek Road with the project compared to without the project is less pronounced in the peak hours than over the course of the day as the peak hour spare capacity on Stoney Creek Road is limited.
- The M5 East Motorway corridor would continue to carry about 50 per cent of the total two-way traffic.
- Along the eastern screenline:
- The total two-way daily traffic volumes at the screenline would remain similar in 2021 with the project. In 2031, traffic volumes would increase by about four per cent with the project
- The M5 East Motorway share of two-way daily traffic would reduce by about six per cent with the project in 2021, and by about four per cent in 2031. Traffic shifting would include:
  - The shift of additional traffic to the New M5 and General Holmes Drive
  - A reduction in the share of traffic using the Princes Highway, and Marsh Street.

Impacts to the broader transport network in 2031 with the operation of the Full WestConnex program of works and the future Southern extension

With the operation of the full WestConnex program of works and the future Southern extension, traffic volumes and the share of total traffic along the western and eastern screenlines are expected to reduce due to the switching of traffic to the M4-M5 Link and the future Southern extension, and to parallel arterial roads.

Along the western screenline:

- The two-way daily traffic volumes at the screenline would be reduced by about 10 per cent as a result of traffic using the M4-M5 Link and the future Southern extension.
- Daily traffic on the M5 East Motorway corridor would reduce by about 24 per cent.
- The M5 East Motorway corridor share of two-way traffic is forecast to reduce by about eight per cent, with the majority of this traffic shifting on to Stoney Creek Road. The increase in traffic on Stoney Creek Road with the project compared to without the project is less pronounced in the peak hours than over the course of the day as the peak hour spare capacity on Stoney Creek Road is limited.

Along the eastern screenline:

- The New M5 share of two-way daily traffic crossing the screenline is forecast to be 21 per cent. The total 2031 two-way daily volume on the New M5 at the screenline is forecast to be about 134 per cent more than in the 2031 'with project' scenario. This is due to traffic using the M4-M5 Link and the future Southern extension.
- Once the full WestConnex program of works and the future Southern extension is operational, the total 2031 two-way daily volume at the screenline is forecast to be about two per cent more than in the 2031 'without project' scenario. These changes would be minimal and within daily traffic limits of traffic volume changes on the road network.
- Some of the traffic forecast to use the New M5 would shift from General Holmes Drive (six per cent decrease) and the M5 East Motorway (nine per cent decrease). The total 2031 two-way daily volume on the Princes Highway is forecast to be about 69 per cent less than in the 2031 'without project', resulting in a significant reduction.

Table 9-47 Two-way comparison of screenlines in 2021 and 2031 with and without the project and with the full WestConnex program of works in 2031

Location	2021					2031							
	Without project	Share (per cent)	With project	Share (per cent)	Per cent change (with project)	Without project	Share (per cent)	With project	Share (per cent)	Per cent Change (with project)	Full WestConnex program of works and the future Southern extension	Share (per cent)	Change (with project)
Western screenline													
Two-way Canterbury Road	47,849	22	51,583	24	8	55,958	23	57,163	22	2	56,799	26	2
M5 East Corridor (including M5 East Motorway and New M5)	115,889	53	98,528	46	-15	118,651	50	118,688	47	0	90,175	42	-24
Stoney Creek Road	27,045	12	36,297	17	35	32,820	14	47,068	18	43	38,420	18	17
Forest Road / Queens Road	28,731	13	28,800	13	0	32,066	13	31,610	12	-1	30,984	14	-3
Total	219,514		215,208		-2	239,494		254,530		6	216,379		-10
Eastern screenline													
Princes Highway	72,415	21	68,388	20	-6	79,085	20	75,628	19	-5	24,950	6	-69
New M5	–	–	29,339	9	–	–	–	34,748	9	–	81,739	21	
Marsh Street	75,979	22	66,723	19	-12	92,805	24	86,501	22	-7	97,563	25	5
M5 East Motorway	101,554	29	80,775	23	-20	109,634	28	95,208	24	-13	86,763	22	-21
General Holmes Drive	95,018	28	99,706	29	5	104,804	27	108,233	27	3	101,722	26	-3
Total	344,966		344,931		0	386,328		400,318		4	392,737		2

Area around the St Peters interchange and local road upgrades

Travel times

Table 9-48 provides a comparison of travel times through the network modelled around the St Peters interchange and local road upgrades in 2021 with and without the project, and in 2031 without the project and with the full WestConnex program of works and the future Southern extension.

In 2021 with the project, and in 2031 with the full WestConnex program of works and the future Southern extension, travel times along the New M5 to north of Euston Road would be significantly faster in comparison to travel times along the Princes Highway. In 2021, travel times along the Princes Highway in the AM peak would be similar with and without the project. There would be some minor travel time improvements along the Princes Highway during the PM peak with the project.

With the full WestConnex program of works and the future Southern extension in 2031, travel times would significantly improve along the Princes Highway during the AM and PM peak. Travel time savings along the Princes Highway would be due to a reduction in congestion as a result of traffic shifting from the Princes Highway to the WestConnex motorway network (including the Sydney Gateway).

Table 9-48 Comparison of average peak travel times along the Princes Highway and the New M5 in 2021 with and without the project and in 2031 without the project and with the Full WestConnex program of works and Southern extension during the AM and PM peak

From	To	Average travel time (minutes)				
		Existing (2012)	2021 'without project'	2021 'with project'	2031 'without project'	2031 'with full WestConnex program of works and the future Southern extension'
AM peak						
Princes Highway (south of Railway Road)	North of Euston Rd	10:30	22:00	21:30	25:30	24:30
WestConnex*	North of Euston Rd	-	-	6:00	-	6:00
Princes Highway North (King St)	Sydney Airport Domestic Terminal	13:00	14:00	14:00	44:30	15:00
PM peak						
Princes Highway (south of Railway Road)	North of Euston Rd	8:00	14:00	9:00	38:00	9:30
WestConnex*	North of Euston Rd	-	-	6:00	-	6:30
Princes Highway North (King St)	Sydney Airport Domestic Terminal	15:30	17:30	14:30	45:00	13:00

*Taken from an equivalent distance to the Princes Highway (south of Railway Road)

Network performance

Road network performance

The performance of local roads around St Peters interchange in 2021 under the 'with project' scenario compared to road network performance without the project in 2021 and 2031, and with the full WestConnex program of works and the future Southern extension in 2031 is presented in **Table 9-49**.

In 2021, the performance of the road network is similar under the 'with project' and 'without project' scenarios. During the AM peak, the average travel time per vehicle through the core modelled road network around the St Peters interchange with the project is similar to travel times without the project; however, there would be a minor increase in average traffic speeds (refer to **Table 9-49**). During the PM peak in 2021 under the 'with project' scenario, there would be a large improvement in road network performance on local roads around the St Peters interchange. The average travel times and speeds would improve during the PM peak, indicating a reduction in congestion (refer to **Table 9-49**).

Under the 'with project' scenario in 2031, local roads would only be able to accommodate about 80 per cent of the total traffic demand if not further capacity is added to the road network. This additional capacity could be achieved by completing the WestConnex program of works and the future Southern extension, particularly the M4-M5-Link.

By 2031, it is expected that with the project, traffic entering the local road network from St Peters interchange would increase the total traffic demand along local roads by about 20 per cent in the PM peak. In addition, it is expected that urban and residential development at Green Square, Mascot and nearby suburbs would generate additional traffic that would also need to be accommodated in the local road network.

The total network traffic demand between 2021 and 2031 under the 'with project' scenario would increase by about 17 per cent in the AM peak and 16 per cent in the PM peak. In the absence of the development of the full WestConnex program of works and the future Southern extension, additional network upgrades would be required to accommodate the 2031 'with project' traffic demand in the St Peters interchange area.

Under the 'full WestConnex program of works and the future Southern extension' scenario in 2031, there would be a significant increase in total traffic demand during the AM and PM peak (refer to **Table 9-49**). Although total traffic demand would increase, the completion of the WestConnex program of works and the future Southern extension, including the Sydney Gateway would provide enough additional capacity on the road network to effectively distribute and accommodate the predicted increases in traffic on the local road network around St Peters interchange. As a result, there would be significant increases in travel speeds through the local road network, and a reduction in the average travel times.

Table 9-49 Comparison of the road network performance for the in 2021 with and without the project and 2031 without the project and with the full WestConnex program of works and the future Southern extension on local roads around the St Peters interchange

Network measure	2021 (without project)	2021 (with project)	Per cent change (with project)	2031 (without project)	2031 (with full WestConnex program of works and the future Southern extension)	Per cent change (with full WestConnex program of works and the future Southern extension)
AM peak						
All vehicles						
Total traffic demand (vehicles)	23,800	25,290	+6	27,000	34,520	+28
Total vehicle kilometres travelled in network (km)	66,400	74,860	+13	72,500	117,330	+62
Total time travelled in network (hours)	3510	3380	-4	3,840	4,360	+14
Total number of stops	170,600	156,270	-8	160,600	175,140	+9
Average per vehicle						
Average vehicle kilometres travelled in network (km)	2.8	3.0	+6	2.7	4.6	+72
Average time travelled in network (minutes)	8.8	8.0	-9	8.5	7.6	-11
Average number of stops	7.2	6.2	-14	5.9	5.1	-14
Average speed (km/h)	18.9	22.1	+17	18.9	26.9	+42
Unreleased vehicles						
Unreleased demand (vehicles)	980	710	-27	2530	1,000	-60
Per cent of total traffic demand	4	3	-	9	3	-
PM peak						
All vehicles						
Total traffic demand (vehicles)	24,800	26,320	+6	27,600	36,720	+33
Total vehicle kilometres travelled in network (km)	67,000	76,720	+15	72,800	125,120	+72
Total time travelled in network (hours)	2900	2,860	-1	4470	4,420	-1
Total number of stops	124,100	129,480	+4	172,700	173,530	+0

Network measure	2021 (without project)	2021 (with project)	Per cent change (with project)	2031 (without project)	2031 (with full WestConnex program of works and the future Southern extension)	Per cent change (with full WestConnex program of works and the future Southern extension)
Average per vehicle						
Average vehicle kilometres travelled in network (km)	2.7	2.9	+8	2.6	4.8	+83
Average time travelled in network (minutes)	7.0	6.5	-7	9.7	7.2	-26
Average number of stops	5.0	4.9	-2	6.3	4.7	-25
Average speed (km/h)	23.1	26.8	+16	16.3	28.3	+74
Unreleased vehicles						
Unreleased demand (vehicles)	520	50	-90	2,200	270	-88
Per cent of total traffic demand	2	0	-	8%	1	-

Intersection performance on local roads around the St Peters interchange

A summary of intersection performance on local roads around the St Peters interchange in 2021 with the project and in 2031 with the full WestConnex program of works and the future Southern extension is shown on **Table 9-50**.

Under the 'with project' scenario in 2021, the performance of intersections along the Princes Highway with Campbell Street, Canal Road and Railway Road would operate at a level of service F as a result of additional traffic demand. The queuing at these intersections would impact on the performance of other intersections along the Princes Highway, including the Princes Highway / Sydney Park Road and Princes Highway / May Street intersections.

In 2031 under the 'full WestConnex program of works and the future Southern extension' scenario, intersection performance at intersections along the Princes Highway would improve due to the reduction in forecast traffic demand.

The Princes Highway/ Railway Road and Gardeners Road/ O'Riordan Street intersections would continue to operate at a level of service F in 2021 and 2031 under the 'with project' and 'without project' scenarios.

The New South Wales Government is committed to fixing pinch points along key Sydney road corridors to improve road network performance. Funding has been committed for works along the Princes Highway as part of the 'Gateway to the South', Sydney to Illawarra Pinch Point program. Details of this work have yet to be finalised, but it is expected that any improvements to the operation of these intersections would likely lead to improved performance to local roads around the St Peters interchange.

Two intersections have been included in the network performance modelling around the St Peters interchange and local road upgrades which would not be upgraded or modified as part of the project; the Sydney Park / Mitchell Road and the Princes Highway / May Street intersections.

Additional measures may be required at these two intersections to allow traffic to move around the local road network as modelled. The options, described below, are an example of the types of measures which could be implemented to deter any undesirable movements through the wider road network should they occur.

Roads and Maritime would monitor the traffic movements at these locations closely upon opening of the New M5 and, if required and subject to the successful outcome of further consultation with the local councils, stakeholders and community, plan to implement localised schemes, subject to separate assessment and approval.

The following describes a suggested intersection treatment at these locations and why they have been included in the modelling:

- Prohibition of right-hand turn movements from Mitchell Road into Sydney Park Road. The local road upgrades would result in the prohibition of right-hand turn movements from Sydney Park Road southbound onto Euston Road. As a result, some additional through traffic could travel through the area to the west of Euston Road. By restricting the right-hand turn at the intersection of Mitchell Road and Sydney Park Road, this movement would be prohibited for general traffic and would limit these additional movements through the area. This could also be achieved by implementing other alternative measures outside of the modelling area
- Alterations to the layout of the Princes Highway / May Street intersection to only allow left-in and left-out turning movements at May Street to prevent traffic travelling southbound to turn right onto May Street from the Princes Highway. As part of the project, an alternative route to provide access to May Street has been provided by allowing vehicles to turn right at the Princes Highway / Campbell Street intersection, which is currently prohibited.

Table 9-50 Intersection performance on local roads around the St Peters interchange in 2021 with the project and in 2031 with the full WestConnex program of works and the future Southern extension

Intersection	Existing (2012)	2021		2031	
		Without project	With project	Without project	Full WestConnex program of works and the future Southern extension
AM peak					
Princes Highway / Sydney Park Road	C	B	C	F	C
Princes Highway / May Street	E	B	C	C	A
Princes Highway / Campbell Street	D	C	E	D	F
Princes Highway / Canal Road	E	C	F	F	C
Princes Highway / Railway Road	F	F	F	F	F
Sydney Park Road / Mitchell Road	C	B	D	B	D
Euston Road / Sydney Park Road / Huntley Street	A	A	C	A	C
Unwins Bridge Road / Campbell Street	C	B	C	B	D
Campbell Road / Euston Road	A	A	C	A	D
Campbell Road / Bourke Road	-	-	C	-	D
Ricketty Street / Kent Street	-	-	C	-	B
Gardeners Road / Kent Street*	-	-	C	-	C
Gardeners Road / Bourke Road	C	C	D	D	D
Gardeners Road / O'Riordan Street	E	F	F	F	F
PM peak					
Princes Highway / Sydney Park Road	D	F	C	F	C
Princes Highway / May Street	D	D	A	D	A
Princes Highway / Campbell Street	D	C	E	F	E
Princes Highway / Canal Road	F	E	D	F	C
Princes Highway / Railway Road	E	F	D	F	F
Sydney Park Road / Mitchell Road	D	B	D	D	D
Euston Road / Sydney Park Road / Huntley Street	D	A	C	E	C

Intersection	Existing (2012)	2021		2031	
		Without project	With project	Without project	Full WestConnex program of works and the future Southern extension
Unwins Bridge Road / Campbell Street	C	C	D	F	D
Campbell Road / Euston Road	A	A	D	F	E
Campbell Road / Bourke Road	-	-	B	-	E
Ricketty Street / Kent Street	-	-	C	-	C
Gardeners Road / Kent Street*	-	-	B	-	C
Gardeners Road / Bourke Road	C	C	D	E	F
Gardeners Road / O'Riordan Street	D	D	F	F	F

Source: AECOM (2015)

* These intersections are either new or substantially changed as a result of the project and so were not reported on in the base or without project scenarios.

Impacts to road network performance on routes adjacent to the traffic and transport study area

Changes in peak hour traffic volumes on traffic routes adjacent to the traffic and transport study area in 2021 with the project, and in 2031 with the full WestConnex program of works and the future Southern extension is provided in **Table 9-51**.

With the operation of the project in 2021, increased peak hour volumes are forecast along Railway Road, Euston Road (north of Sydney Park Road), Edgeware Road and Gardeners Road in the AM and PM peak periods. Similar or slightly reduced peak hour volumes are generally forecast along King Street and Princes Highway (south of Railway Road) in the AM and PM peak periods.

In 2031 with the operation of the full WestConnex program of works and the future Southern extension, increased peak hour volumes are generally forecast along Railway Road, Euston Road (north of Sydney Park Road), Edgeware Road and Gardeners Road in both the AM and PM peak periods. Reduced peak hour volumes are forecast along Princes Highway (south of Railway Road), while similar or reduced flows along King Street northbound and increased flows along King Street southbound are forecast, in AM and PM peak periods.

Table 9-51 Changes to mid-block traffic flows on traffic routes adjacent to the traffic and transport study area near the St Peters interchange and local road upgrades in 2021 with the project and in 2031 with the full WestConnex program of works and the future Southern extension

Location	Direction	2021 'without project'	2021 'with project'	Change in flow (per cent)	2031 'without project'	2031 'full WestConnex program of works and the future Southern extension'	Change in flow (per cent)
AM peak							
King Street, south of Alice Street	Northbound	880	800	-10	1100	870	-21
	Southbound	560	620	11	450	730	62
Railway Road, west of Princes Highway	Eastbound	540	590	9	490	650	33
	Westbound	630	730	16	630	990	57
Princes Highway, south of Railway Road	Northbound	2,590	2580	0	2550	2180	-15
	Southbound	1060	980	-8	1150	550	-52
Euston Road, north of Sydney Park Road	Northbound	1050	1950	86	990	2120	114
	Southbound	790	1110	41	970	1580	63
Edgeware Road, west of Edinburgh Road	Eastbound	720	780	8	760	820	8
	Westbound	770	910	18	830	920	11
Gardeners Road, west of O'Riordan Street	Eastbound	1230	1350	10	1280	1790	40
	Westbound	1150	1150	0	1150	1410	23
PM peak							
King Street, south of Alice Street	Northbound	830	910	10%	890	940	6
	Southbound	1030	1010	-2%	980	1210	23
Railway Road, west of Princes Highway	Eastbound	640	910	42%	700	680	-3
	Westbound	1150	1490	30%	1280	1910	49
Princes Highway, south of Railway Road	Northbound	1710	1760	3%	1660	720	-57
	Southbound	2390	2360	-1%	2310	2110	-9
Euston Road, north of Sydney Park Road	Northbound	820	1280	56%	780	1530	96
	Southbound	1340	1940	45%	1500	2160	44
Edgeware Road, west of Edinburgh Road	Eastbound	1060	1090	3%	1030	1110	8
	Westbound	830	1030	24%	730	1040	42
Gardeners Road, west of O'Riordan Street	Eastbound	1410	1570	11%	1560	1650	6
	Westbound	1060	1270	20%	1140	1660	46

Impacts to property access and on-street parking

The operational footprint required to accommodate the local road upgrades would require permanent property acquisition, including land currently used for residential and commercial parking (refer to **Section 13.3.2**). A summary of the indicative impact on on-street (and some off-street) parking is summarised in **Table 9-52**. Most of the parking provisions that would be permanently removed would be located along non-residential roads. The final numbers would be confirmed during detailed design. Given the location of car parking spaces that would be lost, and the changes to land use (refer to **Section 13.3.2**).

Table 9-52 Indicative permanent changes to car parking around the local road upgrades

Road section	Indicative impact
Campbell Street, between Princes Highway and Unwins Bridge Road	Addition of 34 on-street and 26 off-street spaces
Albert Street	Loss of 44 spaces along both sides
Campbell Road, between Barwon Park Road and Burrows Road	Loss of 111 spaces along both sides
Burrows Road, south-west of Campbell Road	Loss of 8 spaces along both sides
Burrows Road, north-east of Campbell Road	Loss of 15 spaces along both sides
Euston Road, north of Sydney Park Road intersection	Loss of 24 spaces along both sides
Huntley Street, east of Euston Road	Loss of 28 spaces along both sides
Princess Highway	Loss of 18 spaces along both sides
May Street	Loss of 38 spaces along both sides
Unwins Bridge Road	Loss of 33 spaces along both sides
Gardeners Road, between Kent Road and cul-de-sac of Gardeners Road	Loss of 47 on-street spaces
Bourke Road, north of Bourke Street / Gardeners Road intersection	Loss of 16 off-street spaces

As part of the local road upgrades, the following car parking facilities would be provided following the opening of the project (refer to **Chapter 5** for more detail):

- On-street parking along Euston Road and Campbell Street
- A new car-park on Campbell Street, catering for 26 cars for use by St Peters Public School.

Impacts to public and active transport infrastructure and facilities

Changes to bus infrastructure

To accommodate construction of the project, some bus stops would be removed and / or relocated as part of the local road upgrades at St Peters and Mascot. Where bus stops are relocated, pedestrian access, including disabled access would be maintained.

The bus stop on Canal Road (southbound) near the corner of the Princes Highway would be permanently relocated further south to allow construction and operation of the Canal Road construction compound (C8) and St Peters motorway operations complex (MOC4).

The existing bus stop on Euston Road northbound, south of the intersection with Maddox Street, would be temporarily relocated throughout the upgrade of Euston Road and Maddox Street. The bus stop would be reinstated following upgrade of Euston Road.

Due to their location, the following bus stops would be temporarily removed at the start of construction and reinstated in a similar location at the earliest possible time during construction:

- Princes Highway (southbound) outside 136 Princes Highway, St Peters
- Bourke Road (northbound) outside 81A to 83 Bourke Road, Mascot
- Bourke Road (northbound) outside 520-530 Gardeners Road, Mascot
- Gardeners Road (eastbound) outside 538 to 540 Gardeners Road. Mascot.

Changes to bus services

Bus services operating through the St Peters study area may experience impacts as a result of the forecast changes in traffic volumes and local road upgrades. Modelling has been undertaken to assess the travel time impact for these buses.

A summary of the changed travel times for the bus routes planned to be in operation in 2021 with the project is provided in **Table 9-53**.

There are 22 bus services crossing the St Peters area, including several 'Suburban' tier strategic routes, identified in Sydney's Bus Future as among the city's most important bus corridors. Of these 22 services, 15 PM peak services would experience a travel time improvement in 2021 with the opening of the project. Six of these bus services would experience improvements in travel time by more than 20 per cent or better for the sections of the route running through the area, in comparison with a future scenario without the project in 2021. Ten bus services are expected to experience improved AM peak travel times in 2021 with the opening of the project through the area, in comparison with a future scenario without the project.

The travel times of some bus routes would increase, while others would improve. While some of the increased travel time is due to additional traffic, changed conditions on the network (eg Sydney Park Road / Euston Road intersection changing from the current roundabout control to traffic signals) would also affect bus travel times.

The travel times of some bus routes would increase, while others would improve. While some of the increased travel time is due to additional traffic, changed conditions on the network (eg Sydney Park Road / Euston Road intersection changing from the current roundabout control to traffic signals) would also affect bus travel times. It is also noted that the buses travelling through the modelled network have origins and destinations further afield and therefore the travel time changes (ranging from a saving of 9.6 minutes to an increase of 3.3 minutes) should be seen in the context of the longer journey times and distances.

Transport for NSW has identified the following planned 'Suburban' routes, which have target average speeds, including dwell times, of 18 to 25 kilometres per hour: These would be delivered under TfNSW's Bus Strategic Operations Plan.

- Burwood to Bondi Junction via Sydenham (current route 418)
- Burwood to Bondi Junction via Sydney Airport (current route 400)
- Lane Cove to Eastgardens via Botany Rd (new route)
- Chatswood to Sydney Airport via Botany Road (new route replacing the M20)
- Miranda to Bondi Junction via Sydney Airport (new route)
- Hurstville to Sydney CBD via Newtown (current route 423).

An increase in vehicles on the St Peters road network would result in lower travel speeds and associated increased delays at intersections.

If the New M5 project was not constructed, the following impacts to bus services around the St Peters interchange and local road upgrades would potentially be experienced:

- An increase in bus service travel times due to slower travel speeds and increased intersection delays
- More frequent delays to services caused by traffic incidents and congestion in the project area
- The potential for crashes caused by buses stopping to pick-up and drop-off passengers would increase in proportion to the expected growth in traffic
- Longer travel times to and from bus stops by supplementary travel modes (e.g. car passenger, walking to / from bus stop, etc) due to an increase in traffic volumes, slower travel speeds and increased intersection delays
- Reduced amenity for bus users waiting at stops. An increase in traffic would result in impacts including a reduction in pedestrian roadside safety.

The project offers a flexible design which does not preclude any bus priority measures being included in the future. Roads and Maritime and TfNSW will continue to work together to deliver *Sydney's Bus Future* in this area, and the surface road network can be adapted to include measures identified at a future date.

Table 9-53 Changes to bus travel times in 2021 with the project

Route	Direction	AM Peak		PM Peak	
		Travel time difference with the project (minutes)	Change in travel time (per cent)	Travel time difference with the project (minutes)	Change in travel time (per cent)
5	Northbound	0.6	5	0.7	6
	Southbound	1.4	11	-0.2	-1
305	Northbound	2.8	25	2.6	24
	Southbound	-0.2	-1	0.0	0
308	Eastbound	0.0	0	-3.4	-33
	Westbound	1.5	24	-0.1	-2
309	Northbound	0.6	6	-0.6	-5
	Southbound	-0.2	-2	-0.6	-6
310	Northbound	-0.1	-1	-1.0	-8
	Southbound	-0.4	-5	-0.6	-6
348	Eastbound	1.4	8	-6.0	-29
	Westbound	-0.7	-5	0.7	5
370	Eastbound	-0.6	-7	-3.8	-35
	Westbound	2.5	33	3.3	48
400	Eastbound	-0.8	-4	0.5	2
	Westbound	0.1	0	-3.6	-14
410	Eastbound	-0.6	-3	-1.4	-8
	Westbound	1.7	8	-0.6	-3
418	Eastbound	-6.0	-19	-9.6	-33
	Westbound	0.3	2	2.1	13
422	Northbound	1.4	9	-6.4	-36
	Southbound	-2.2	-15	-4.0	-26

Source: AECOM (2015)

Active transport

The local road upgrades would include new and upgraded pedestrian and cycle infrastructure. This infrastructure has been designed to maintain and enhance pedestrian and cyclist accessibility and connectivity, particularly around the St Peters interchange and Sydney Park.

The most significant new infrastructure would be the construction of a pedestrian and cycle bridge across the on and off ramps at the St Peters interchange and construction of a grade-separated pedestrian and cycle bridge across Campbell Road. This would provide east-west connectivity across Alexandra Canal connecting the Bourke Road cycleway to St Peters at Unwins Bridge Road.

Other key pedestrian and cycle infrastructure to be delivered as part of the local road upgrades would include:

- A shared path along the western side of Euston Road between Campbell Road and Sydney Park Road
- An on-road cycle lane along Bourke Road between Campbell Road and Church Avenue
- Retention of the on-road cycle lane on Bourke Road, north of the Campbell Road extension
- Provision of footpaths along all local roads upgraded as part of the project.

The upgrades to pedestrian and cycle infrastructure would provide for a safe cyclist and pedestrian environment by minimising the interface of cyclists and pedestrians with vehicular traffic, and would also provide a regional cycle connection between Mascot and Marrickville.

Three new pedestrian pathways would also be provided around the St Peters interchange to enhance pedestrian connectivity:

- Parallel to the Princes Highway along the north-western site boundary, providing a pedestrian connection between the Princes Highway at the intersection of Canal Road and Campbell Street, near the intersection of Albert Street
- Along the northbound (western) side of Canal Road
- Between the future Sydney Gateway and the Princes Highway, providing a pedestrian connection between the future Sydney Gateway crossing of Canal Road with the Princes Highway at the intersection with Canal Road.

Road safety

Forecast crash statistics on local roads around St Peters interchange under the ‘with project’ and ‘without project’ scenarios in 2021 and 2031, as well as 2031 under the ‘full WestConnex program of works and the future Southern extension’ scenario are presented in **Table 9-54**. The frequency of crashes would be expected to change in proportion to the forecast traffic changes, as well as the intersection and road upgrades planned as part of the project.

Daily traffic on the Princes Highway, Canal Road / Ricketty Street / Gardeners Road and Bourke Road is generally forecast to decrease in the 2021 under the ‘with project’ scenarios compared to the ‘without project’ scenarios. This in combination with the planned intersection upgrades would result in a decrease in the total number and cost of crashes.

About 85 per cent of crashes on Euston Road are at the Euston Road / Sydney Park Road intersection. This intersection would be signalised as part of the local road upgrades and would be an effective approach to reducing the number of incidents by an estimated 30 per cent. Nonetheless, an increase in the total number and cost of crashes is still expected on Euston Road due to an increase in forecast traffic.

In 2031 under the ‘full WestConnex program of work’ scenario, the forecast increase in traffic on Euston Road would result in an increase in the total number and cost of crashes on Euston Road, south of Sydney Park Road. However, the significant decrease in daily traffic forecast on the Princes Highway and Canal Road / Ricketty Street / Gardeners Road, in combination with the intersection upgrades as part of the local road upgrades to the local road network would result in a significant reduction in the total number and cost of crashes on these roads.

Table 9-54 Comparison of forecast crash statistics with and without the project in 2021 and 2031

Road	Section length (km)	ADT (vehicles)	Average annual crashes	Average annual cost
2021 (without project)				
Princes Highway between Enmore Road and Gannon Street	3.8	62,840	100	$22,289,840
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	2.4	47,280	59	$11,410,421
Euston Road, between Sydney Park Road and Campbell Road	0.9	5,870	5	$1,325,584
Bourke Road, between Wyndham Street and Gardeners Road	2.1	15,250	18	$3,902,584
2021 (with project)				
Princes Highway between Enmore Road and Gannon Street	3.8	59,370	95	$21,059,607
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	2.4	37,010	45	$8,711,249
Euston Road, between Sydney Park Road and Campbell Road	0.9	43,960	33	$7,062,407
Bourke Road, between Wyndham Street and Gardeners Road	2.1	11,250	12	$2,570,652
2031 (without project)				
Princes Highway between Enmore Road and Gannon Street	3.8	69,950	112	$24,810,976
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	2.4	54,940	69	$13,257,922
Euston Road, between Sydney Park Road and Campbell Road	0.9	6,950	6	$1,569,242
Bourke Road, between Wyndham Street and Gardeners Road	2.1	17,350	21	$4,439,148
2031 (full WestConnex program of works and the future Southern extension)				
Princes Highway between Enmore Road and Gannon Street	3.8	18,080	29	$6,414,542
Canal Road / Ricketty Street / Gardeners Road, between the Princes Highway and Botany Road	2.4	22,120	27	$5,207,199
Euston Road, between Sydney Park Road and Campbell Road	0.9	51,500	39	$8,273,733
Bourke Road, between Wyndham Street and Gardeners Road	2.1	14,420	16	$3,295,414

9.4 Environmental management measures

Where possible, the project has been designed and planned in order to avoid and minimise impacts to traffic during construction. For example:

- Construction compounds which provide tunnelling support have been located adjacent to State and National roads to minimise impacts on the local road network
- Construction compounds have been designed to provide off-street car parking facilities to minimise impacts on access and parking for local residents.

Despite this, the project would result in impacts to the road network during construction. Mitigation and management measures would be implemented to avoid, minimise and/ or manage these impacts to the road network. These mitigation measures, as well as those proposed to be implemented throughout operation of the project are provided in **Table 9-55**.

Table 9-55 Environmental management measures – traffic and transport

Impact	No.	Environmental management measure	Timing
Construction			
General	TT01	A Construction Traffic Management and Safety Plan (CTMSP) would be prepared as part of the construction environmental management plan. The CTMSP would include the guidelines, general requirements and principles of traffic management to be implemented during construction, including: • Signage requirements (eg temporary speed restrictions, changes to the road environment, traffic management controls) • Lane possession and approval process during periods of online construction (eg line marking and temporary barriers) • Traffic control devices such as traffic signals • A local and regional communications strategy, including methods to provide advanced notice of any major or prolonged impacts (eg leaflets and local media), and real-time information regarding current impacts (eg variable message signs, radio traffic news) • Details of both the general approach to be used for access and egress to construction compounds and the specific controls required at specific locations • Any specific provisions required to manage potential impacts to sensitive users, such as schools, child care centres and health facilities. The CTMSP would be prepared in accordance with Austroads *Guide to Road Design* (with appropriate Roads and Maritime supplements), the RTA *Traffic Control at Work Sites* manual and AS1742.3: *Manual of uniform traffic control devices – Part 3:Traffic control for works on roads*, and any other relevant standard, guide or manual.	Pre-construction
Impacts to road network performance	TT02	Construction methods and staging would be designed to minimise road closures, subject to other project constraints, and ensure that disruptions to existing traffic are minimised as much as feasible and reasonable.	Construction

Impact	No.	Environmental management measure	Timing
(delays) and safety	TT03	Construction works would be carried out offline, where possible. Where offline construction is not practical, and for tie-ins between online and offline sections of the project, construction sequencing and any temporary works identified would aim to minimise user delay while providing sufficient flexibility for the selected contractor to safely and efficiently construct the project	Construction
	TT04	Works that would significantly reduce the performance of the road network would be scheduled for periods of typically lower traffic volumes where feasible and reasonable.	Construction
	TT05	Work areas would be isolated from general traffic using temporary safety barriers where possible.	Construction
	TT06	Temporary closed-circuit television (CCTV) and Variable Message Signs (VMS) would be provided at the outset of construction to link with the existing Transport Management Centre (TMC) network to facilitate monitoring and management of traffic impacts	Construction
	TT07	Traffic volume data would be analysed to identify capacity requirements, assess the potential impact of lane occupancies on traffic flows, plan lane occupancies to minimise the work area, and identify the best time to minimise inconvenience to road users. Restrictions and obstructions would be limited, road capacities maximised and peak traffic periods avoided where possible	Construction
	TT08	Impacts on pedestrian paths and cycle lanes would be minimised, and alternatives provided during construction where practical and safe to do so	Construction
	TT09	Impacts to bus stops would be identified and alternative locations and access would be provided. This would be undertaken in consultation with Transport for NSW and the relevant bus service provider	Construction
	TT10	Local road closures would be managed and adequate property access maintained. This would be undertaken in consultation with Roads and Maritime, local councils and property owners likely to be impacted	Construction
	TT11	A spoil management plan would be prepared with subsequent monitoring of heavy vehicle and haulage routes to ensure compliance and minimise impact on local roads off the arterial road network	Construction
	TT12	A road dilapidation report(s) would be prepared identifying existing conditions of local roads and mechanisms to repair damage to the road network caused by heavy vehicle movements associated with the project.	Construction
	TT13	Road occupancy licences would be obtained where required.	Construction
Impacts to emergency services	TT14	The CTSMP would be developed in consultation with local emergency services and procedures would be implemented to maintain priority access and a safe environment for emergency vehicles to travel through construction areas. The CTSMP would include measures to keep emergency services informed of the staging and progress of construction works.	Construction

Impact	No.	Environmental management measure	Timing
Operation			
Impacts to road safety	OpTT01	A road safety audit would be undertaken by a qualified auditor(s) as part of the detailed design, and again immediately prior to project opening, to examine the design from a road safety perspective and identify potential safety issues. This process would be undertaken in accordance with the Roads and Maritime Accident Reduction Guide Part 2: Road Safety Audits (RTA, 2005a).	Detailed design and prior to operation
Impacts to road network performance	OpTT02	An operational traffic review would be conducted 12 months following the commencement of operation to confirm the operational traffic impacts of the project on surrounding arterial roads and major intersections. The operational traffic review would be undertaken by a suitably qualified traffic specialist that is independent of the design and traffic studies undertaken as part of the environmental impact statement. The operational traffic review would include an assessment of the level of service at major intersections on local roads around the St Peters interchange, the King Georges Road interchange and changes in traffic levels on parallel arterial roads, such as Stoney Creek Road.	Operation

10 Air quality

This chapter describes the methodology used to assess the impacts of the New M5 project (the project) on regional, local and in-tunnel air quality, and summarises the results of that assessment. The Technical working paper: Air Quality (**Appendix H)** provides greater detail of the air quality monitoring and modelling methodologies and air quality impact assessment results.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. **Table 10-1** sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to air quality, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 10-1 SEARs – air quality

SEAR	Section where requirement is addressed
An assessment of construction and operational activities that have the potential to impact on in-tunnel, local and regional air quality. The air quality impact assessment must provide an assessment of the risk associated with potential discharges of fugitive and point source emissions on sensitive receivers, and include:	An assessment of potential air quality impacts from construction, closure of the Alexandria Landfill and operation is provided in **Section 10.6**, **Section 10.7** and **Section 10.8**.
• The identification of all sources of air pollution and assess potential emissions of PM_{10}, $PM_{2.5}$, CO, NO_2 and other nitrogen oxides and volatile organic compounds (e.g. BTEX) and consider the impacts from the dispersal of these air pollutants on the ambient air quality along the proposal route, proposed ventilation outlets and portals, surface roads and ramps, the alternative surface road network, and in-tunnel air quality.	The identification of emission sources relevant to the project are detailed in **Section 10.5.4**. An assessment of PM_{10}, $PM_{2.5}$, CO, NO_2 and other nitrogen oxides and volatile worst case organic compounds is provided in **Section 10.6**, **Section 10.7** and **Section 10.8**.
• Assessment of worst case scenarios for in-tunnel and ambient air quality, including assessment of a range of traffic scenarios, including worst case design maximum traffic flow scenario (variable speed) and worst case breakdown scenario, and discussion of the likely occurrence of each.	An assessment of in-tunnel and ambient air quality is provided in **Section 10.8**.
• Details of the proposed tunnel design and mitigation measures to address in-tunnel air quality and the air quality in the vicinity of portals and any mechanical ventilation systems (i.e. ventilation outlets and air inlets) including details of proposed air quality monitoring (including criteria).	The tunnel design and management measures to address in-tunnel air quality, including mechanical ventilation and air quality is described in **Section 10.10**. **Table 10-32**
• Demonstrate how the project and ventilation design ensures that concentrations of air emissions meet NSW, national and international best practice for in-tunnel and ambient air quality, and taking into consideration the approved criteria for the NorthConnex project.	The tunnel ventilation system is described in **Section 10.10.2**.

SEAR	Section where requirement is addressed
• Consideration of any advice from the Advisory Committee on Tunnel Air Quality on the project.	Advice provided by the Advisory Committee for the NorthConnex project was taken into account when developing the assessment methodology, which is summarised in **Section 10.2**, **Section 10.3** and **Section 10.4**.
• Details of any emergency ventilation systems, such as air intake/exhaust outlets, including protocols for the operation of these systems in emergency situations, potential emission of air pollutants and their dispersal, and safety procedures.	Emergency ventilation systems are described in **Section 10.10**.
• Details of in-tunnel air quality control measures considered, including air filtration. Justification must be provided to support the proposed measures.	Environmental management measures relating to in-tunnel air quality are described in **Section 10.10**.
Details of the proposed mitigation measures to prevent the generation and emission of dust (particulate matter and total suspended particulate (TSP)) and air pollutants (including odours) during the construction of the proposal, particularly in relation to ancillary facilities (such as concrete batching plants), the use of mobile plant, stockpiles and the processing and movement of spoil.	Environmental management measures to be implemented during construction are described in **Section 10.10**.
Cumulative assessment of the local and regional air quality due to the operation of the M4-M5 Link and surface road operations.	A cumulative air quality assessment is provided in **Section 10.9**.
The air quality assessment, including the setting of air quality criteria, must be done in consultation with NSW Health and the Environment Protection Authority and with the consideration of any applicable advice provided by the Advisory Committee on Tunnel Air Quality.	The air quality assessment approach is described in **Section 10.1.1**.
Modelling (including dispersion modelling) must be conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b) or a suitably justified and verified alternative method based on current scientific understanding of atmospheric dispersion. Particular attention must be given to the verification of the method of predicting local air quality or meteorological conditions based on non-local or modelled data.	A summary of the air quality approach is provided in **Section 10.1**. Additional detail regarding air quality modelling is provided in the Technical working paper: Air Quality (**Appendix H**)

10.1 Assessment approach

10.1.1 Overview

The air quality assessment considers the potential impacts of the project on regional and local air quality. Consideration is also given to the potential cumulative impacts of the project with the other component projects of the WestConnex program of works. The assessment also includes detailed analysis of the predicted quality of air inside the main alignment tunnels during operation of the project.

Recent air quality assessments for surface roads and road tunnels in Australia and New Zealand were reviewed to identify appropriate methodologies, tools and findings to inform the project assessment. These previous assessments are summarised in Appendix D of the Technical working paper: Air quality in **Appendix H** of this EIS. The summary includes details of the pollutants considered, the sources of emissions, the dispersion models used, and the approaches used to assess impacts on air quality during construction and operation of the project.

The following Government agencies and bodies were consulted during the development and preparation of the assessment methodology and the air quality assessment for the project:

- NSW Environmental Protection Authority (NSW EPA)
- NSW Health
- Roads and Maritime Services (Roads and Maritime)
- The Advisory Committee on Tunnel Air Quality.

Comments provided by the Government agencies and bodies, and how these have been considered during the assessment, are provided in the Technical working paper: Air quality in **Appendix H**.

10.1.2 Terminology

The concentration of a pollutant at a given location comprises contributions from various sources. The following terms have been used in this chapter to describe the concentration of a pollutant at a specific location (receiver) over a specific averaging period:

- **Background concentration** describes all contributing sources of a pollutant concentration other than road traffic. It includes, for example, contributions from natural sources, industry and domestic activity
- **Surface road concentration** describes the contribution of pollutants from the surface road network. It includes not only the contribution of the nearest road at the receiver, but also the net contribution of the modelled road network at the receiver
- **Ventilation outlet concentration** describes the contribution of pollutants from tunnel ventilation outlets
- **Total concentration** is the sum of the sources defined above: background, surface road and ventilation outlet concentrations. It may relate to conditions with or without the project under assessment
- **The change in concentration due to the project** is the difference between the total concentration with the project and the total concentration without the project, and may be either an increase or a decrease, depending on factors including the redistribution of traffic on the road network as a result of the project.

10.1.3 Air quality criteria

Two types of criteria were applied to the air quality assessment to determine the potential air quality issues associated with the project. These are ambient air quality criteria and in-tunnel criteria.

Compliance with ambient air quality standards is a major consideration during road project design and operation. An ambient air quality standard defines a metric relating to the concentration of an air pollutant in the ambient air. Standards are usually designed to protect human health, including sensitive populations such as children, the elderly, and individuals suffering from respiratory disease, but may relate to other adverse effects such as damage to buildings and vegetation. The form of an air quality standard is typically a concentration limit for a given averaging period (eg annual mean, 24-hour mean), which may be stated as a 'not-to-be-exceeded' value or with some exceedances permitted. Several different averaging periods may be used for the same pollutant to address long-term and short-term exposure. Each metric is often combined with a goal, such as a requirement for the limit to be achieved by a certain date.

Air pollutants are often divided into 'criteria' pollutants and 'air toxics'. Criteria pollutants tend to be ubiquitous (ie present, appearing or found everywhere) and emitted in relatively large quantities, with their effects on health studied in some detail. Air toxics are gaseous or particulate organic pollutants that are present in the air in low concentrations, but are defined on the basis that they are, for example, highly toxic, carcinogenic or highly persistent in the environment so as to be a hazard to humans, plants or animal life.

10.1.4 Criteria pollutants

Ambient Air quality NEPM

In 1998 Australia adopted a *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) with the goal of ensuring compliance with air quality standards within 10 years of commencement in order to attain 'ambient air quality that allows for the adequate protection of human health and wellbeing'.

The AAQ NEPM established national standards for six criteria pollutants:

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

The AAQ NEPM was extended in 2003 to include advisory reporting standards for particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$), and these are shown in **Table 10-2**.

Table 10-2 Advisory reporting standards for $PM_{2.5}$ in AAQ NEPM

Pollutant or metric	Criterion		Averaging method	Source
	Concentration	Averaging period		
Particulate matter <2.5 µm ($PM_{2.5}$)	25 µg/m^3	24 hour	Calendar day	AAQ NEPM 2003
	8 µg/m^3	1 year	Calendar year	AAQ NEPM 2003

It should be noted that the AAQ NEPM is a national monitoring and reporting protocol. The AAQ NEPM standards are applicable to urban background monitoring sites which are broadly representative of population exposure. The use of any AAQ NEPM air quality criteria in relation to the assessment of projects and developments is outside the scope of the NEPM itself, and is decided by the Australian States and Territories. The criteria for air quality assessments for projects / developments in NSW are contained in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005b) (NSW Approved Methods) (see below). However, should the Approved Methods be revised it is possible that they will take into account the new AAQ NEPM standards, but they may not necessarily take exactly the same form. Nevertheless, the project would be designed so that any increases in $PM_{2.5}$ concentrations due to emissions from the ventilation outlets are minimal.

NSW Approved Methods

The Australian States and Territories manage emissions and air quality in relation to certain types of source (eg landfills, quarries, crematoria, and coal mines). The Australian States and Territories have legislation or guidance which includes design goals, licence conditions or other instruments for protecting local communities from ground-level impacts of pollutants in residential areas outside site boundaries. Where this is the case, the AAQ NEPM standards are often used for air quality assessments.

The NSW Approved Methods sets out the statutory methods to be used for assessing air pollution from stationary sources in NSW. The NSW Approved Methods are designed mainly for the assessment of industrial point sources, and do not contain specific information on the assessment of, for example, transport schemes and land use changes. Air quality must be assessed in relation to standards and averaging periods for specific pollutants that are taken from several sources, notably the AAQ NEPM.

The metrics, criteria and goals set out for criteria pollutants in the NSW Approved Methods are listed in **Table 10-3**. The $PM_{2.5}$ advisory standards (refer to **Table 10-2**) are designed for the evaluation of overall population exposure rather than the impacts of a specific facility, and there is no requirement to evaluate $PM_{2.5}$ in the NSW Approved Methods. However, they are often considered to be applicable in this respect.

Table 10-3 Impact assessment criteria for 'criteria pollutants' in NSW Approved Methods (DEC, 2005b)

Pollutant or metric	Criterion		Calculation	Source
	Concentration	Averaging period		
CO	87 ppm[(a)] or 100 mg/m^3	15 minutes		WHO (2000)
	25 ppm or 30 mg/m^3	1 hour	One hour clock mean	WHO (2000)
	9 ppm or 10 mg/m^3	8 hours	Rolling mean of 1-hour clock means	AAQ NEPM 1998
NO_2	120 ppb[(b)] or 246 μg/m^3	1 hour	One hour clock mean	AAQ NEPM 1998
	30 ppb or 62 μg/m^3	1 year	Calendar year mean	AAQ NEPM 1998
PM_{10}	50 μg/m^3	24 hours[(c)]	Calendar day mean	AAQ NEPM 1998
	30 μg/m^3	1 year	Calendar year mean	NSW EPA (1998)[(d)]
SO_2	250 ppb or 712 μg/m^3	10 minutes		NHMRC (1996)
	200 ppb or 570 μg/m^3	1 hour	One hour clock mean	AAQ NEPM 1998
	80 ppb or 228 μg/m^3	1 day	Calendar day mean	AAQ NEPM 1998
	20 ppb or 60 μg/m^3	1 year	Calendar year mean	AAQ NEPM 1998

Pollutant or metric	Criterion		Calculation	Source
	Concentration	Averaging period		
Pb	0.5 µg/m^3	1 year	Calendar year mean	AAQ NEPM 1998
Total suspended particulate matter (TSP)	90 µg/m^3	1 year	Calendar year mean	NHMRC (1996)
Photochemical oxidants (as ozone (O_3))	100 ppb or 214 µg/m^3	1 hour	One hour clock mean	AAQ NEPM 1998
	80 ppb or 171 µg/m^3	4 hours	Rolling mean of 1-hour clock means	AAQ NEPM 1998
Hydrogen fluoride (HF)[(e)]	0.50/0.25 µg/m^3	90 days		ANZECC (1990)
	0.84/0.40 µg/m^3	30 days		ANZECC (1990)
	1.70/0.40 µg/m^3	7 days		ANZECC (1990)
	2.90/1.50 µg/m^3	24 hours		ANZECC (1990)

(a) ppm = parts per million
(b) ppb = parts per billion
(c) Up to 5 exceedances per year are allowed in the AAQ NEPM, but not in the Approved Methods
(d) The AAQ NEPM does not specify an annual mean standard for PM_{10}
(e) The first value is for general land use, which includes all areas other than specialised land use. The second value is for specialised land use, which includes all areas with vegetation that is sensitive to fluoride, such as grape vines and stone fruits.

10.1.5 Air toxics

Air toxics NEPM

In recognition of the potential health problems arising from the exposure to air toxics, the *National Environment Protection (Air Toxics) Measure* (Air Toxics NEPM) identifies 'investigation levels' for five priority pollutants: benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons (PAH)). **Table 10-4** outlines these investigation levels for air toxics. These are not compliance standards but are for use in assessing the significance of the monitored levels of air toxics with respect to protection of human health.

Table 10-4 Investigation levels for air toxics in accordance with the Air Toxics NEPM

Substance	Concentration	Averaging period
Benzene	0.003 ppm	1 year[(a)]
Toluene	1.0 ppm	24 hours
	0.1 ppm	1 year[(a)]
Xylenes	0.25 ppm	24 hours
	0.20 ppm	1 year[(a)]
PAH (as b(a)p)[(b)]	0.3 ng/m^3 [(c)]	1 year[(a)]
Formaldehyde	0.04 ppm	24 hours

(a) Arithmetic mean of concentrations of 24-hour monitoring results
(b) b(a)p – benzo(a)pyrene, the most widely studied PAH and used as an indicator compound
(c) ng/m3 – nanograms per cubic metre

NSW Approved Methods

The NSW Approved Methods specify air quality impact assessment criteria and odour assessment criteria for many other substances (mostly hydrocarbons), including air toxics, which are too numerous to reproduce in this chapter. The SEARs for the project require an evaluation of BTEX compounds: benzene, toluene, ethylbenzene, and xylenes. The impact assessment criteria in the NSW Approved Methods for priority air toxics and BTEX compounds are given in **Table 10-5**.

Table 10-5 Impact assessment criteria for air toxics

Source	Substance	Concentration	Averaging period
NSW Approved Methods (impact assessment criteria)	Benzene	0.009 ppm or 0.029 mg/m^3	1 hour
	Toluene[(a)]	0.09 ppm or 0.36 mg/m^3	1 hour
	Ethylbenzene	1.8 ppm or 8 mg/m^3	1 hour
	Xylenes[(a)]	0.04 ppm or 0.19 mg/m^3	1 hour
	PAH (as benzo(a)pyrene)	0.0004 mg/m^3	1 hour
	1,3-butadiene	0.018 ppm or 0.04 mg/m^3	1 hour
	Acetaldehyde[(a)]	0.023 ppm or 0.042 mg/m^3	1 hour
	Formaldehyde	0.018 ppm or 0.02 mg/m^3	1 hour

(a) Odour criterion

In-tunnel air quality

Carbon monoxide

CO has historically been an indicator of the level of motor vehicle emissions in tunnels and has therefore been used as the basis for in-tunnel air quality criteria. Advances in vehicle technology have been effective in reducing the levels of CO emissions so that other emissions are now more relevant indicators of in-tunnel air quality. Chief among these is NO_2.

Nitrogen dioxide

NO_2 is a respiratory irritant with identified health effects at levels that may be encountered in road tunnels. NO_2 was identified as the key pollutant of concern for in-tunnel air quality during the assessment of the NorthConnex project, with new criteria applied to the NorthConnex tunnel in its approval conditions (NSW Department of Planning and Environment, 2015). The new criterion for NO_2 is a tunnel average of 0.5 ppm, measured as a rolling average throughout the tunnel, with a limit at any point in the tunnel of 1.0 ppm. This criterion is equivalent to the most stringent international workplace health and safety criteria and compares favourably to international design guidelines for in-tunnel NO_2 levels, which range between 0.4 ppm and 1.0 ppm. Detailed design of the project tunnel would ensure that the project's ventilation system is appropriately designed to achieve these criteria under all operating conditions, in addition to the CO and visibility (particulate) limits noted in **Table 10-6** and **Table 10-7**. These are the same operational criteria applied to the recently approved NorthConnex tunnel.

Table 10-6 In-tunnel operational criteria for CO and NO_2

Parameter	Averaging period	Concentration limit (ppm)
In-tunnel average limit along tunnel length		
CO	Rolling 15-minute	87
	Rolling 30-minute	50
NO_2	Rolling 15-minute	0.5
In-tunnel single point exposure limit		
CO	Rolling 3-minute	200

Visibility and particulate matter

Visibility is an important consideration in the design of a road tunnel ventilation system. The visibility is required to be greater than the minimum vehicle stopping distance at the design speed (Permanent International Association of Road Congresses (PIARC), 2012). Visibility is reduced by the scattering and absorption of light by particles suspended in the air. The measurement of visibility in a tunnel (using an opacity meter) is based on the concept that a light beam 'decays' (reduces in intensity) as it passes through air containing particles or other pollutants. The level of decay can thus be used to determine the opacity of the air. For tunnel ventilation, visibility is expressed by the extinction coefficient K.

The amount of light scattering, or absorption, in road tunnels is principally dependent on the composition, diameter and density of the particles in the air. Particles that affect visibility are generally in a size range of 0.4 to 1.0 micrometres. **Table 10-7** provides the in-tunnel operational criteria for visibility.

Table 10-7 In-tunnel operational criteria for visibility

Parameter	Averaging period	Average extinction coefficient limit (m^{-1})[(a)]
In-tunnel average limit along tunnel length		
Visibility	Rolling 15-minute	0.005

(a) m^{-1} = reciprocal metre: Standard unit of measurement for extinction coefficient

The operational extinction coefficient limit of 0.005 m^{-1} may result in tunnel emissions being visible under congested conditions, but not at sufficient levels to produce hazy conditions (PIARC, 2012).

Pollutants and metrics not assessed in detail

The following pollutants and metrics were not considered to be relevant to the ambient air quality assessment of the project (nor to road transport projects in general):

- SO_2 - Although emitted from road vehicles, SO_2 emissions are directly proportional to the sulfur content of the fuel, and given that petrol and diesel in NSW now contain less than 50 ppm and 10 ppm of sulfur respectively, the emissions of SO_2 are very low. SO_2 is therefore not a major concern in terms of transport related air quality
- Pb - The removal of Pb from petrol means that it is no longer considered to be an air quality problem other than in relation to specific industrial activities, such as smelting
- TSP - For road transport, TSP can be broadly assumed to be equivalent to PM_{10}, and therefore within the controlling standard. While this is certainly the case for exhaust particles, it is possible that some non-exhaust particles are greater than 10 µm in diameter
- O_3 - Because of its secondary and regional nature, ozone cannot practicably be considered in a local air quality assessment. In addition, the changes in emissions associated with the project were well below the thresholds that trigger an ozone assessment (see **Section 10.8.2**)
- HF - The standards for HF relate to sensitive vegetation rather than human health, and HF is not a pollutant that is relevant to road vehicle operation.

There are currently no standards for assessment of 'ultrafine' particles. These are particles with a diameter of less than 0.1 µm. While there is some evidence that particles in this size range are associated with adverse health effects, it is not currently practical to incorporate them into an environmental impact assessment. There are several reasons for this including:

- The rapid transformation of such particles in the atmosphere
- The need to treat 'ultrafine' particles in terms of number rather than mass
- The lack of robust emission factors
- The lack of robust concentration response functions
- The lack of ambient background measurements
- The absence of air quality standards.

In relation to concentration response functions, the World Health Organisation (WHO) Regional Office for Europe (2013) has stated the following:

> '… *the richest set of studies provides quantitative information for $PM_{2.5}$. For ultrafine particle numbers, no general risk functions have been published yet, and there are far fewer studies available. Therefore, at this time, a health impact assessment for ultrafine particles is not recommended*.'

For the purpose of the project, assessment the effects of 'ultrafine' particles on health are adequately included in the assessment of the health effects of $PM_{2.5}$ (refer **Section 10.8.6**).

10.1.6 Modelling scenarios

Overview

Two types of scenario were considered for ambient air quality modelling:

- Expected traffic scenarios - These scenarios take into account future changes over time in the composition and performance of the vehicle fleet, as well as predicted traffic volumes and the distribution of traffic on the road
- Regulatory worst case scenarios - The objective of these scenarios is to demonstrate that compliance with the concentration limits for the tunnel ventilation outlets will deliver acceptable ambient air quality.

In each case the following were determined:

- The total pollutant concentration from all contributions (background, surface roads and ventilation outlets)
- The change in the total pollutant concentration
- The pollutant contribution from ventilation outlets alone.

The results have been presented as:

- Pollutant concentrations at discrete receivers (in charts and tables)
- Pollutant concentrations across the modelling domain (as contour plots).

The scenarios evaluated for in-tunnel air quality reflected the potential modes of operation of the tunnel ventilation system. These scenarios are detailed in the following section and include:

- Expected traffic - these scenarios reflected the optimum or best operating conditions, where traffic volumes were high and traffic was flowing freely
- Capacity (maximum) traffic flow scenarios - these were included to reflect conditions that can generate high in-tunnel pollution levels. Several different speeds were considered, including congestion
- Vehicle breakdown scenario - this included incidents such as vehicle breakdowns or accidents and heavy congestion. It was assessed on the basis that it would represent a worst case in terms of pollution generation, especially over the shorter term, and all in-tunnel and ambient air quality limits must be met.

Expected traffic scenarios

The expected traffic scenarios included in the operational ambient air quality assessment are summarised in **Table 10-8**. The scenarios took into account changes over time in the composition and performance of the vehicle fleet, as well as predicted traffic volumes and the distribution of traffic on the road network. The results from the modelling of these scenarios were also used in the health risk assessment for the project (described in **Chapter 11** (Human health)).

Future year land use projections and infrastructure were included in the traffic modelling to understand the level of traffic demand and associated travel patterns, including induced demand. The air quality scenarios modelled used the expected traffic conditions in the corresponding years in terms of volume, composition and speed, as represented in the WestConnex Road Traffic Model (WRTM).

Table 10-8 Expected traffic scenarios for the operational assessment

Scenario code	Scenario description	WestConnex projects included
2014-BY	2014 − Base year (existing conditions)	No WestConnex projects
2021-DM	2021 – 'Do minimum' (ie without project)	King Georges Road Interchange Upgrade and M4 Widening
2021-DS	2021 – 'Do something' (ie with project)	King Georges Road Interchange Upgrade, M4 Widening and New M5
2031-DM	2031 – 'Do minimum' (ie without project)	King Georges Road Interchange Upgrade and M4 Widening
2031-DS	2031 – 'Do something' (ie with project)	King Georges Road Interchange Upgrade, M4 Widening and New M5
2031-DSC	2031 – 'Do something cumulative' (ie with the project and future M4-M5 Link)	King Georges Road Interchange Upgrade, M4 Widening, New M5 and other WestConnex stages including M4 East, future M4−M5 Link, and Sydney Gateway. The future Southern extension was also included.

2014 Base Year

For the purpose of the air quality assessment, a 2014 base year was used. This was used to establish existing conditions. The inclusion of a base year enables the dispersion modelling methodology to be verified against real-world air pollution monitoring data. The base year also provided a current baseline that helped to define underlying trends in projected emissions and air quality, and provided a sense of scale and context for the project impacts.

2021 'Do minimum' (ie without the project)

The year 2021 was adopted as the primary year for forecasting impacts of the project. The primary 'do minimum' case (ie without the project) assumes that the King Georges Road Interchange Upgrade and M4 Widening projects are complete, but that the remainder of the WestConnex program of works and future Southern extension is not built. It is called 'do minimum' rather than 'do nothing' as it assumes that infrastructure schemes currently incomplete but scheduled for opening prior to the assessment year are operational.

2021 'Do something' (ie with the project)

As per the primary 'do minimum' scenario, this represents conditions with the project complete and open to traffic, but without the operation of any other subsequent WestConnex projects or the Southern extension.

2031 'Do minimum' (ie without the project)

A future network including the King Georges Road Interchange Upgrade and M4 Widening and some upgrades to the broader transport network over time to improve capacity and cater for traffic growth, but does not include the other components of the WestConnex program of works or the future Southern extension.

2031 'Do something' (ie with the project)

As per the 2031 'do minimum' scenario with the New M5 project complete and open to traffic, but without other WestConnex program of works or the future Southern extension.

2031 'Do something (cumulative)'

An additional 'do something' scenario with the M4 East, New M5 and future M4-M5 Link projects in place. This excluded contributions from the M4 East ventilation outlets (including the shared outlet with the future M4-M5 Link) given geographical distance. In other words, it was assumed that there would be no 'overlap' in the areas affected by the emissions from the M4 East and New M5 ventilation outlets (approximately six to eight kilometres away) as contribution from the project outlets would be negligible at these distances.

Regulatory worst case scenarios

The objective of these scenarios was to demonstrate that compliance with the proposed emission limits for the tunnel ventilation outlets would provide acceptable ambient air quality. The proposed emission limits were assumed to be the same as those specified in the conditions of approval for the NorthConnex project.

The regulatory worst case scenarios assessed for the project were:

- RWC-A. This scenario applied to the operation of the project only. The scenario considered air quality in 2021 and 2031, and assumed no change in the New M5 ventilation outlets or their operation
- RWC-B. This scenario applied to the operation of the project and the future M4-M5 Link, taking into account additional ventilation outlets required for the future M4-M5 Link (in addition to the ventilation outlets forming part of the New M5 project).

These scenarios assessed constant ventilation outlet concentrations (at proposed maximum allowable limits) over a 24-hour period to provide a representation of the theoretical maximum changes in air quality across all potential operational modes, including unconstrained and worst case traffic conditions (from an emissions perspective) as well as vehicle breakdown situations.

The proposed concentration limits for the ventilation outlets are summarised in **Table 10-9** and are consistent with the limits specified in the approval for the NorthConnex project. These limits were converted to mass emission rates (in kilograms per hour (kg/h)) based on tunnel ventilation rates. A 'medium' level air flow of 400 cubic metres per second (m^3/s) was assumed for each ventilation outlet, with fans in operation, effective outlet diameters and normal exit velocities.

Table 10-9 Concentration limits for ventilation outlets

Pollutant	Limit concentration (mg/m^3)
PM_{10}	1.1[(a)]
$PM_{2.5}$	1.1
NO_X	20.0
NO_2	2.0
CO	40.0
Volatile organic hydrocarbons/total hydrocarbons (VOC/THC)	1.0

(a) Stated as 'solid particles' in the NorthConnex conditions of approval.

The ventilation outlet assumptions for the regulatory worst case scenarios are detailed in **Appendix H** (Table 9.22) and the air quality impact assessment results are presented in **Section 10.8.2**.

The assessment of regulatory worst case scenarios was undertaken to assist regulatory authorities in assessing and determining potential ventilation outlet concentration limits that could be applied through conditions of approval. Assuming that concentration limits are applied to the ventilation outlets, the results of the analysis would demonstrate the air quality performance of the project if it operates continuously at the limits. In reality, ventilation outlet concentrations would vary over a daily cycle due to changing traffic volumes and tunnel fan operation. The regulatory worst case assessment scenarios would therefore overestimate anticipated actual ambient air quality impacts.

10.1.7 Accuracy and conservatism

There is generally a desire for an appropriate level of conservatism in air quality assessments. The reasons for this include:

- Allowing for uncertainty: An assessment on the scale undertaken for this project is a complex, multi-step process that involves a range of 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)
- Providing flexibility: It is undesirable to define the potential environmental impacts of a project too narrowly in the early stages of the development process. A conservative approach provides flexibility, allowing for ongoing design refinements within an approved environmental envelope. Conversely, excessive conservatism in an assessment risks overstating potential air quality impacts and associated human health risks. This, in turn, may lead to some undesirable outcomes that need to be mitigated and managed. An overly conservative approach may create, or contribute to, concerns within the local community and among other stakeholders about the impacts of the project. It may lead to additional or more stringent conditions of approval than necessary, including requirements for the mitigation, monitoring and management of air quality. Overstatement of vehicle contributions to local air quality may also lead to overstating the benefit where vehicle emissions are reduced by the project (AECOM, 2014b).

Air quality assessments therefore need to strike a balance between these potentially conflicting requirements.

The operational air quality assessment for the project has been conducted, as far as possible, with the intention of providing accurate and 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 that provides a 'typical' or 'average' one-hour NO_2 concentration will 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 be difficult to define, and this can sometimes result in assumptions being overly conservative. Skill and experience is required to estimate impacts that err on the side of caution but are not unreasonably exaggerated or otherwise skewed. By demonstrating that a deliberate overestimate of impacts is acceptable, it can be confidently predicted that the actual impacts that are likely to be experienced in reality would also lie within acceptable limits (AECOM, 2014c).

10.1.8 Model selection and validation

Both the emissions and dispersion models were validated for use in the air quality assessment of this project. The Graz Lagrangian (GRAL) dispersion model (version 14.11) was selected for this study and was validated by comparing model predictions and actual air quality monitoring data collected in the 2014 base year.

GRAL was chosen as the most suitable dispersion model because it is:

- Suitable for regulatory applications and can utilise a full year of meteorological data
- Able to predict low wind speed conditions (less than one metre per second) better than most other models
- Specifically designed for the simultaneous modelling of road transport networks, including line sources (surface roads), point sources (tunnel ventilation outlets) and other sources
- Able to take into account vehicle wake effects
- Able to characterise pollution dispersion in complex local terrain and topography, including the presence of buildings in urban areas

- Validated in a wide range of studies featuring complex and flat terrain and with varying meteorological conditions (high/low wind speeds, stable/unstable atmospheric conditions etc.).

While the GRAL system has not been used extensively in Australia, it was used in the assessment of the Waterview Connection tunnels near Auckland, New Zealand and more recently for the assessment of the WestConnex M4 East project. The model set up for this project has been tailored to suit the needs of both the study at hand and the regulatory requirements in NSW in relation to air quality. The GRAL model is described in more detail in **Appendix H**.

For the purpose of model validation, GRAL was configured to provide concentration predictions for each main pollutant (CO, NO_X, NO_2 and PM_{10}) at each of nine air quality monitoring sites (seven background and two roadside) in the WestConnex GRAL domain and for the full 2014 base year. The WestConnex and New M5 model domains are described in **Section 10.4.2**. $PM_{2.5}$ was not included as no independent testing of the model performance for $PM_{2.5}$ was possible.

The GRAL predictions used in the model validation were for the combined surface road network and the M5 East tunnel ventilation outlet. For each monitoring site the GRAL predictions were extracted for an hourly time series of concentrations for 2014. These were combined with an estimated background contribution for each monitoring site.

The performance of the GRAL model was also validated at each of the project-specific air quality monitoring stations, by comparing model predictions with data from the monitoring stations. Given that only partial monitoring data for 2014 were available at each site, the comparisons between the model and the monitoring data were made for the monitoring period covered at each site.

The vehicle emission models used in the in-tunnel and ambient air quality assessments were validated by comparison with the NSW EPA measured emissions from the Lane Cove Tunnel (see Appendix E of the Technical working paper: Air quality in **Appendix H**).

Further details on the method and results of the model evaluation are provided in Appendix K of the Technical working paper: Air quality provided in **Appendix H**.

10.1.9 Sensitivity tests

Sensitivity tests were conducted to investigate the effects of varying the key assumptions in the ambient air quality assessment. These included:

- The influence of ventilation outlet temperature
- The influence of ventilation outlet height
- The inclusion of buildings near tunnel ventilation outlets.

These tests were based on a sub-area of the New M5 GRAL domain of approximately three kilometres by three kilometres around the project's western ventilation outlet. Only the ventilation outlet contribution, and annual mean $PM_{2.5}$ and maximum 24-hour $PM_{2.5}$, were included in the sensitivity tests. A sub-set of nine sensitive receivers was evaluated. The predicted concentrations were indicative as the aim of the sensitivity tests was to assess the proportional sensitivity of the model to specific input parameters.

10.1.10 Alexandria Landfill

The site of the Alexandria Landfill at St Peters is currently licensed by the NSW EPA as a solid waste landfill, waste storage and recycling facility. The area would form a major component of the St Peters interchange, which would include surface roads, tunnel portals, overpasses and associated infrastructure. The remainder of the site is planned to be redeveloped as public open space, comprising a mixture of parkland and pathways.

The redevelopment of the site means that it would need to be closed and managed in accordance with the *Protection of the Environment and Operations Act 1997*. Assessments were therefore undertaken to estimate the potential impacts of operations during the closure of the landfill on dust (particulate matter) and odour.

Dust assessment

Activities associated with dust generation include:

- Excavators loading material to trucks
- Hauling cut and fill material on unsealed roads
- Dumping material from trucks
- Dozers pushing and shaping material
- Grading roads
- Wind erosion from exposed surfaces.

The criteria that were applied to the assessment were those stated for airborne particulate matter and deposited dust in the NSW Approved Methods. The criteria for airborne particulate matter are summarised in **Table 10-10**.

Table 10-10 Assessment criteria for particulate matter (DEC, 2005b)

Pollutant	Criterion	Averaging period
TSP	90 µgm^3	Annual
PM_{10}	50 µg/m^3	24-Hour
	30 µg/m^3	Annual
$PM_{2.5}$	25 µg/m^3	24 - Hour
	8 µg/m^3	Annual

Table 10-11 shows the maximum acceptable increase in dust deposition over the existing dust levels, as well as the maximum total deposition. The criteria for dust deposition are set to protect against nuisance impacts (DEC, 2005b).

Table 10-11 EPA criteria for dust fallout (insoluble solids)

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Odour assessment

The main activity associated with odour generation is the excavation of non-putrescible waste during earthworks at the former Alexandria Landfill site. The site has operated as a landfill for non-putrescible solid waste and so any excavation of that waste and its subsequent exposure to the atmosphere may result in odour emission.

In order to conservatively assess the potential impacts, it has been assumed that the Sequencing Batch Reactor (SBR) tanks that hold the collection of leachate from the landfill site and the sludge dewatering area may be exposed to the atmosphere.

Two modelling scenarios were completed. The first scenario considered the predicted impacts of the exposed excavated waste areas and a fully enclosed leachate treatment system. The second scenario considered the exposed excavated waste areas combined with open SBR tanks and dewatered sludge bin.

The Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b) include ground-level concentration criteria for complex mixtures of odorous air pollutants, taking into account the population density in the affected area. **Table 10-12** lists the odour criteria which cannot be exceeded more than one per cent of the time for different population densities.

The most stringent impact assessment criterion of two odour units (OU) (at the 99th percentile; EPA, 2005) has been applied for this assessment.

Table 10-12 Odour performance criteria for the assessment of odour

Population of affected community	Criteria for complex mixtures of odour (OU)
≤ ~2	7
~10	6
~30	5
~125	4
~500	3
Urban (>2000) and/or schools and hospitals	2

It is common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because Gaussian dispersion models directly predict concentrations over an averaging period of three-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a three-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

As a result, the NSW EPA commissioned a study to more rigorously determine the ratio between the one-second peak concentrations and the three-minute, longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model. The study carried out by Katestone Scientific Pty Ltd (1995, 1998) recommended peak-to-mean ratios for a range of variables, such as source type, receptor distance, stability class and stack height (for point sources).

It is important to note that those peak-to-mean factors determined are based on the Pasquill-Gifford stability classes. Since AERMOD replaces the Pasquill-Gifford stability based dispersion with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence based dispersion, a conservative approach has been taken for area sources and a value of 2.5 has been applied when multiplying the peak mean factor.

The Approved Methods take account of this peaking factor and the goals shown in **Table 10-12** are based on nose-response time.

10.2 Construction air quality assessment methodology

Construction activities can be categorised into four types to reflect their potential impacts. The potential for dust emissions has been assessed for each likely activity in each category:

- **Demolition** is any activity that involves the removal of existing structures
- **Earthworks** covers the processes of soil stripping, ground levelling, excavation and landscaping. Earthworks primarily involves excavating material, haulage, tipping and stockpiling
- **Construction** is any activity that involves the provision of new structures, or modification or refurbishment of existing structures. ‘Structures’ include buildings, ventilation outlets and roads
- **Track-out** involves the transport of dust and dirt from the construction/demolition site onto the public road network on construction vehicles. These materials may then be deposited and re-suspended by vehicles using the network.

It is difficult to quantify dust emissions from construction activities since it is not possible to predict the weather conditions that will prevail during specific construction activities. In any case, the effects of construction on airborne particulate matter would generally be temporary and of relatively short duration, and mitigation should be straightforward since dust suppression measures are routinely employed as ‘good practice’ at most construction sites. It is therefore common practice to provide a qualitative assessment of potential construction dust impacts. This approach follows the guidance published by the UK Institute of Air Quality Management (IAQM, 2014), the aim of which is to identify risks and recommend appropriate mitigation measures.

Construction activities would occur at several sites within the project area, as described in **Chapter 6** (Construction work). Many of these activities would be transitory (ie not permanent). The majority of the construction footprint would be underground; however, surface works would be required to support tunnelling activities and to construct surface infrastructure including the western surface works, St Peters interchange, local road upgrades, tunnel portals, ventilation facilities, ancillary operations buildings and facilities.

The guidance published by the IAQM (2014) was used for the assessment of air quality during construction (see **Appendix H**). The IAQM guidance has been adapted for use in NSW, taking into account factors such as the assessment criteria for ambient PM_{10} concentrations. The potential construction air quality impacts were assessed based on the proposed works, plant and equipment, and the potential emission sources and levels.

The IAQM procedure for assessing construction dust impacts is shown in **Figure 10-1**.

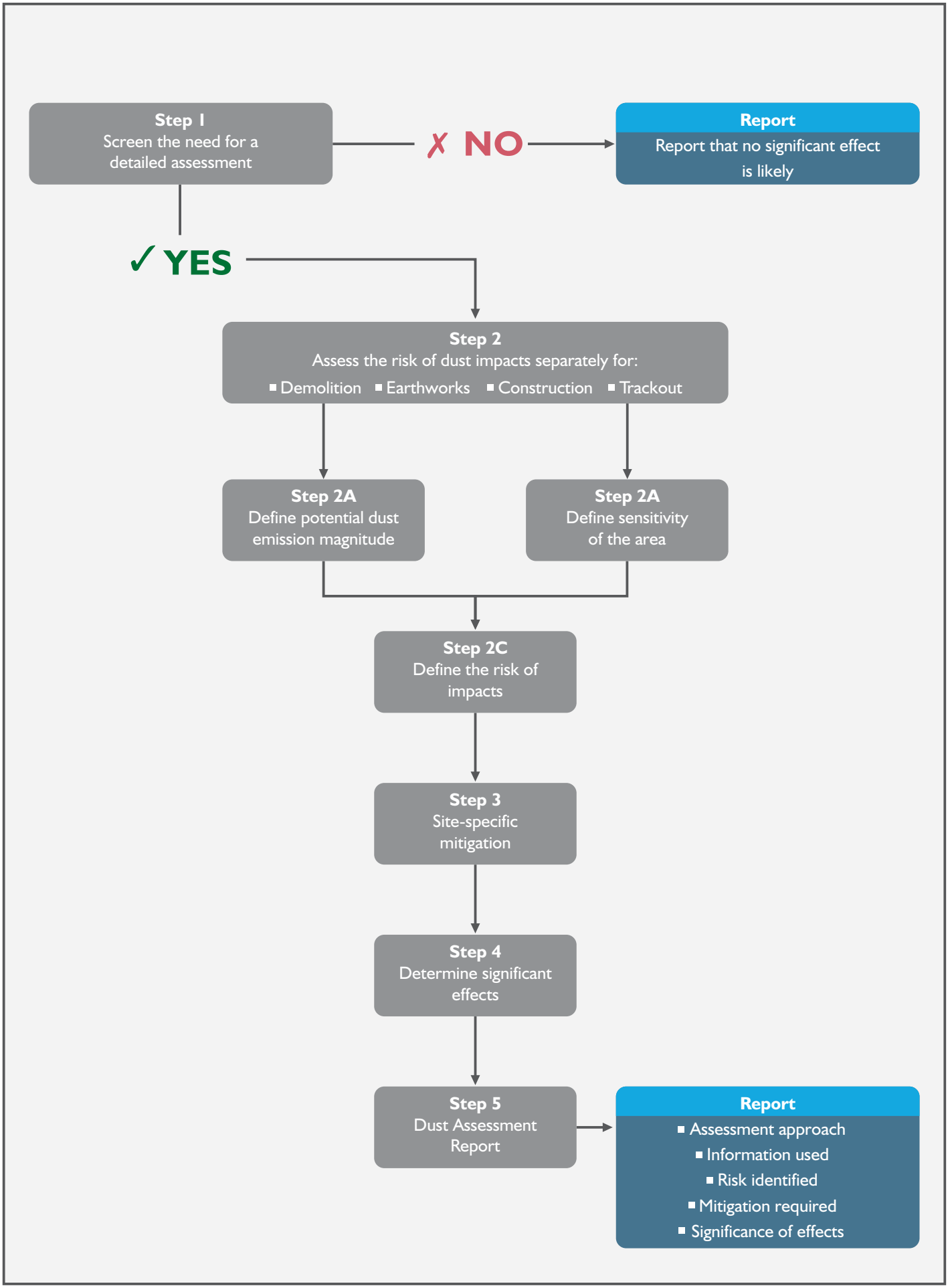


Figure 10-1 Steps in an assessment of construction dust (IAQM, 2014)

(blank page)

The main air pollution and amenity issues from construction activities are:

- Dust deposition (soiling of surfaces) and visible dust plumes
- Elevated PM_{10} concentrations due to dust-generating activities
- Exhaust emissions from diesel-powered construction equipment.

The assessment methodology considers three types of dust impacts:

- Annoyance due to dust deposition (soiling of surfaces)
- The risk of health effects from increased exposure to PM_{10}
- Harm to ecological receivers.

The risk of dust impacts from a demolition / construction ancillary facility causing loss of amenity and / or health or ecological impacts is related to the following (IAQM, 2014):

- The nature of the activities being undertaken
- The duration of the activities
- The size of the site
- The meteorological conditions (wind speed, direction and rainfall) - adverse impacts are more likely to occur downwind of the site and during drier periods
- The proximity of receivers to the activities
- The sensitivity of the receivers to dust
- The adequacy of the mitigation measures applied to reduce or eliminate dust.

10.3 Alexandria Landfill air quality assessment methodology

10.3.1 Dust assessment

Relevant activities

Activities associated with dust generation during the closure and remediation of Alexandria Landfill include:

- Excavation and exhuming wastes to develop the required final landform
- Excavators loading material to trucks
- Hauling cut and fill material on unsealed roads
- Dumping material from trucks
- Dozers pushing and shaping material
- Grading roads
- Wind erosion from exposed areas.

Model used

Off-site dust concentration and deposition levels due to the landfill closure activities were predicted using the AERMOD dispersion model. The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data.

Appropriate values for three surface characteristics are required for AERMET. These are:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile
- Albedo, which is an indicator of reflectivity of the surface
- Bowen ratio, which is an indicator of surface moisture.

Values of surface roughness, albedo and Bowen ratio were determined based on a review of aerial photography for a radius of three kilometres centred on the project site. Default values for land use were chosen to represent the surrounding area.

Background concentrations

The air quality goals relate to the total dust burden in the air and not just the dust from the landfill closure activities. In other words, consideration of background dust levels has been made when using these goals to assess potential impacts.

Background concentrations of PM_{10} and $PM_{2.5}$ are discussed in Appendix F of the Technical working paper: Air quality in **Appendix H**. Conservative estimates were made of the concentrations in the vicinity of the landfill. These were:

- Annual average PM_{10} – 21 $\mu g/m^3$
- Annual average $PM_{2.5}$ – 8 $\mu g/m^3$
- Annual average TSP – 52 $\mu g/m^3$ (assuming a PM_{10}:TSP ratio of about 0.4)
- Annual average deposition – 2 g/m^2/month

Emission estimation

Estimates of emissions for each source were developed taking into account the activities that would take place (noted above). For each source and for each hour, an emission rate which depended on the level of activity and the wind speed was determined. Dust generating activities were represented by a series of volume sources situated across the site. The locations of these volume sources as represented in the model are shown in Figure 8-4 of the Technical working paper: Air quality in **Appendix H**.

The proposed activities were analysed and estimates of dust emissions for the key dust generating operations were made. Emission factors developed by the US EPA were applied to estimate the amount of dust produced by each activity.

10.3.2 Odour assessment

Odour concentrations were predicted using the dispersion model AERMOD, the configuration of which was described in **Section 10.3.1**.

Emission estimation

In order to represent a disturbed area of excavated non-putrescible waste, a specific odour emission rate of 0.424 odour units per cubic metre of air per second per square metre of exposed surface ($OU.m^3/s/m^2$) was used. This value was taken from measurements made at the tipping face of a landfill which receives both putrescible and non-putrescible solid waste, and would be considered conservative for this assessment.

The value of 0.424 $OU.m^3/s/m^2$ was multiplied by a peak to mean ratio of 2.5 to account for nose-response time. The resultant emission rate was then multiplied by the estimated area of exposed material, which was assumed to be emitting odour at that constant rate for the entire one year modelling period. These are conservative estimates as it is likely that any odorous material would be covered at the end of each day.

For modelling purposes it was assumed that there would be six areas being excavated at any one time across the site and that these areas would be emitting at the full rate for every hour of the year.

In addition to the excavated areas, open SBR tanks and a dewatered sludge bin were also assessed. The specific odour emission rate for these point sources are summarised in **Table 10-13.**

The specific odour emission rate from the leachate contained in the SBR tanks was estimated to be approximately 0.06 $OU.m^3/s/m^2$ (direct measurement made from a leachate pond). This was then multiplied by the exposed area (two tanks with a diameter of 9.75 m) and again by the peak to mean ratio of 2.5. The emission from the dewatered sludge bin is approximately 0.17 $OU.m^3/s/m^2$ (representative of dewatered sewage sludge), multiplied by the exposed area of approximately 50 m^2 and the 2.5 peak to mean ratio.

Table 10-13 Point source specific odour emission rate

Source	Specific odour emission rate ($OU.m^3/s/m^2$)
Excavated waste	0.424
SBR tanks	0.06
Dewatered sludge bin	0.17

10.4 Operational air quality assessment methodology

Details of the various components of the operational air quality assessment methodology are provided in **Appendix H** and a summary of the in-tunnel and external air quality assessment is provided below.

10.4.1 In-tunnel assessment methodology

In-tunnel traffic, airflow, pollution levels and temperature for the project and for the future M4-M5 Link were modelled using IDA Tunnel software. The data used in the tunnel ventilation simulation, and the results of the simulation, are provided in full within Appendix L of the Technical working paper: Air quality in **Appendix H**.

Scenarios

The scenarios evaluated for in-tunnel air quality reflected the potential modes of operation of the tunnel ventilation system. These scenarios were:

- **Expected traffic**: The expected traffic scenarios included in the in-tunnel air quality assessment are summarised in **Table 10-14.** The objective of these scenarios was to demonstrate that the expected operation of the project would result in acceptable in-tunnel air quality capacity (maximum) traffic flow scenarios. These were included to reflect conditions that can generate high in-tunnel vehicle emission concentrations. Several different speeds were considered, including congested traffic conditions
- **Vehicle breakdown scenario**: This included incidents such as vehicle breakdowns or accidents and heavy congestion. It was assessed on the basis that it would represent a worst case in terms of vehicle emissions generation, particularly over the shorter term until the breakdown or accident had been cleared.

Table 10-14 Expected traffic scenarios for the in-tunnel air quality assessment

Scenario code	Scenario description
2021-DS	2021 – 'Do something (ie with project)
2031-DS	2031 – 'Do something (ie with project)
2031-DSC	2031 – 'Do something cumulative' (ie with the project and future M4-M5 Link)

The three pollutants assessed for in-tunnel air quality were NO_2, CO and $PM_{2.5}$ (exhaust only, as visibility). For the operating years of the project, NO_2 would be the pollutant that determines the required airflow and drives the design of ventilation for in-tunnel pollution.

10.4.2 External air quality assessment methodology

The operational ambient air quality assessment was based on the GRAMM / GRAL modelling system. This system consists of two main modules: a prognostic wind field model (the Graz Mesoscale Model, or GRAMM) and a dispersion model (GRAL). The elements of the system are shown in **Figure 10-2** and summarised below. Full details of the methodology are presented in the Technical working paper: Air quality in **Appendix H**.

The GRAL dispersion model is a three-dimensional model used to predict pollutant concentrations. It is suitable for regulatory applications and can use a full year of meteorological data. It predicts pollutant concentrations under low wind speed conditions (less than one metre per second) more accurately than Gaussian models (eg CALINE). It is specifically designed for the simultaneous modelling of surface roads, point sources (tunnel ventilation outlets) and tunnel portals, and takes into account vehicle wake effects.

GRAL characterises pollution dispersion in complex local terrain and topography, including the presence of buildings in urban areas. It has been validated in a wide range of studies featuring complex and flat terrain, and with different meteorological conditions such as high and low wind velocities, and stable or unstable atmospheric conditions (refer to Appendix J of the Technical working paper: Air quality in **Appendix H**) and is not inherently conservative (see discussion of conservatism in **Section 10.1.7**).

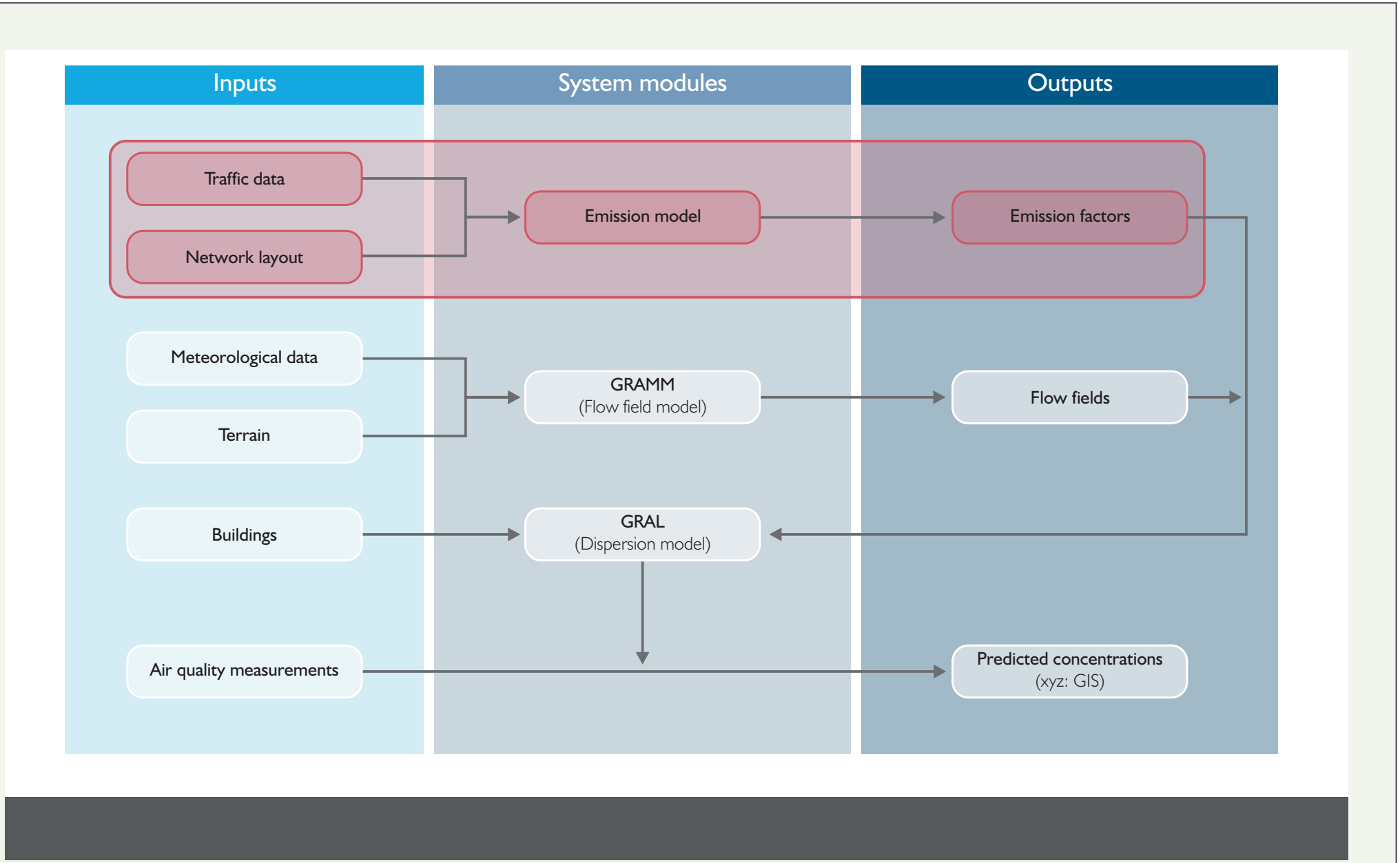


Figure 10-2 Overview of the GRAMM/GRAL modelling system

(blank page)

Definition of modelling domains

The modelling domains for the project are shown in **Figure 10-3**. The following terms are used in this report to describe the different geographical areas of the assessment:

- The GRAMM domain (also referred to as the 'study area') is shown by the red boundary in **Figure 10-3**. This was used for the modelling of meteorology, and was the largest area included in the assessment. The GRAMM domain covers a substantial part of Sydney, extending 25 kilometres in the east−west (x) alignment and 20 kilometres in the north−south (y) alignment.
- The WestConnex GRAL domain for dispersion modelling is shown by the green boundary in **Figure 10-3**. This extended 15 kilometres in the east−west (x) alignment and 14 kilometres in the north−south (y) alignment. Every dispersion model run was undertaken for the WestConnex GRAL domain, which includes all project components of the WestConnex program of works (a section of the M4 Widening, M4 East, King Georges Road Interchange Upgrade, New M5 and future M4−M5 Link). The large size of the WestConnex GRAL domain was defined for a number of reasons:
  - It facilitated a 'whole of project' modelling approach, whereby the specific information for each WestConnex project could be extracted and presented in more detail for the separate EISs (in this case, for the New M5 project). This improved both the efficiency and consistency of the air quality assessments for the various WestConnex projects
  - It provided the cumulative impacts of all relevant projects, such as the combined ventilation outlet for the New M5 and future M4−M5 Link, but excluded contributions from the M4 East ventilation outlets (including the shared outlet with the future M4-M5 Link) given geographical distance
  - It maximised the flexibility of the assessment process, and is capable of accommodating any future changes in the requirements of any project
  - It refined the model outcomes by maximising the number of meteorological and air quality monitoring stations that could be included for model evaluation purposes.
- The New M5 GRAL domain is shown by the orange boundary in **Figure 10-3**. This extended 12 kilometres in the east−west (x) alignment and eight kilometres in the north−south (y) alignment. No separate modelling was undertaken for this domain; rather, the model results for this area were extracted from the model results for the WestConnex GRAL domain.

(blank page)

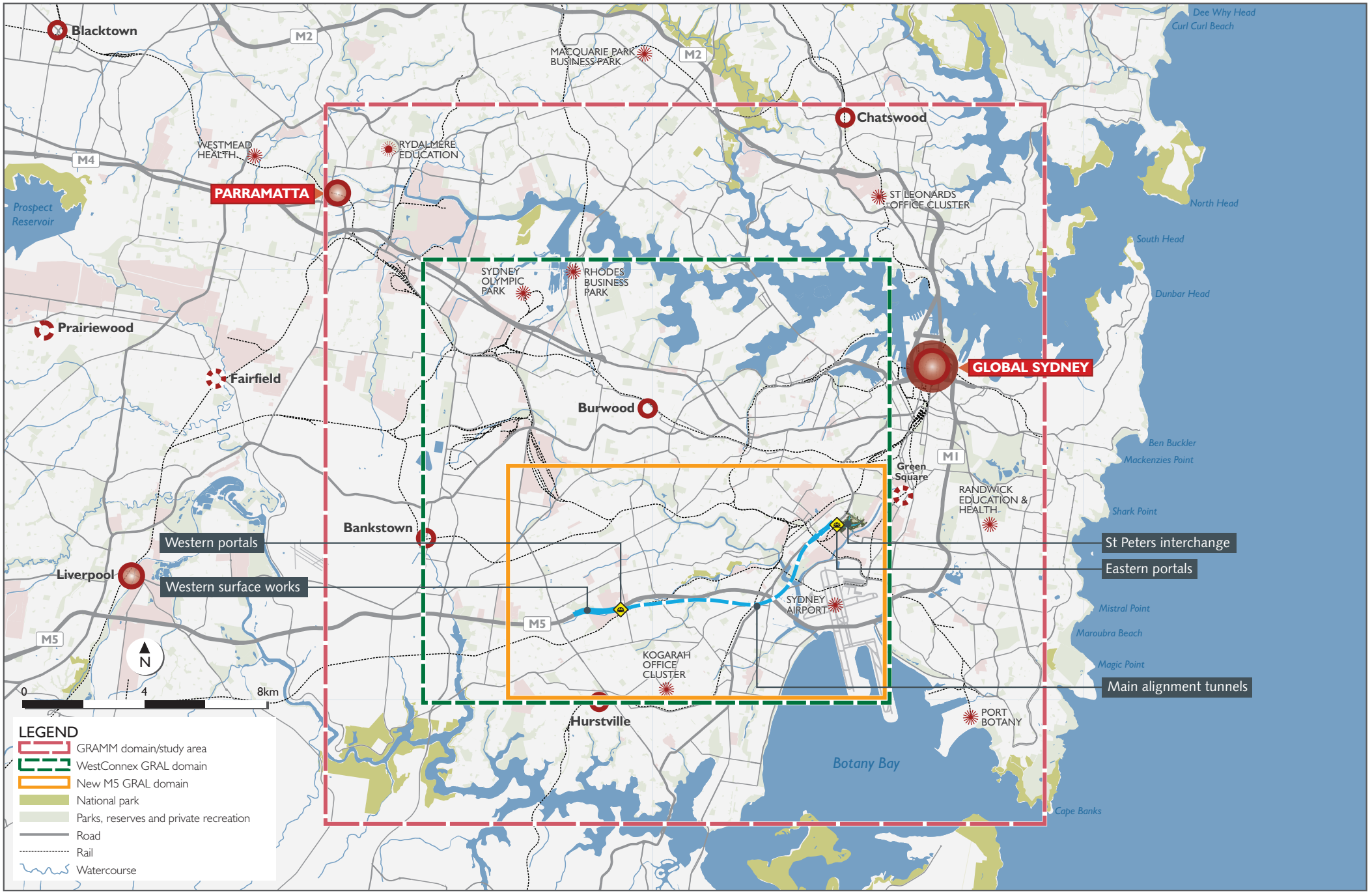


Figure 10-3 Modelling domains for GRAMM and GRAL

(blank page)

Determination of components of assessment

The various pollutant concentrations were determined as follows:

- Background concentrations were based on measurements from air quality monitoring stations at urban background locations in the study area, but well away from roads (as defined in Australian Standard AS/NZS 3580.1.1:2007 - *Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment*). The approaches used to determine long-term and short-term background concentrations are explained in Appendix F of the Technical working paper: Air quality in **Appendix H**. Background concentrations were assumed to remain unchanged in future years
- Surface road concentrations and ventilation outlet concentrations were estimated (separately) using the GRAL dispersion model
- For all pollutants except NO_2, the project increment was equal to the difference between the road concentration (surface roads and ventilation outlets) with and without the project. A different method was required for NO_2 to account for the change in atmospheric chemistry in the roadside environment (see Appendix G of the Technical working paper: Air quality in **Appendix H**).

Receivers

Appendix H presents contour maps showing concentrations, and changes in concentration, across the entire New M5 GRAL domain. The concentrations are based on a Cartesian grid of points with an equal spacing of 10 metres in the east to west (x) and north to south (y) directions. This results in 960,000 grid locations across the New M5 GRAL domain.

Appendix H also presents distributions of changes in concentration at over 46,000 discrete receiver locations along the project corridor where people are likely to be present for some period of the day.

Two types of discrete receiver locations were defined for use in the assessment:

- 'Community receivers' - these were taken to be representative of particularly sensitive locations within a zone (600 metres either side) along the project corridor, including, but not limited to schools, child care centres and hospitals. For these receivers a detailed approach was used to calculate the total concentration of each pollutant. This involved the combination of the contemporaneous road / outlet time series of concentrations from GRAL and the background time series of concentrations, stated as a one-hour mean for each hour of the year in each case. The number of such receivers that could be treated in this way was dictated by the limit on the number of time series that could be extracted from GRAL. In total, 35 community receivers were included in the assessment
- 'Residential, workplace and recreational (RWR) receivers' - These were all discrete receiver locations along the project corridor, and mainly covered residential and commercial land uses. The 35 community receivers were also included. For these receivers a simpler statistical approach was used to combine a concentration statistic for the modelled roads and outlets (eg maximum 24-hour mean PM_{10}, annual mean NO_X) with an appropriate background statistic. Around 46,219 RWR receivers were included in the assessment.

Not all particularly sensitive receivers along the project corridor were included as community receivers. However, all receivers were included in the assessment as RWR receivers.

The RWR receivers are discrete points in space, classified according to the land use identified at that location. The RWR receivers do not identify the number of residential (or other) properties at the location. The residential land use at an RWR receiver location may range from a single-storey dwelling to a multi-storey and multi-dwelling building.

The RWR receivers are therefore not designed for the assessment of changes in total population exposure. The human health risk assessment (**Appendix I**) combines the air quality information with the highest available resolution population data from the Australian Bureau of Statistics to calculate key health indicators that reflect population-weighted change in concentrations across the study area. This included, for example, aged care facilities and some additional schools.

Community receivers are listed in **Table 10-15**. RWR receiver types are listed in **Table 10-16**. The locations of both types of receiver are shown in **Figure 10-4**.

Table 10-15 Full list of community receivers

Receiver code	Receiver name	Receiver location	
		x	y
SR01	Active Kids Beverly Hills	321759.34	6242522.13
SR02	Active Kids Narwee	321834.82	6242572.24
SR03	Beverly Hills North Public School	322057.56	6242739.38
SR04	Beverly Hills Girls High School	322434.56	6241894.31
SR05	Barfa Bear Child Care Centre	322502.71	6242962.37
SR06	Regina Coeli Catholic Primary School	322534.93	6242106.78
SR07	Footsteps Early Learning Centre	322598.30	6242038.13
SR08	Footsteps Early Learning Centre Out of Hours School Care	322634.72	6242067.94
SR09	McCallums Hill Public School	322983.85	6243411.42
SR10	Hurstville City Council Family Day Care Scheme	323188.07	6242153.07
SR11	Kingsgrove North High School	324163.24	6243526.44
SR12	Kingsgrove Early Childhood Health Centre	324237.76	6242567.09
SR13	Kingsgrove World Of Learning	324302.13	6243159.06
SR14	Kingsgrove Day Hospital	324605.26	6242446.62
SR15	Kings Medical Clinic	324617.41	6242385.68
SR16	Kids Oasis Childcare Centre	324938.30	6242947.28
SR17	Clemton Park Public School	325159.24	6244031.99
SR18	The Salvation Army Booth College	326159.87	6242931.27
SR19	Alloa Nursing Home	327926.14	6242694.31
SR20	Athelstane Public School	327937.74	6243217.07
SR21	Kinderoos Childcare Centre	327972.63	6243279.07
SR22	Ladybugs Day Care	328350.84	6243727.16
SR23	Macedonian Community Child Care Centre	328728.78	6243409.25
SR24	Arncliffe Public School	328787.20	6242894.84
SR25	Tempe High School	329994.39	6245223.50
SR26	Tillman Park Child Care Centre	330313.10	6245488.42
SR27	St Pius' Catholic Primary School	331168.07	6246637.69
SR28	Camdenville Public School	331336.13	6246750.02
SR29	Camdenville Public School Preschool	331417.05	6246696.75
SR30	St Peters Public School	331427.41	6246008.99
SR31	Sydney Park Childcare Centre	332359.96	6246661.46
SR32	Sydney Park Childcare Centre	332434.93	6246719.45
SR33	Lady Gowrie Child Centre	332545.11	6247280.29
SR34	Active Kids Mascot	332608.90	6245071.23
SR35	Building Blocks Early Childhood Learning	332838.53	6245806.12

Table 10-16 Summary of RWR receiver types

Receiver type	Number	% of total
Child care / pre-school	25	0.05%
School	129	0.28%
Further education	9	0.02%
Aged care	14	0.03%
Residential	41,579	89.96%
Commercial	2,210	4.78%
Industrial	1,468	3.18%
Hotel	29	0.06%
Park / sport / recreation	136	0.29%
Public services	11	0.02%
Community	13	0.03%
Medical	101	0.22%
Religion	80	0.17%
Construction site	22	0.05%
Other	393	0.85%
Total	**46,219**	**100.0%**

(blank page)

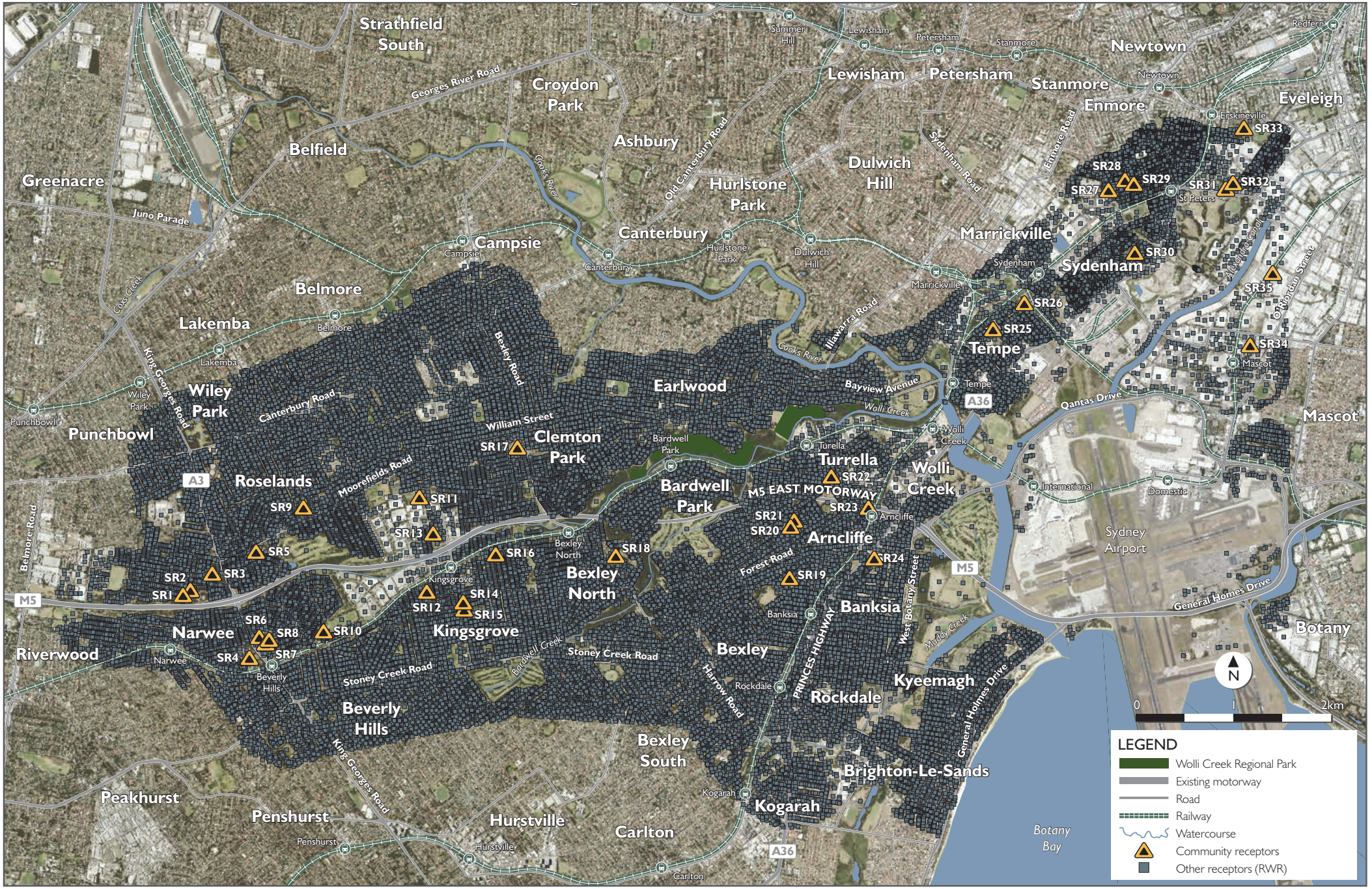


Figure 10-4 Modelled discrete receiver locations

(blank page)

Treatment of elevated receivers

The main emphasis in the external air quality assessment was on ground-level concentrations (as specified in the NSW Approved Methods). However, at a number of locations in the GRAL New M5 domain there are multi-storey residential and commercial buildings. The potential impacts of the project at elevated points at these locations may be different to the impacts at ground level and therefore these were evaluated separately. In addition, it was considered important to understand how future building developments (eg apartment blocks) in the domain might be affected from an air quality perspective.

Information on building height was not available for all RWR receivers in the New M5 domain. The heights of those buildings for which this information was available are shown in **Figure 10-5** and the distribution of building heights is shown in **Figure 10-6**.

The distribution in **Figure 10-6** also includes locations (around 300 in number) that were not buildings and had a height of less than one metre.

Most of the buildings had a height of less than 10 metres and only a small proportion of buildings had a height of more than 15 metres. However, there were some buildings in the vicinity of the Arncliffe ventilation outlet that were taller than 30 metres. Based on this assessment, two elevated receiver heights were selected to cover both existing buildings and future developments: 10 metres and 30 metres. For both heights, a full modelling run across the GRAL WestConnex domain was conducted across the New M5 domain.

This part of the assessment did not cover all pollutants and averaging periods. The focus was on annual average $PM_{2.5}$ concentrations in the 2031-DSC scenario. The GRAL model was used to predict $PM_{2.5}$ concentrations associated with surface roads and tunnel ventilation outlets.

(blank page)

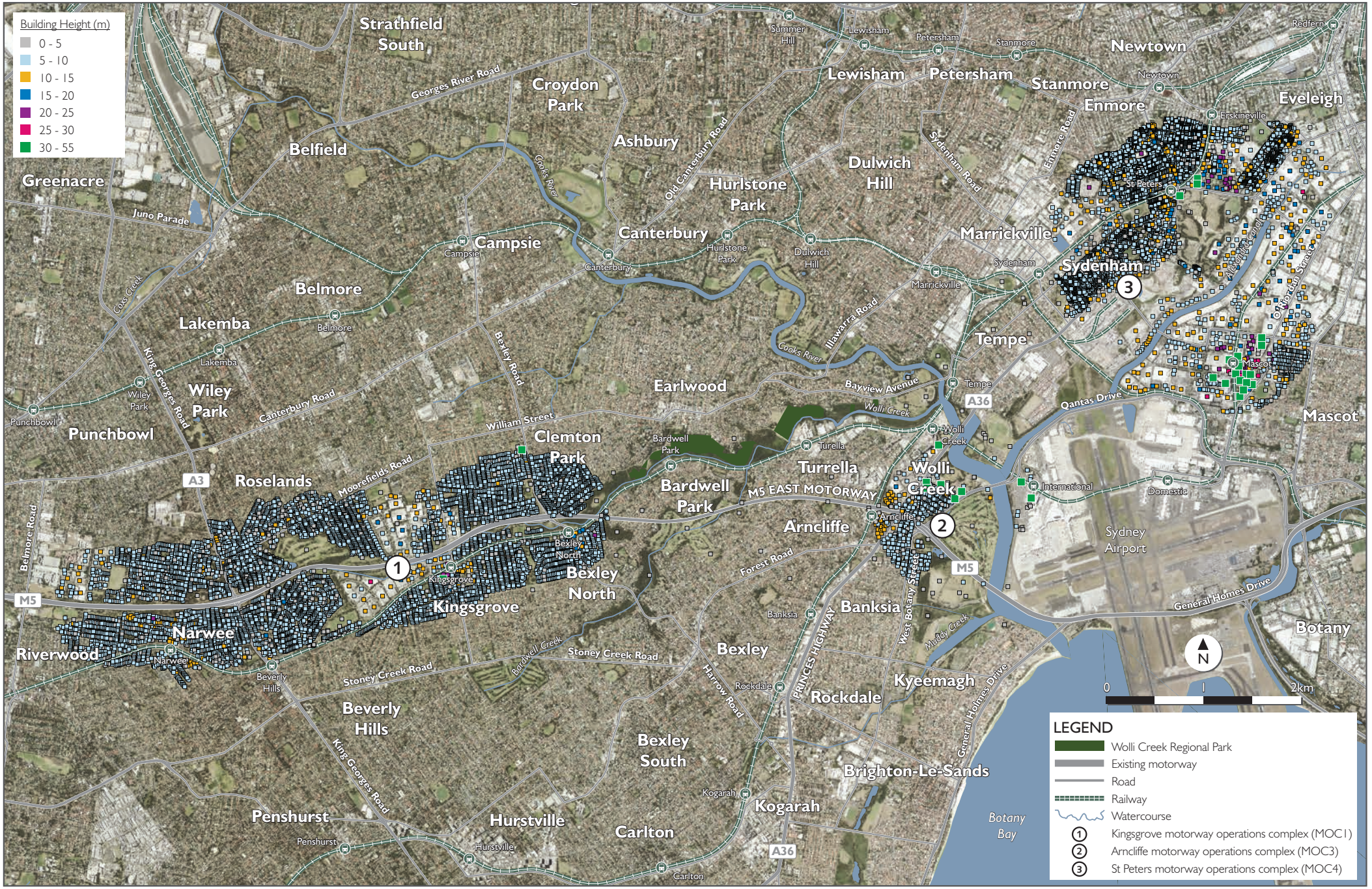


Figure 10-5 Building heights at RWR receiver locations

(blank page)

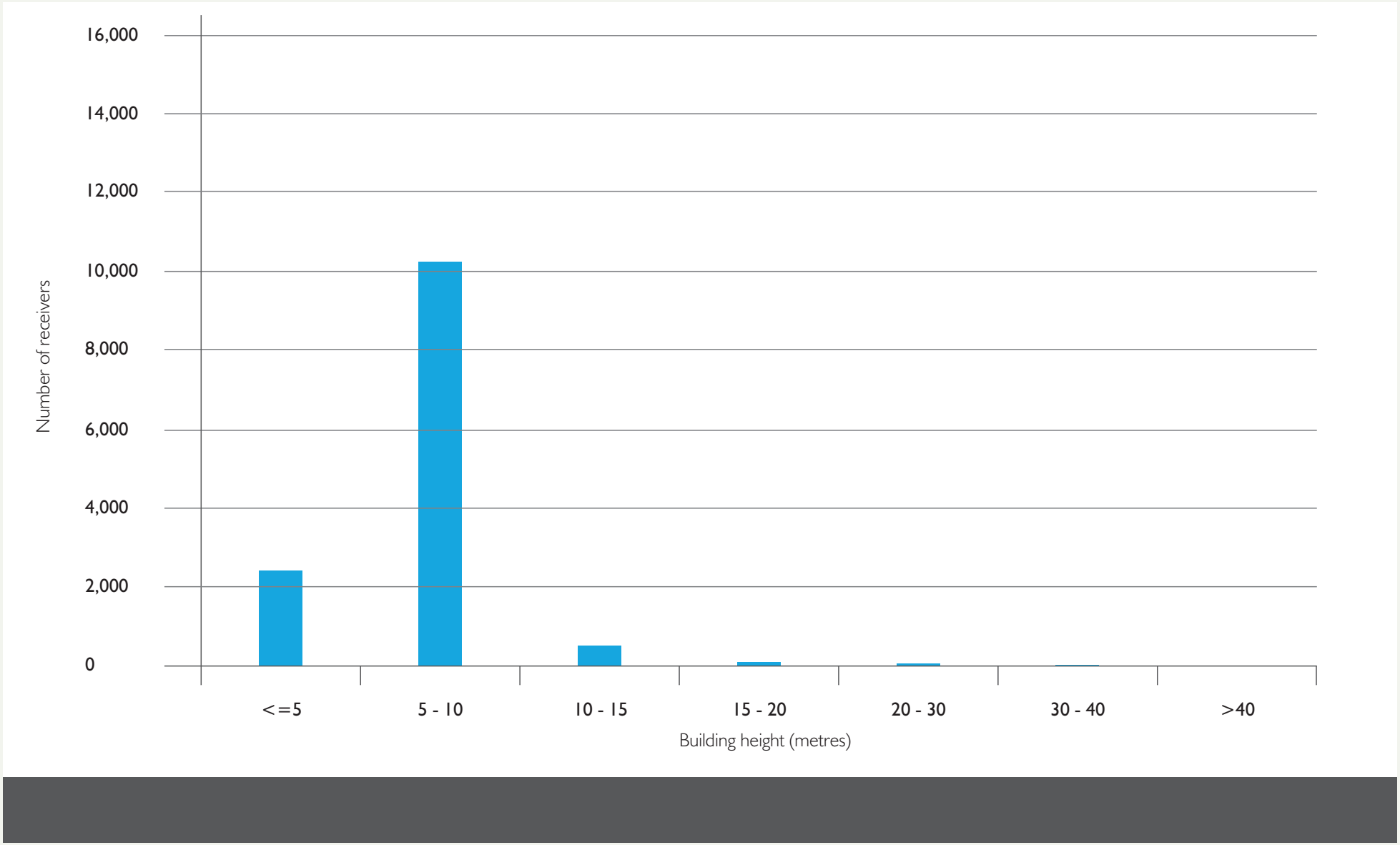


Figure 10-6 Frequency distribution of building heights at RWR receiver locations

(blank page)

The following cases were assessed with regards to elevated receivers:

- 2031-DM at a height of 10 metres (surface roads only)
- 2031-DM at a height of 30 metres (surface roads only)
- 2031-DSC at a height of 10 metres (surface roads and ventilation outlets)
- 2031-DSC at a height of 30 metres (surface roads and ventilation outlets)
- Change in annual $PM_{2.5}$ (2031-DSC minus 2031-DM) at a height of 10 metres
- Change in annual $PM_{2.5}$ (2031-DSC minus 2031-DM) at a height of 30 metres

Background concentrations were not taken into account as these could not be quantified at elevated locations. For the same reason, only the changes in the $PM_{2.5}$ concentration are presented in the report.

10.5 Existing environment

This section describes the existing environment and conditions in the study area, including:

- A description of the terrain and land use in the study area
- The meteorology (weather patterns) in the study area
- Consideration of historical trends in road traffic emissions
- The historical and current air quality environment in the study area
- The meteorological inputs for the operational air quality assessment
- The background concentrations for the operational air quality assessment.

10.5.1 Terrain and land use

The topography of the land in an area plays an important role in the dispersion of air pollutants. It steers winds, generates turbulence and large scale eddies (a current of air moving in a different direction that the main current), and generates drainage flows at night (when air cools and flows downslope) and upslope flows during the day (as a result of surface heating).

Terrain data for Sydney was obtained from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) website. The terrain within the study area is predominantly flat, but increases in elevation to the north of the Five Dock Bay area towards the Hills District and to the south towards the Sutherland Shire and adjoining parkland.

The terrain along the project corridor rises from an elevation of around 41 metres Australian Height Datum (AHD) at the western end to an elevation of around seven metres AHD at Kogarah and 10 metres AHD at St Peters, at the eastern end.

Land use within the New M5 GRAL domain consists primarily of urban areas, with pockets of recreational reserves and waterbodies including Wolli Creek and the Alexandra Canal.

The uniformity of the terrain, and the lack of major obstacles to wind flow, supports good dispersion and air flow throughout the study area.

10.5.2 Climate

Table 10-17 and **Table 10-18** present the 20-year temperature and rainfall data for the two closest Bureau of Meteorology (BoM) sites, located at Sydney Olympic Park (Archery Centre) (site number 066195) and the Canterbury Racecourse (site number 066194). Monthly averages of maximum and minimum temperatures are presented, as well as rainfall data consisting of mean monthly rainfall and the average number of rain days per month.

Table 10-17 Climate averages for Sydney Olympic Park

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temperature (ºC)												
28.4	28.1	26.6	23.9	20.8	18.3	17.6	19.5	22.5	24.3	25.3	27.4	23.6
Mean daily minimum temperature (ºC)												
19.3	19.4	17.8	14.3	11.2	8.9	7.8	8.7	11.6	13.7	15.8	17.9	13.9
Mean monthly rainfall (mm)												
84.4	109.8	66.0	89.2	88.2	75.8	63.5	56.7	52.7	64.9	76.2	58.0	884.0
Mean rain days per month (number)												
7.6	7.7	7.6	6.9	7.7	6.9	6.3	4.4	5.5	7.1	7.8	6.8	82.3

Source: BoM (2015b) Climate averages for Station: 066195; Commenced: 1995 – last record 2015; Latitude: 33.85°S; Longitude: 151.06 °E

Table 10-18 Climate averages for Canterbury Racecourse

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temperature (ºC)												
27.6	27.2	25.9	23.3	20.5	18.1	17.5	19.0	22.1	23.4	24.6	26.3	23.0
Mean daily minimum temperature (ºC)												
18.3	18.3	16.4	12.7	9.3	7.1	5.8	6.5	9.5	12.0	14.8	16.8	12.3
Mean monthly rainfall (mm)												
76.0	103.6	73.3	113.4	84.9	98.8	57.8	63.3	45.7	62.4	81.4	64.7	927.8
Mean rain days per month (number)												
7.6	7.8	7.5	7.8	7.1	8.9	6.7	5.1	4.7	6.2	8.3	6.8	84.5

Source: BoM (2015c) Climate averages for Station: 066194; Commenced: 1995 – last record 2015; Latitude: 33.91°S; Longitude: 151.11 °E

The annual average maximum and minimum temperatures recorded at the Sydney Olympic Park station are 23.6 degrees and 13.9 degrees respectively and 23.2 degrees and 12.3 degrees at Canterbury Racecourse respectively. On average, January is the hottest month, with average maximum temperatures of 28.4 degrees and 27.6 degrees at Olympic Park and Canterbury, respectively. July is the coldest month at both stations, with average minimum temperatures of 7.8 degrees and 5.8 degrees, at Olympic Park and Canterbury respectively.

Rainfall data collected at the Sydney Olympic Park station shows that February is the wettest month, with an average rainfall of about 110 millimetres over an average of eight rain days. The average annual rainfall is 884 millimetres over an average of about 82 rain days per year. Rainfall data from the Canterbury site shows the wettest month on average occurring in April, with about 113 millimetres falling over eight rain days. The average annual rainfall is slightly higher, at about 928 millimetres over an average of about 85 rain days per year.

10.5.3 Meteorology

Several meteorological stations in the study area were considered, and their locations are shown in **Figure 10-7**. Data relevant to the dispersion modelling such as wind speed, wind direction, temperature and cloud cover was obtained for the following locations:

- NSW Office of Environment and Heritage (OEH) meteorological stations:
  - Chullora
  - Earlwood
  - Rozelle
- BoM meteorological stations:
  - Canterbury Racecourse Automatic Weather Station (AWS) (site number 066194)
  - Fort Denison (site number 066022)
  - Sydney Airport Allied Meteorological Office (AMO) (site number 066037)
  - Sydney Olympic Park AWS (site number 066195)
  - Sydney Olympic Park AWS (Archery Centre) (site number 066212).

An analysis of the data required as input for GRAMM was carried out to examine the availability and validity of the data from these meteorological stations. Data recovery, wind speed, wind direction, temperature and relative humidity information for years 2009 to 2014 was analysed, where available, for each of the abovementioned sites. A minimum of five years of data was used for the analysis in line with the requirements of determining site-representative data outlined in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b). It is noted that the OEH Randwick site is also located within the model domain. However, as it would be less than 500 metres away from the western edge of the domain, it was not considered for inclusion in the model due to potential model boundary effects, which could skew the wind fields at this location.

Appendix H (Meteorological model evaluation) of the Technical working paper: Air quality in **Appendix H** provides a summary of the annual data recovery, average wind speed and percentage of calms (wind speeds less than 0.5 metres per second) for each of the selected meteorological stations from 2009 to 2014. The table shows a generally high percentage of data recovery at each site over the last six years which is consistent with the data requirements in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b). There was a high level of consistency in the annual average wind speed and annual percentage of calms across the years within each meteorological station database. Wind speed conditions, including episodes of calm conditions, have remained relatively consistent over the period.

Annual and seasonal wind roses for all six years and for all sites were used to analyse the general wind patterns across the modelling domain. These are presented in **Appendix H**. The wind roses showed very similar wind patterns for all six years at each individual site. The dominant wind patterns are predominantly from the northwest and southeast directions. The seasonal patterns are also very similar between each site.

Based on the analysis of the available meteorological data within the GRAMM modelling domain presented in **Appendix H**, data from the BoM Canterbury Racecourse AWS meteorological station were chosen as the input to GRAMM for modelling. The site was considered to be representative of the meteorology in the domain.

Analysis of the Canterbury Racecourse data showed that the wind speed and direction patterns for the past six years (2009 to 2014) were consistent from year to year, and as detailed in Appendix H (Meteorological Data and Evaluation) of the Technical working paper: Air quality in **Appendix H** of this EIS. Other sites also showed consistencies, but the Canterbury Racecourse AWS site was the most centrally located with respect to WestConnex. The analysis of six years of data also showed that 2014, the most recent year available, was representative of longer term weather conditions. The selection of the 2014 meteorological data was consistent with the use of 2014 measured ambient air quality data to define background concentrations for the assessment.

Figure 10-8 to **Figure 10-11** show the annual and diurnal plots of wind speed and temperature from the Canterbury Racecourse site for 2014. The annual plots show a typical distribution of wind speed and temperature over the course of a year. The diurnal plots also show typical patterns, with higher wind speeds and temperatures during the day, decreasing at night and in the early morning.

Having determined that 2014 was a representative year, the data were then used to run the meteorological model (GRAMM) to determine three-dimensional wind fields across the modelling domain. Wind speed and direction values were extracted at each of the meteorological stations shown in **Figure 10-7** and some statistical analysis was carried out to compare these extracted (predicted) data with the observations at each of those sites. This process is discussed further in **Appendix H**.

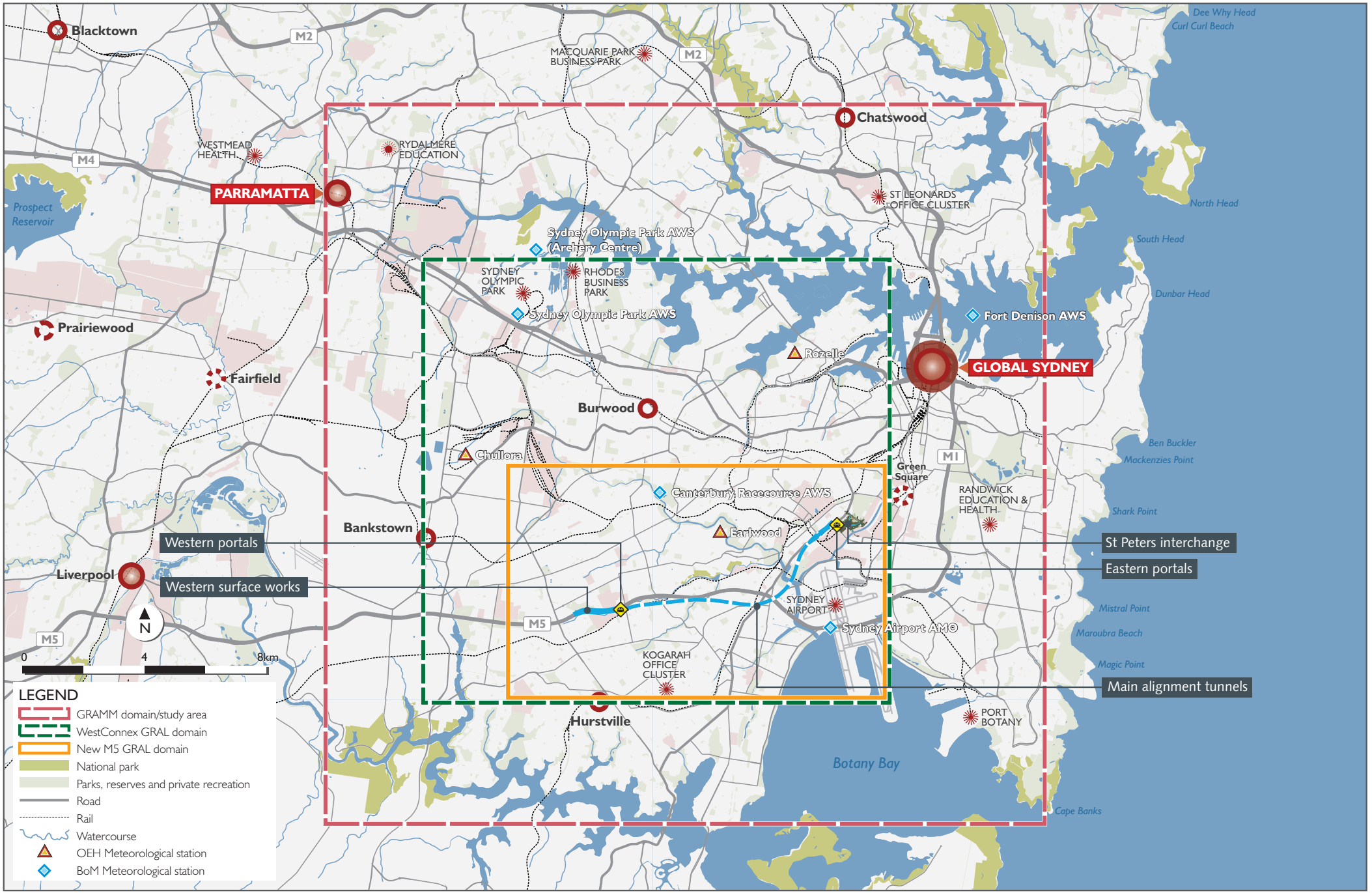


Figure 10-7 Meteorological stations in the GRAMM model domain

(blank page)

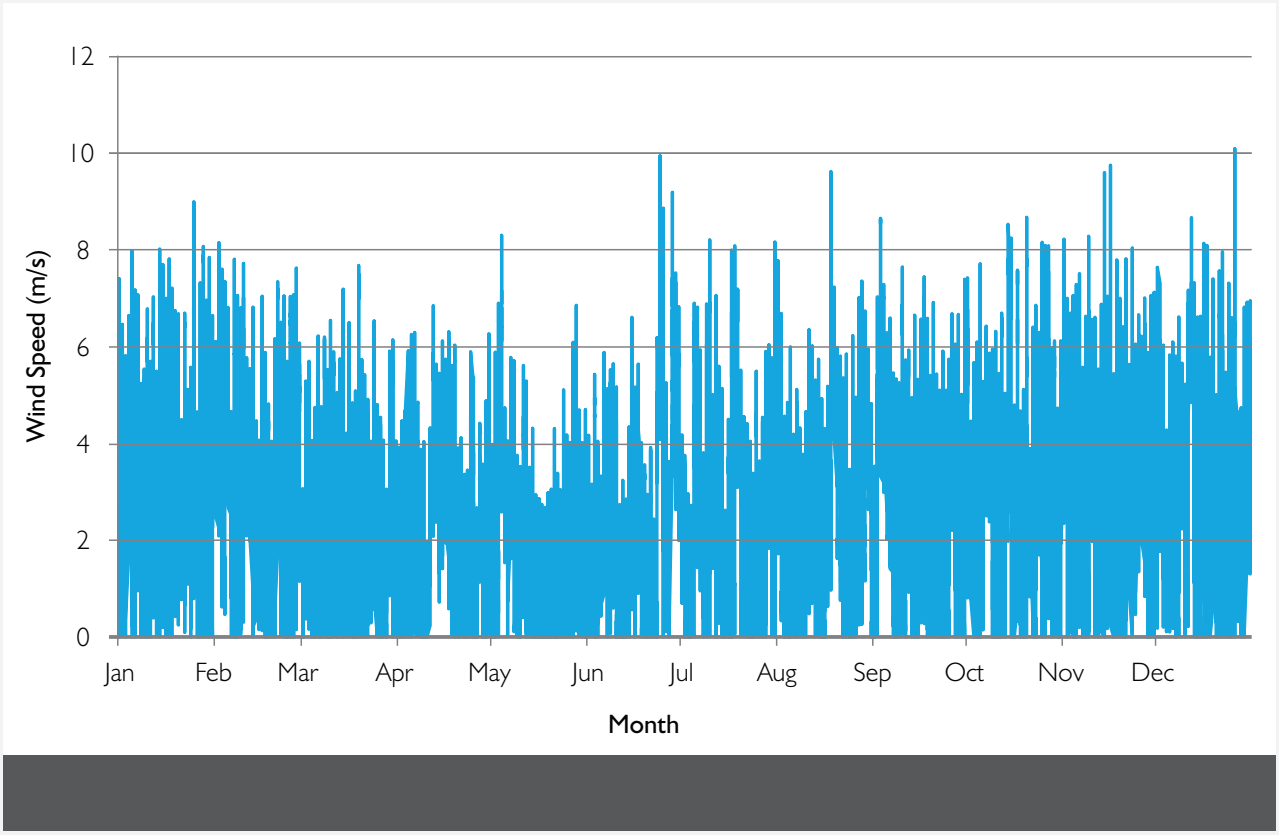


Figure 10-8 Hourly average wind speeds at Canterbury Racecourse - 2014

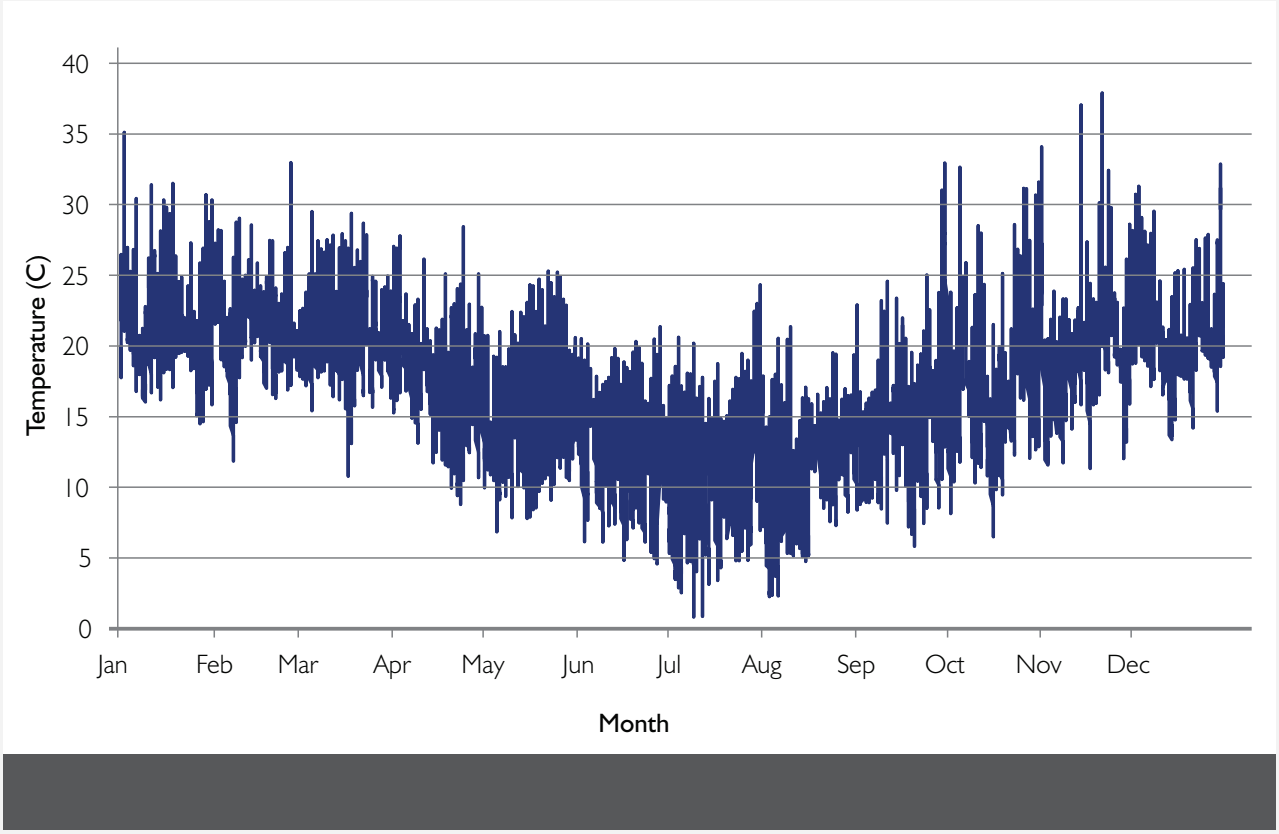


Figure 10-9 Hourly average temperatures at Canterbury Racecourse - 2014

(blank page)

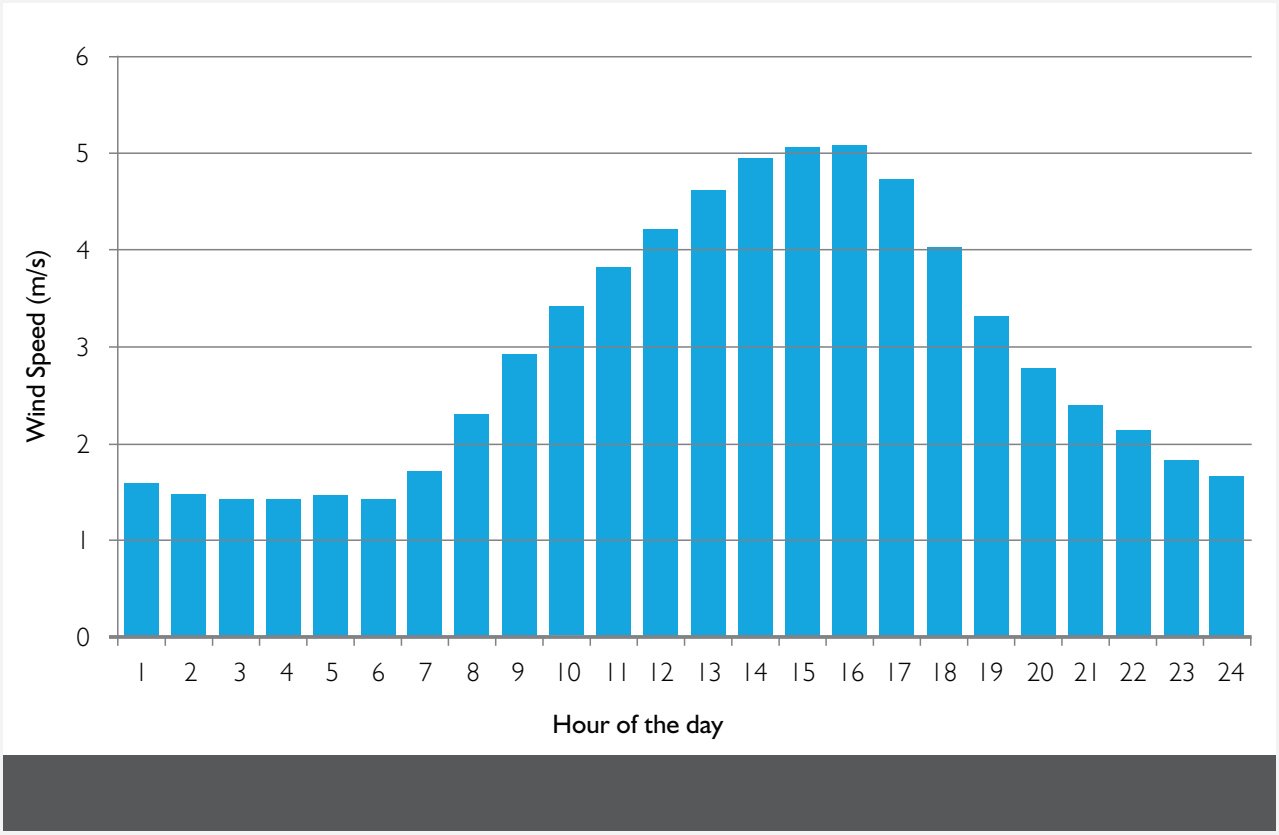


Figure 10-10 Average wind speeds by hour of day at Canterbury Racecourse - 2014

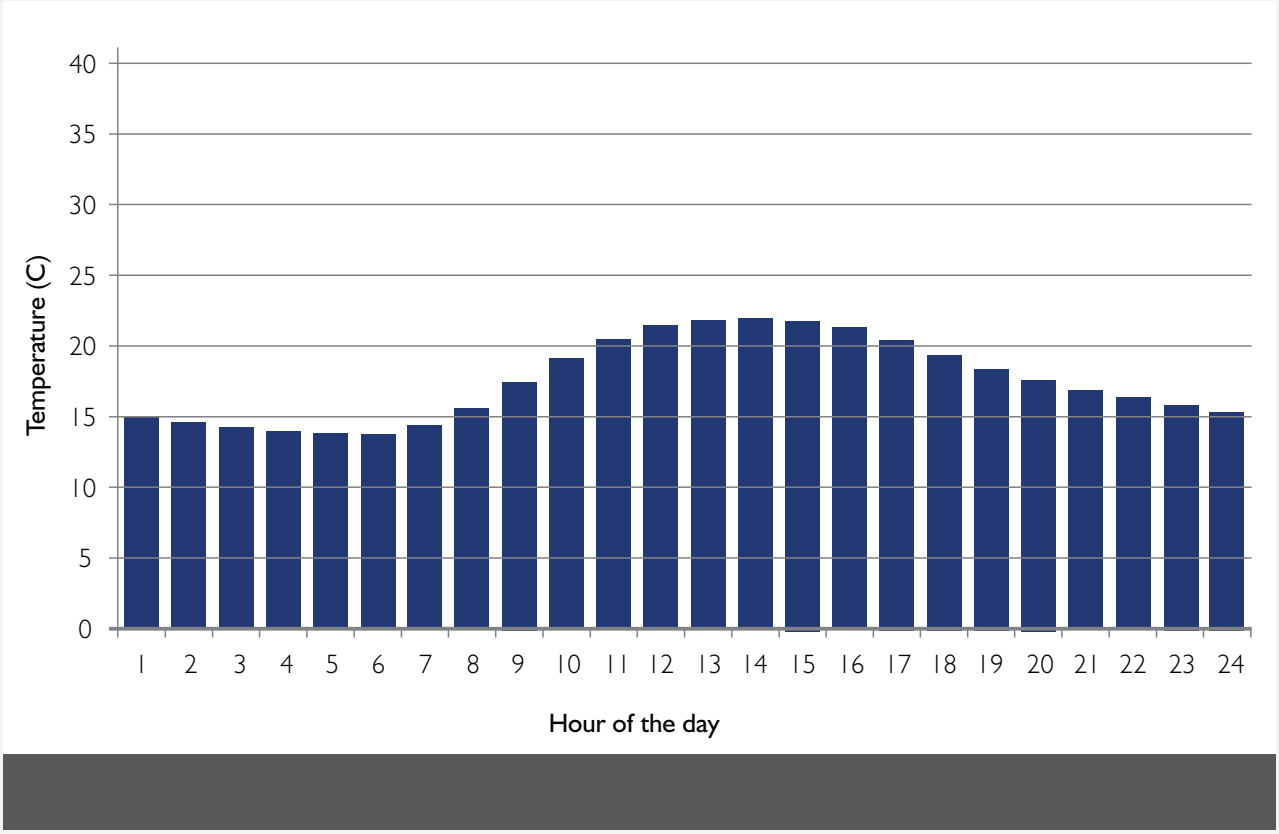


Figure 10-11 Average temperatures by hour of day at Canterbury Racecourse - 2014

(blank page)

10.5.4 Emissions

Calculations have established that exhaust emissions of some pollutants from road transport have decreased over time as vehicle emissions legislation has tightened, and are predicted to continue to decrease in the future (Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2010). However, over the longer term, it is anticipated that emission levels will start to rise again as increases in annual vehicle activity (associated with the projected population growth in Sydney) begin to offset the reductions achieved by the current emission standards and vehicle technologies (Department of Infrastructure and Transport (DIT), 2012).

The most detailed and comprehensive source of information on current and future emissions in the Sydney area is the emissions inventory compiled by the NSW EPA. An emissions inventory defines the amount (in tonnes per year) of each pollutant that is emitted from each source in a given area. The base year of the latest published NSW EPA inventory is 2008 (EPA, 2012a), and projections are available for 2011, 2016, 2021, 2026, 2031 and 2036. The importance of road transport as a source of pollution in Sydney can be illustrated by reference to sectoral emissions. The data for anthropogenic (caused by humans) and biogenic (caused by plants and animals) emissions in Sydney, and also for road transport in Sydney, was extracted from the latest NSW EPA inventory. Emissions were considered for the most recent historical year (2011) and for the future years.

Sectoral emissions

Figure 10-12 shows that in 2011, road transport in Sydney was the largest sectoral contributor to emissions of CO (44 per cent) and NO_X (57 per cent). Road transport was also responsible for a significant proportion of emissions of volatile organic compounds (VOCs) (17 per cent), PM_{10} (10 per cent) and $PM_{2.5}$ (12 per cent). The main contributors to VOCs were domestic and commercial activity and biogenic sources such as volatile oils from vegetation. The most important sources of PM_{10} and $PM_{2.5}$ emissions were the domestic and commercial sector, and industry. The contribution to particulate matter from the domestic sector in Sydney was largely due to wood burning for heating in winter. Emissions from natural sources, such as bushfires, dust storms and marine aerosol, also contributed significantly to particulate matter concentrations. Road transport contributed only two per cent of total SO_2 emissions in Sydney, reflecting the reduction in sulfur in road transport fuels in recent years. SO_2 emissions in Sydney were dominated by the off-road mobile sector and industry.

The projections of sectoral emissions shown in **Figure 10-14** demonstrate that the contribution of road transport CO, VOCs and NO_X emissions are forecast to decrease substantially between 2011 and 2036 as a result of improvements in emission control technology. For PM_{10}, $PM_{2.5}$ and SO_2, the contribution from the road transport sector will also decrease, but their smaller contributions mean that these reductions will have only a minor impact on total emissions.

Road transport sector emissions

The breakdown of emissions in 2011 from the road transport sector by process and vehicle type is presented in **Figure 10-13**. Petrol passenger vehicles (mainly cars) accounted for a large proportion of the vehicle kilometres travelled (VKT) in Sydney. Diesel passenger vehicles have represented only a very small proportion of the total passenger vehicle fleet. However, the improved performance of light-duty diesel vehicles over the last 10 years, together with superior fuel economy, has boosted sales and the market share is increasing (EPA, 2012b). Exhaust emissions from these vehicles were responsible for 62 per cent of CO from road transport in Sydney in 2011, 45 per cent of NO_x and 76 per cent of SO_2. They were a minor source of PM_{10} (around four per cent) and $PM_{2.5}$ (around nine per cent). Non-exhaust processes were the largest source of road transport PM_{10} (around 60 per cent) and $PM_{2.5}$ (around 46 per cent). This is a larger proportion than in most European countries, as there are relatively few diesel cars in Australia. Heavy-duty diesel vehicles are disproportionate contributors of NO_x and particulate matter emissions due to their inherent combustion characteristics, high operating mass (and hence high fuel usage) and level of emission control technology (NSW EPA, 2012b).

The projections of road transport sector emissions are broken down by process and vehicle group in **Figure 10-15**. Substantial reductions in emissions of CO, VOCs, and NO_X are projected between 2011 and 2036. There will be smaller changes in emissions of PM_{10} and $PM_{2.5}$. SO_2 emissions are proportional to fuel sulfur content, and this is assumed to remain constant in the inventory.

The inventory also records emissions of specific organic compounds, based on speciation profiles of petrol and diesel fuels.

Projected emissions for sectoral and road transport emissions in Sydney from 2011 to 2036 are shown in **Figure 10-14** and **Figure 10-15**.

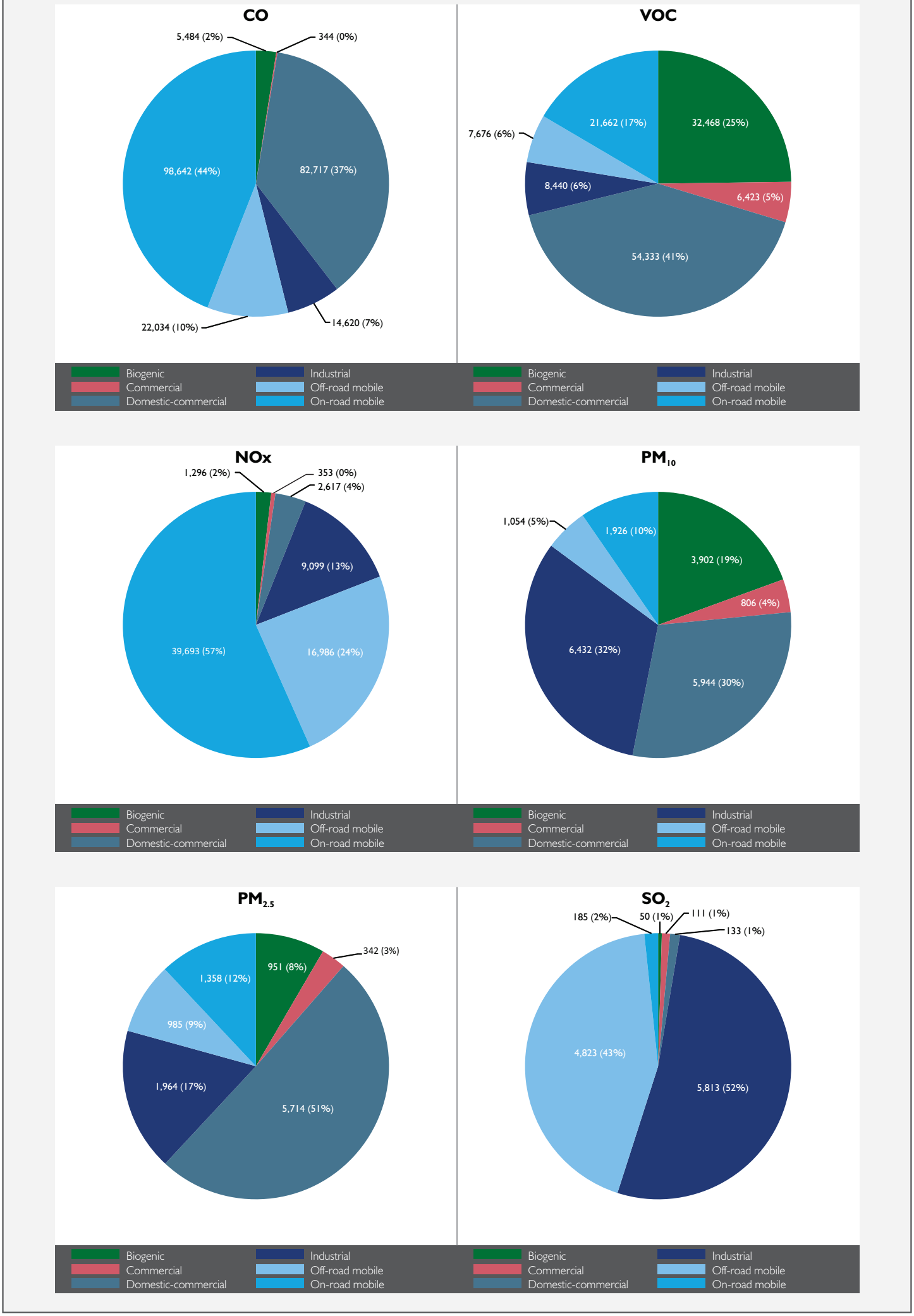


Figure 10-12 Sectoral emissions in Sydney, 2011 (values in tonnes per year and percentage of total)

(blank page)

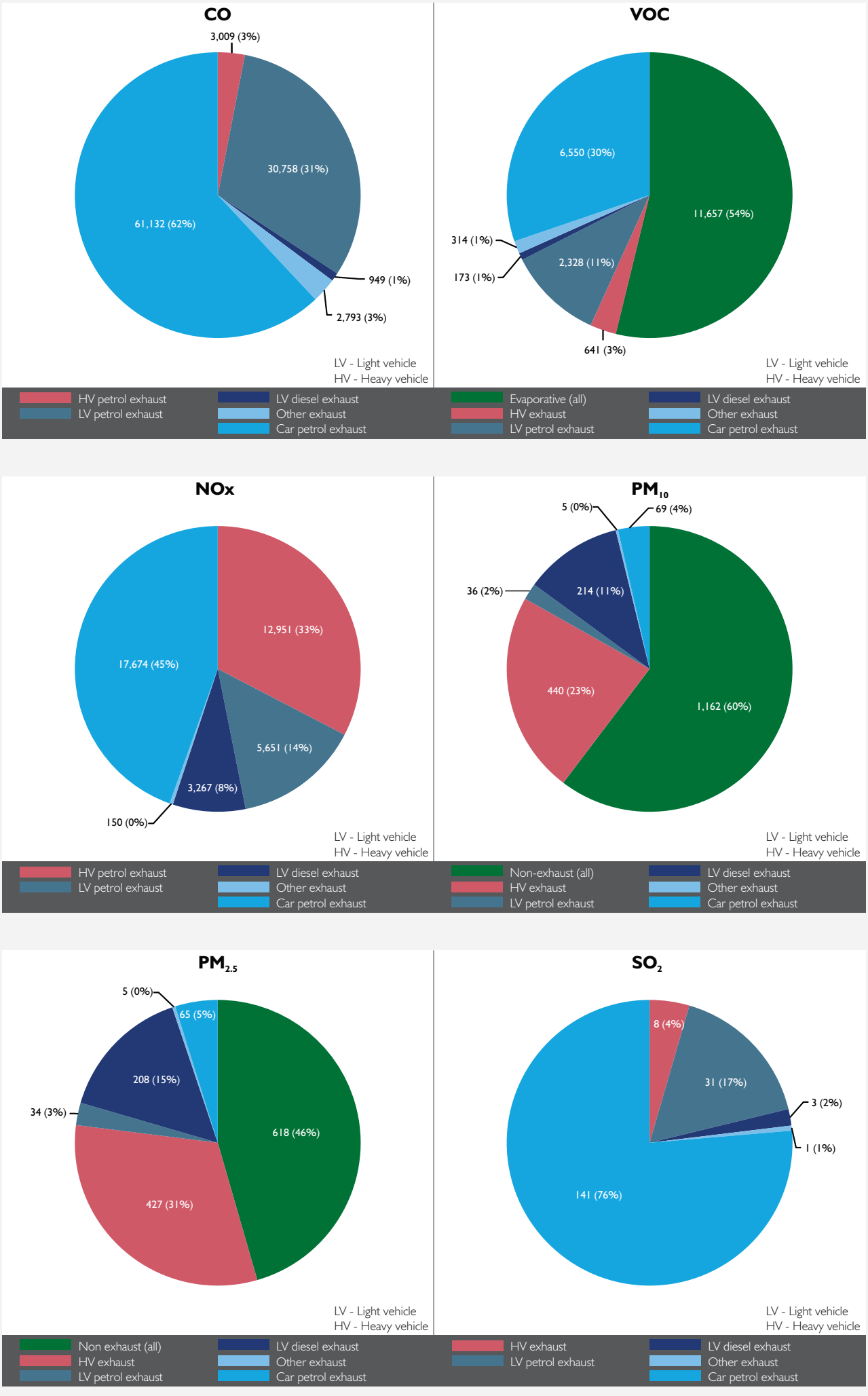


Figure 10-13 Breakdown of road transport emissions - Sydney, 2011 (values in tonnes per year and percentage of total)

(blank page)



Figure 10-14 Future projections of sectoral emissions - Sydney, 2011 - 2036

(blank page)



Figure 10-15 Future projections of road transport emissions - Sydney, 2011 - 2036

(blank page)

10.5.5 General characteristics of Sydney air quality

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 decreased, and the last exceedance of the air quality standard for CO in NSW was recorded in 1998 (NSW Department of Environment, Climate Change and Water (DECCW), 2009 and 2010).

While levels of NO_2, SO_2 and CO continue to be below national standards, levels of ozone and particulate matter (PM_{10} and $PM_{2.5}$) sometimes exceed the standards.

Ozone and particulate matter 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 (OEH, 2015a).

10.5.6 Data from existing monitoring sites in the study area

A detailed analysis of historical trends (2004−2014) and the current state of Sydney's air quality is provided in Appendix F of the Technical working paper: Air quality in **Appendix H**. The analysis was based on data from multiple long-term monitoring stations operated by OEH and Roads and Maritime, as well as from monitoring stations established more recently and specifically for the project. The data from the monitoring sites were also used to identify appropriate background concentrations of pollutants for the project assessment.

The data for specific air quality metrics during the period 2004−2014 can be summarised as follows:

- Maximum one-hour and rolling eight-hour mean CO concentrations
  - All maximum CO values were well below the air quality criteria of 30 mg/m^3 (one-hour) and 10 mg/m^3 (eight-hour)
  - There was a general downward trend in concentrations, but it was not statistically significant at any site
- Annual mean NO_2 concentrations
  - Concentrations of NO_2 at all sites were well below the NSW air quality criterion of 62 µg/m^3. Values at the OEH monitoring sites exhibited a systematic, and generally significant, downward trend. However, in recent years the concentrations at some sites appear to have stabilised. At the Roads and Maritime monitoring sites there was no significant downward trend
  - The average NO_2 concentrations at the roadside monitoring sites were 34-37 µg/m^3, and therefore around 10-15 µg/m^3 higher than those at monitoring sites away from roads. Even so, the NO_2 concentrations at roadside monitoring sites were also well below the assessment criterion
- Maximum one-hour NO_2 concentrations
  - Although variable, maximum NO_2 concentrations have remained largely stable over time and the values at all monitoring sites continue to be below the NSW air quality criterion of 246 µg/m^3
  - The maximum one-hour mean NO_2 concentrations at the Roads and Maritime roadside monitoring sites in 2014 were 115 µg/m^3 and 122 µg/m^3 respectively. These values are similar to the higher maximum values recorded at monitoring sites away from roads

- Annual mean PM_{10} concentrations
  - Concentrations at the OEH monitoring sites showed a downward trend between 2004 and 2014, but this was only statistically significant at two sites. In recent years the annual mean concentration at the OEH sites has been between 17 µg/m^3 and 20 µg/m^3, except at Lindfield where the concentration is substantially lower (around 14 µg/m^3). The concentration at the Roads and Maritime background monitoring sites appears to have stabilised at around 15 µg/m^3. These values can be compared with an air quality criterion of 30 µg/m^3
- Maximum 24-hour PM_{10} concentrations
  - Maximum 24-hour PM_{10} concentrations exhibited a slight downward trend, but there was significant variability in data from year to year. In 2014 the concentrations at the various monitoring sites were around 40 µg/m^3, but the large between-site variation in recent years suggests that this clustering would be unlikely to continue into the future
- Annual mean $PM_{2.5}$ concentrations
  - $PM_{2.5}$ is only measured at three OEH monitoring sites in the study area. Concentrations at the two OEH sites closest to the project – Chullora and Earlwood − showed a broadly similar pattern, with a systematic reduction between 2004 and 2012 being followed by a substantial increase between 2012 and 2014. The main reason for the increase was a change in the measurement method, which indicated that background $PM_{2.5}$ concentrations in the study area during 2014 were already very close to, or above, the advisory reporting standard in the AAQ NEPM of 8 µg/m^3
- Maximum 24-hour $PM_{2.5}$ concentrations
  - There has been no systematic trend in the maximum 24-hour $PM_{2.5}$ concentration based on data from OEH and Roads and Maritime monitoring stations. As with the annual mean $PM_{2.5}$ concentration, the maximum one-hour concentrations are very close to, or above, the advisory reporting standard in the AAQ NEPM of 25 µg/m^3.

10.5.7 Project-specific monitoring

There are seven air quality monitoring stations in the New M5 GRAL domain to support the development and assessment of the project. The monitoring stations were designed to supplement the existing OEH and Roads and Maritime stations, to establish the representativeness of the data from these sites, and to provide long-term air quality data in the vicinity of the project. The locations of the monitoring stations were determined with consideration given to a number of criteria. Three stations are located at urban background sites and four stations are located to characterise population exposure near busy roads.

All monitoring stations are listed in **Table 10-19**. Further details are provided in Appendix F of the Technical working paper: Air quality in **Appendix H**.

Table 10-19 Air quality monitoring stations

Authority	Project	Location	Site type	Period covered
OEH	N/A	Southern Sydney TAFE, Worth Street, Chullora	Urban background	2004-2014
		Beaman Park, Earlwood	Urban background	2004-2014
		Bradfield Road, Lindfield	Urban background	2004-2014
		Rose Street, Liverpool	Urban background	2004-2014
		William Lawson Park, Prospect	Urban background	2004-2014
		Randwick Barracks, Randwick	Urban background	2004-2014
		Rozelle Hospital, Rozelle	Urban background	2004-2014

Authority	Project	Location	Site type	Period covered
Roads and Maritime	M5 East tunnel	Gipps Street, Bardwell Valley	Urban background[(a)]	2008-2013
		Thompson Street, Turrella	Urban background[(a)]	2008-2013
		Jackson Place, Undercliffe	Urban background[(a)]	2008-2013
		Wavell Parade, Earlwood	Urban background[(a)]	2008-2013
		Flat Rock Rd, Kingsgrove (M5 East Freeway)	Peak (roadside)[(b)]	2008-2013
		M5 East tunnel portal	Peak (roadside)[(b)]	2008-2013
	NorthConnex	Headen Sports Park	Urban background	Dec 2013 to Jan 2015
		Rainbow Farm Reserve	Urban background	Dec 2013 to Jan 2015
		James Park	Urban background	Dec 2013 to Jan 2015
		Observatory Park	Peak (roadside)	Dec 2013 to Jan 2015
		Brickpit Park	Peak (roadside)	Dec 2013 to Jan 2015
	Lane Cove Tunnel	Longueville Road/ Epping Road	Peak (roadside)	Oct 2008 to Nov 2009
Sydney Motorway Corporation	WestConnex M4 East	Wattle Street, Haberfield	Peak (roadside)	Aug 2014 to Apr 2015
		Edward Street, Concord	Peak (near-road)[(c)]	Sep 2014 to Apr 2015
		Bill Boyce Reserve, Homebush	Peak (near-road)[(c)]	Sep 2014 to Apr 2015
		Concord Oval, Concord	Peak (roadside)	Nov 2014 to Apr 2015
		St Lukes Park, Concord	Urban background	Nov 2014 to Apr 2015
	WestConnex New M5	St Peters Public School, Church St, St Peters	Urban Background	Aug 2015
		Princes Highway, St Peters	Peak (roadside)	Jul 2015 to Aug 2015
		West Botany St, Arncliffe	Peak (roadside)	Jul 2015 to Aug 2015
		Bestic St, Rockdale	Urban Background	Jul 2015 to Aug 2015
		Bexley Rd, Kingsgrove	Peak (roadside)	Jul 2015 to Aug 2015
		Beverley Hills Park, Beverley Hills	Urban Background	Jul 2015 to Aug 2015
		Canal Rd, St Peters	Peak (roadside / industrial)	Jul 2015 to Aug 2015

(a) These sites were established to characterise air quality in the vicinity of the M5 East tunnel ventilation outlets, but are effectively at urban background locations.
(b) These sites were established to characterise air quality in the vicinity of the M5 East tunnel portals.
(c) Due to practical constraints at this location, the monitoring site is some distance from the closest major road (M4 motorway). Nevertheless, the monitoring station should adequately characterise exposure to air pollution at nearby properties.

10.6 Assessment of air quality impacts during construction

An assessment of construction impacts on air quality was undertaken in accordance with the procedure described in **Section 10.1**. A risk based assessment is provided in the Technical working paper: Air quality in **Appendix H**. The following sections discuss the potential impacts on air quality during construction as identified through this assessment.

10.6.1 Significance of risks

For all construction activity, the aim is to prevent significant effects on receivers through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual impacts will normally be 'not significant' (IAQM, 2014).

However, even with a rigorous Construction Air Quality Management Plan 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 receiver 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 would be 'not significant'.

There are unlikely to be any construction projects of this magnitude occurring concurrently with this project in the immediate vicinity. As such, cumulative impacts due to dust from construction are unlikely.

10.7 Assessment of air quality impacts during Alexandria Landfill closure

10.7.1 Dust assessment

This section presents the results for the particulate matter concentrations and dust deposition rates predicted due to proposed activities as part of the landfill closure. The model predictions already incorporate dust mitigation measures including watering of unsealed haul routes, keeping travel routes moist for dozers and graders onsite and watering of exposed areas that are likely to be prone to wind erosion such as unseeded temporary stockpiles.

For the annual averages, model predictions were added to the background estimates listed in **Section 10.3.1** and the total cumulative concentrations are presented in Figure 8-5 to Figure 8-10 in the Technical working paper: Air quality in **Appendix H**.

The predicted concentrations due to the closure and remediation works are low and even when added to existing concentrations will remain below their relevant air quality criteria. The exceptions to this are annual average $PM_{2.5}$ and 24-hour average PM_{10} at a single receiver to the south of the landfill boundary (Figure 8-6 in the Technical working paper: Air quality in **Appendix H)**.

In the case of annual average $PM_{2.5}$, existing levels are already estimated to be at the criterion of 8 $\mu g/m^3$. The estimated contribution from the closure works at the nearest receivers is less than 0.5 $\mu g/m^3$ and is based on activities occurring across the entire site continuously, 24-hours per day every day of the year. This is considered an overestimation and would not happen in practice.

The other potential exceedance relates to cumulative 24-hour PM_{10} in the industrial area on the southern boundary. Again, this is unlikely to be an exceedance in reality. The maximum predicted 24-hour PM_{10} concentration due to operations at the landfill closure site is approximately 10-20 $\mu g/m^3$ in that area. To exceed the criterion, this modelled maximum would need to occur on the same day as the conservative background of 40 $\mu g/m^3$. This is considered conservative as the maximum prediction is based on all activities occurring at the maximum rate on all days of the year.

In terms of predicted off-site dust concentrations due to activities at the landfill closure site, it is unlikely that any further dust mitigation measures would be required, other than those already set out in the Landfill Closure Management Plan.

10.7.2 Odour assessment

This section provides the modelled results for the predicted odour concentrations as a result of activities as part of the proposed landfill closure works. The results presented in **Figure 10-16** show that the predicted 99th percentile odour concentrations at most of the nearest receivers are below 1 OU, the theoretical level of detection. For all but one of the off-site receivers, the NSW EPA odour criterion of 2 OU (99th percentile) would not be exceeded.

There is the chance of some industrial receivers at the southern boundary of the landfill site experiencing odour levels of up to 7 OU and therefore some occupants may experience occasional; odour annoyance. However, the modelling has assumed that large areas of the whole site would be exposed continuously which is unlikely to be the case. Daily cover would be applied to exposed areas as part of the odour management plan which would significantly reduce impacts to receivers near site.

(blank page)



Figure 10-16 Predicted 99th percentile odour concentration due to landfill closure works – waste excavation and leachate management

(blank page)

10.8 Assessment of air quality impacts during operation

10.8.1 In-tunnel air quality

Air quality is monitored continuously in all of Sydney's major road tunnels, with monitors installed along the length of each tunnel. These typically measure CO and visibility, and are specially designed for use in road tunnels where access for routine essential maintenance is restricted by the need to minimise traffic disruption. While these instruments typically only have a coarse resolution, more precise instrumentation has been installed in the ventilation outlets of some tunnels, with measurements including PM_{10}, $PM_{2.5}$, NO_X and NO_2. Some of the data from these instruments are available on the web sites of the tunnel operators of the Lane Cove and Cross City Tunnels. Measurements from those tunnels were used to inform the air quality assessment for this project.

In-tunnel traffic, airflow, vehicle emissions concentrations and tunnel air temperature for the project and for the future M4–M5 Link were modelled using the IDA Tunnel software. The data used in the tunnel ventilation simulation, and the results of the simulation, are provided in full in Appendix L of the Technical working paper: Air quality in **Appendix H**.

The three pollutants assessed for in-tunnel air quality were NO_2, CO and $PM_{2.5}$ (exhaust only, as visibility). For the operating years of the project, NO_2 will be the pollutant that determines the required airflow and drives the design of ventilation for in-tunnel pollution. The NSW Department of Planning and Environment issued a report that included discussion on this topic for the NorthConnex project in January 2015. From the Secretary's Environmental Assessment Report for the NorthConnex project:

> *"The Department considers that nitrogen dioxide (NO_2) is now the key pollutant of concern for in-tunnel air quality. While carbon monoxide has historically been the basis for in-tunnel criteria in NSW and internationally, improvements in modern vehicle technology mean that NorthConnex will comply with existing health based carbon monoxide standards. By contrast, vehicle emissions of NO_2 have fallen less quickly, and uptake of diesel vehicles (which produce more NO_2 than petrol based vehicles) has risen……..Accordingly, it is recommended that the Proponent's design criteria for NO_2 of 0.5 ppm (averaged over 15 minutes) be applied as an average across the tunnel under all operating conditions."*

Because most urban road tunnels, including WestConnex, have portals higher than the general tunnel, pollutant generation is higher when climbing toward the exit, biasing the exposure towards the end of the tunnel trip. This means that the average level is somewhat less than half the peak level near the exit. With an average NO_2 limit of 0.5 ppm, a peak limit of 1.0 ppm is used, acknowledging that it will generally be slightly conservative.

The results for the 2021-DS, 2031-DS and 2031-DSC scenarios are presented in **Figure 10-17**. These plots, which show the diurnal change in the peak in-tunnel value, confirm that the tunnel ventilation system would be designed to maintain in-tunnel air quality well within operational limits.

The maximum in-tunnel concentrations across all time periods for the expected traffic scenarios, the capacity traffic scenarios and the worst case regulatory assessment are presented in **Table 10-20**. The maximum concentrations for all traffic scenarios, including worst-case conditions, were within the concentrations associated with the regulatory worst case.

(blank page)

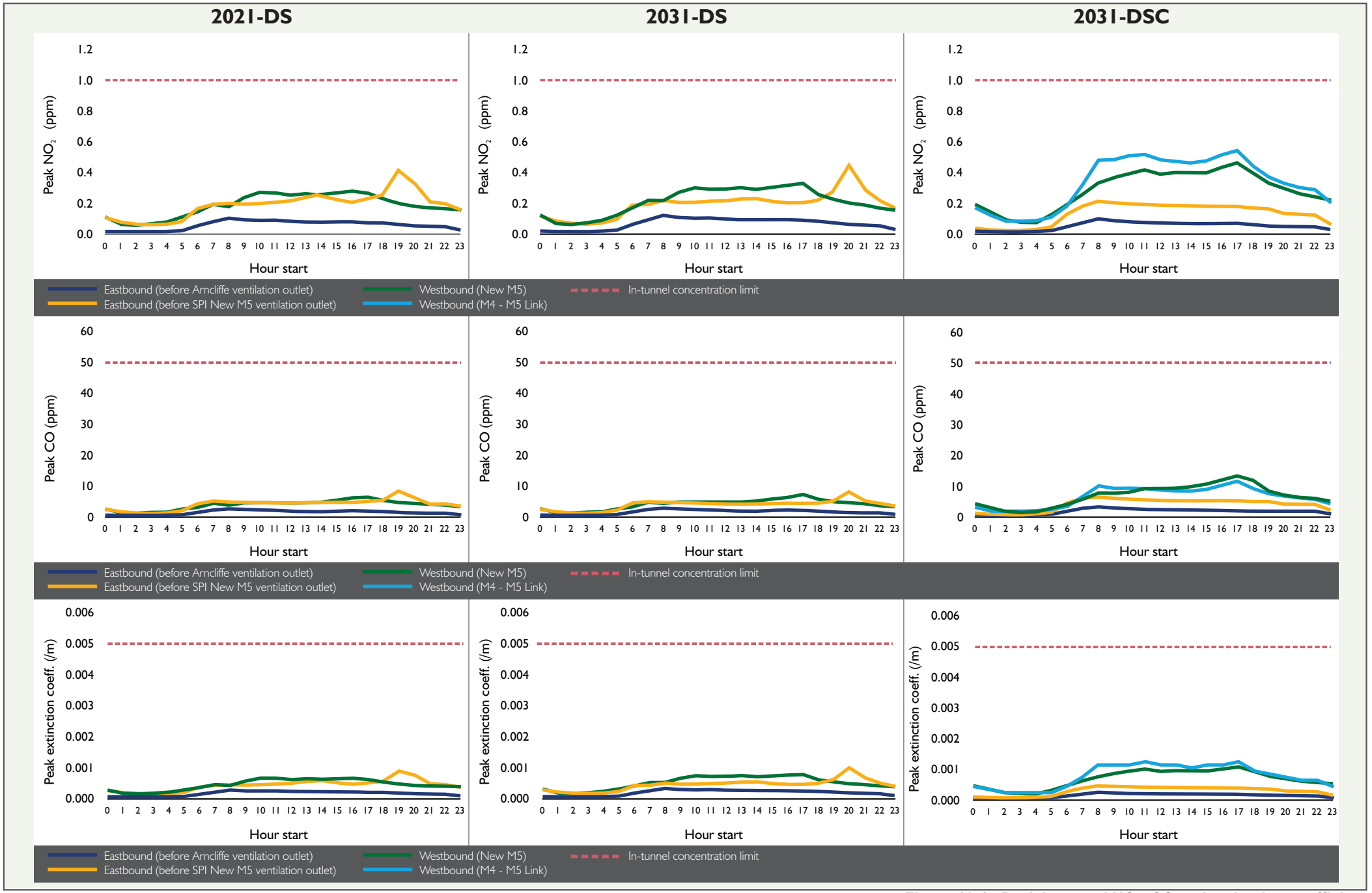


Figure 10-17 Peak in-tunnel NO_2, CO and extinction coefficient

(blank page)

Table 10-20 Maximum in-tunnel concentrations for all scenarios

Scenario		Maximum in-tunnel concentration					
		NO_2 (ppm)[(b)]		CO (ppm)[(c)]		$PM_{2.5}$ (mg/m^3)	
		East-bound	West-bound	East-bound	West-bound	East-bound	West-bound
Expected traffic	2021-DS	0.41	0.27	7.99	5.99	0.42	0.38
	2031-DS	0.46	0.32	8.33	6.87	0.5	0.47
	2031-DSC	0.38	0.53	7.15	12.97	0.53	0.8
Capacity traffic	2021-DS	n/a	n/a	n/a	n/a	n/a	n/a
	2031-DS	n/a	n/a	n/a	n/a	n/a	n/a
	2031-DSC	0.52	0.66	9.73	14.84	0.75	0.96
Regulatory worst case[(a)]		**1.07**	**1.07**	**35.0**	**35.0**	**1.1**	**1.1**

(a) CO and NO_2 volume concentrations estimated for a temperature of 25°C.

(b) 1 ppm NO_2 is equivalent to 2.03 mg/m^3

(c) 1 ppm CO is equivalent to 1.23 mg/m^3

10.8.2 Assessment of ambient air quality impacts

Surface roads

Comparing total vehicle emissions with and without the project has been used to assess the air quality impacts of the project at a regional level. Total emissions were calculated for all surface roads included in the WRTM for the WestConnex GRAL domain.

The emissions in the WestConnex GRAL domain, in tonnes per year, are shown in **Table 10-21** and the changes in emissions are shown in **Table 10-22**. For the pollutants NO_X and PM_{10}, the net effects of the project on total emissions in 2021 and 2031 were small. In the cumulative case for 2031 there would be an increase in emissions of NO_X and PM_{10} of around 1.6 and two per cent respectively. The effects of the project on emissions were similar to the projected reductions in emissions with time. For example, between 2014 and 2031, NO_X emissions without the project were projected to decrease by 55 per cent, which is similar to the decrease for the 2014 and 2031 NO_X emissions with the project.

Table 10-21 Total emissions in the WestConnex GRAL domain

Scenario code	Scenario description	Total VKT[(a)] per day (million vehicle-km)	Total emissions (tonnes/year)				
			CO	NO_x	PM_{10}	$PM_{2.5}$	THC
2014-BY	2014 - Base Year (existing conditions)	14.5	15,240	6,581	322	234	1,542
2021-DM	2021 - Do Minimum (no New M5)	15.7	9,025	4,068	278	182	934
2021-DS	2021 - Do Something (with New M5)	15.8	9,196	4,056	275	180	940
2031-DM	2031 - Do Minimum (no New M5)	17.6	6,102	2,963	288	179	598
2031-DS	2031 - Do Something (with New M5)	17.7	6,253	2,925	285	176	599
2031-DSC	2031 - Do Something Cumulative (with New M5 and future M4-M5 Link)	19.1	6,582	3,010	294	182	585

(a) VKT = vehicle kilometres travelled

Table 10-22 Changes in total emissions in the WestConnex model domain

Scenario comparison	Change in total emissions (per cent)				
	CO	NO_x	PM_{10}	$PM_{2.5}$	THC
Do Minimum (without project) scenarios					
2021-DM vs 2014-BY	-40.8	-38.2	-13.7	-22.4	-39.4
2031-DM vs 2014-BY	-60.0	-55.0	-10.4	-23.6	-61.2
Do Something (with project) scenarios					
2021-DS vs 2021-DM	+1.9	-0.3	-0.9	-0.8	+0.7
2031-DS vs 2031-DM	+2.5	-1.3	-1.0	-1.2	+0.3
2031-DSC vs 2031-DM	+7.9	+1.6	+2.0	+1.9	-2.2

Regional air quality can also be measured in terms of a change in the capacity for ozone production. The NSW EPA has recently developed a Tiered Procedure for Estimating Ground Level Ozone Impacts from Stationary Sources (ENVIRON, 2011). While this does not relate specifically to road projects, it gives an emission threshold for NO_X and VOCs of 90 tonnes / year for new sources, above which projects should proceed to a detailed modelling assessment for ozone. The changes in emissions associated with this project were well below this threshold.

For example, in 2021 there was a projected decrease in NO_X emissions for the assessed road network of around 12 tonnes per year. This value also equates to a tiny proportion of anthropogenic NO_X emissions in the Sydney airshed in 2016 (around 53,700 tonnes). It was therefore concluded that as well as being below the emission threshold for NO_X and VOCs of 90 tonnes/year for new sources, the regional impacts of the project would be negligible, and undetectable in ambient air quality measurements at background locations.

No emission modelling was required for the regulatory worst case scenarios, as the emissions from the ventilation outlets were simply determined by the outlet concentration limits.

New M5 tunnel ventilation outlets

The tunnel would be designed and operated to avoid emissions from the tunnel portals as far as practicable. Elevated ventilation outlets would be designed and constructed as described in **Chapter 5** (Project description) and **Chapter 6** (Construction works). Tunnel ventilation outlets are effective in dispersing emissions from tunnels using the momentum and buoyancy of the plume. A combination of the design height of the outlet and the amount of fresh air mixed with the contaminated air from a tunnel can be used to ensure appropriate dilution and compliance with local air quality standards.

The locations and heights of the New M5 (and future M4-M5 Link) ventilation outlets included in the assessment are given in **Table 10-23**.

Table 10-23 Ventilation outlet locations and heights

Tunnel project	Ventilation facility	Traffic direction	Ventilation outlet	Outlet location (MGA)		Ground elevation (metres)	Outlet height (metres AHD)
				X	Y	Z	
New M5	**A** (Kingsgrove)	WB	KIN-01	323916.00	6242795.00	23	30
	B (Arncliffe)	EB	ARN-01	329446.00	6243283.10	4.0	35
			ARN-02	329453.90	6243289.20	3.5	35
			ARN-03	329450.30	6243276.70	3.7	35
			ARN-04	329458.20	6243283.10	3.2	35
	C (St Peters, New M5)	EB	SPI-01	331340.00	6245650.00	5.3	20
			SPI-02	331346.00	6245655.00	5.2	20
			SPI-03	331334.00	6245656.00	5.1	20
			SPI-04	331340.30	6245661.90	5.4	20
New M5 and future M4-M5 Link	**A** (Kingsgrove)	WB	KIN-01	323916.00	6242795.00	23.0	30
	B (Arncliffe)	EB	ARN-01	329446.00	6243283.10	4.0	35
			ARN-02	329453.90	6243289.20	3.5	35
			ARN-03	329450.30	6243276.70	3.7	35
			ARN-04	329458.20	6243283.10	3.2	35
			ARN-05	329454.20	6243300.00	3.4	35
			ARN-06	329450.30	6243305.10	3.7	35
			ARN-07	329458.00	6243311.30	3.1	35
			ARN-08	329461.80	6243306.00	2.8	35
	C (St Peters, New M5)	EB	SPI-01	331340.00	6245650.00	5.3	20
			SPI-02	331346.00	6245655.00	5.2	20
			SPI-03	331334.00	6245656.00	5.1	20
			SPI-04	331340.30	6245661.90	5.4	20
	D (Southern Extension)	WB	SC-01	329025.00	6240855.00	5.0	20
			SC-02	329031.00	6240860.00	5.0	20
			SC-03	329037.00	6240865.00	5.0	20
			SC-04	329026.00	6240865.00	5.0	20
	E (St Peters, future M4-M5 Link)	WB	SPI-05	331894.00	6245838.00	11.0	20
			SPI-06	331900.00	6245843.00	11.0	20
			SPI-07	331889.00	6245843.00	11.0	20
			SPI-08	331895.00	6245848.00	11.0	20

Emissions from the traffic in the New M5 tunnel were calculated using the emission factors provided in the Permanent International Association of Road Congress (PIARC) *Road Tunnels: Vehicle Emissions and Air Demand for Ventilation* (PIARC, 2012).

Appendix 3, Section 3.1 of the PIARC guidance includes aggregated emission rates for Australian vehicles. These Australia-specific emission rates have recently been used for tunnel ventilation calculations in NSW and they were also used for this project. The three pollutants assessed for tunnel ventilation purposes were NO_2, CO and $PM_{2.5}$.

Some modifications were required to the emission rates of these pollutants for the purpose of dispersion modelling. These modifications involved the following:

- Converting the NO_2 emission rates to the NO_X emission rates required for dispersion modelling
- Estimating emissions of pollutants and metrics not included in the in-tunnel assessment (PM_{10} and THC).

The diurnal profiles of outlet emission rates for each scenario and ventilation outlet are given in Appendix I of the Technical working paper: Air quality in **Appendix H**. The diurnal profiles for the emission rates of CO, NO_X, PM_{10}, $PM_{2.5}$ and THC in the 2021-DS, 2031-DS and 2031-DSC scenarios are shown in **Figure 10-18** and **Figure 10-19**.

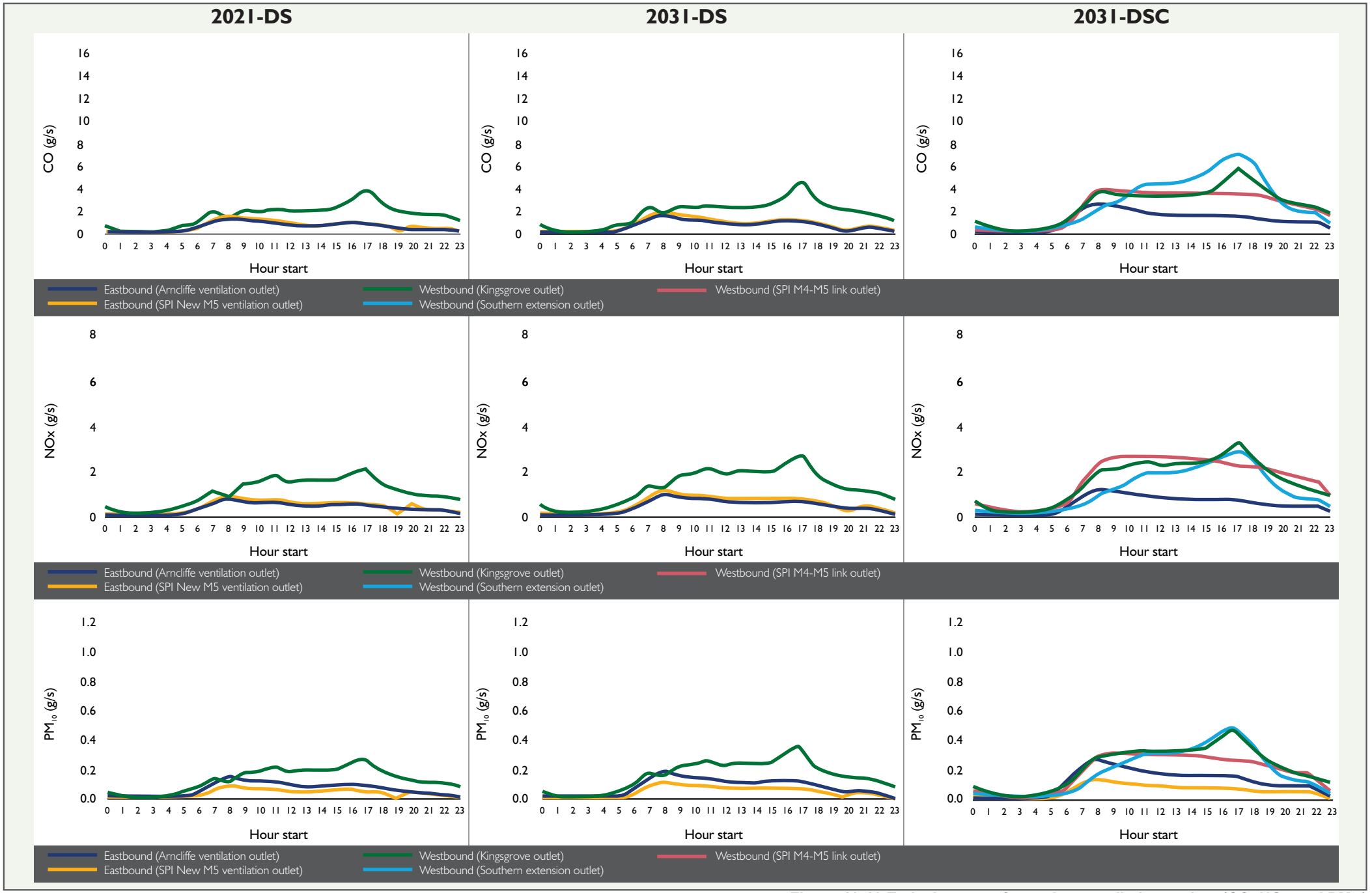


Figure 10-18 Emission rates for project ventilation outlets (CO, NOx and PM_{10})

(blank page)

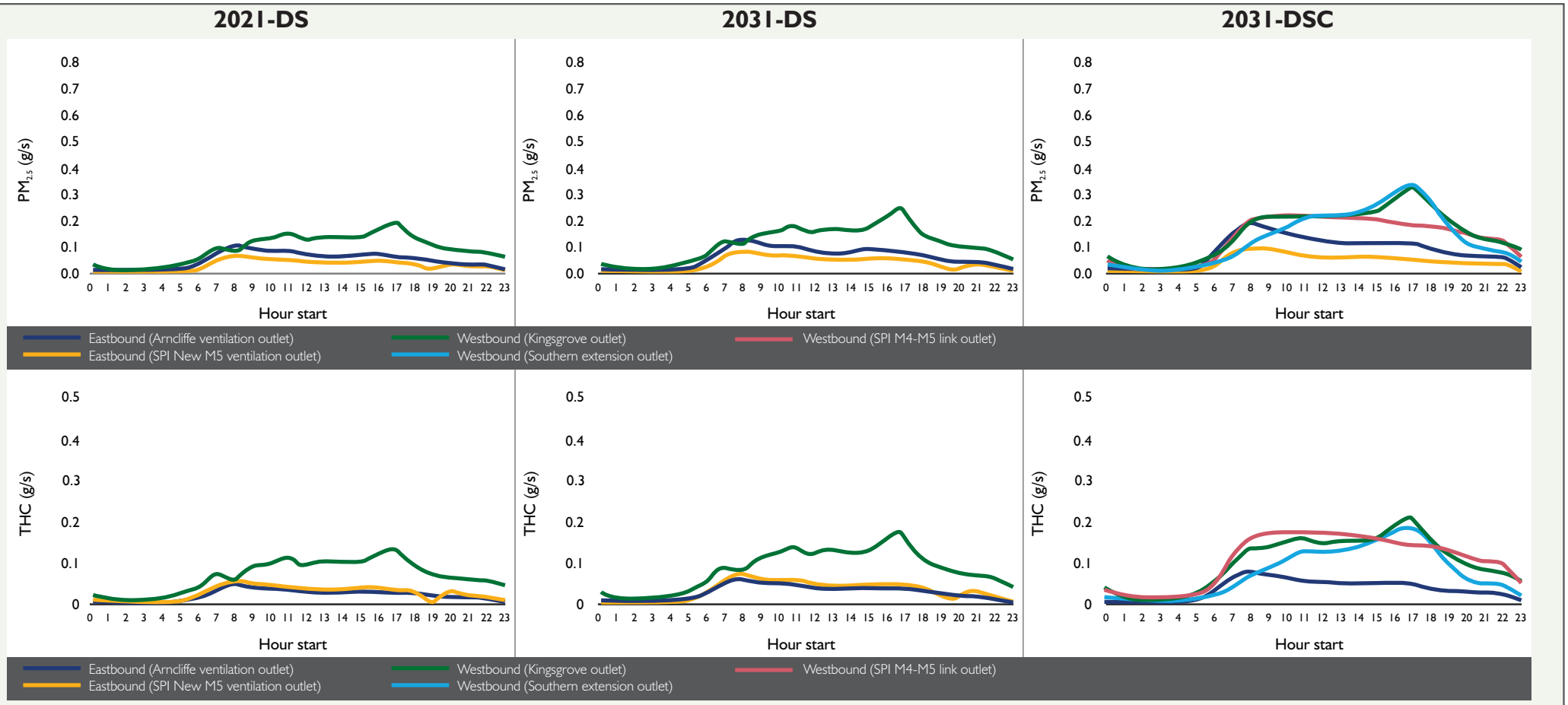


Figure 10-19 Emission rates for project ventilation outlets ($PM_{2.5}$ and THC)

(blank page)

A summary of the results for the regulatory worst case scenario and expected traffic scenario for the 46,219 RWR receivers is presented in **Table 10-24**.

Table 10-24 Results of regulatory worst case assessment (RWR receivers)

Pollutant and period	Units	Maximum ventilation outlet contribution at any receiver				
		Regulatory worst case scenario		Expected traffic scenario		
		RWC-A	RWC-B	2021-DS	2031-DS	2031-DSC
CO (one hour)	(mg/m^3)	0.29	0.33	N/A[(a)]	N/A[(a)]	N/A[(a)]
NO_X (annual)	($\mu g/m^3$)	10.61	13.44	2.48	2.98	2.63
NO_X (1 hour)	($\mu g/m^3$)	146.43	173.34	92.51	120.17	43.45
NO_2 (annual)	($\mu g/m^3$)	1.70[(b)]	2.14[(b)]	0.57	0.75	0.61
NO_2 (1 hour)	($\mu g/m^3$)	23.43[(b)]	27.73[(b)]	14.80[(b)]	19.23[(b)]	6.95[(b)]
PM_{10} (annual)	($\mu g/m^3$)	0.58	0.74	0.11	0.11	0.31
PM_{10} (24 hour)	($\mu g/m^3$)	3.67	4.29	0.54	0.53	1.84
$PM_{2.5}$ (annual)[(c)]	($\mu g/m^3$)	0.58	0.74	0.08	0.07	0.22
$PM_{2.5}$ (24 hour)[(c)]	($\mu g/m^3$)	3.67	4.29	0.39	0.39	1.25
THC (one hour)	($\mu g/m^3$)	30.25	31.64	N/A[(a)]	N/A[(a)]	N/A[(a)]

(a) Not determined
(b) Estimated as 16% of NO_X.
(c) The same emission rates were used for PM_{10} and $PM_{2.5}$.

Emissions from the project ventilation outlets, even in the regulatory worst case scenarios, would be extremely unlikely to result in adverse impacts on local air quality. Roads and Maritime would conduct ambient air quality monitoring to demonstrate that emissions from the ventilation outlets will have no detectable impact on local air quality.

Existing M5 East tunnel ventilation outlet

The ventilation outlet for the M5 East Motorway tunnel was also included as it was within the New M5 GRAL domain. The location and height of the M5 East ventilation outlet is provided in **Table 10-25.**

Table 10-25 M5 East ventilation outlet location and height

Tunnel ventilation outlet	Outlet location (MGA)		Outlet height (m)
	x	y	
M5 East	328204.2	6244290.1	35

Emissions of NO_X, CO, PM_{10} and $PM_{2.5}$ from the M5 East tunnel were calculated using hourly in-stack concentration and air flow measurements for 2014 supplied by Roads and Maritime. Emission scaling factors for the future years (2021 and 2031) were developed using the NSW EPA emission model and typical tunnel traffic. The emission rates are summarised in **Table 10-26**. As with the project ventilation outlets, two separate source groups were defined to reflect different air flow regimes, and hourly 'modulation factors' (ratios relative to the average) were used in GRAL to replicate the variation in emissions within each time period. Seasonal variation in emissions was represented using monthly modulation factors.

Table 10-26 Emission rates: existing M5 East outlet

Year	Period (hour start)	Emission rate (kilograms per hour)			
		NO_X	CO	PM_{10}	$PM_{2.5}$
2014	Hours 00-05 and 22-23	6.31	32.89	0.14	0.07
	Hours 06-21	20.39	74.21	0.84	0.63
2021	Hours 00-05 and 22-23	3.52	22.13	0.10	0.04
	Hours 06-21	11.65	40.48	0.67	0.45
2031	Hours 00-05 and 22-23	2.41	18.08	0.10	0.04
	Hours 06-21	7.95	27.01	0.63	0.40

10.8.3 Carbon monoxide (maximum rolling eight-hour mean)

Results for community receivers

Figure 10-20 shows the maximum rolling eight-hour mean CO concentrations at community receivers with the project in 2021 and 2031. The maximum background value was combined with the maximum model prediction at each receiver. The background was therefore taken to be the same at all locations. As with the one-hour mean (refer to Section 9.5.1 of the Technical working paper: Air quality in **Appendix H**), at all the receivers the concentration was well below the NSW impact assessment criterion, which in this case is 10 µg/m^3.

The main contributor at these receivers in the 2021-'Do something' scenario was the background concentration (**Figure 10-21**). The surface road contribution ranged from eight per cent to 25 per cent, whereas the tunnel ventilation outlet contribution was less than one per cent.

Figure 10-22 shows that the change in the maximum rolling eight-hour CO concentration at all the community receivers was less than 0.4 mg/m^3. The largest increase was around 0.1 mg/m^3.

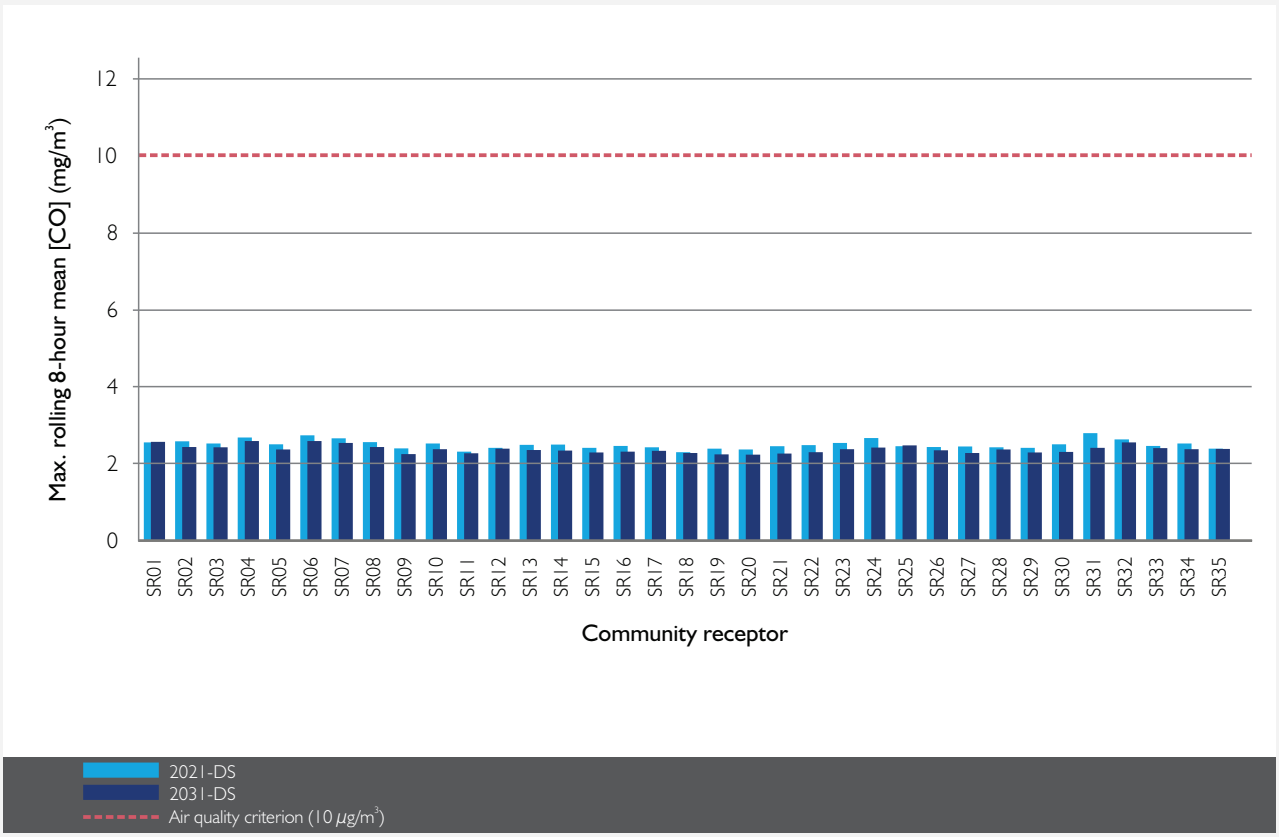


Figure 10-20 Maximum rolling 8-hour mean CO at community receivers (2021-DS and 2031-DS)

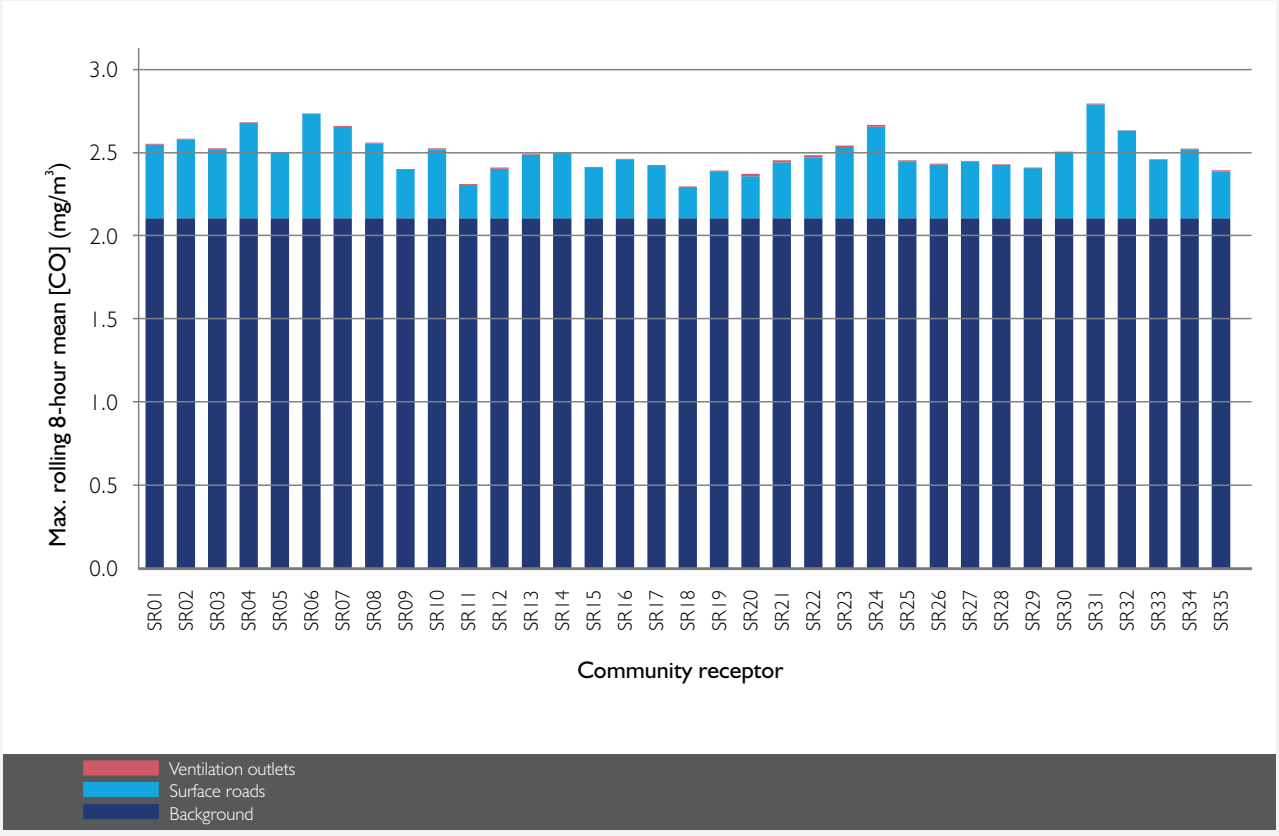


Figure 10-21 Source contributions to maximum rolling 8-hour mean CO at community receivers (2021-DS)

(blank page)

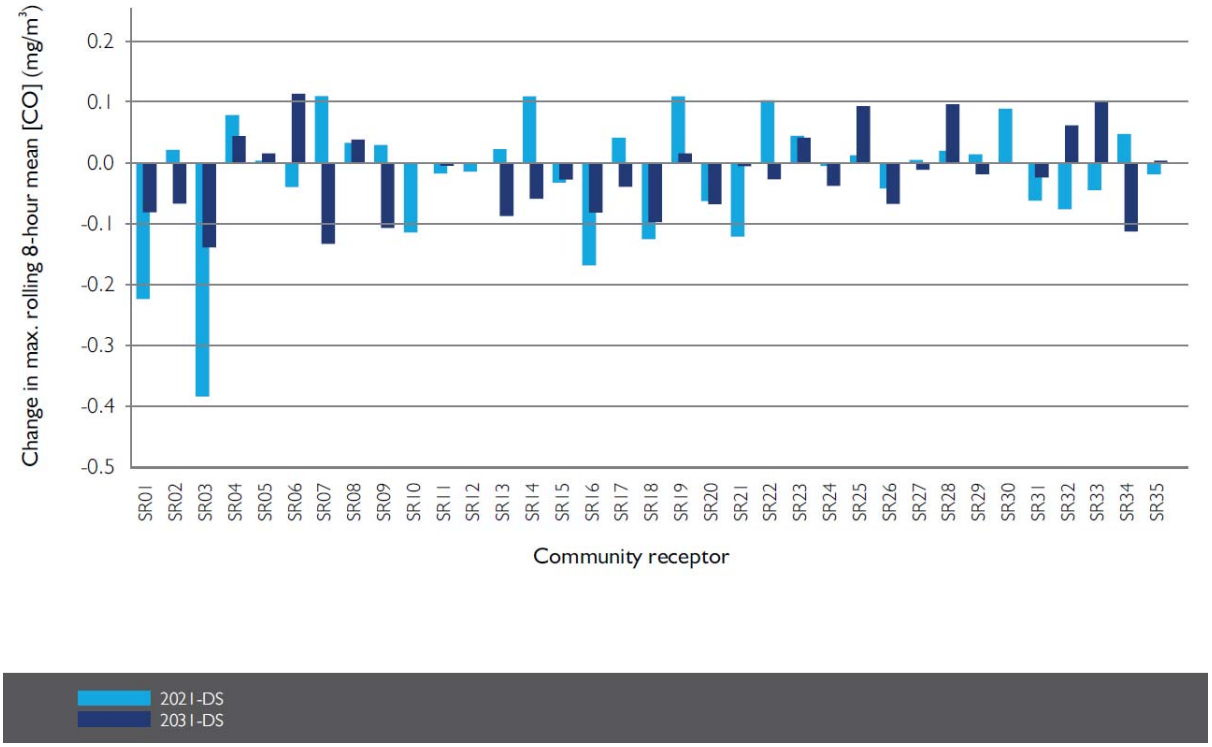


Figure 10-22 Change in maximum rolling 8-hour mean CO at community receivers (2021-DS and 2031-DS)

Results for residential, workplace and recreational (RWR) receivers

Rolling eight-hour mean CO concentrations were not extracted from GRAL as these would be broadly similar to those obtained for maximum one-hour concentrations.

10.8.4 Nitrogen dioxide (annual mean)

Results for community receivers

Figure 10-23 shows the annual mean NO_2 concentrations at the 35 community receivers with the project in 2021 and 2031. At all these receiver locations the concentration was below 35 µg/m^3 and therefore well below the NSW impact assessment criterion of 62 µg/m^3.



Figure 10-23 Annual mean NO_2 at community receivers (2021-DS and 2031-DS)

Figure 10-24 presents the source contributions to total annual mean NO_2 concentrations in the 2021-DS scenario.

The source contributions were estimated using a 'cumulative' approach as described in Section 9.5.3 of the Technical working paper: Air quality in **Appendix H**. The results indicate that the background air quality at these receivers is likely to responsible for, on average, around 80 per cent of the predicted annual mean NO_2, with most of the remainder being due to surface roads. Surface roads were responsible for between 12 per cent and 30 per cent of the total NO_2 in 2021, depending on the receiver. The contribution of tunnel ventilation outlets was less than 1.3 per cent.

Figure 10-25 shows the changes in concentration in the do something (ie with the project) scenarios relative to the do minimum scenarios (without the project) for community receivers. There was a small increase in NO_2 concentration at some receivers (generally <1 µg/m^3), although at some locations there were larger reductions. The largest reduction for these community receivers was around 2.7 µg/m^3 in 2021 and was predicted to occur at receiver SR13 (Kingsgrove World of Learning).

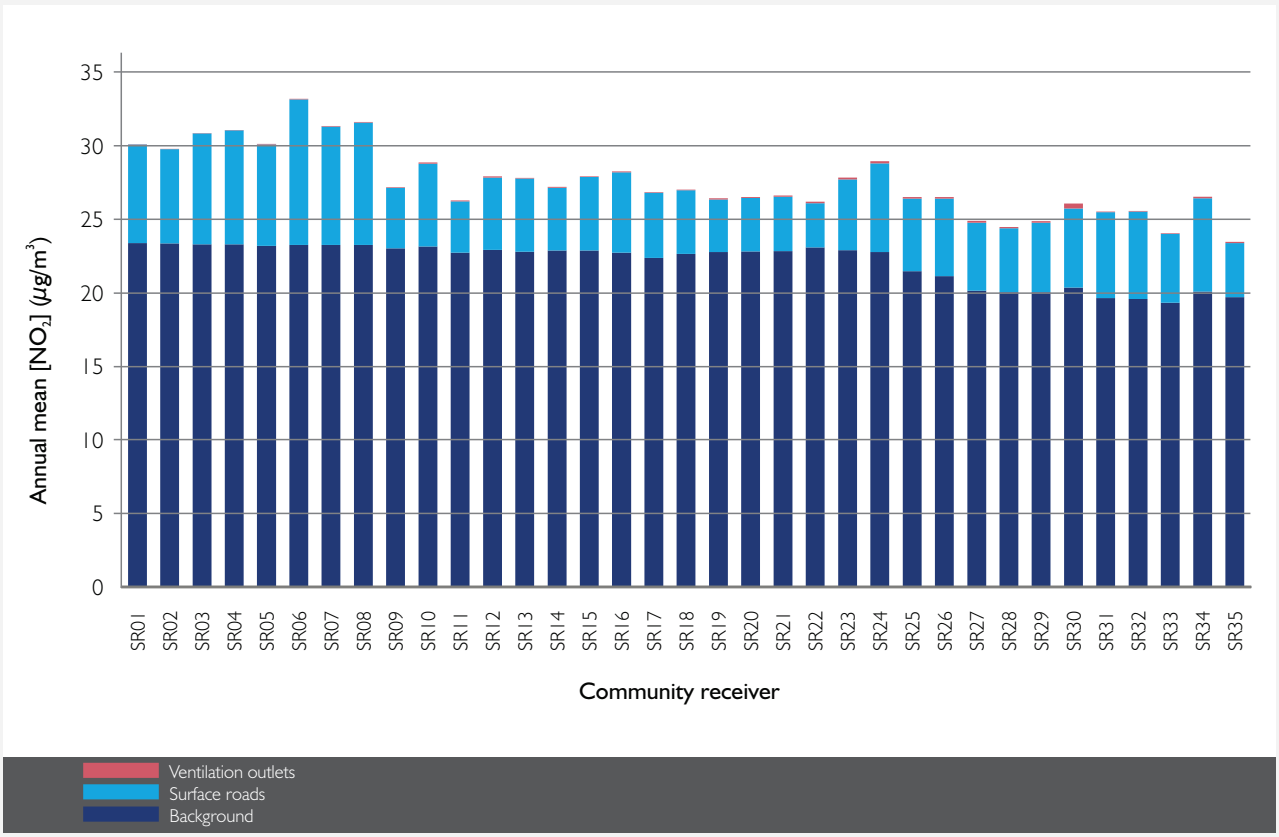


Figure 10-24 Source contributions to annual mean NO_2 at community receiver (2021-DS)

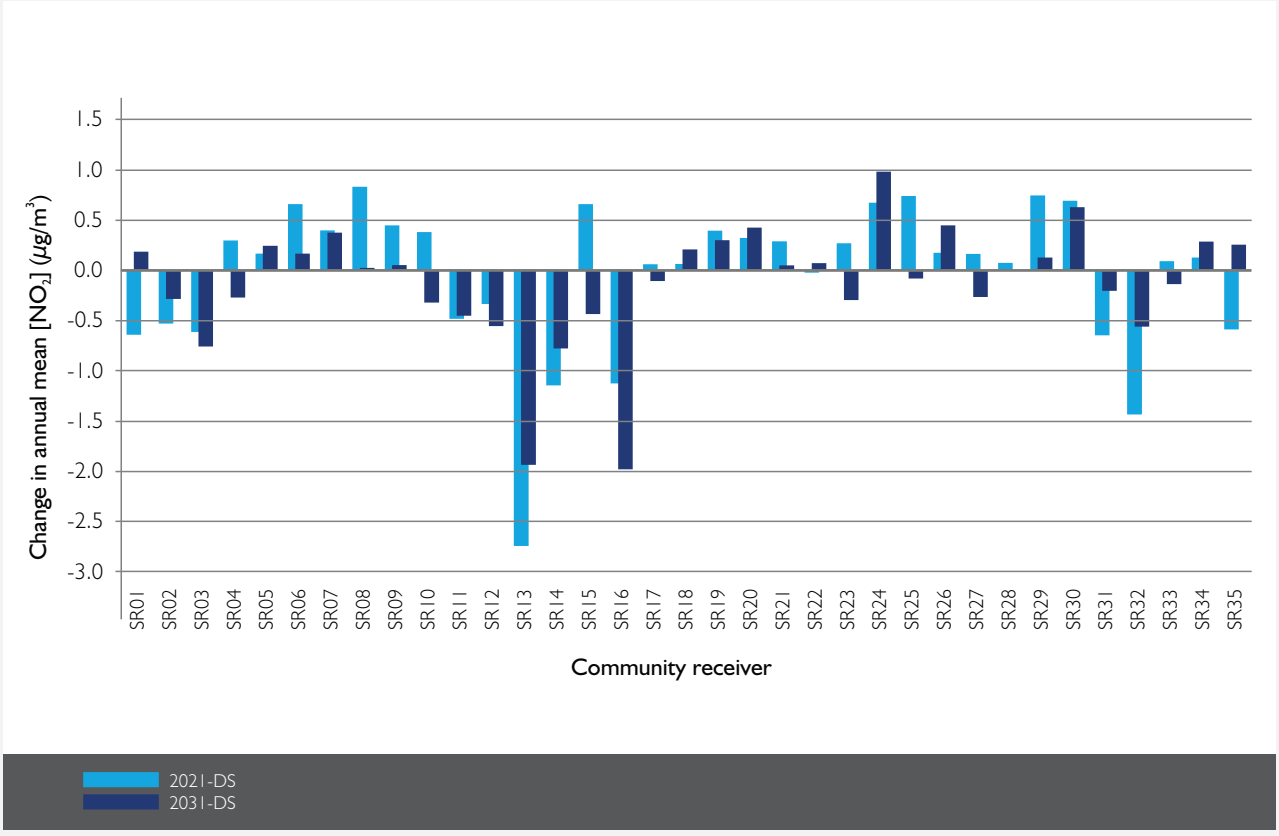


Figure 10-25 Change in annual mean NO_2 at community receiver (2021-DS and 2031-DS)

(blank page)

Results for residential, workplace and recreational (RWR) receivers

The modelled annual mean NO_2 criterion for NSW was not exceeded at any of the 46,219 RWR receivers in any scenario. In 2021 and 2031, the highest concentrations under the 'do something' scenario were predicted to be 43.0 µg/m^3 and 39.8 µg/m^3 respectively. The maximum annual mean NO_2 concentration in the cumulative case (2031-DSC) was 36.8 µg/m^3.

The annual mean NO_2 concentrations at the RWR receivers in the 2021-do something scenario are shown, with a ranking by total concentration, in **Figure 10-26**. Concentrations at the majority (more than 95 per cent) of receivers were between around 23 µg/m^3 and 32 µg/m^3. As noted above, all concentrations were well below the assessment criterion of 62 µg/m^3. The maximum contribution of tunnel ventilation outlets at any location in the 2021-do something scenario was 0.6 µg/m^3, whereas the surface road contribution ranged between 2.2 µg/m^3 and 19.8 µg/m^3. The corresponding values for the 2031-do something scenarios were 0.7 µg/m^3 for the maximum contribution of tunnel ventilation outlets and a range of 1.4 µg/m^3 and 16.6 µg/m^3 for the surface road contribution.

The changes in the annual mean NO_2 concentration at the RWR receivers in the 2021-DS scenario (relative to the 2021-DM scenario) are shown, ranked by change in concentration, in **Figure 10-27**. There was predicted to be an increase in the annual mean NO_2 concentration at 62 per cent of receivers, and a decrease at 38 per cent, in 2021 as a result of the project. Whilst the largest increase was 5.5 µg/m^3, less than one per cent of receivers would experience an increase greater than 2 µg/m^3.

The annual mean NO_2 concentrations, and the changes in the annual mean, in the 2031-DS scenario are given in Appendix K of the Technical working paper: Air quality in **Appendix H**. These closely resemble the results for 2021, with the largest increase in concentration in 2031 being 4.0 µg/m^3.

(blank page)

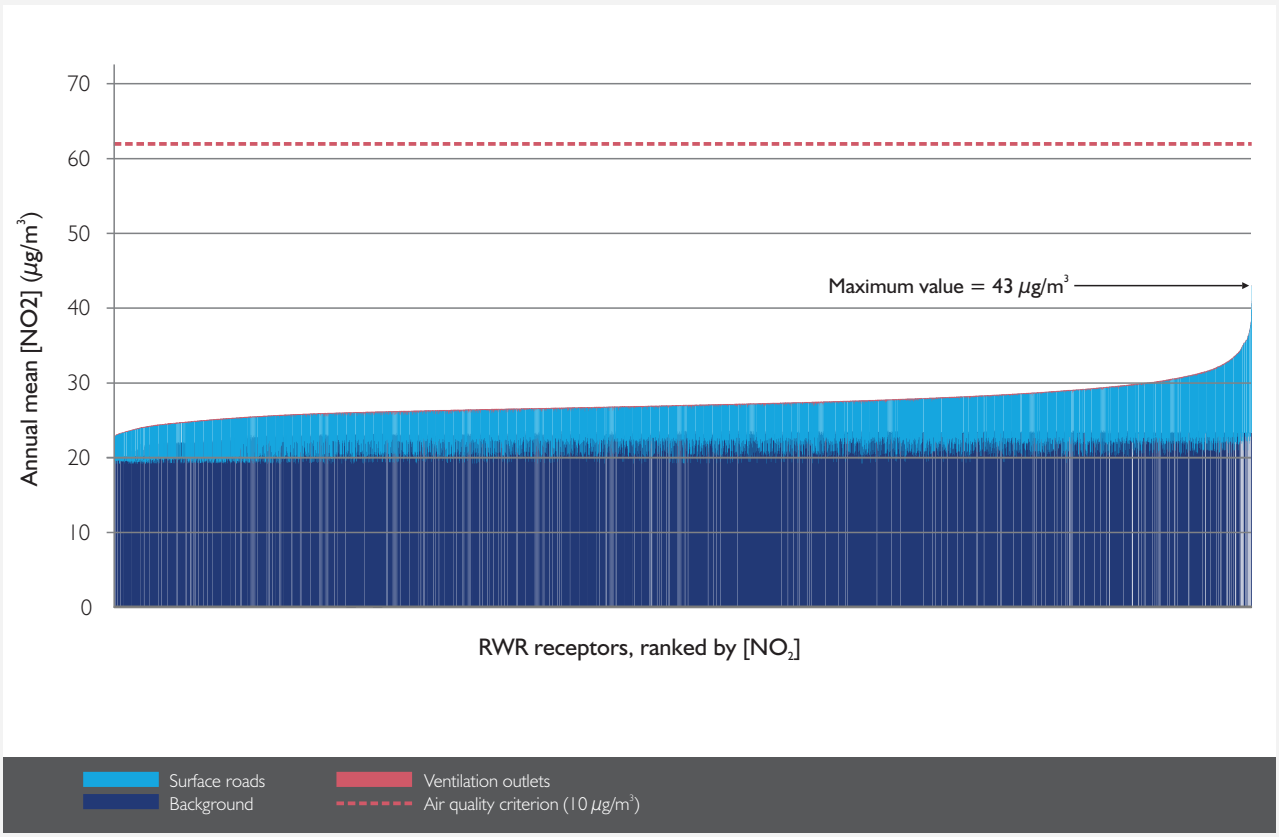


Figure 10-26 Source contributions to annual mean NO_2 at RWR receptors (2021-DS)

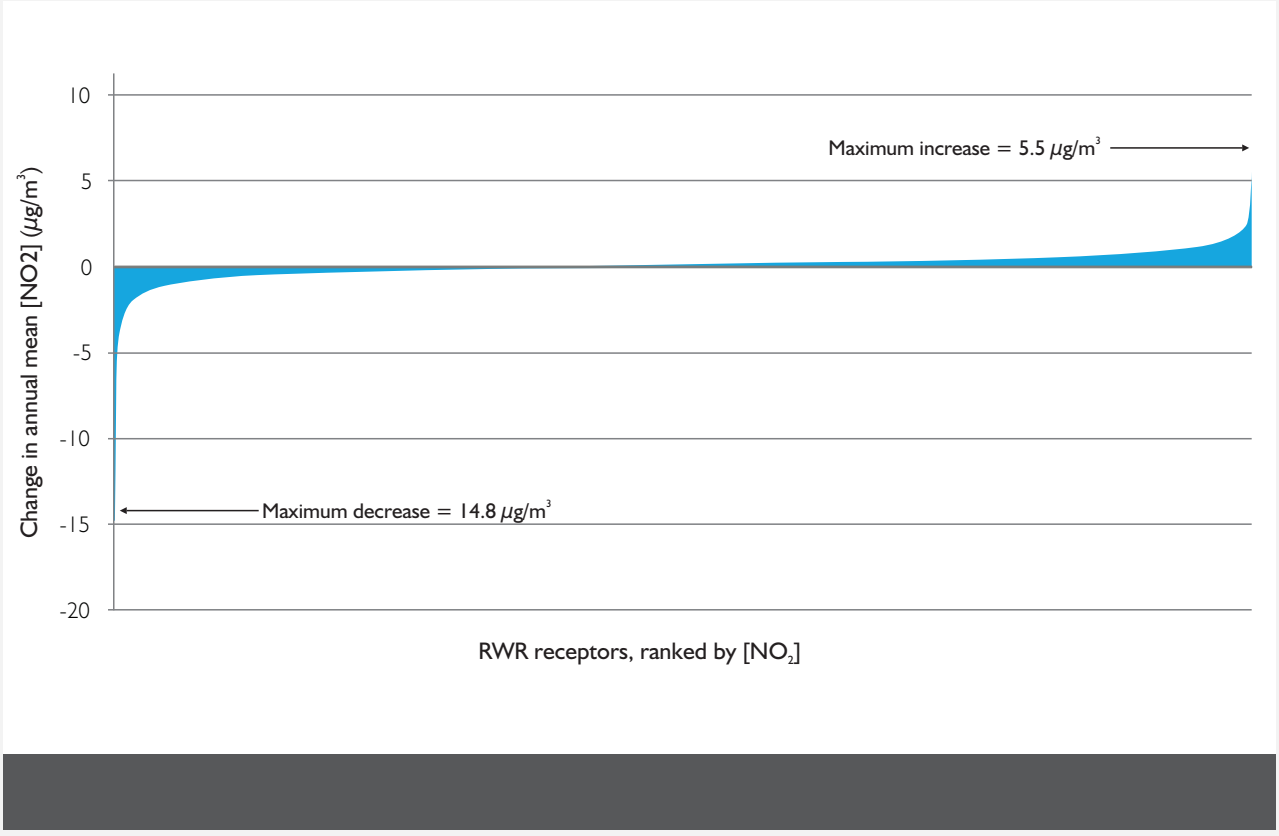


Figure 10-27 Changes in annual mean NO_2 at RWR receptors (2021-DS)

(blank page)

Contour plots

Contour plots showing the spatial distribution of annual mean NO_2 concentrations across the New M5 GRAL domain in 2021 are provided for the do minimum case (ie. without the project) in **Figure 10-28**, and for the do something case (ie. with the project) in **Figure 10-29**.

These plots are based on 960,000 data points, spaced at 10 metre intervals across the GRAL domain. Many of the points therefore fall along the axes of roads and are not necessarily representative of population exposure. The maps also show main surface roads and the locations of the project's ventilation facilities.

The contour plots illustrate the strong links between the spatial distribution of air pollution and the traffic on the surface road network. The highest concentrations are found along the most heavily trafficked roads in the New M5 GRAL domain, being the M5 East Motorway, General Holmes Drive and King Georges Road. The M5 East Motorway tunnel is also apparent where there is a 'gap' in concentrations along the east-west axis of the M5 East Motorway. It is also noticeable that the tunnel ventilation outlets have little impact on annual mean NO_2 concentrations, including around the M5 East ventilation outlet.

The contour plot for the change in concentration of NO_2 with the project in 2021 (**Figure 10-30**) shows a fairly complex pattern. The green shading represents a decrease in concentration with the project, and the purple shading an increase in concentration. Changes of less than 2 $\mu g/m^3$ are not shown.

In 2021 under the do something scenario, there are predicted to be substantial reductions in concentration of NO_2 along the M5 East Motorway, both to the east and west of the M5 East Motorway tunnel, as well as along General Holmes Drive and other roads around the airport. In 2021 the New M5 is predicted to have a two-way average weekday traffic of around 29,500 vehicles per day. By comparison, average weekday traffic volumes on the M5 East Motorway under the do something scenario in 2021 are predicted to decrease from about 116,000 and 101,500 vehicles per day to about 69,000 and 81,000 vehicles per day with the project at the western and eastern end of the M5 East respectively. This equates to a 40 per cent and 20 per cent reduction in daily volumes respectively. Reductions in concentrations are also predicted along the section of King Georges Road to the north of the M5 East Motorway, around the northern perimeter of Sydney Park, and on a number of other roads.

Increases in concentration of NO_2 in the 2021 'do something' scenario are predicted for King Georges Road to the south of the M5 East Motorway, Stoney Creek Road, Bexley Road to the south of the M5 East Motorway, Harrow Road, Bay Street, Forest Road, and around the southern perimeter of Sydney Park, amongst other roads. Daily two-way volumes on Stoney Creek Road are predicted to increase by around 35 per cent with the project. This increase reflects the relocation of traffic from the M5 East due to tolling. This relocation would mainly occur in off-peak periods, as the peak hour spare capacity on Stoney Creek Road is limited.

(blank page)



Figure 10-28 Contour plot showing annual mean NO_2 without the project (2021-DM)

(blank page)

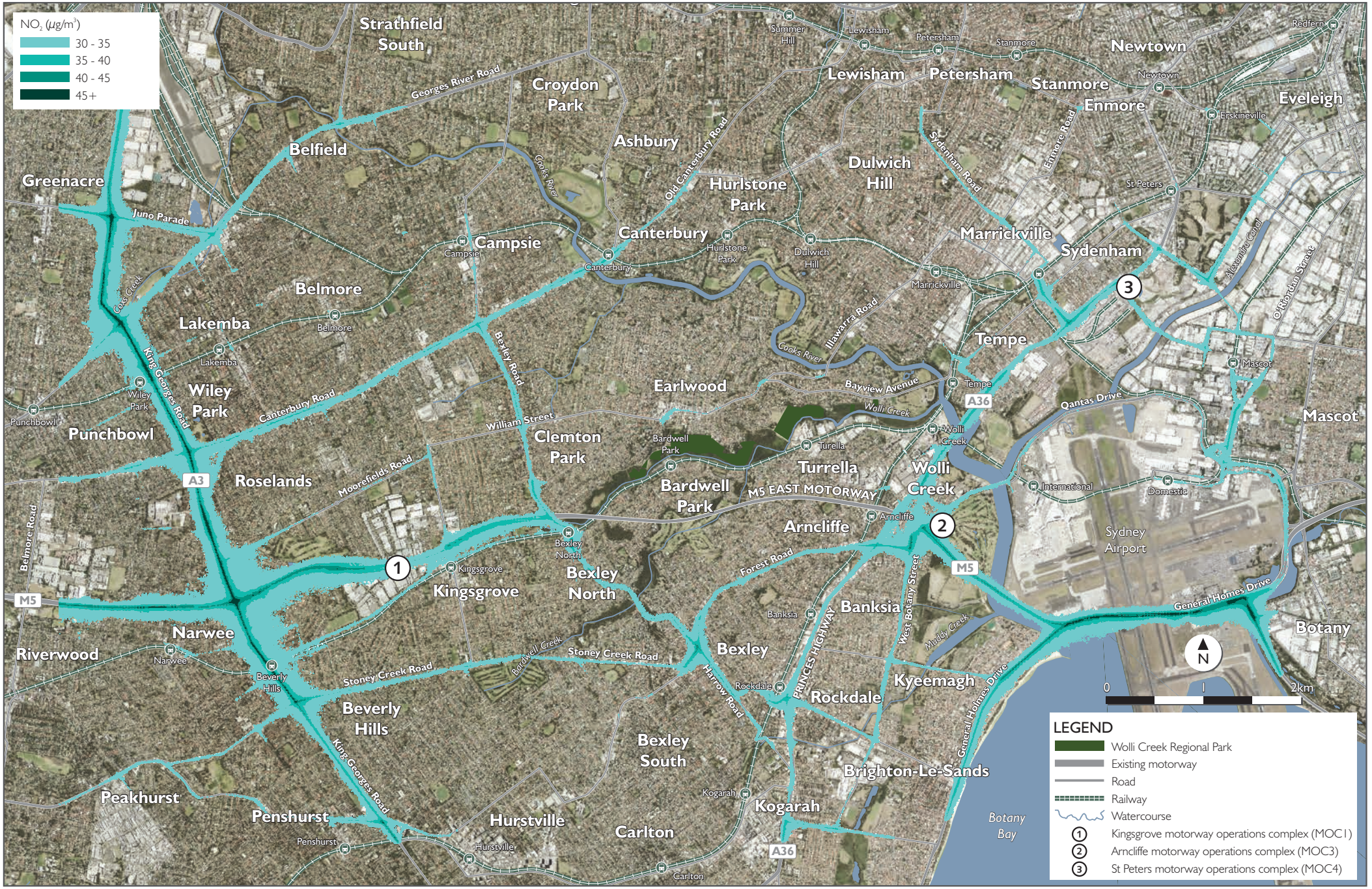


Figure 10-29 Contour plot showing annual mean NO_2 with the project (2021-DS)

(blank page)

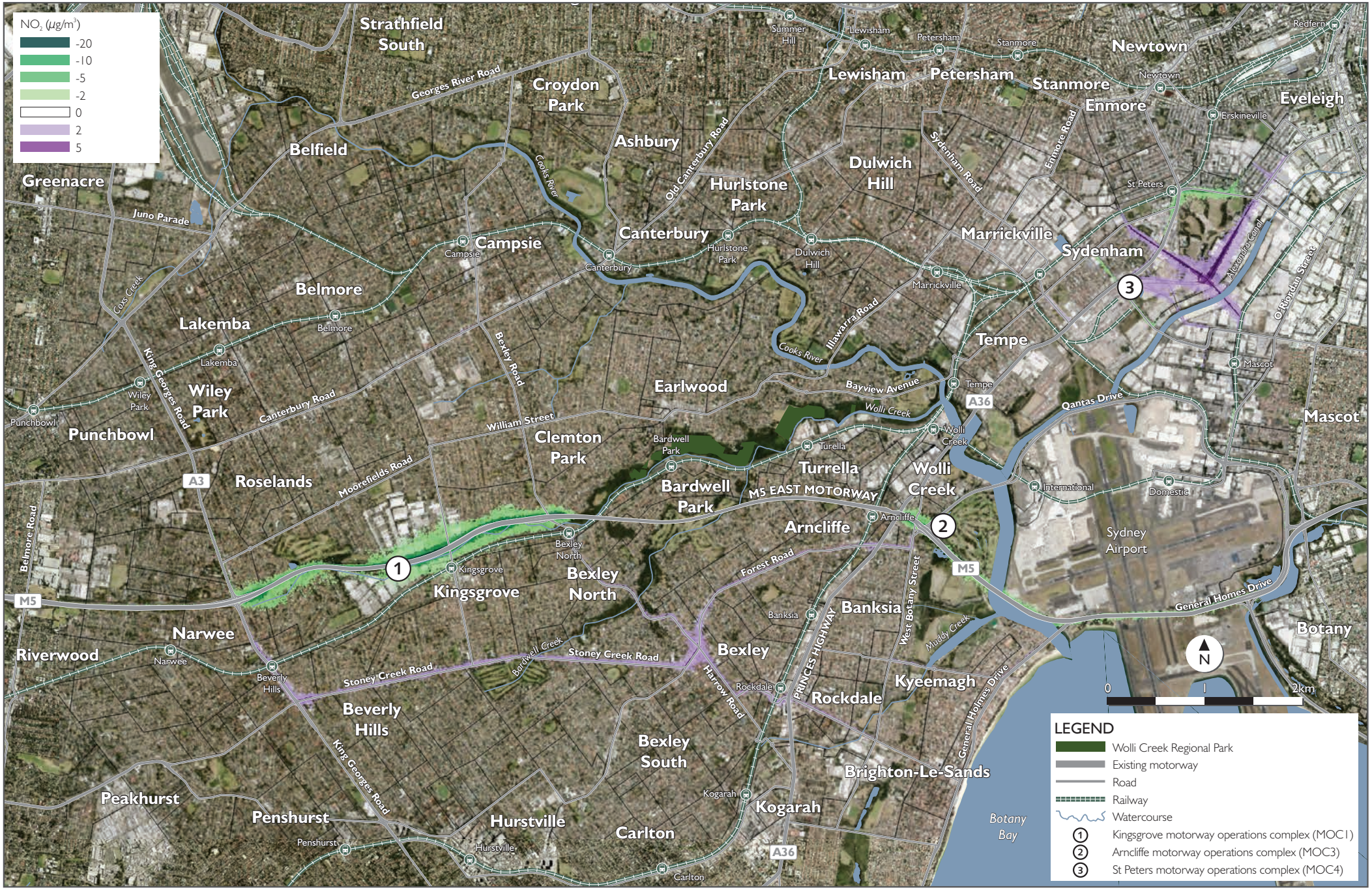


Figure 10-30 Contour plot showing change in annual mean NO_2 with the project (2021-DS)

(blank page)

Contour plots for ventilation outlets only

Contour plots for annual mean NO_X (not NO_2) were also produced for the New M5 ventilation outlets only. These are shown in **Figure 10-31** (Kingsgrove outlet), **Figure 10-32** (Arncliffe outlet) and **Figure 10-33** (St Peters interchange New M5 outlet). The contributions from the surface road network and the background are not included in these plots.

The range of annual NO_X concentrations at each ventilation outlet under the 'do something' scenario in 2021, 2031 and 2031 under the cumulative case is provided in **Table 10-27**. It should be noted that the values across the grid do not necessarily coincide with receiver location, and the ranges of values at actual receivers would be lower.

The NO_X increments from each ventilation outlet were very low and their effects were quite localised. The values in the 2021 'do something' scenario ranged from 0.20 µg/m^3 to 2.2 µg/m^3 (0.20 µg/m^3 to 2.5 µg/m^3 in the 2031 'do something' scenario). The outlet contributions to NO_2 would be even lower and negligible compared with the annual mean criterion of 62 µg/m^3.

Table 10-27 Contribution of project ventilation outlets to annual mean NO_X concentration

Ventilation outlet	Outlet contribution to annual mean NO_x (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.2 - 0.5	0.2 - 0.6	0.2 - 0.6
Arncliffe	0.4 – 1.0	0.4 – 1.0	0.4 - 0.6
St Peters interchange	0.5 – 2.2	0.5 – 2.5	0.5 – 2.5

(blank page)



Figure 10-31 Contour plot showing annual mean NOx for ventilation outlets only (Kingsgrove outlet, 2021-DS)

(blank page)

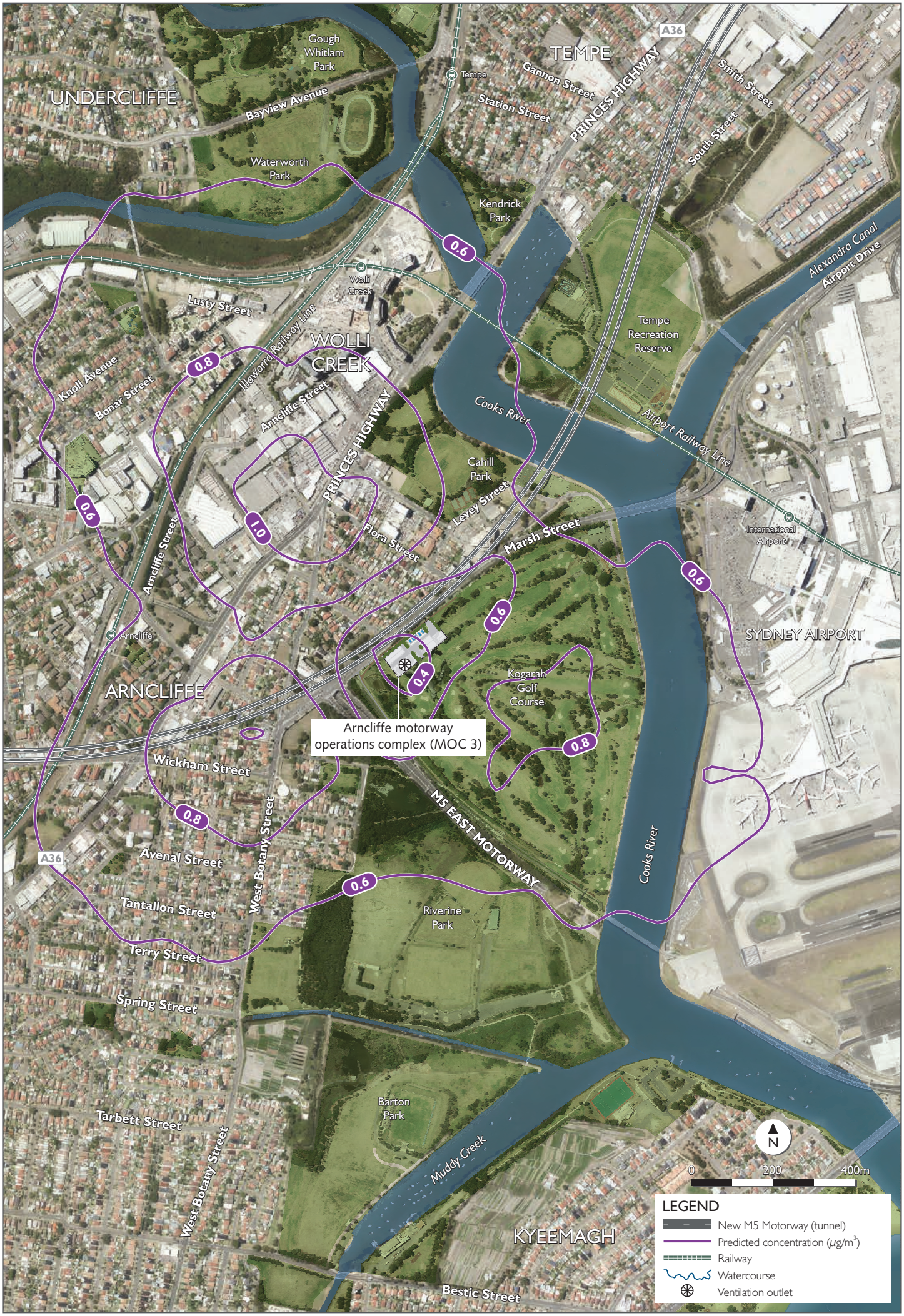


Figure 10-32 Contour plot showing annual mean NOx for ventilation outlets only (Arncliffe outlet 2021-DS)

(blank page)

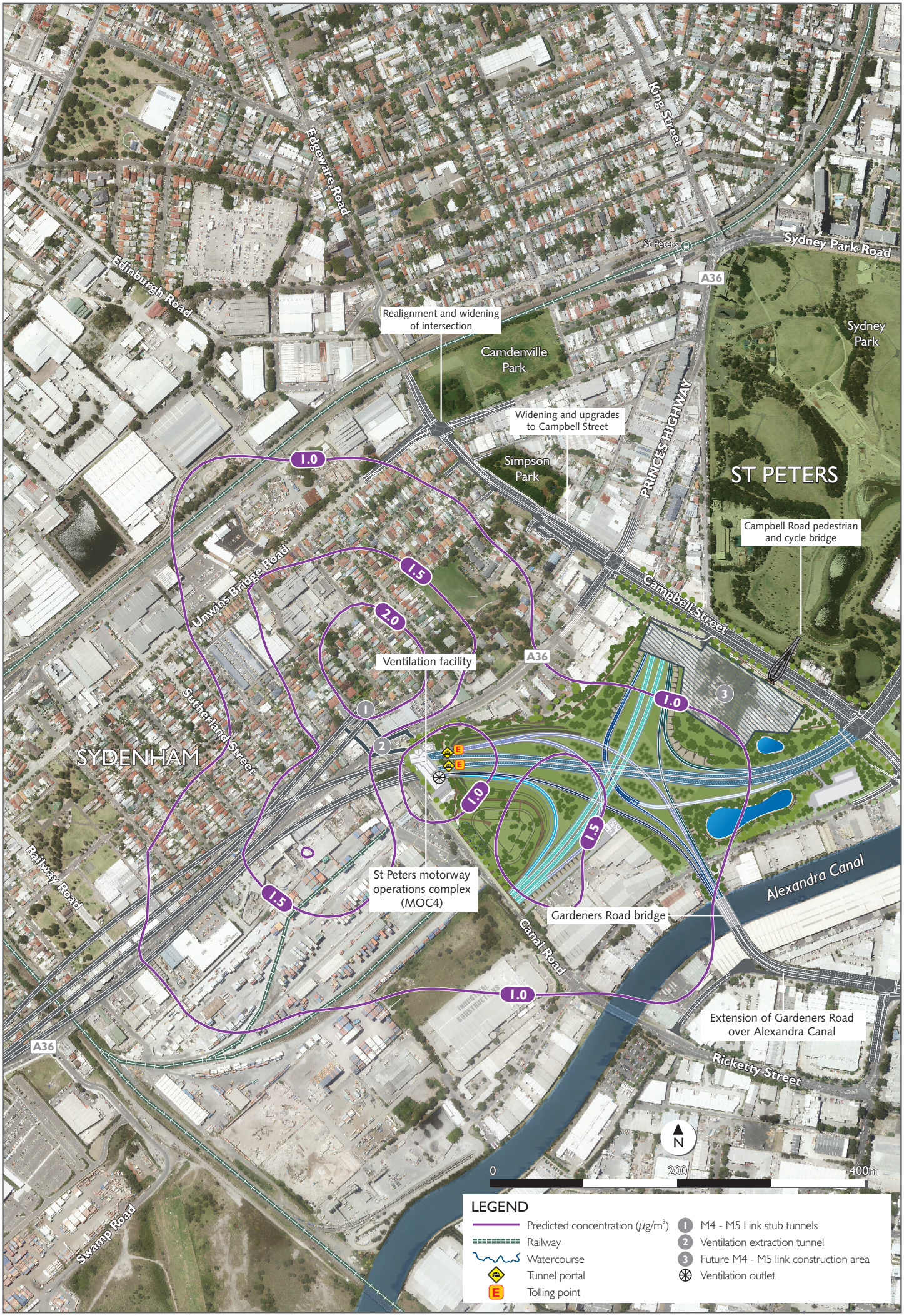


Figure 10-33 Contour plot showing annual mean NOx for ventilation outlets only (SPI outlet, 2021-DS)

(blank page)

10.8.5 PM_{10} (annual mean)

Results for community receivers

The annual mean PM10 concentrations at the 35 community receivers under the 'do something' scenario in 2021 and 2031 are shown in **Figure 10-34**. At all community receivers the concentration was below or equal to 20 µg/m3, and therefore well below the NSW impact assessment criterion of 30 µg/m3. PM10 concentrations at these receivers, which are near busy roads, were mostly lower than the proposed target for NSW of 20 µg/m3.

Concentrations in the 2021 'do something' scenario were again dominated by the background (**Figure 10-35**) with a small contribution from roads (0.9 µg/m3 - 3.1 µg/m3) and a negligible contribution from ventilation outlets.

Figure 10-36 shows the changes in concentration in the 'do something' scenarios relative to the 'do minimum' scenarios for community receivers. The largest increase was around 0.6 µg/m3 and the largest decrease around 0.8 µg/m3.

Results for residential, workplace and recreational (RWR) receivers

The ranked annual mean PM_{10} concentrations at the RWR receivers in the 2021 'do something' scenario are shown in **Figure 10-37**. The concentration at the majority of receivers was below 20 µg/m3 and concentrations at all receivers were well below the NSW assessment criterion of 30 µg/m3.

The highest predicted concentration at any receiver in this scenario was 24.6 µg/m3, but as with other pollutants and metrics the highest values were only predicted for a small proportion of receivers. The surface road contribution was between 1.4 µg/m3 and 7.4 µg/m3. The largest contribution from tunnel ventilation outlets was 0.11 µg/m3 in the 2021 and 2031 'do something' scenarios.

(blank page)

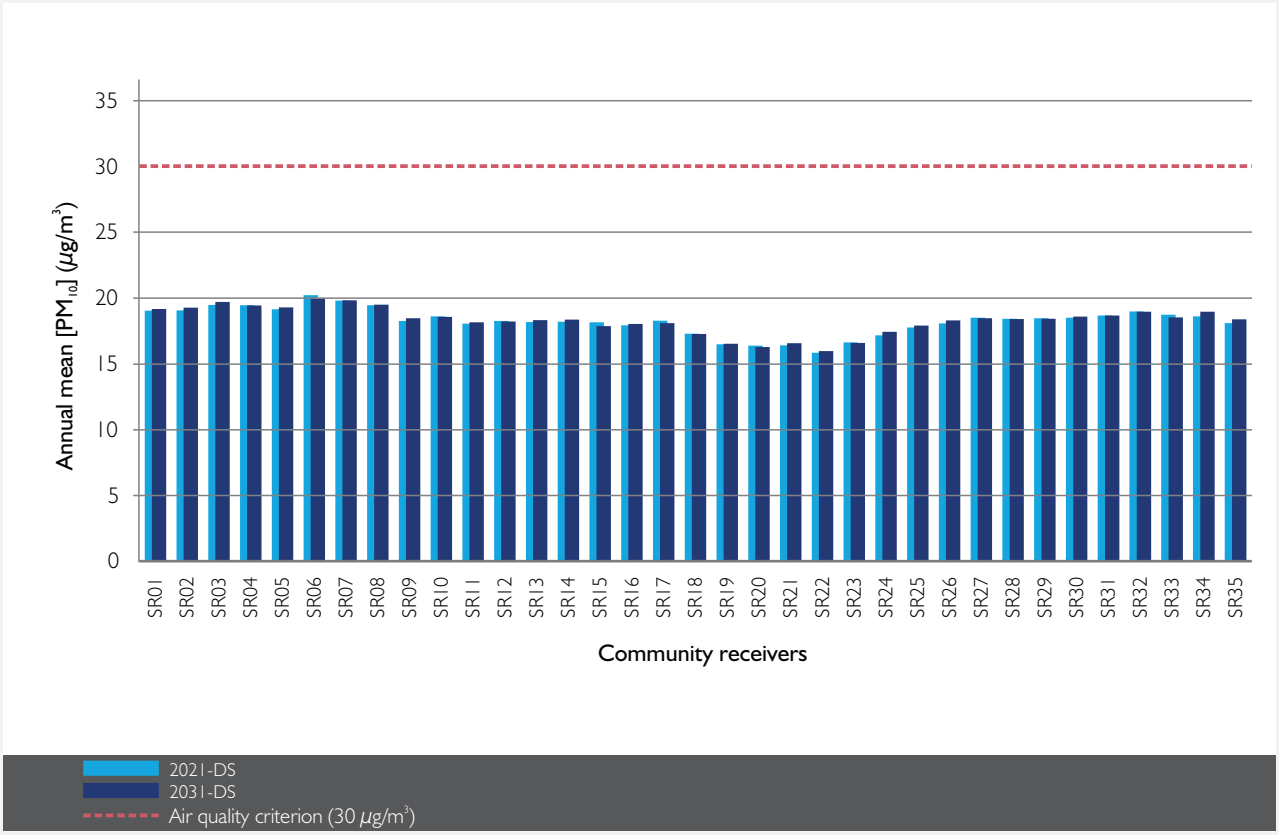


Figure 10-34 Annual mean PM_{10} at community receivers (2021-DS and 2031-DS)

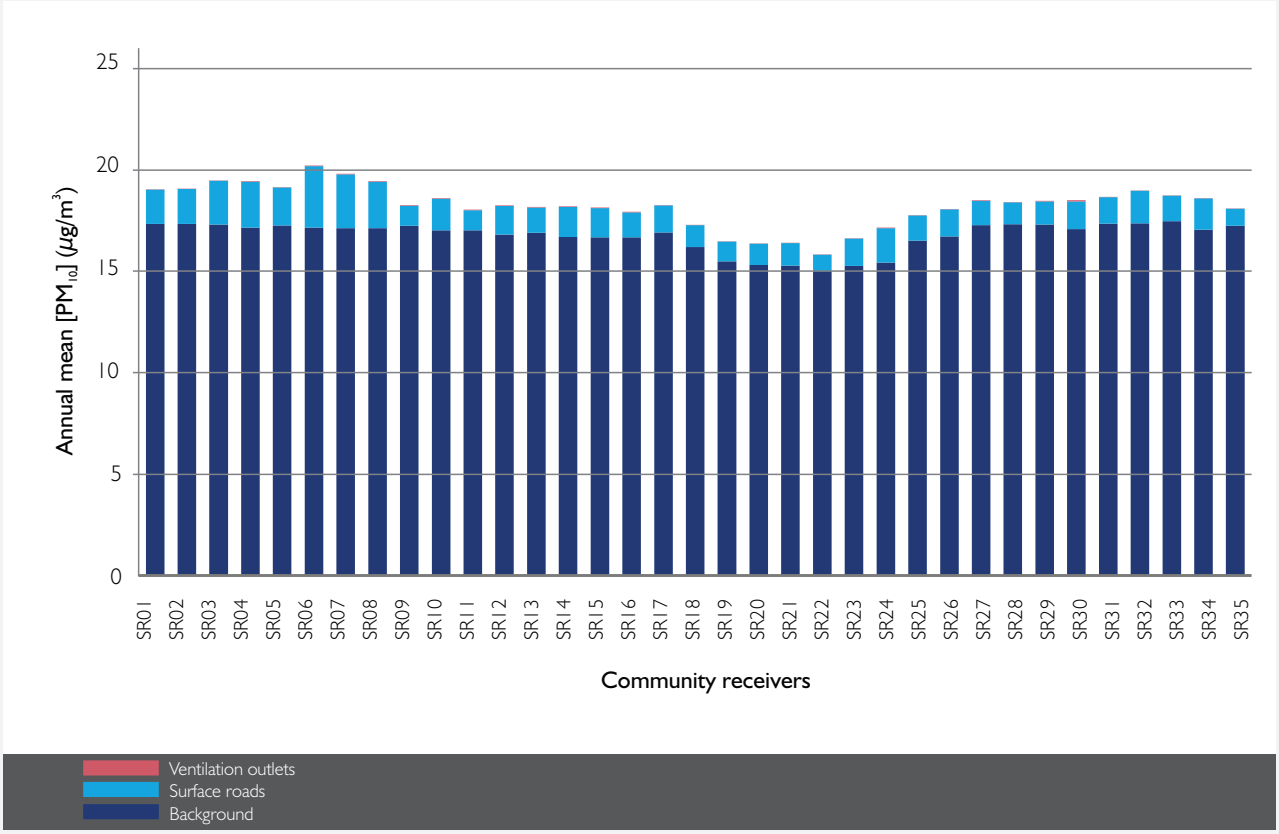


Figure 10-35 Source contributions to annual mean PM_{10} at community receivers (2021-DS)

(blank page)

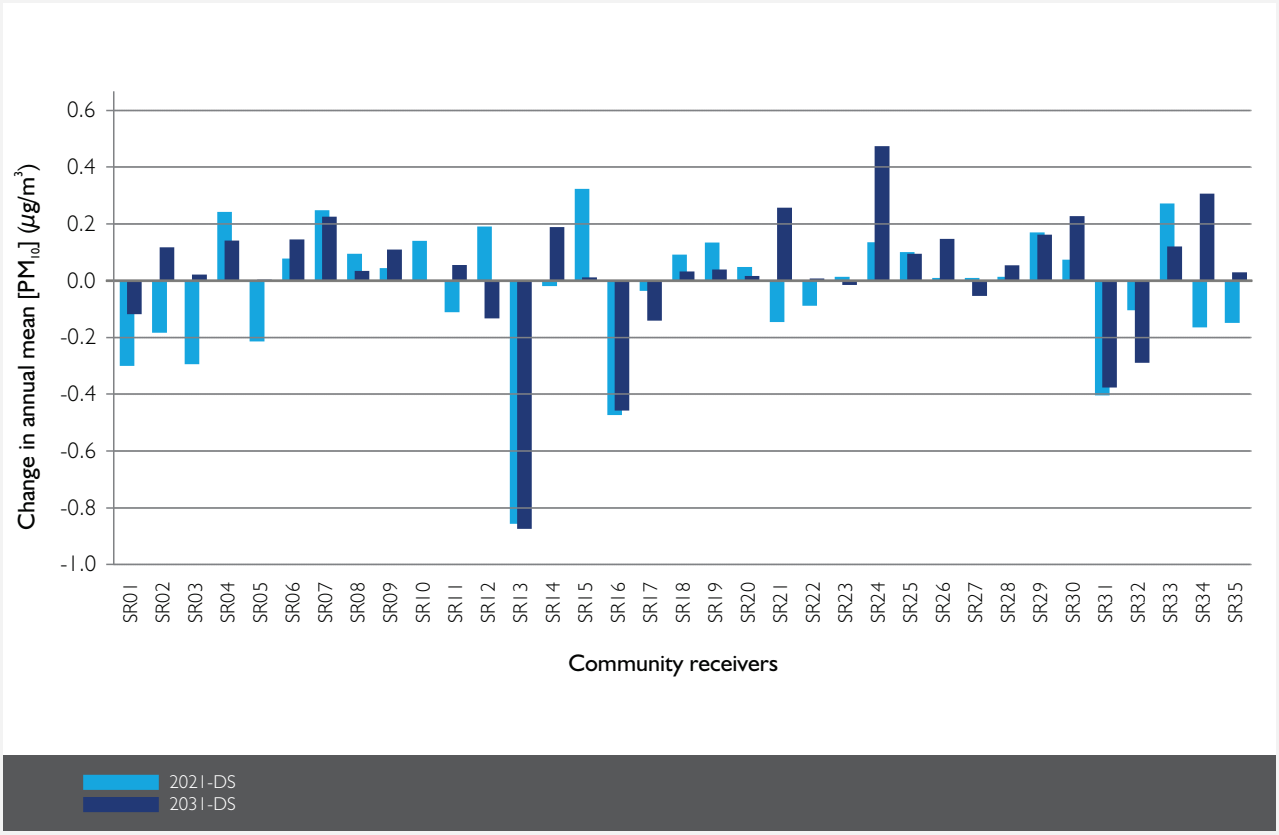


Figure 10-36 Change in annual mean PM_{10} at community receivers (2021-DS and 2031-DS)

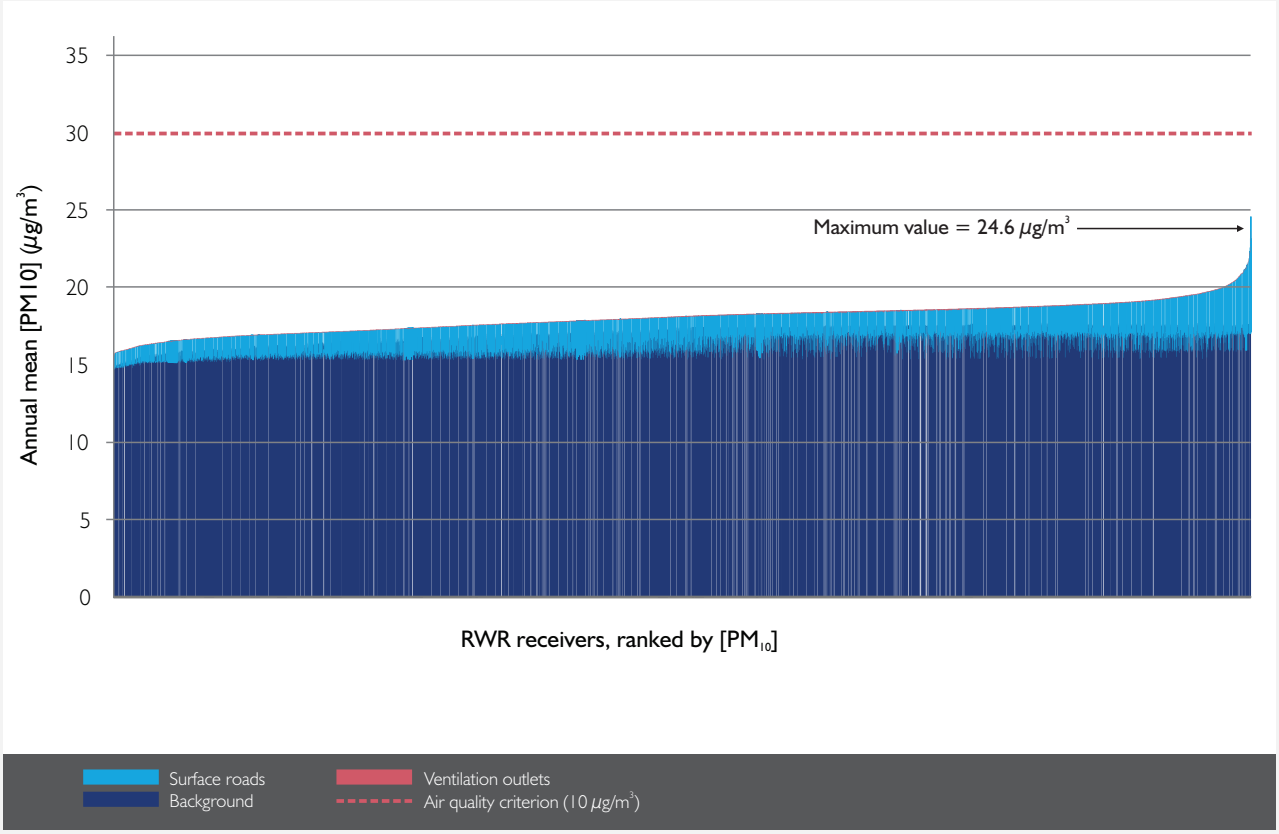


Figure 10-37 Source contributions to annual mean PM_{10} at RWR receivers (20-21DS)

(blank page)

The changes in the annual mean PM10 concentration at the RWR receivers in the 2021 'do something' scenario (relative to the 2021'do minimum' scenario) are shown, ranked by change in concentration, in **Figure 10-38**. There was an increase in concentration at 64 per cent of the RWR receivers. At the majority of receivers the change was relatively small and only 0.1 per cent of receivers would experience an increase greater than 1 µg/m3.

The corresponding plots for the 2031 'do something' scenario are given in Appendix K of the Technical working paper: Air quality in Appendix H.

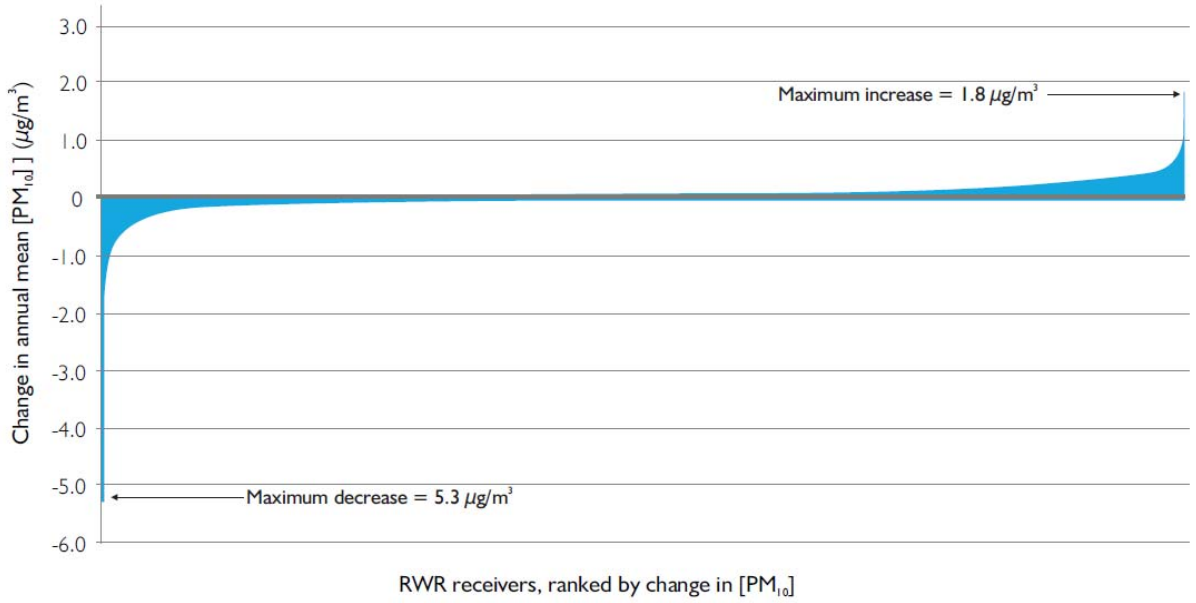


Figure 10-38 Changes in annual mean PM_{10} at RWR receivers (2021-DS)

Contour plots for GRAL New M5 domain

The contour plots for annual mean PM_{10} in 2021 under the 'do minimum' and 'do something' scenarios are presented in **Figure 10-39** and **Figure 10-40**. The change in annual mean PM_{10} with the project in 2021 are shown in **Figure 10-41**. As in the case of NO_2, elevated concentrations of PM_{10} are evident along the major road corridors. The contour plot for the change in concentration with the project in 2021 (**Figure 10-41**) also shows complex changes similar to those for NO_2.

(blank page)



Figure 10-39 Contour plot showing annual mean PM_{10} without the project (2021-DM)

(blank page)

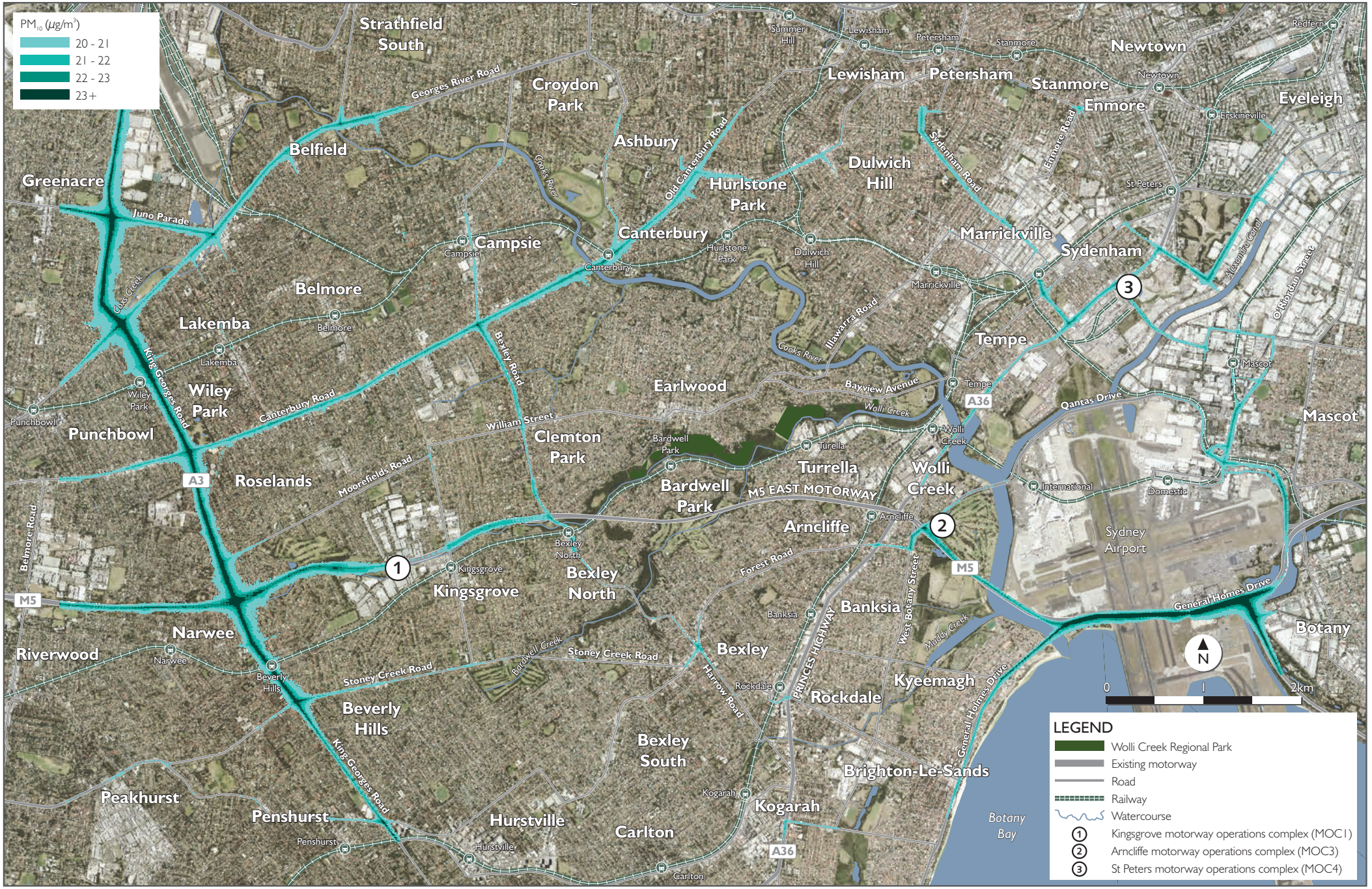


Figure 10-40 Contour plot showing annual mean PM_{10} with the project (2021-DS)

(blank page)

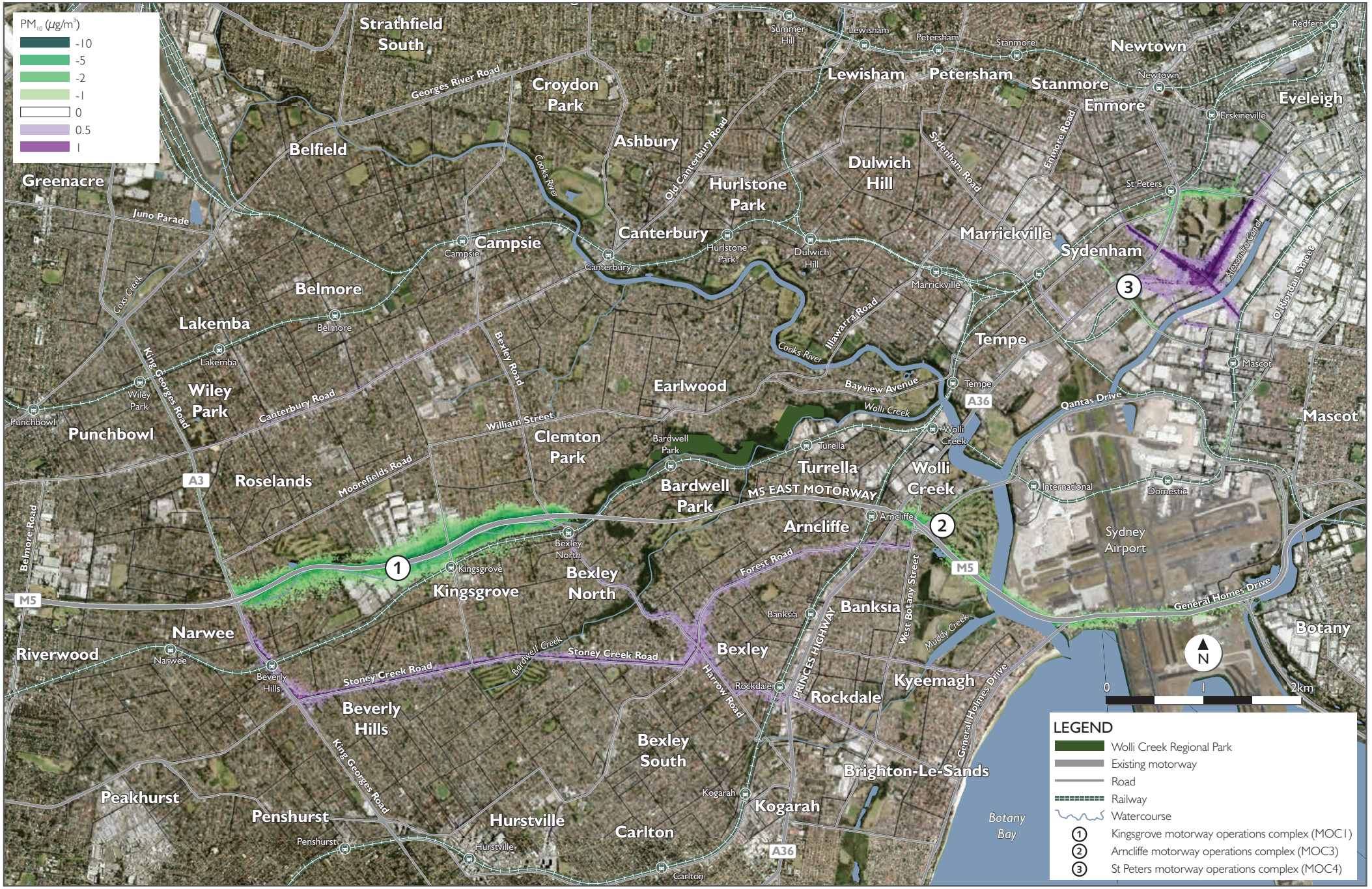


Figure 10-41 Contour plot showing change in annual mean PM_{10} with the project (2021-DS)

(blank page)

Contour plots for ventilation outlets only

The annual mean PM_{10} concentrations near the New M5 Kingsgrove, Arncliffe and St Peters interchange ventilation outlets only in 2021 are shown in **Figure 10-42**, **Figure 10-43** and **Figure 10-44**.

Contribution of project ventilation outlets to annual mean PM_{10} across the grid is given in **Table 10-28**. The maximum value of 0.3 µg/m^3 (St Peters interchange, 2031 'do something (cumulative)') is two orders of magnitude lower than the criterion for annual mean PM_{10} of 30 µg/m^3.

Table 10-28 Contribution of project ventilation outlets to annual mean PM_{10} concentration in 2 km x 2 km grid around outlet

Ventilation outlet	Outlet contribution to annual mean PM_{10} (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.02 – 0.05	0.02 – 0.06	0.03 – 0.09
Arncliffe	0.02 – 0.04	0.02 – 0.04	0.05 – 0.10
St Peters Interchange	0.02 – 0.09	0.01 – 0.09	0.05 – 0.30

(blank page)



Figure 10-42 Contour plot showing annual mean PM_{10} for ventilation outlets only (Kingsgrove outlet, 2021-DS)

(blank page)



Figure 10-43 Contour plot showing annual mean PM_{10} for ventilation outlets only (Arncliffe outlet 2021-DS)

(blank page)



Figure 10-44 Contour plot showing annual mean PM_{10} for ventilation outlets only (SPI outlet, 2021-DS)

(blank page)

For each ventilation outlet, the range of annual mean PM_{10} concentrations for each ventilation outlet PM_{10} (maximum 24-hour mean)

Results for community receivers

The maximum 24-hour mean PM_{10} concentrations at the 35 community receivers in the 'do something' scenario in 2021 and 2031 are shown in **Figure 10-45**. At all receiver locations the maximum PM_{10} concentration was below the NSW impact assessment criterion of 50 µg/m^3, which is also the most stringent standard internationally. At all but one of the receivers, the maximum total 24-hour PM_{10} concentration occurred on one day of the year (10 February), and coincided with the highest 24-hour PM_{10} background concentration in the synthetic PM_{10} profile (44.5 µg/m^3). This provided support for the use of a maximum or high percentile value as the background for the RWR receivers across the New M5 GRAL domain.

The surface road contribution to the maximum 24-hour PM_{10} concentration at each receiver was small (generally less than 2 µg/m^3), as shown in **Figure 10-46**. The tunnel ventilation outlet contributions to 24-hour PM_{10} at community receivers were negligible (mostly less than 0.1 µg/m^3).

Figure 10-47 shows the changes in concentration in the 'do something' scenarios relative to the 'do minimum' scenarios for the community receivers. The changes were generally small (<1 µg/m^3).

Results for residential, workplace and recreational (RWR) receivers

The ranked maximum 24-hour mean PM_{10} concentrations at the RWR receivers in the 2021 'do something' scenario are shown in **Figure 10-48**. The results for the RWR receivers were highly dependent on assumption for the background air quality. The concentration at the majority of receivers was below the NSW impact assessment criterion of 50 µg/m^3. The proportion of receivers with a concentration above the criterion decreased slightly as a result of the project, from 2.6 per cent in the 2021 'do minimum' scenario to 2.1 per cent in the 2021 'do something' scenario. The contributions of surface roads and ventilation outlets were not significant. The maximum contribution of tunnel ventilation outlets at any receiver was 0.5 µg/m^3 in 2021 and 1.8 µg/m^3 in 2031.

(blank page)

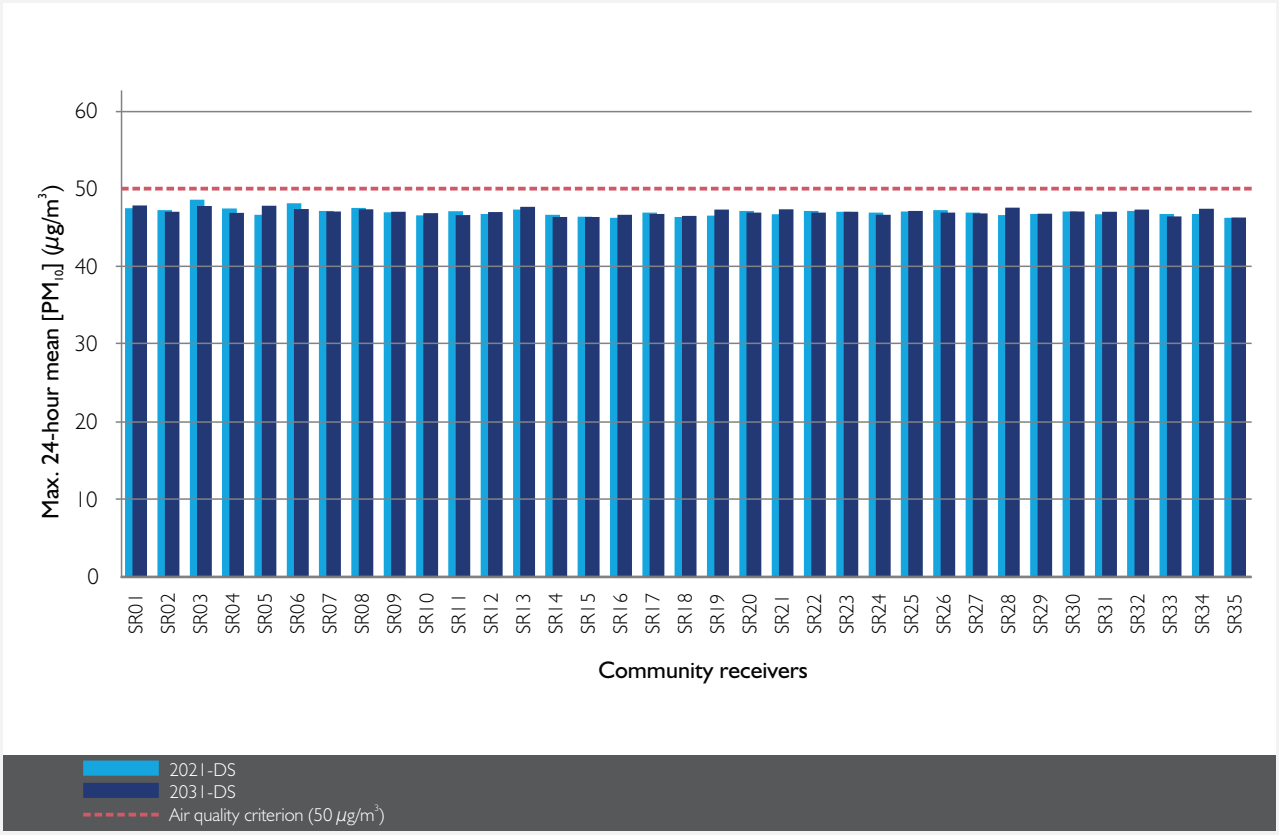


Figure 10-45 Maximum 24-hour PM_{10} at community receivers (2021-DS and 2031-DS)

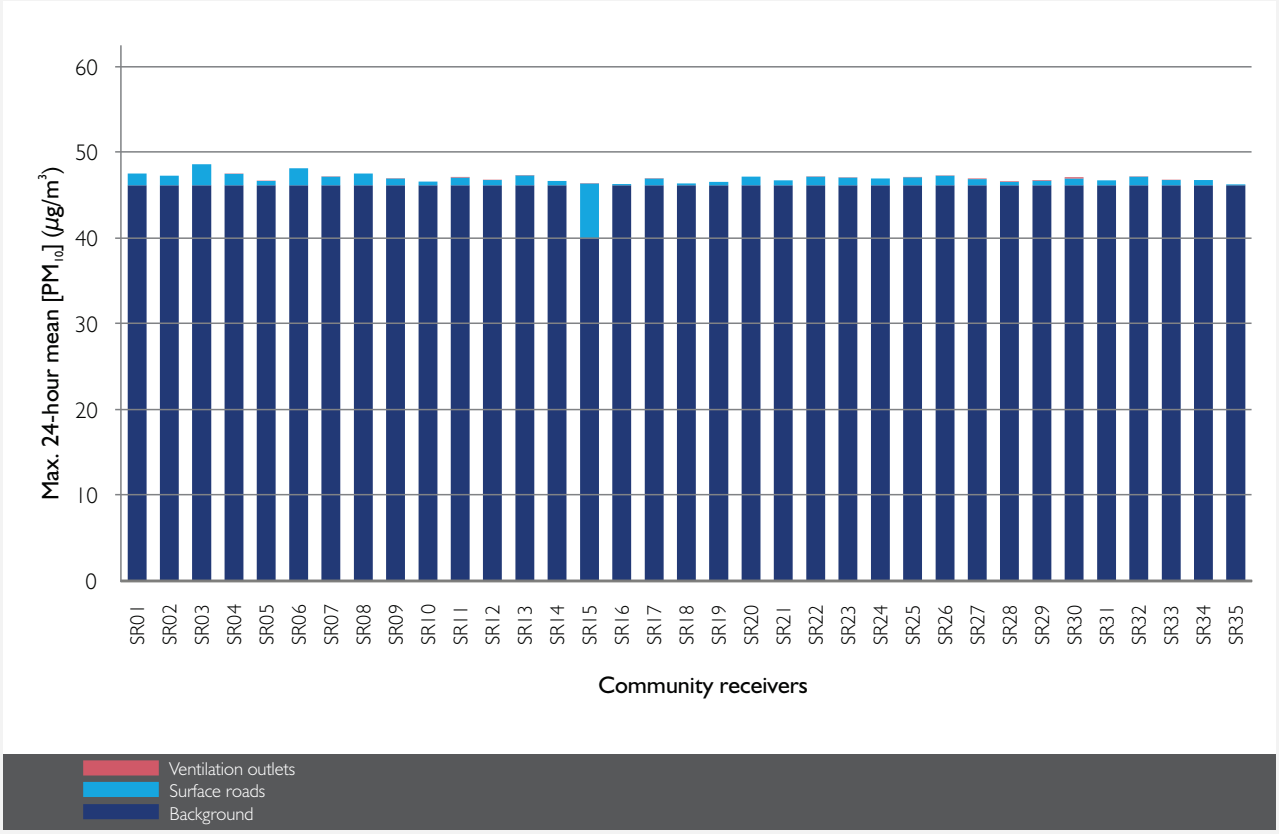


Figure 10-46 Source contributions to maximum 24-hour PM_{10} at community receivers (2021-DS)

(blank page)

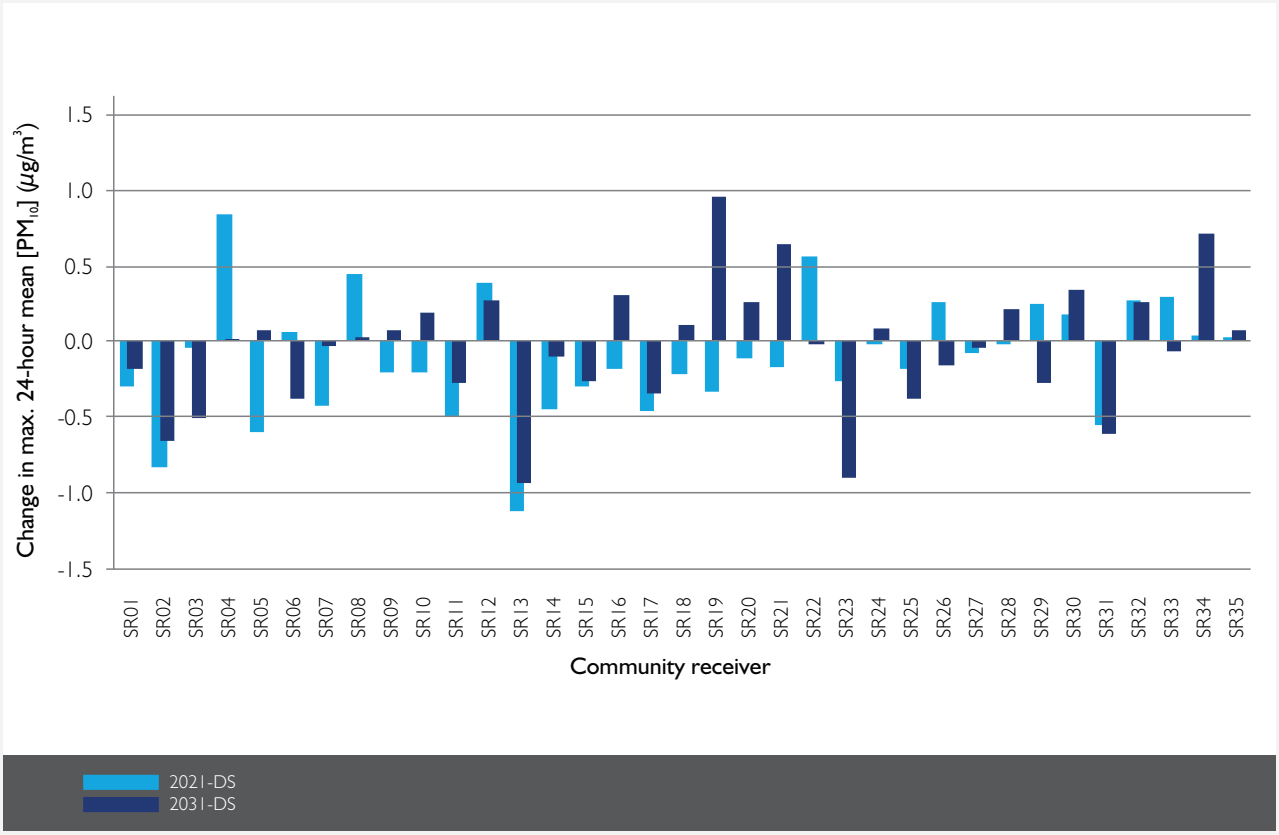


Figure 10-47 Change in maximum 24-hour PM_{10} at community receivers (2021-DS and 2031-DS)

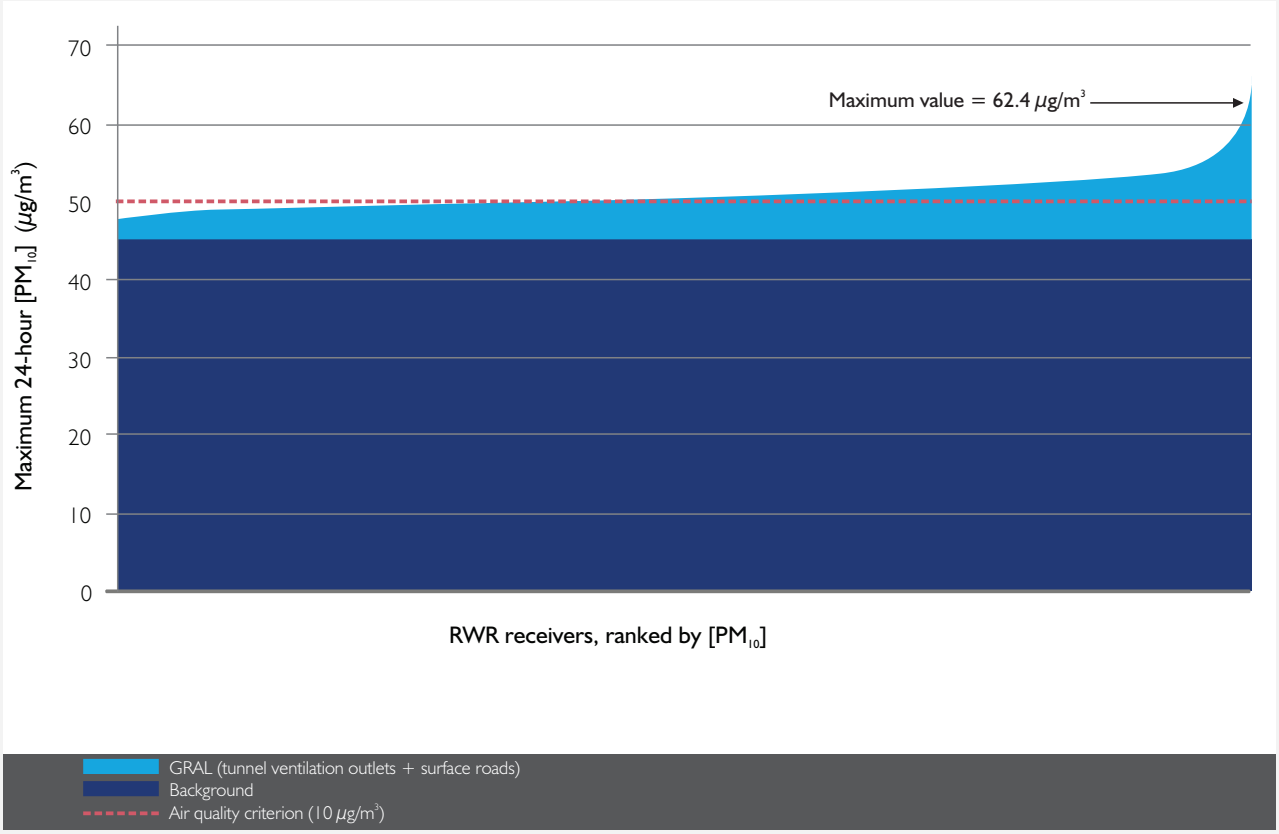


Figure 10-48 Source contributions to maximum 24-hour PM_{10} at RWR receivers (2021-DS)

(blank page)

Figure 10-49 shows the changes in the maximum 24-hour mean PM10 concentration with the project in 2021, ranked by change in concentration. There was an increase in maximum 24-hour mean PM10 concentration at 54 per cent of the receivers. The largest predicted increase in concentration at any receiver as a result of the project in 2021 was 6.8 µg/m3 and the largest predicted decrease was 18.3 µg/m3. At 2.4 percent of receivers, there was an increase in maximum 24-hour PM10 concentration greater than 2 µg/m3.

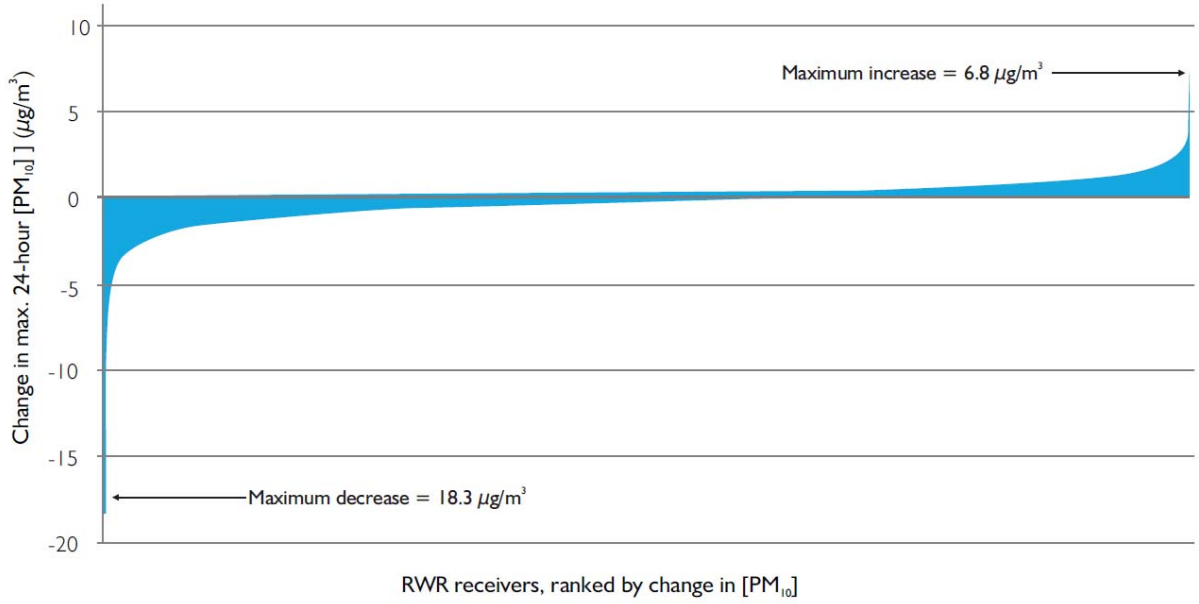


Figure 10-49 Changes in maximum 24-hour PM_{10} at RWR receivers (2021-DS)

Contour plots

The contour plots for maximum 24-hour average PM10 in 2021 under the 'do minimum' and 'do something' scenarios are shown in **Figure 10-50** and **Figure 10-51**. The change in maximum 24-hour average PM10 in 2021 with the project is shown in **Figure 10-52**.

(blank page)



Figure 10-50 Contour plot showing maximum 24-hour average PM_{10} without the project (2021-DM)

(blank page)



Figure 10-51 Contour plot showing maximum 24-hour average PM_{10} with the project (2021-DS)

(blank page)

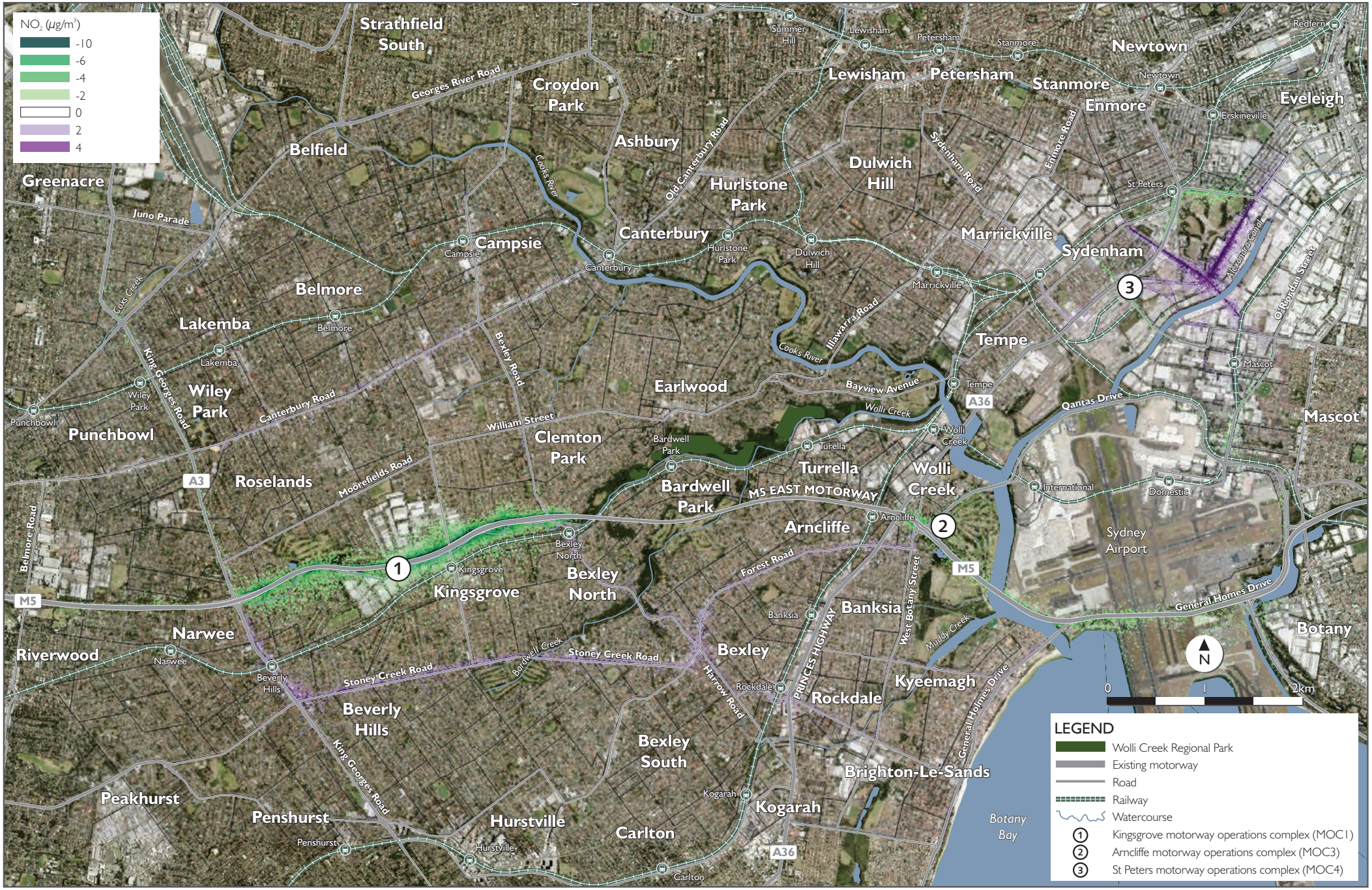


Figure 10-52 Contour plot showing change in maximum 24-hour PM_{10} with the project (2021-DS)

(blank page)

Contour plots for ventilation outlets only

The contour plots for annual mean PM_{10} concentrations near the New M5 ventilation outlets at Kingsgrove, Arncliffe and St Peters interchange only are shown in **Figure 10-53**, **Figure 10-54** and **Figure 10-55** respectively.

For each ventilation outlet, the range of maximum 24-hour PM_{10} concentrations across the grid is provided in **Table 10-29**. The maximum value of 1.5 µg/m^3 (St Peters interchange, 2031 'do something (cumulative)') is much lower than the 50 µg/m^{3}criterion for 24-hour PM_{10}.

Table 10-29 Contribution of project ventilation outlets to maximum 24-hour PM_{10} concentration

Ventilation outlet	Outlet contribution to max. 24-hour PM_{10} (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.10 – 0.30	0.10 – 0.30	0.10 – 0.40
Arncliffe	0.06 – 0.16	0.06 – 0.17	0.20 – 0.40
St Peters interchange	0.10 – 0.40	0.10 – 0.45	0.30 – 1.50

(blank page)



Figure 10-53 Contour plot showing maximum 24-hour PM_{10} for ventilation outlets only (Kingsgrove outlet, 2021-DS)

(blank page)



Figure 10-54 Contour plot showing annual maximum 24-hour PM_{10} for ventilation outlets only (Arncliffe outlet 2021-DS)

(blank page)

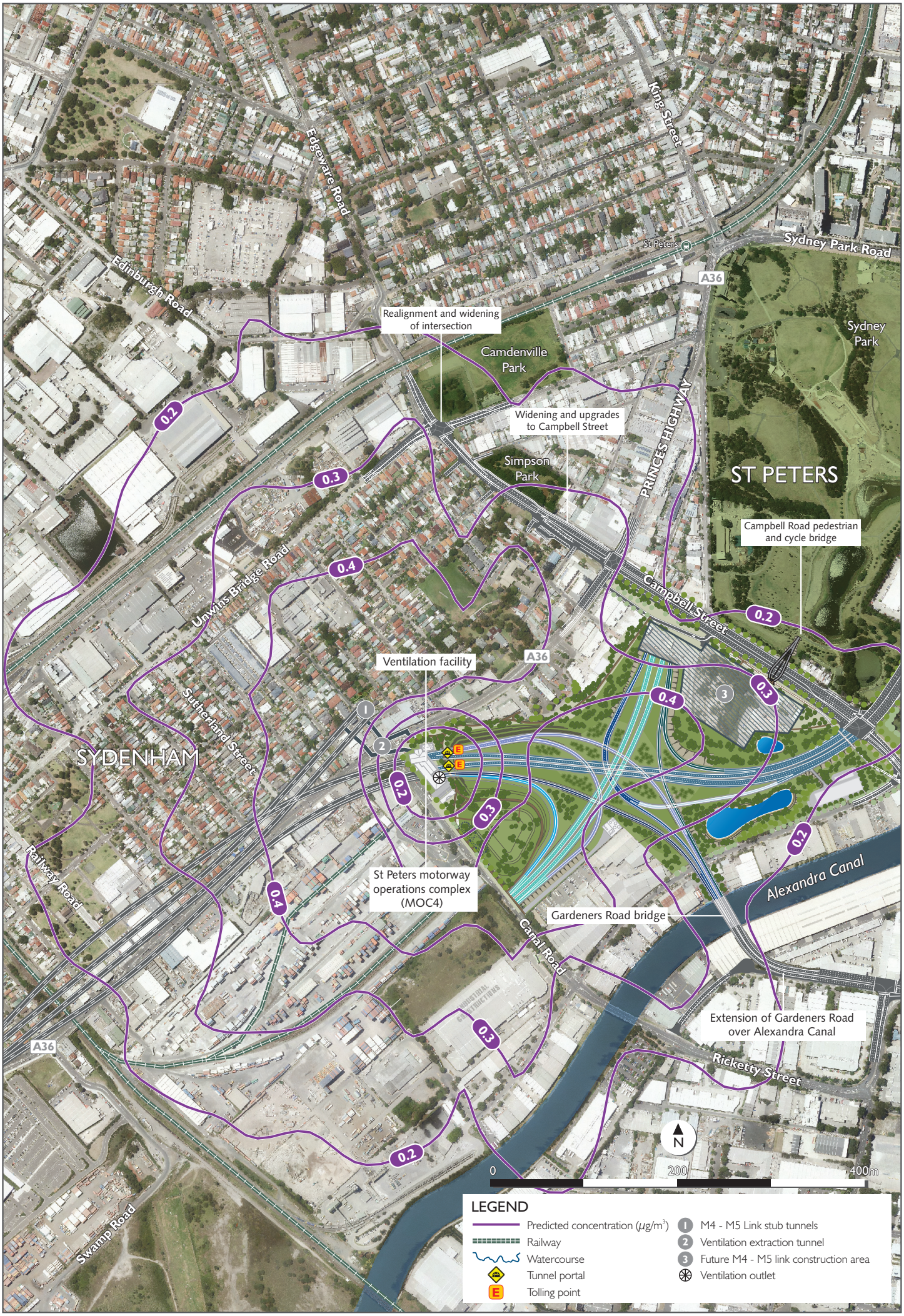


Figure 10-55 Contour plot showing maximum 24-hour PM_{10} for ventilation outlets only (SPI outlet, 2021-DS)

(blank page)

10.8.6 $PM_{2.5}$ (annual mean)

Results for community receivers

The annual mean PM2.5 concentrations at the 35 community receivers in the 2021 and 2031 'do something' scenarios are presented in **Figure 10-56**. The results are based on an assumed background concentration of 8 µg/m3 (the AAQ NEPM advisory reporting standard) and therefore shows exceedances at all receivers. There would also be exceedances of the proposed NSW target of 7 µg/m3.

Figure 10-57 shows that the modelled annual mean of $PM_{2.5}$ concentrations were dominated by the background contribution in 2021. The surface road contribution was between 0.6 µg/m^3 and 2.1 µg/m^3. The largest contribution from tunnel ventilation outlets was 0.06 µg/m^3.

Figure 10-58 shows the changes in PM2.5 concentration in the 'do something' scenarios relative to the 'do minimum' scenarios for the community receivers in 2021 and 2031. The changes in concentration with the project were generally less than ±0.2 µg/m3. At receiver SR06 (Regina Coeli Catholic Primary School) an increase in concentration of around 0.5 µg/m3 was predicted in 2021, but the increase in 2031 was much smaller. An increase of just below 0.4 µg/m3 was predicted in 2031 for receiver SR04 (Beverly Hills Girls High School). These increases represented less than 6% of the air quality criterion for annual mean PM2.5.

Results for residential, workplace and recreational (RWR) receivers

The ranked annual mean PM2.5 concentrations at the 46,219 RWR receivers in the 2021 'do something' scenario are shown in **Figure 10-59**, including the contributions of surface roads and ventilation outlets. As the background concentration was taken to be the same as the NSW criterion of 8 µg/m3, the concentration at all receivers was above this value. The highest concentration at any receiver in this scenario was 12.7 µg/m3. However, as with the other pollutants and metrics, the highest values were only predicted for a small proportion of receivers. In 2021, the surface road contribution was between 0.4 µg/m3 and 4.7 µg/m3. The largest contribution from tunnel ventilation outlets in both 2021 and 2031 was 0.08 µg/m3.

The change in the annual mean PM2.5 concentration at the RWR receivers in the 2021-do something scenario are ranked in **Figure 10-60**. The pattern here was similar to that for annual mean PM10.

There was an increase in concentration at 63 per cent of the receivers. The largest predicted increase in concentration at any receiver as a result of the project in 2021 was 1.2 µg/m3, and the largest predicted decrease was 3.5 µg/m3. Only 0.04 per cent of receivers would experience an increase greater than 0.5 µg/m3.

(blank page)

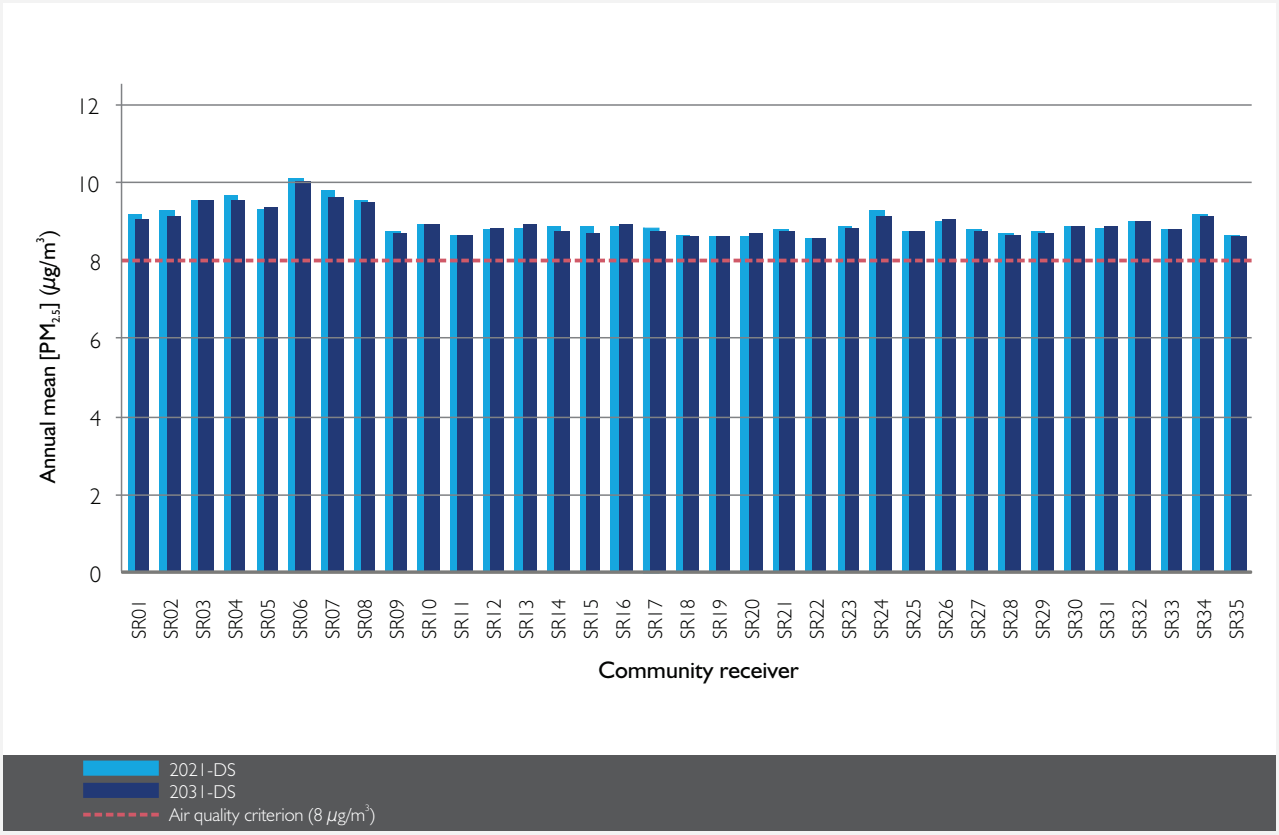


Figure 10-56 Annual mean $PM_{2.5}$ at community receivers (2021-DS and 2031-DS)

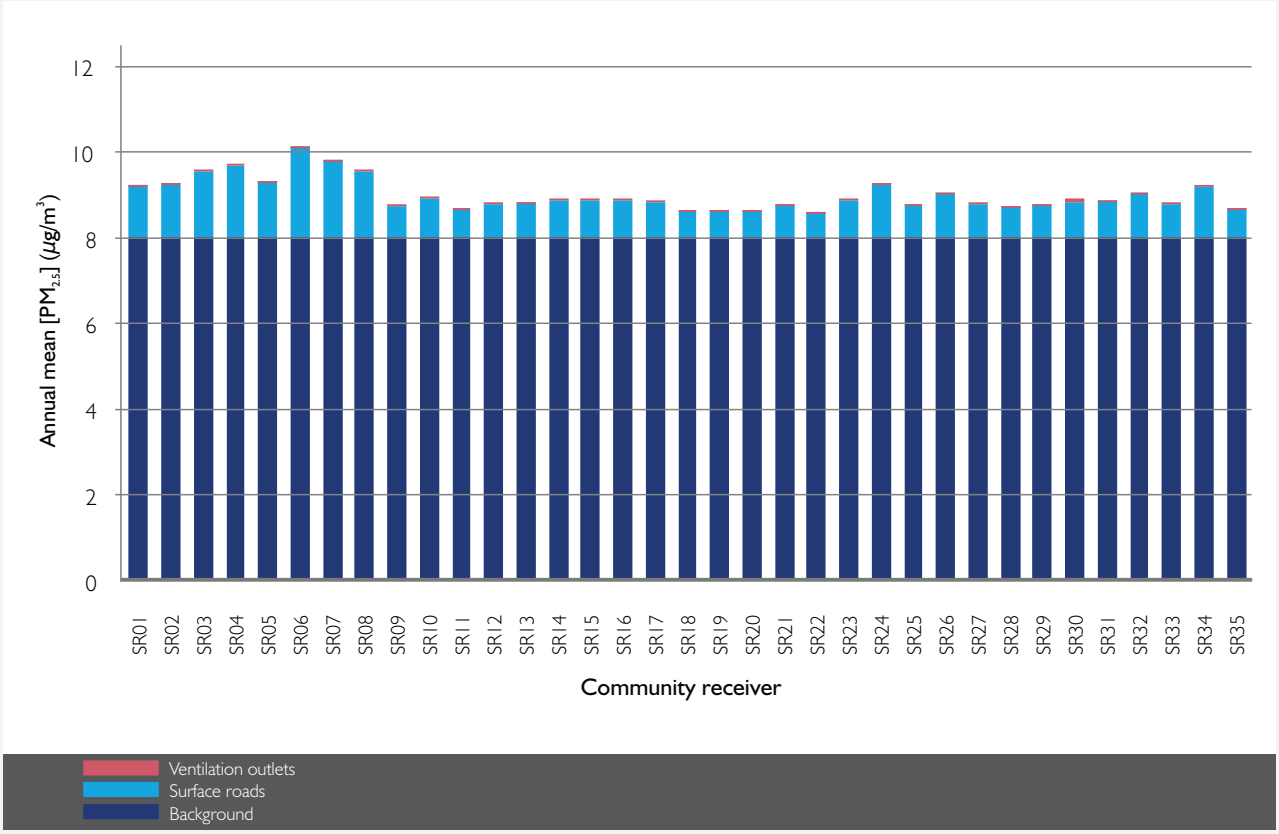


Figure 10-57 Source contributions to annual mean $PM_{2.5}$ at community receivers (2021-DS)

(blank page)

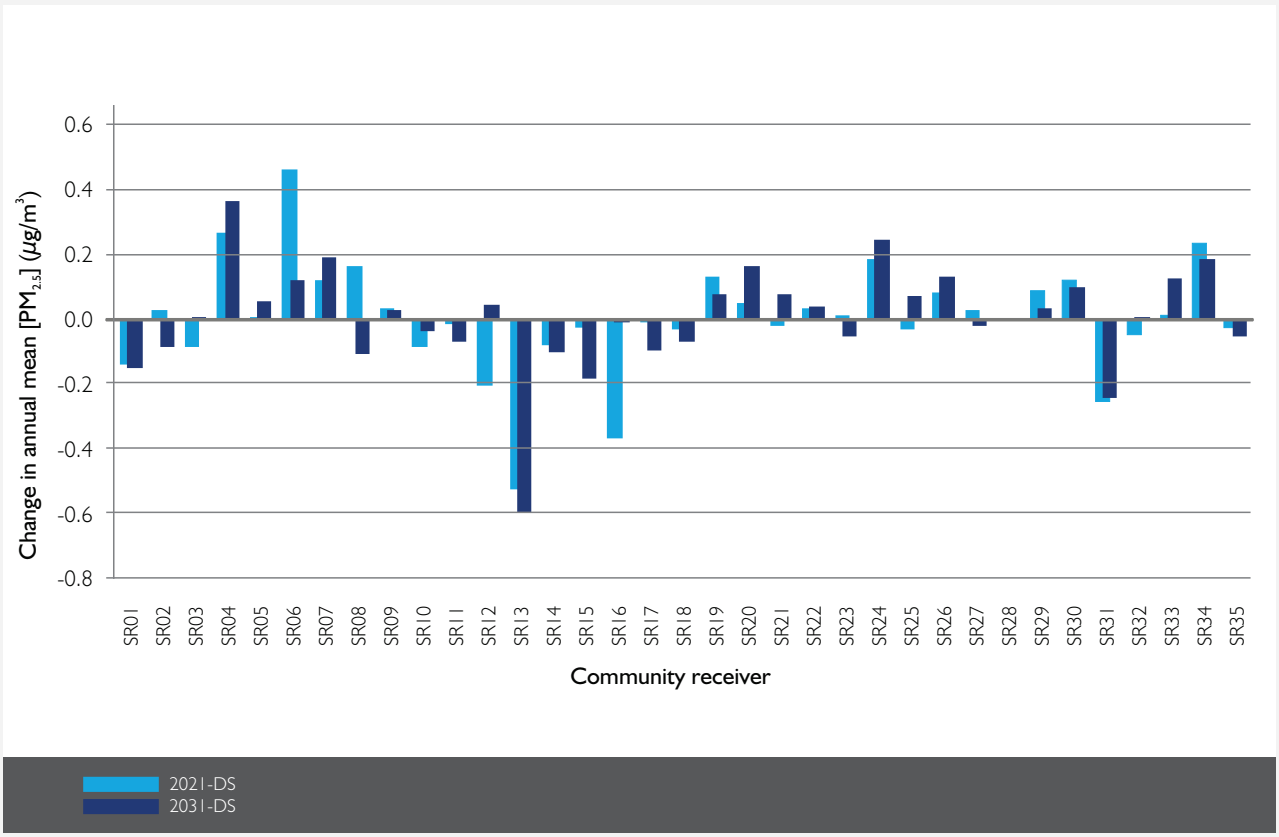


Figure 10-58 Change in annual mean $PM_{2.5}$ at community receivers (2021-DS and 2031-DS)

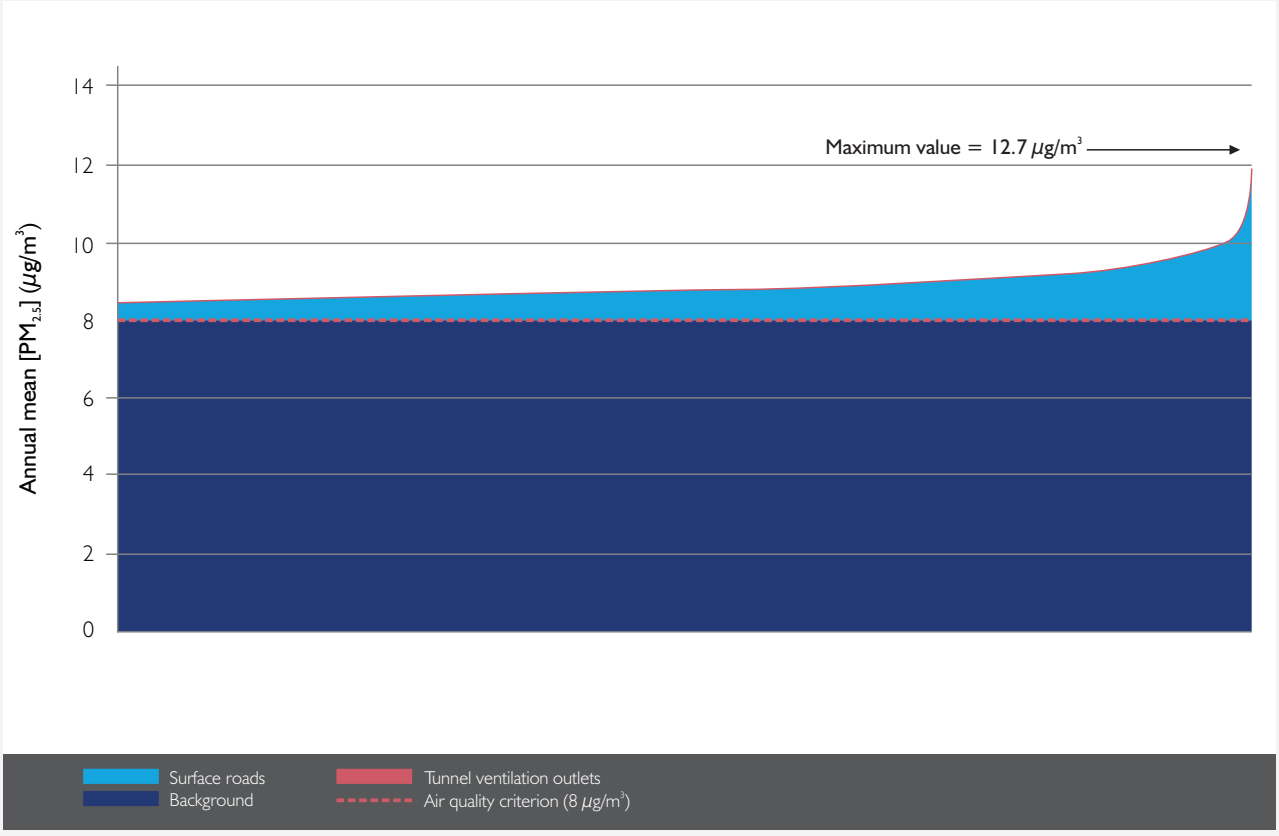


Figure 10-59 Source contributions to annual mean $PM_{2.5}$ at RWR receivers (2021-DS)

(blank page)

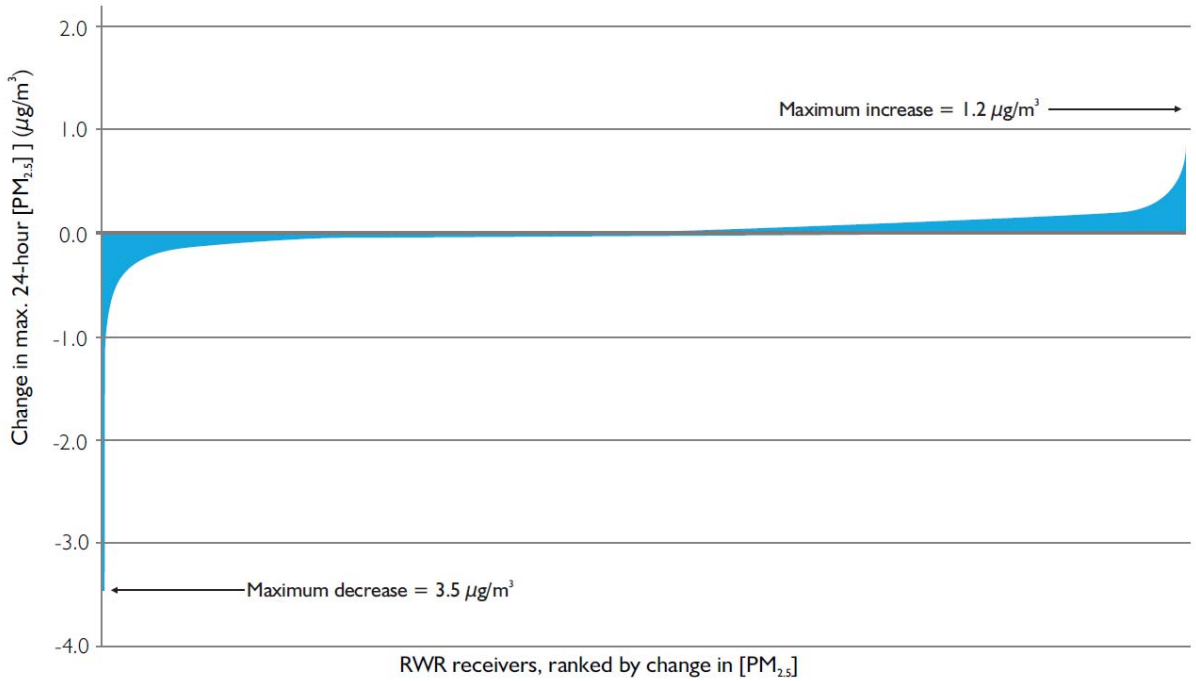


Figure 10-60 Changes in annual mean $PM_{2.5}$ at RWR receivers (2021-DS)

Contour plots – all sources

The contour plots for absolute annual mean $PM_{2.5}$ in 2021 under the 'do minimum' and 'do something' scenarios are presented in **Figure 10-61** and **Figure 10-62** respectively. The contour plot for the change in concentration with the project in 2021 is shown in **Figure 10-63**.

Contour plots for ventilation outlets only

The contour plots for annual mean $PM_{2.5}$ concentrations for the New M5 ventilation outlets only at Kingsgrove, Arncliffe and St Peters are shown in **Figure 10-64**, **Figure 10-65** and **Figure 10-66** respectively.

(blank page)

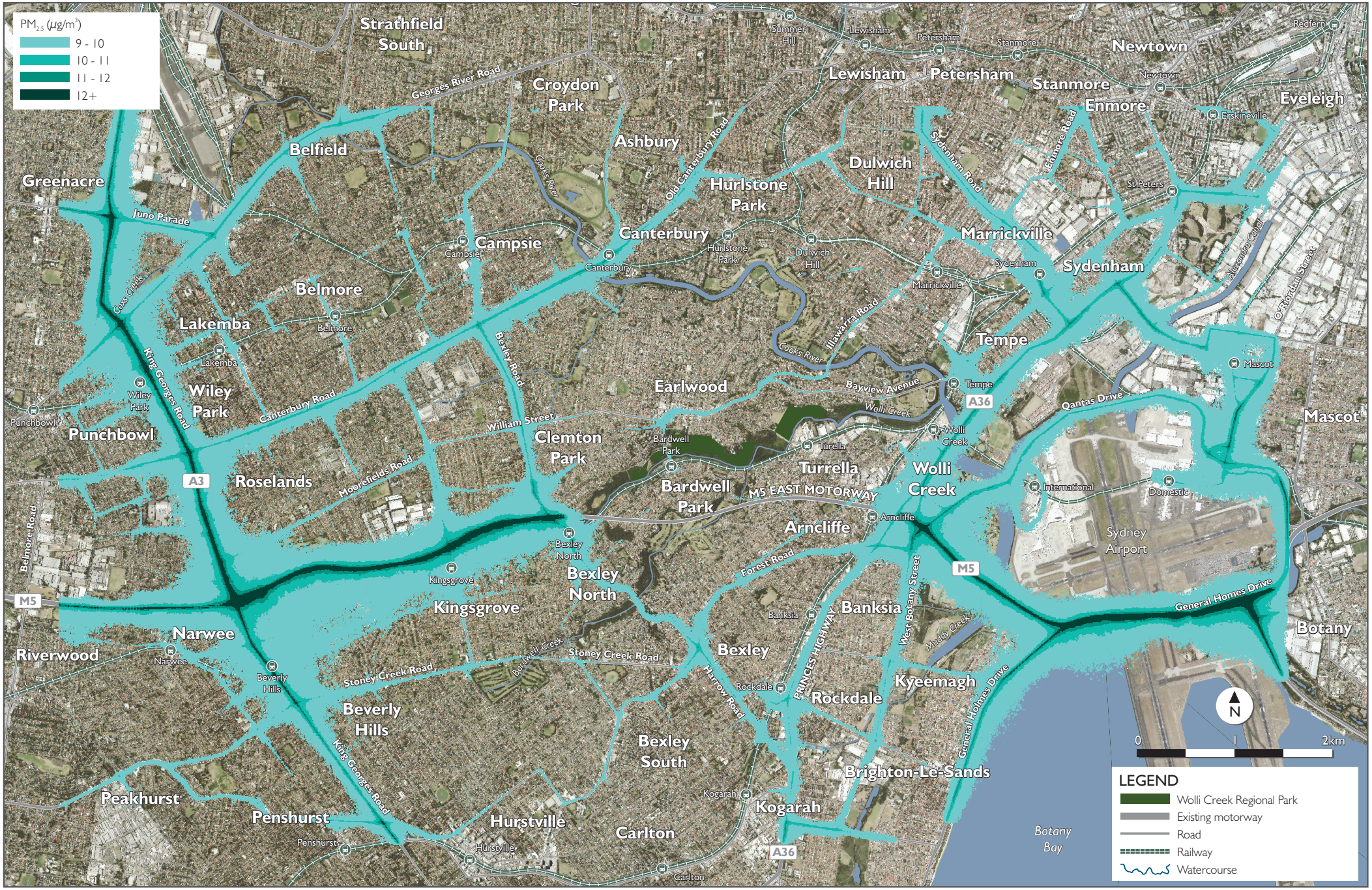


Figure 10-61 Contour plot showing annual mean $PM_{2.5}$ without the project (2021-DM)

(blank page)

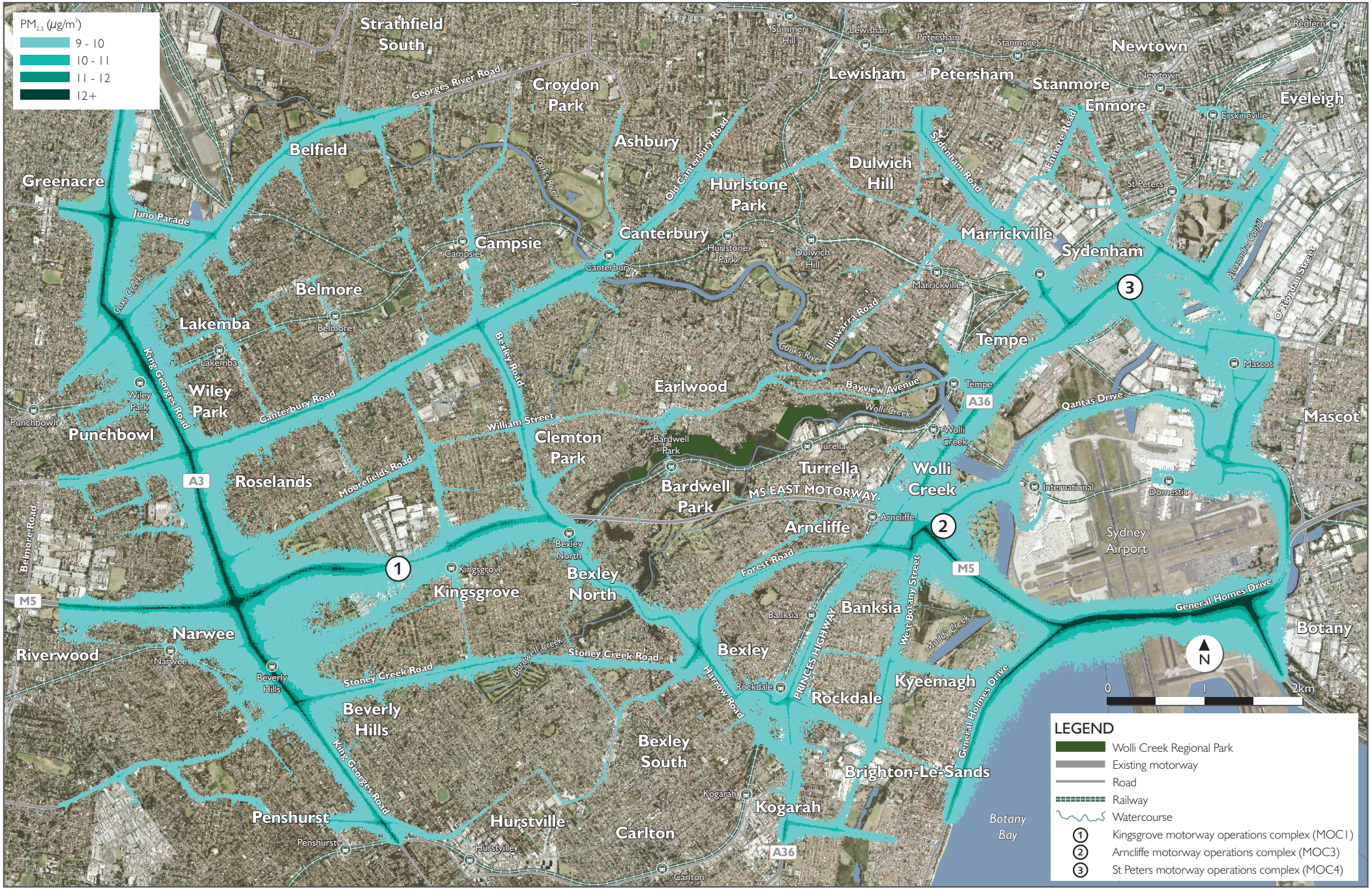


Figure 10-62 Contour plot showing annual mean $PM_{2.5}$ with the project (2021-DM)

(blank page)

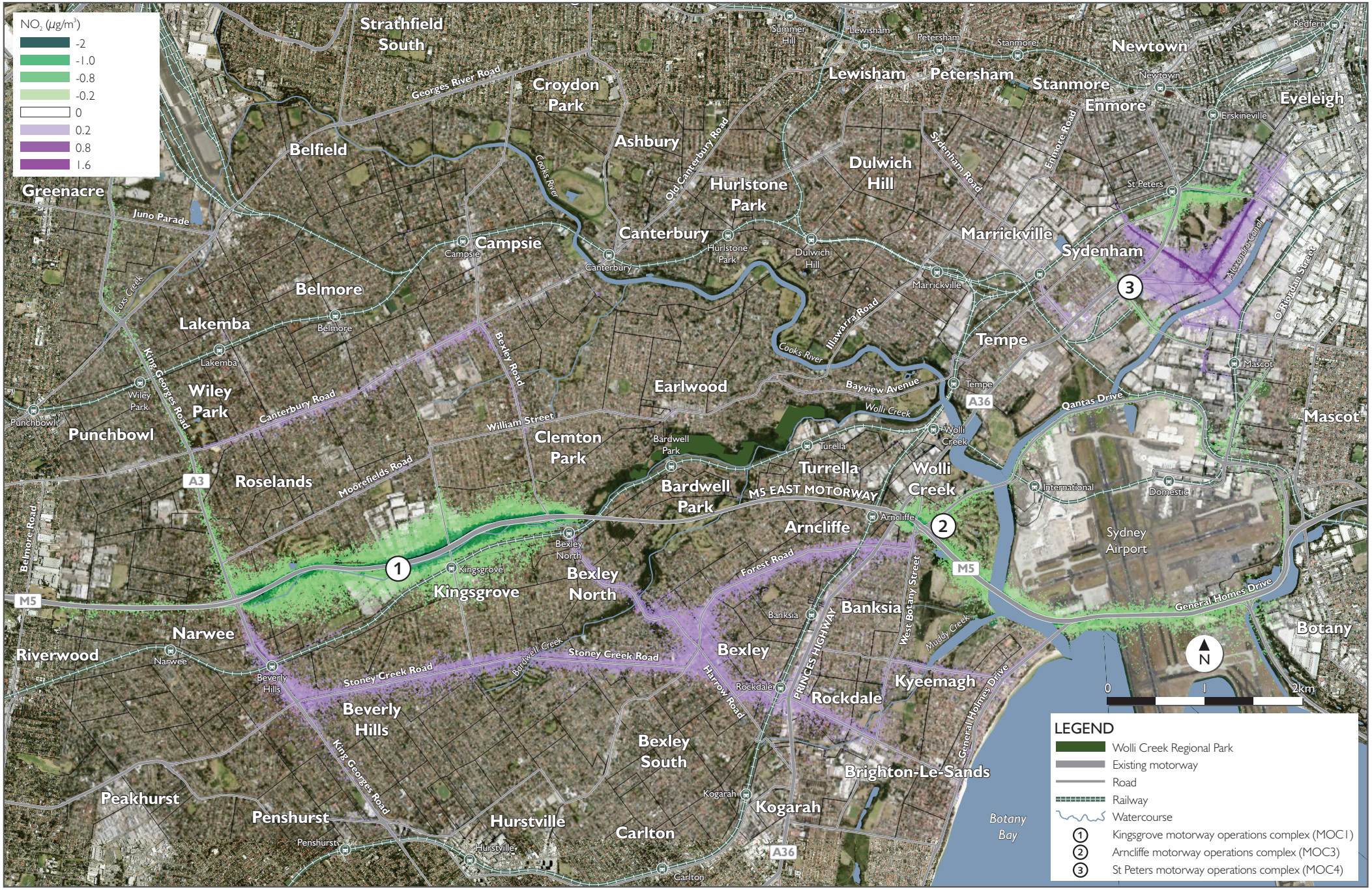


Figure 10-63 Contour plot showing change in annual mean $PM_{2.5}$ with the project (2021-DS)

(blanks page)



Figure 10-64 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (Kingsgrove outlet, 2021-DS)

(blank page)



Figure 10-65 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (Arncliffe outlet 2021-DS)

(blank page)



Figure 10-66 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (SPI outlet, 2021-DS)

(blank page)

For each ventilation outlet, the range of annual mean $PM_{2.5}$ concentrations across the grid is provided in **Table 10-30**. The maximum value of 0.2 µg/m^3 (St Peters interchange, 2031-DSC) is much lower than the criterion for annual mean $PM_{2.5}$ of 8 µg/m^3

Table 10-30 Contribution of project ventilation outlets to annual mean $PM_{2.5}$ concentration

Ventilation outlet	Outlet contribution to annual mean $PM_{2.5}$ (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.01 – 0.04	0.01 – 0.04	0.02 – 0.05
Arncliffe	0.01 – 0.03	0.01 – 0.03	0.04 – 0.07
SPI	0.01 – 0.06	0.01 – 0.06	0.05 – 0.20

10.8.7 Air toxics

Four air toxics – benzene, PAH (as benzo(a)pyrene), formaldehyde and 1,3-butadiene – were considered in the assessment. These compounds were taken to be representative of the much wider range of air toxics associated with motor vehicles and have commonly been assessed for road projects.

The changes in the maximum one-hour benzene concentration at the community receivers in the 2021 and 2031 'do something' scenarios were compared against the NSW impact assessment criterion from the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b), taking into account emissions from both surface roads and tunnel ventilation outlets. **Figure 10-67** shows that where there was an increase in the concentration in the maximum 1-hour benzene concentration, it still remained significantly below the assessment criterion of 29 mg/m^3.

The changes in the maximum one-hour benzo(a)pyrene, formaldehyde and 1,3-butadiene concentration in the 2021 and 2031 'do something' scenarios are presented in **Figure 10-68**, **Figure** 10-69, and **Figure 10-70** respectively. For each compound, where there was an increase in the concentration this was well below the NSW impact assessment criterion. The largest increases for the community receivers were also representative of the largest increases for the RWR receivers.

(blank page)

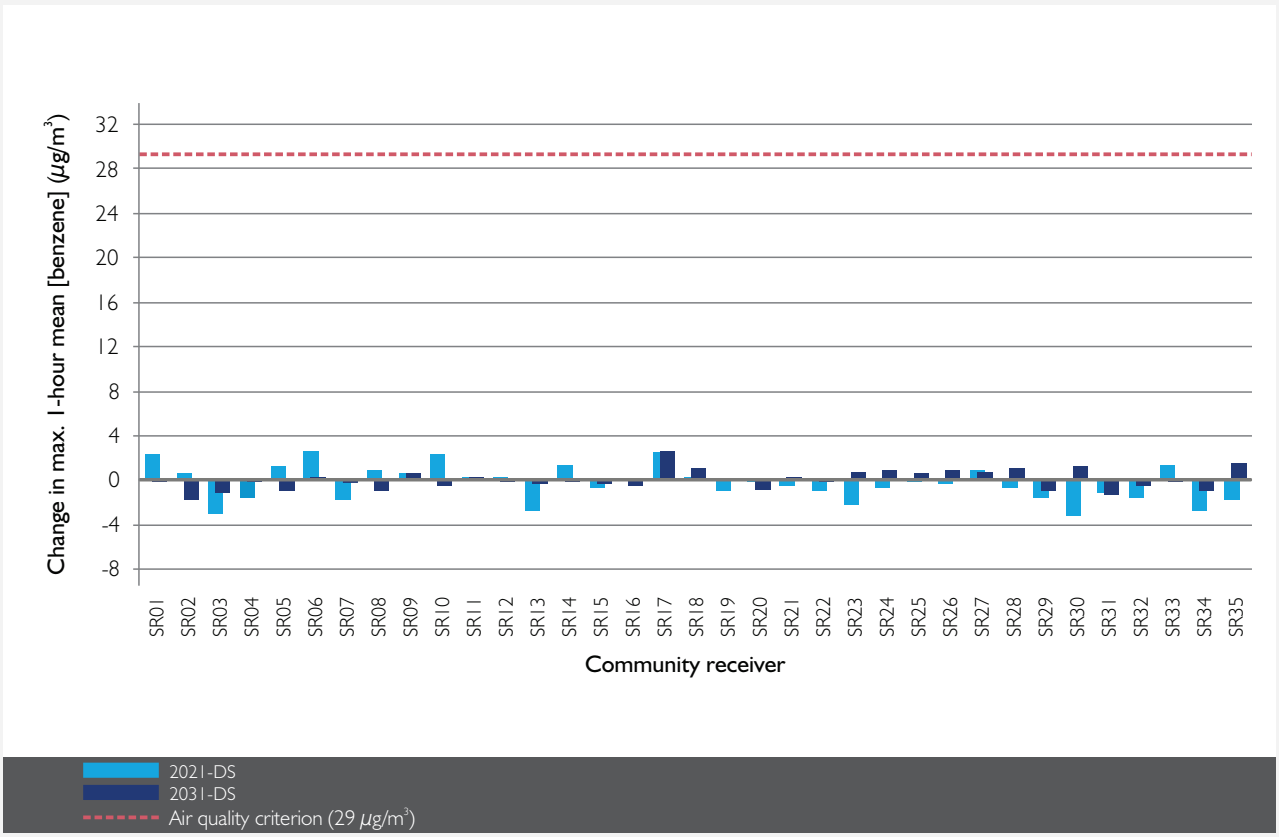


Figure 10-67 Change in maximum 1-hour mean benzene at community receiver (2021-DS and 2031-DS)

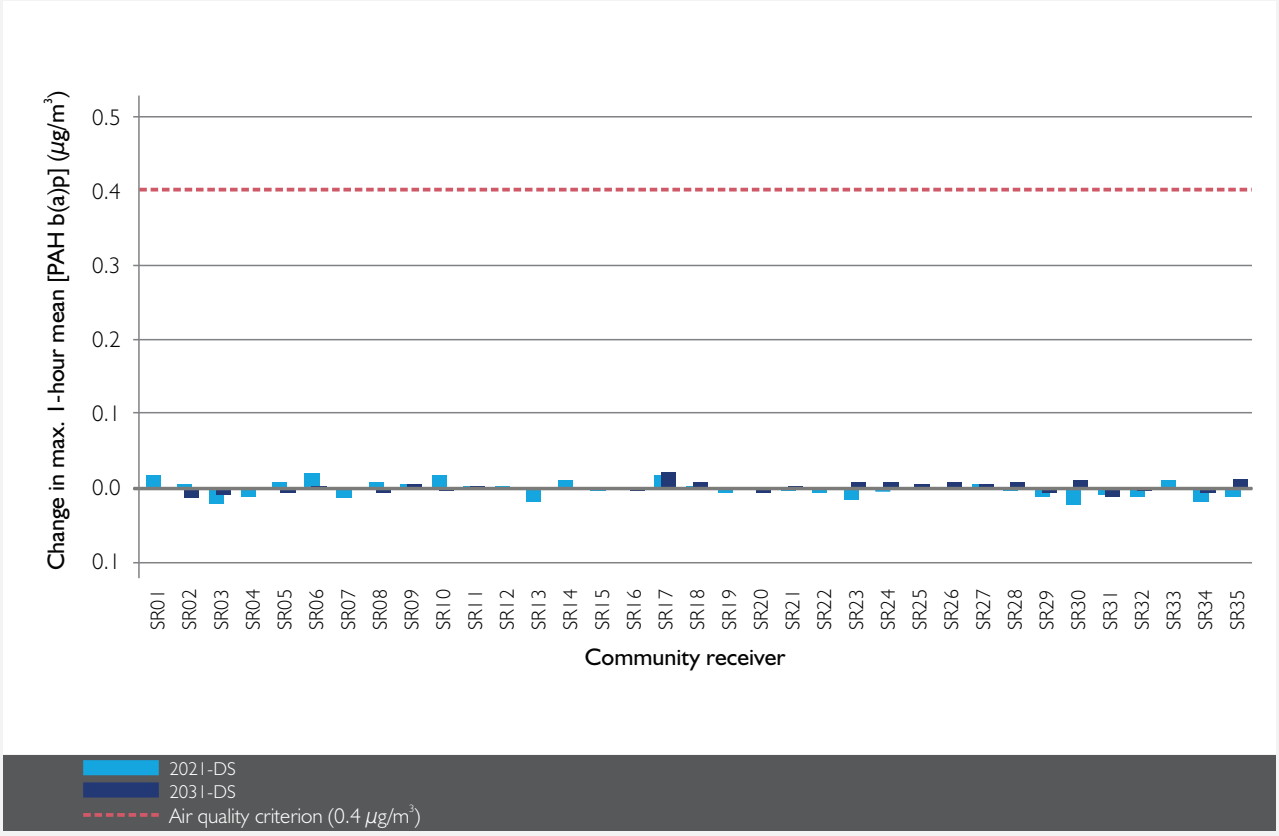


Figure 10-68 Change in maximum 1-hour mean b(a)p at community receiver (2021-DS and 2031-DS)

(blank page)

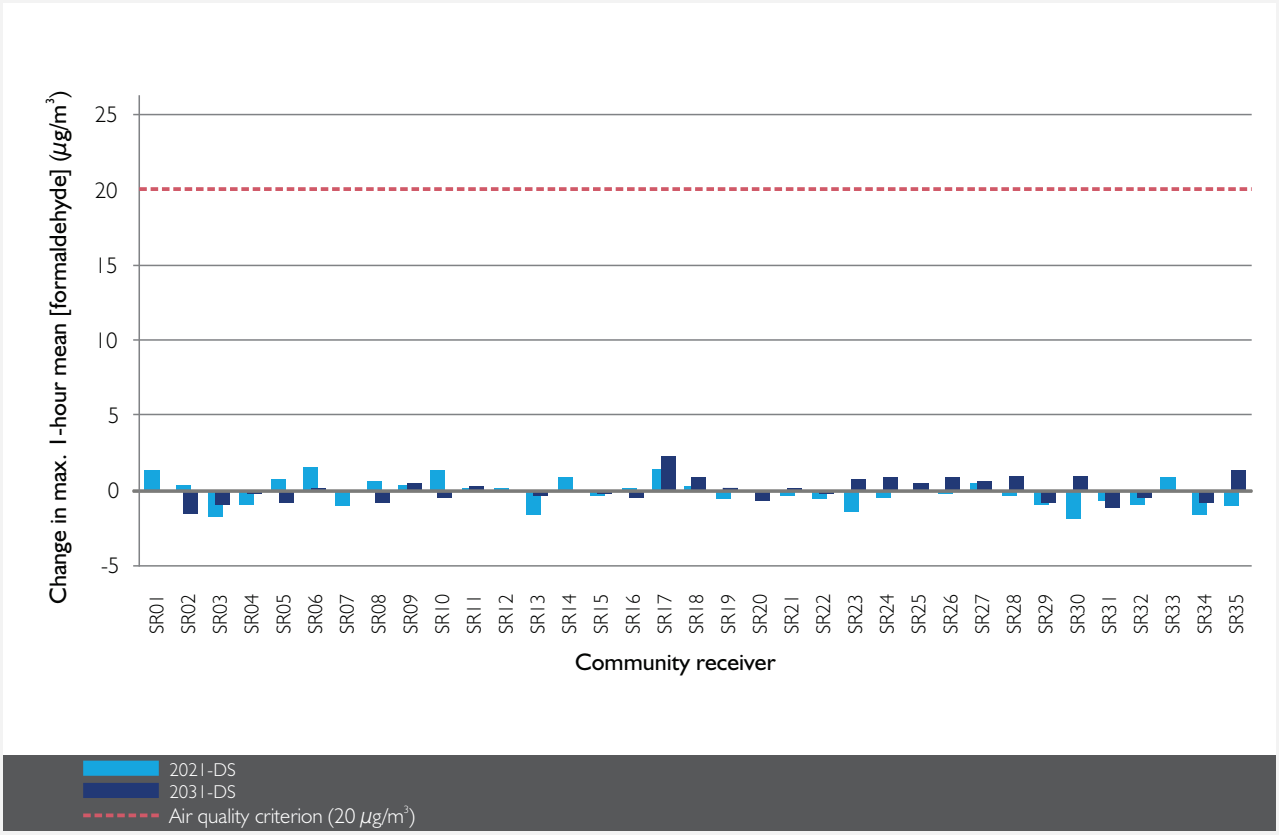


Figure 10-69 Change in maximum 1-hour mean formaldehyde at community receiver (2021-DS and 2031-DS)

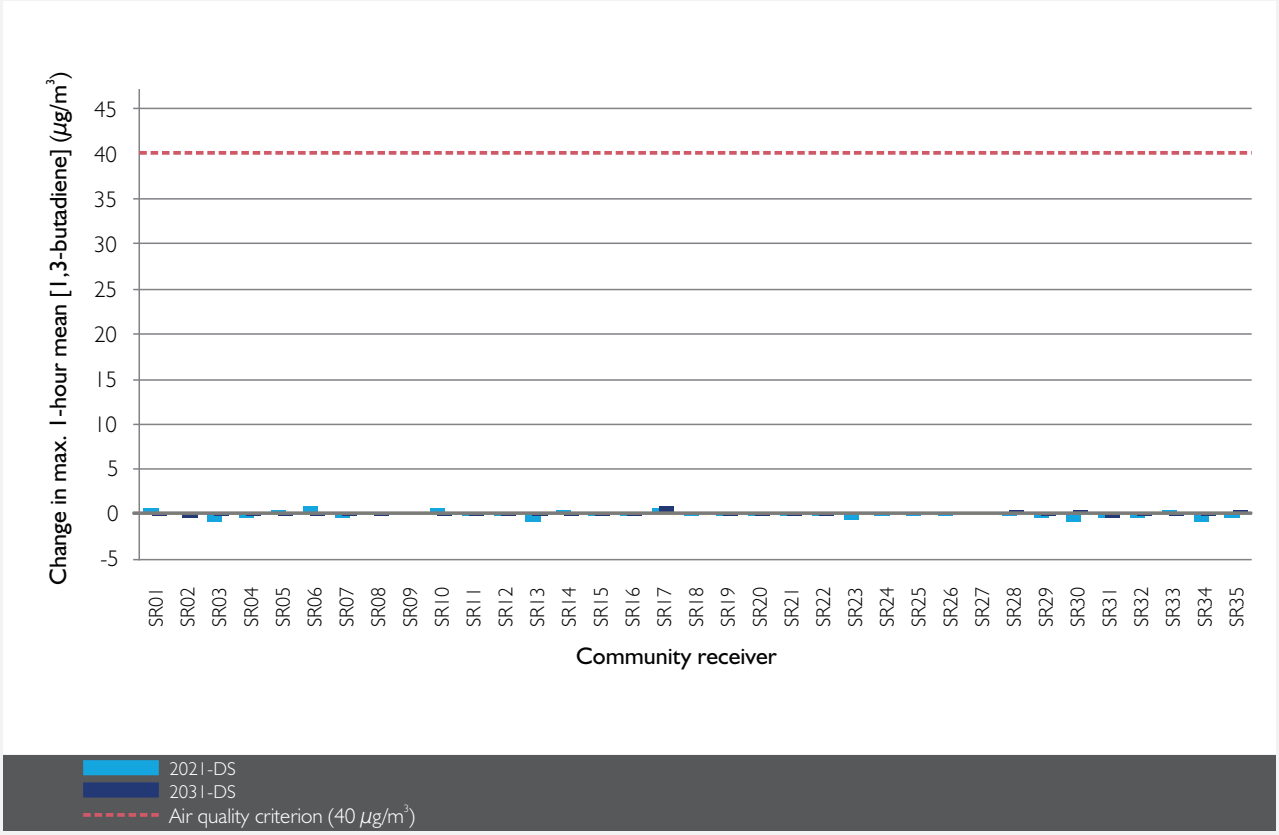


Figure 10-70 Change in maximum 1-hour mean 1,3-butadiene at community receivers (2021-DS and 2031-DS)

(blank page)

10.8.8 Odour

Odours associated with motor vehicle emissions tend to be very localised and short-lived. The project is not expected to result in any significant, predictable or detectable changes in odour. For each of the RWR receivers, the change in the maximum one hour THC concentration in the 2021 and 2031 'do something' scenarios was calculated. The largest change in the maximum 1-hour THC concentration across all receivers was then determined and converted to an equivalent change for three of the odorous pollutants identified in the Approved Methods (toluene, xlyenes and acetaldehyde). These pollutants were taken to be representative of other odorous pollutants from motor vehicles.

The changes in the levels of toluene, xlyenes and acetaldehyde as a result of the project, and the corresponding odour assessment criteria from the Approved Methods, are provided in **Table 10-31**. The change in the maximum 1-hour concentration of toluene, xlyenes and acetaldehyde was an order of magnitude below the corresponding odour assessment criterion in the Approved Methods.

Table 10-31 Comparison of changes in odorous pollutant concentrations with criteria in Approved Methods (RWR receivers)

Scenario	Largest increase in maximum 1-hour THC concentration relative to 'do minimum' scenario (µg/m^3)	Largest increase in maximum 1-hour concentration for specific compounds		
		Toluene (µg/m^3)	Xylenes (µg/m^3)	Acetaldehyde (µg/m^3)
2021-DS	243.7	19.8	16.3	3.1
2031-DS	170.8	13.9	11.5	2.6
2031-DSC	111.8	9.1	7.5	1.7
Odour criterion (µg/m^3)		360	190	42

10.9 Assessment of cumulative impacts

This assessment considers the potential cumulative impacts of the project and the future M4-M5 Link.

By 2031, the New M5 is predicted to accommodate a two-way average weekday traffic volume of about 34,500 vehicles per day with the project and about 81,500 vehicles per day with the full WestConnex program of works. The complete WestConnex program of works would result in about a 134 percent increase in two-way average weekday traffic volumes using the future M4-M5 Link and the future Southern extension. If the full WestConnex program of works is completed, the two-way daily volume on Stoney Creek Road is forecast to reduce and two-way daily traffic on the Princes Highway, north of the M5 East Motorway interchange, is forecast to decrease from 79,000 vehicles per day without the project to about 25,000 vehicles per day. This 69 per cent decrease is a substantial reduction along this congested section of the strategic road network.

10.9.1 In-tunnel air quality

The peak in-tunnel concentrations for the expected traffic cumulative scenario (2031 'do something (cumulative)') were assessed in Appendix L of the Technical working paper: Air quality in **Appendix H**. The results showed that the peak concentrations for all traffic scenarios, including worst-case conditions, were well within the concentrations associated with the regulatory worst case.

10.9.2 Ambient air quality

Results for expected traffic scenarios

The results for the expected traffic scenarios and all pollutants under the 2031 'do something' cumulative scenario are presented in Appendix K of the Technical working paper: Air quality in **Appendix H**. In the majority of cases the results for the community receivers in the 2031 'do something cumulative' scenario were very similar to those in the 2031 'do something' scenario.

The ambient air quality results for the 2031 'do something cumulative' scenario at the RWR receivers were broadly similar to those for the 2031 'do something' scenario. However, there are predicted to be some increases in concentration for a very small number of receivers. These are illustrated in **Figure** 10-71 to **Figure 10-79**.

(blank page)

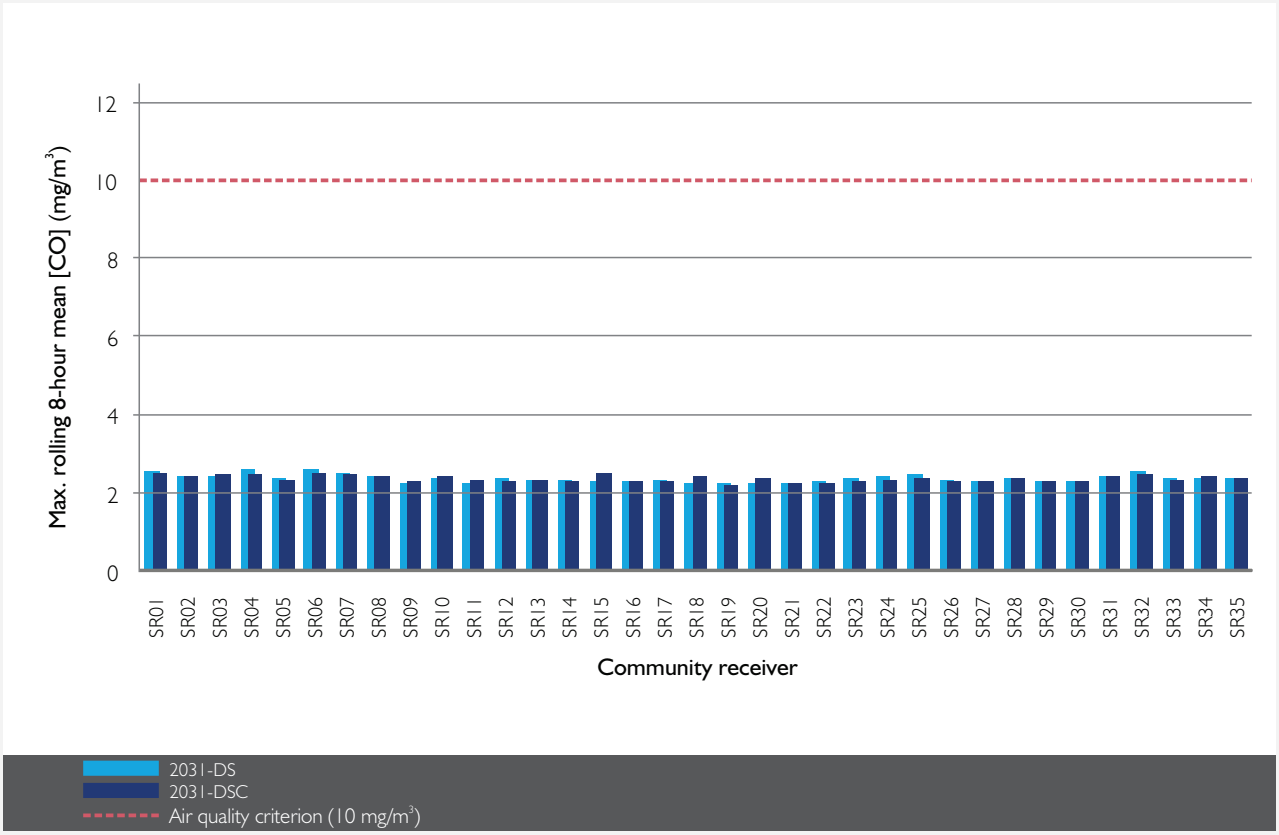


Figure 10-71 Maximum rolling 8-hour mean CO at community receivers (2031-DS and 2031-DSC)

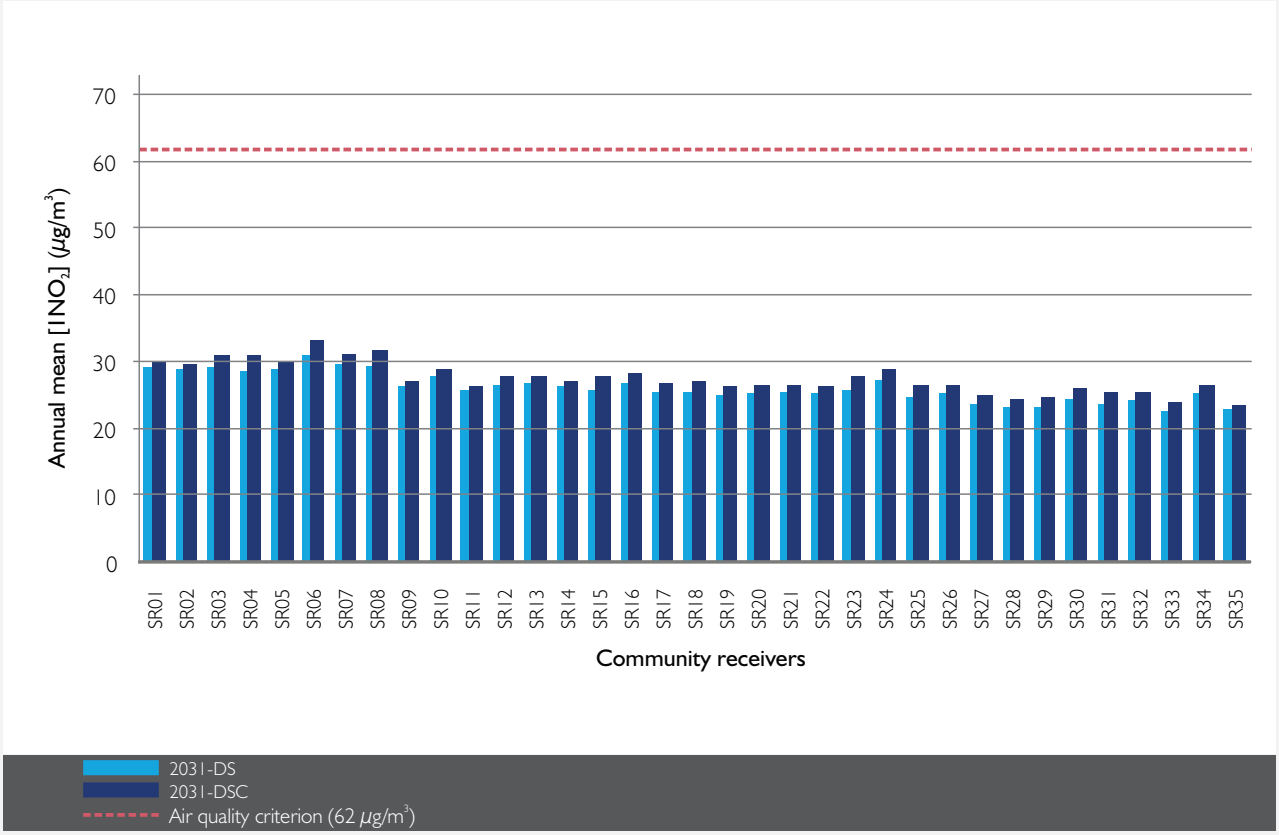


Figure 10-72 Annual mean NO_2 at community receivers (2031-DS and 2031-DSC)

(blank page)

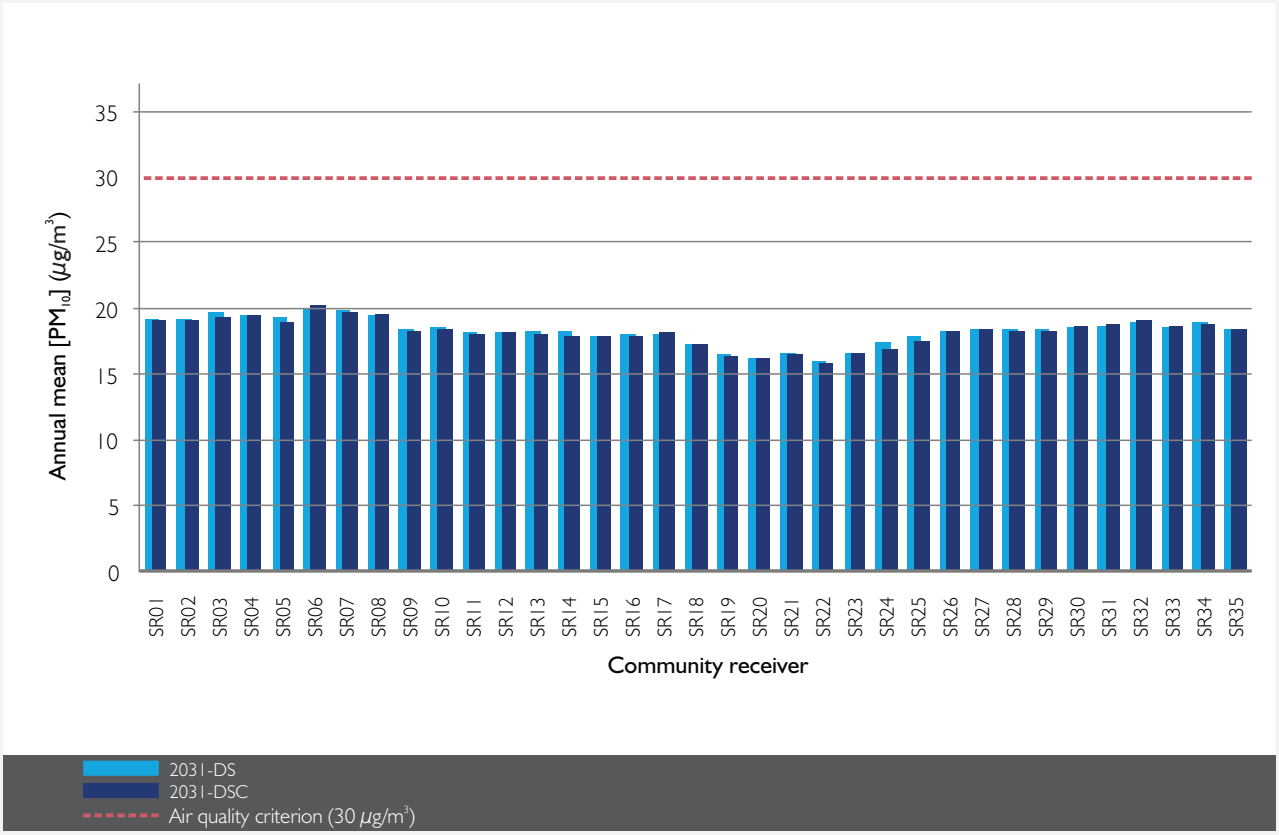


Figure 10-73 Annual mean PM_{10} at community receivers (2031-DS and 2031-DSC)

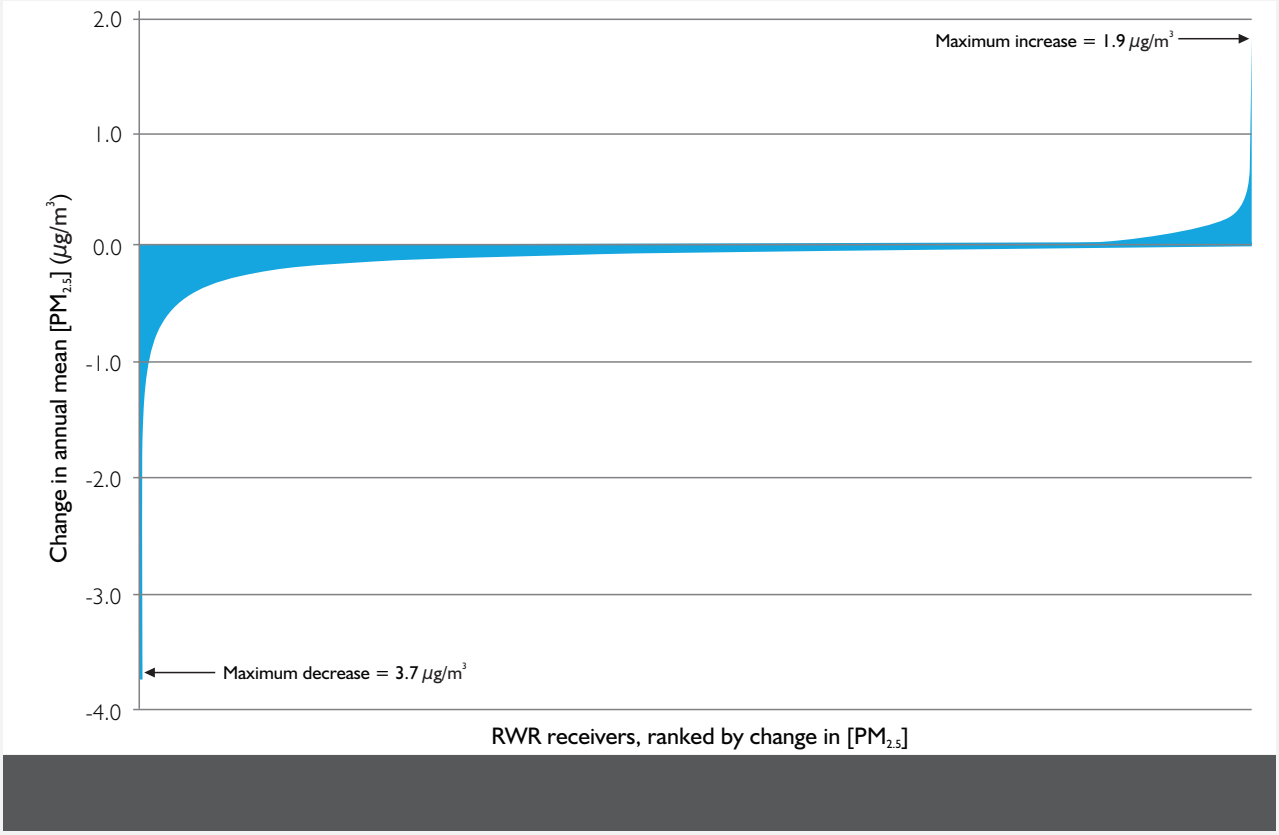


Figure 10-74 Changes in annual mean $PM_{2.5}$ at RWR receivers (2031-DSC)

(blank page)

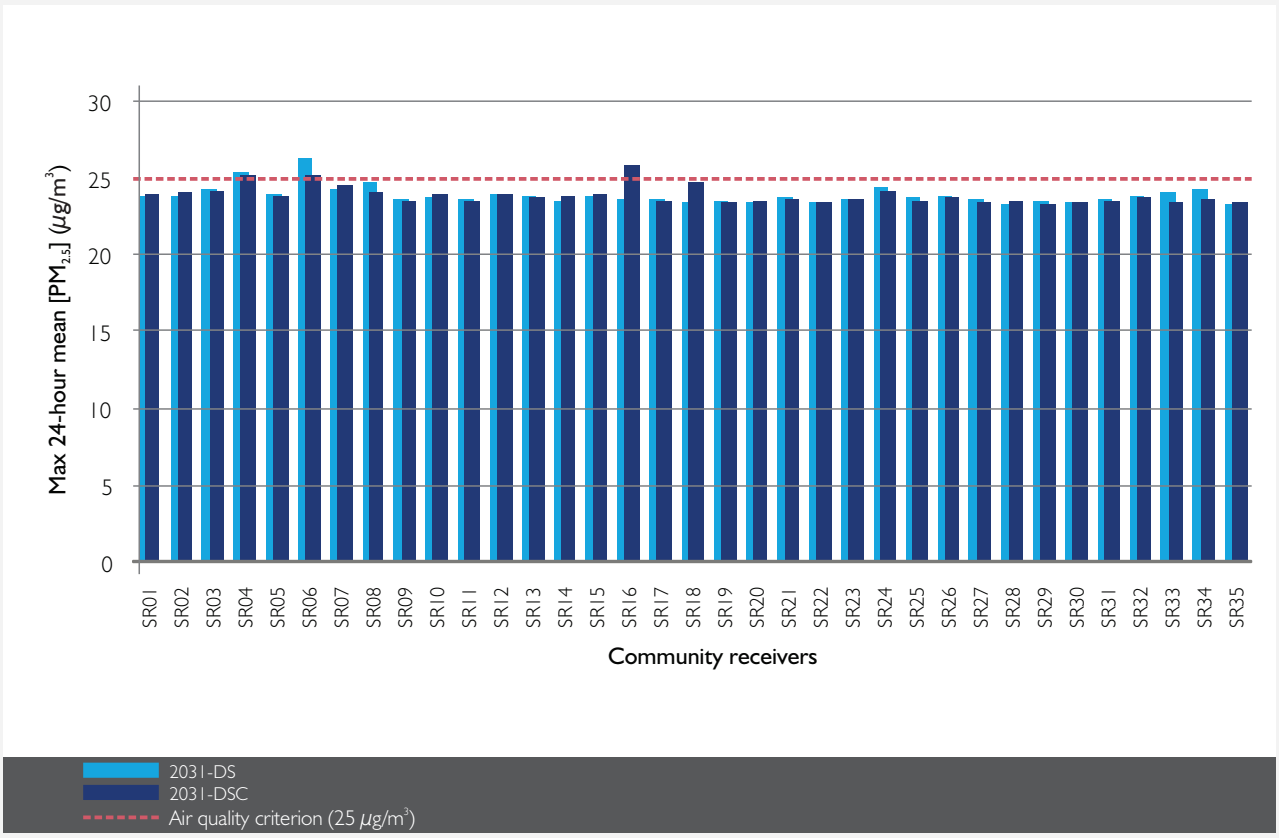


Figure 10-75 Maximum 24-hour $PM_{2.5}$ at community receivers (2031-DS and 2031-DSC)

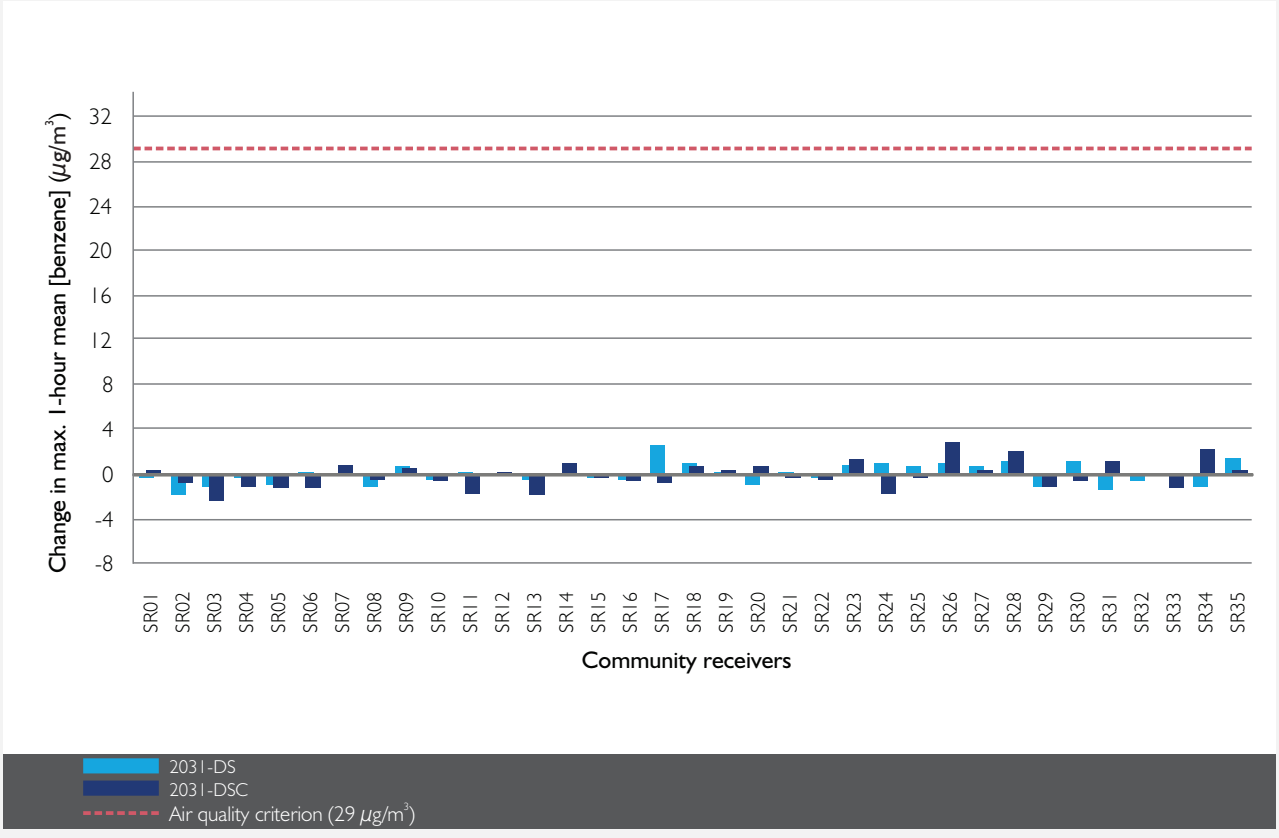


Figure 10-76 Change in maximum one hour mean benzene at community receivers (2031-DS and 2031-DSC)

(blank page)

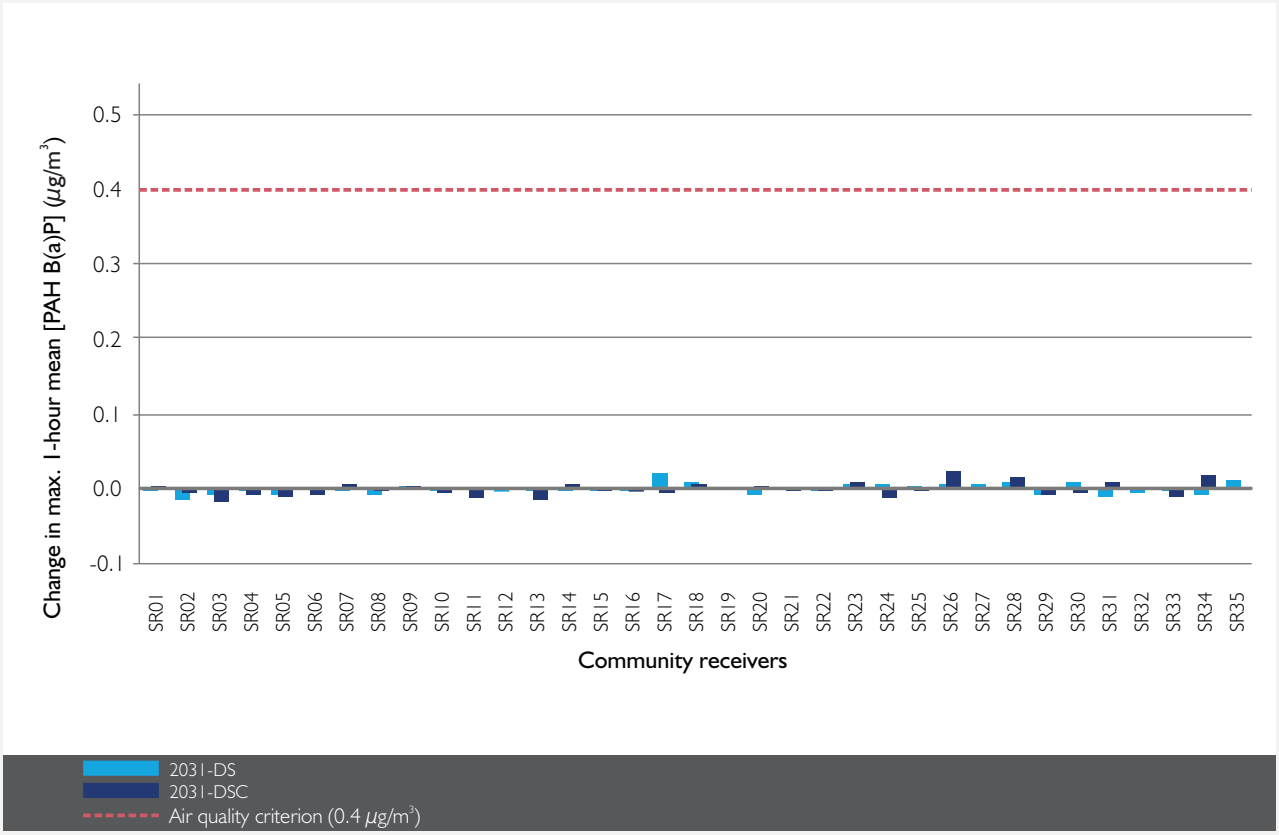


Figure 10-77 Change in maximum 1-hour mean b(a)p at community receivers (2031-DS and 2031-DSC)

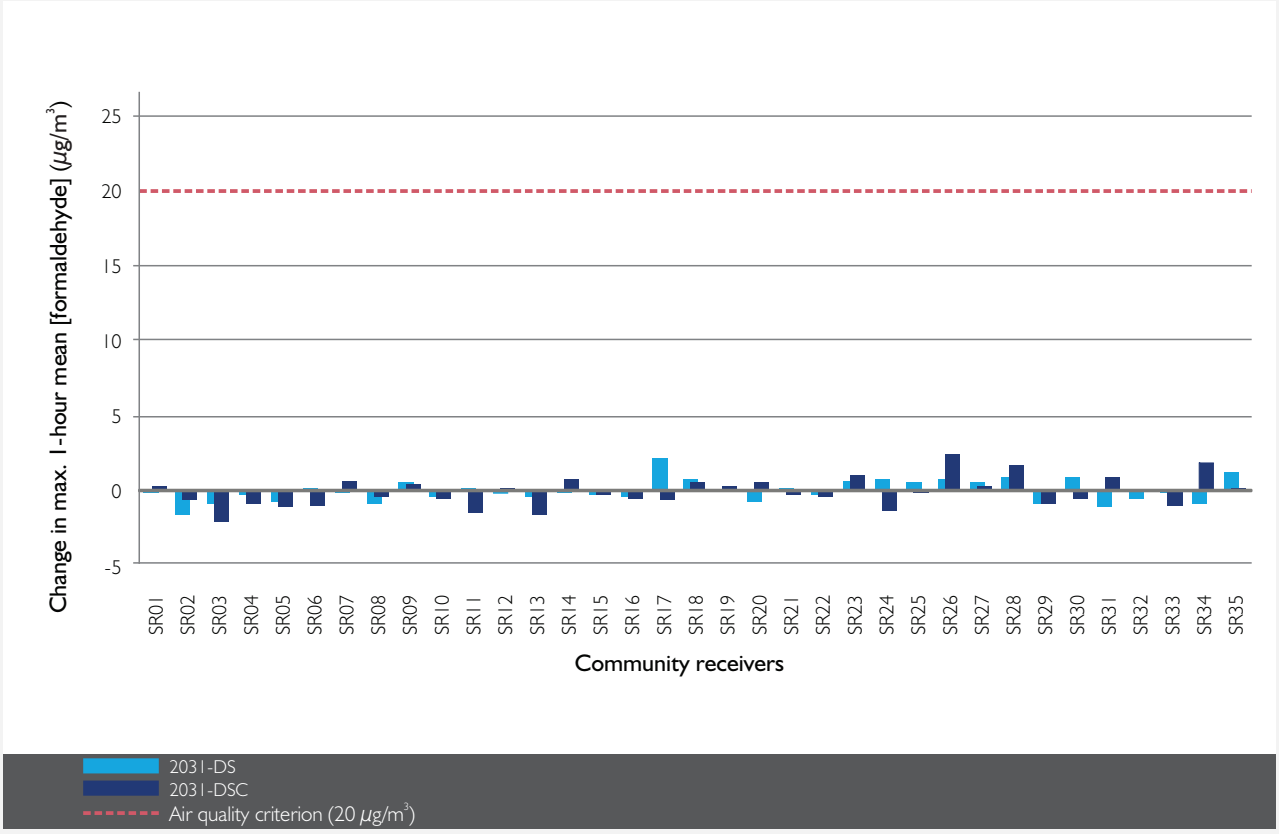


Figure 10-78 Change in maximum 1-hour formaldehyde at community receivers (2031-DS and 2031-DSC)

(blank page)

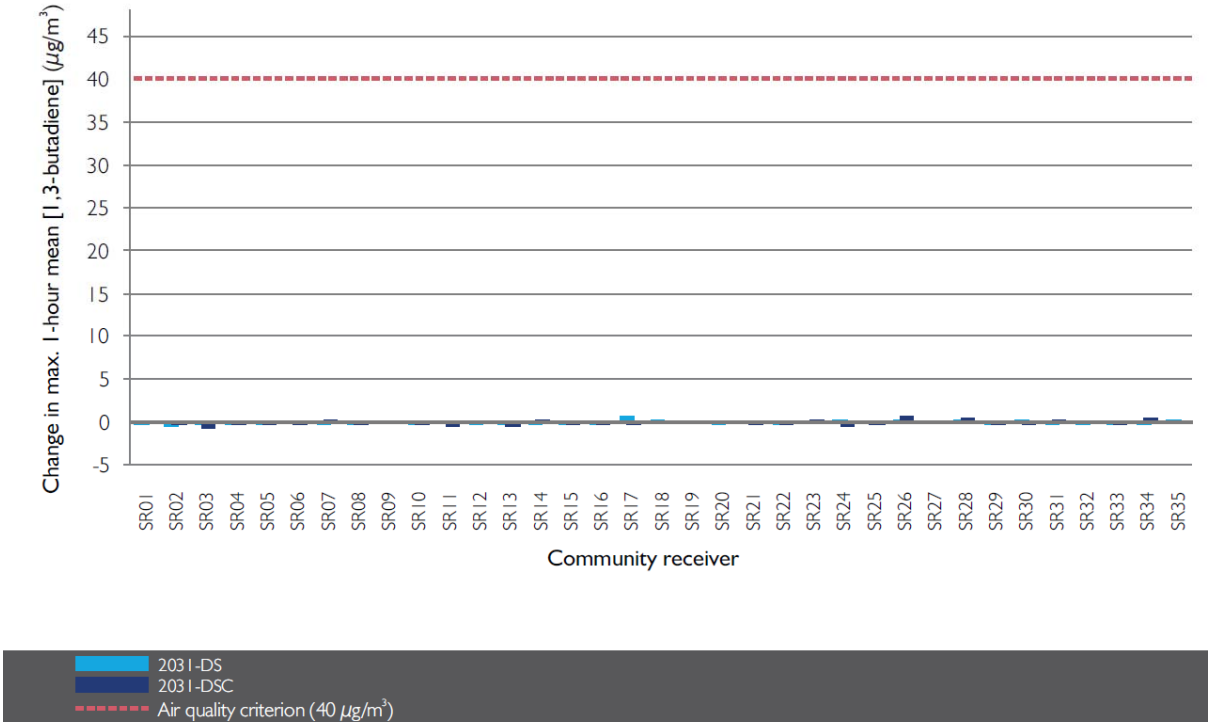


Figure 10-79 Change in max. one-hour 1,3-butadiene at community receivers (2031-DS, 2031-DSC)

10.10 Environmental management measures

10.10.1 Construction impacts

Environmental management measures to be applied during construction of the project are provided in **Table 10-32**. Most of the measures are routinely employed as 'good practice' on construction sites.

A Construction Air Quality Management Plan would be produced to cover all construction stages of the project. This plan would contain details of the site-specific mitigation measures to be applied. Additional guidance on the control of dust at construction ancillary facilities in NSW is provided as part of the NSW EPA Local Government Air Quality Toolkit.

Table 10-32 Environmental management measures – air quality

Impact	No.	Environmental management measure	Responsibility	Timing
Construction				
General	AQ1	Develop and implement a Construction Air Quality Management Plan in consultation with the NSW EPA. Any measures that are required will differ depending on the activities occurring, and so will need to be tailored for each individual site.	Construction contractor	Pre-construction
	AQ2	Carry out regular site inspections to monitor compliance with the Construction Air Quality Management Plan, record inspection results.	Construction contractor	Construction
	AQ3	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Construction contractor	Pre-construction

Impact	No.	Environmental management measure	Responsibility	Timing
	AQ4	Display the name and contact details of person(s) accountable for air quality and dust issues at the boundaries of each construction area. This may be the environment manager/engineer or the site manager. Display the head or regional office contact information.	Construction contractor	Construction
Dust management	AQ5	Plan site layout so that machinery and dust causing activities are located away from receivers, as far as is possible.	Construction contractor	Construction
	AQ6	Erect solid screens or barriers around dusty activities or the site boundary.	Construction contractor	Construction
	AQ7	Ensure, where reasonable and feasible, that appropriate control methods are implemented to minimise dust emissions from the project site.	Construction contractor	Construction
	AQ8	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, cover as soon as practicable.	Construction contractor	Construction
	AQ910	Impose and signpost a maximum-speed-limit of 20 km/h on surfaced and unsurfaced haul roads and in work areas.	Construction contractor	Construction
	AQ11	Where practicable, only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, (e.g. suitable local exhaust ventilation systems).	Construction contractor	Construction
	AQ12	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Construction contractor	Construction
	AQ13	Where possible, use enclosed chutes and conveyors and covered skips.	Construction contractor	Construction
	AQ14	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Construction contractor	Construction
	AQ15	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using appropriate cleaning methods.	Construction contractor	Construction
	AQ16	Avoid scabbling (roughening of concrete surfaces) if possible.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
Stockpile management	AQ17	Stockpiles would be located outside overland flowpaths, and where left exposed and undisturbed for longer than 28 days, would be finished and contoured to minimise loss of material in flood or rainfall events. Materials which require stockpiling for longer than 28 days would be stabilised by compaction, covering with anchored fabrics, or seeded with sterile grass where appropriate.	Construction contractor	Construction
	AQ18	Where a stockpile, eg sand or fine aggregate, has the potential to generate dust, control measures would be implemented. These would include wetting the stockpile, covering the stockpile or contouring the stockpile.	Construction contractor	Construction
	AQ19	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	Construction contractor	Construction
	AQ20	For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Construction contractor	Construction
Tracking of material on roads	AQ21	Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site.	Construction contractor	Construction
	AQ22	Avoid dry sweeping of large areas.	Construction contractor	Construction
	AQ23	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Construction contractor	Construction
	AQ24	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Construction contractor	Construction
	AQ25	Record all inspections of haul routes and any subsequent action in a site log book.	Construction contractor	Construction
	AQ26	Where reasonable and feasible, haul roads will be maintained with water carts and graders, and the condition of the roads will be monitored.	Construction contractor	Construction
	AQ27	Implement site exit controls (e.g. wheel washing system and rumble grids) to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable.	Construction contractor	Construction
	AQ28	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
	AQ29	Access gates to be located at least 10 metres from receivers where possible.	Construction contractor	Construction
Emissions management	AQ30	Ensure all construction vehicles comply with their relevant emission standards.	Construction contractor	Construction
	AQ31	Ensure that, where practicable, engine idling is minimised when stationary.	Construction contractor	Construction
	AQ32	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.	Construction contractor	Construction
	AQ33	Promote and encourage sustainable travel (public transport, cycling, walking, and car-sharing).	Construction contractor	Construction
	AQ34	No bonfires and burning of waste materials.	Construction contractor	Construction
Demolition	AQ35	Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).	Construction contractor	Construction
	AQ36	Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground and may be more useful for covering larger areas.	Construction contractor	Construction
	AQ37	Minimise explosive blasting where possible during demolition, using appropriate manual or mechanical alternatives.	Construction contractor	Construction
	AQ38	Bag and remove any biological debris or other hazardous materials such as asbestos, damp down such material before demolition.	Construction contractor	Construction
Earthworks	AQ39	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	Construction contractor	Construction
	AQ40	Use hessian, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Construction contractor	Construction
	AQ41	Where possible, only remove any cover for exposed areas in small areas during work and not all at once.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
Cumulative impacts	AQ42	Regular communication with other high risk construction ancillary facilities within 500 metres of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes.	Construction contractor	Construction
	AQ43	Undertake regular on-site and off-site inspection, where receivers are nearby, to monitor dust, record inspection results.	Construction contractor	Construction
Complaints management	AQ44	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	Construction contractor	Construction
	AQ45	Make complaints available to the Secretary upon request.	Construction contractor	Construction
	AQ46	Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.	Construction contractor	Construction

10.10.2 Operational impacts

The SEARs for the project require details of, and justification for, the air quality management measures that were considered for the project. This section reviews the environmental management measures that are available for improving tunnel-related air quality, and then describes their potential application in the context of the project. The measures are categorised as follows:

- Tunnel design
- Ventilation design and control
- Air treatment systems
- Emission controls and other measures
- Monitoring.

Tunnel design

It is important that the tunnel infrastructure is designed in such a way that the generation of pollutant emissions by traffic using the tunnel is minimised. The main considerations include avoiding large gradients and congested traffic conditions, including the management of traffic on the roads leading in and out of the tunnel. In addition, the risk of incidents leading to congestion would be addressed, including accidents involving oversized vehicles.

Ventilation design and control

There are several reasons why a tunnel needs to be ventilated. The main reasons are:

- Control of the internal environment - it must be safe and comfortable to drive through the tunnel. Vehicle emissions must be sufficiently diluted so as not to be hazardous during normal operation, or when traffic is moving slowly

- Protection of the external environment - it is unacceptable for polluted air from tunnel portals or ventilation outlets to present a health or nuisance hazard to the community. Ventilation, and the dispersion of pollutants, is overwhelmingly the most effective and accepted method for minimising the impacts of tunnels on ambient air quality. Collecting emissions and venting them via ventilation outlets is a very efficient way of dispersing pollutants. Studies show that the process of removing surface traffic from heavily trafficked roads and dispersion of emissions from an elevated location results in substantially lower concentrations at sensitive receivers (PIARC, 2008)
- Ventilation outlets need to be designed and sited accordingly. Discharge velocities from outlets must be assessed to ensure dispersion of pollutants is achieved
- Emergency situations. When a fire occurs in a tunnel it is a requirement to be able to control the heat and other combustion products in the tunnel, to permit safe evacuation of occupants, and to provide the emergency services with a safe access route to deal with the fire and to rescue anyone trapped or injured.

A two-fold approach to ventilation design is generally adopted:

- The amount of fresh air required to dilute pollutants to acceptable levels is calculated based on the likely emissions from vehicles in the tunnel, and the ventilation system is designed accordingly. The choice and design of a suitable ventilation system depends on:
  - Tunnel length and geometry
  - Traffic flow and composition
  - Fresh air requirement under normal and specific traffic conditions
  - Admissible air pollution levels around tunnel portals
  - Fire safety considerations.
- Sensors are installed in the tunnel to initiate the operation of the ventilation system in order to maintain the level of pollutants below limit values, or to force the closure of the tunnel should certain limit values be exceeded.

Short tunnels can be adequately and safely ventilated by the piston effect. The external wind may also generate a flow of air within a tunnel due to the static air pressure difference between the portals.

There are three basic concepts for mechanical tunnel ventilation and these are described and illustrated in **Chapter 4** (Project development and alternatives)

- Longitudinal ventilation, whereby air is introduced to, or removed from, the tunnel at a limited number of points
- Transverse ventilation, whereby air may be introduced into a tunnel at regular points along its length, and extracted at corresponding points along its length
- Semi-transverse ventilation. Semi-transverse ventilation involves a combination of longitudinal and transverse ventilation. For example, fresh air can be delivered uniformly (and transversely) over the length of the tunnel, and exhaust air is removed longitudinally through the tunnel portals.

Jet fans may also be mounted within the tunnel space, usually at fixed intervals along the tunnel and near to the tunnel ceiling. Ventilation control is achieved by adjusting the number of fans in operation at any one time, with each unit being operated at full power or not running. A further refinement is available in installations where fan speed is controllable. The required level of ventilation at any particular time tends is determined in response to NO_x, CO and visibility levels.

The predicted criteria in-tunnel pollutant levels for this tunnel support the use of a longitudinal ventilation system for the project as the air quality criteria can be achieved under all traffic conditions within the tunnel.

Emergency procedures

Except for short sections at exit portals, prior to an incident the air would be flowing strongly with the traffic. At the onset of a fire, any exit portal flow against traffic would be reversed, with the flow direction maintained for the majority of the tunnel. Exit portal inflows can be reversed quickly by turning off the ventilation station fans which extract the tunnel air prior to the portal.

Jet fans maintain an air flow in the traffic direction in order to prevent people held behind the fire from being affected by smoke. Sufficient jet fans would be provided to control backlayering of the smoke at the fire-site.

Under normal operation, traffic control measures would be applied to ensure that the traffic speed in the tunnel does not drop below 20 km/h for any significant period. This would ensure that, if a vehicle ignites, the smoke movement does not overtake downstream traffic.

Depending on the fire location, the smoke may be discharged through the normal ventilation outlet, using the ventilation station fans. The alternative is to drive the smoke out the exit portal. The non-incident tube will be closed to traffic and the airflow in that tube will be reversed using jet fans. This is to ensure that smoke issuing from a portal is not drawn into the adjacent portal of the non-incident tube. The jet fans would also be used to maintain the non-incident tube at a higher pressure than the incident tube, to prevent smoke flow through cross passages

Air treatment systems

There are several air treatment options for mitigating the effects of tunnel operation on both in-tunnel and ambient air quality. Where in-tunnel treatment technologies have been applied to road tunnels, these technologies have focused on the management and treatment of particulate matter. The most common of these is the electrostatic precipitator (ESP), often used for improving visibility in long tunnels. Other techniques include filtering, denitrification and biofiltration, agglomeration and scrubbing.

In Australia, the issue of air treatment frequently arises during the development of new tunnel projects. All tunnel projects rely instead on the primary approach of dilution of air pollution in the tunnel and effective dispersion though elevated outlets through ventilation systems (Cente d'Etudes des Tunnels (CETU), 2010 and Roads and Maritime Services, 2014a). Further details of air treatment systems and their use internationally are presented in the Technical working paper: Air quality in **Appendix H**.

The air quality assessment demonstrates that ventilation outlets are effective at maintaining local air quality. Provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is therefore not being proposed.

Mitigation of potential impacts by design

Tunnel design

The project design would reduce pollutant emissions and concentrations within the tunnel by including:

- Minimal gradients. The main alignment tunnels would have a maximum gradient of four per cent. By comparison, the M5 East tunnel has a grade of up to eight per cent on the western exit, which causes trucks to slow down and increase emissions
- Large main line tunnel cross-sectional area (90 square metres). The tunnel will have a large cross-sectional area to reduce the pollutant concentration for a given emission into the tunnel volume, and to permit greater volumetric air throughput
- Increased height. The height of the New M5 tunnel (5.3 metres) would be significantly greater than that of the M5 East tunnel (4.6 metres). This would reduce the risk of incidents involving high vehicles blocking the tunnel and leading to disruption of traffic.

Ventilation design and control

The project ventilation system has been designed so that it would achieve some of the most stringent standards in the world for in-tunnel air quality and would be effective at maintaining local air quality. The design of the ventilation system would provide zero portal emissions.

The ventilation system would be automatically controlled using real-time traffic data covering both traffic mix and speed, and feedback from air quality sensors in the tunnel, to ensure in-tunnel conditions are managed effectively in accordance with the agreed criteria. Furthermore, specific ventilation modes would be developed to manage breakdown, congested and emergency situations.

Air treatment

The effectiveness of the treatment of tunnel emissions has been evaluated as part of the environmental assessment phase of a number of existing Sydney road tunnels, including the M5 East, Cross City Tunnel and Lane Cove Tunnel. It has also been subject of numerous NSW Legislative Council (Upper House) inquiries and independent scientific reviews including by the CSIRO. In general these evaluations have indicated that it is more cost-effective to reduce pollutants at the source, using improved fuel standards and engine technology, which will result in greater benefits to air quality, both in-tunnel and in the ambient air, at the local and regional scales (WDA, 2013).

Incorporating filtration to the ventilation outlets would have negligible benefit and require a significant increase in the size of the tunnel facilities to accommodate the equipment. It would result in increased project size, community footprint, and capital cost. The energy usage would be substantial and does not represent a sustainable approach. Further, the air leaving the outlet is not highly concentrated with pollutants (as demonstrated by the air quality assessment) since it must be of a quality to be acceptable for tunnel users. Any predicted impact on local air quality is very small even without a filtration system.

In summary, the provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is not being proposed.

Emission controls

Smoky vehicle cameras would be installed to automatically detect vehicles with excessive exhaust smoke, with penalties applying to offenders. A similar initiative is in place for the M5 East tunnel and has resulted in a reduction of smoky vehicles using the tunnel.

Monitoring

The assessment has demonstrated that even at the regulatory worst case, any changes in ambient air quality due to emissions from the ventilation outlets would be small and unlikely to result in adverse impacts on local air quality. Nevertheless, ambient air quality monitoring would be conducted to validate the EIS predictions.

11 Human health

A Technical working paper: Human health (**Appendix I**) has been prepared to assess the potential impacts of the project on human health. This chapter includes:

- An outline of the methodology used to undertake the human health assessment
- A summary of the existing environment as it relates to human health
- A description of the potential impacts of the project on human health during construction and operation
- Environmental management measures proposed to be implemented to minimise any potential impacts of the project on human health.

Table 11-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to human health, and where in the environmental impact statement (EIS) these have been addressed.

Table 11-1 SEARs – human health

SEARs	Where addressed
An assessment of human health impacts with particular consideration of:	
• how the design of the proposal minimises adverse health impacts,	**Section 11.3** and **Section 11.4**
• human health impacts from the operation of the tunnel under a range of conditions, including worst case operating condition, and	**Section 11.3** and **Section 11.4**
• human health risks and costs associated with the proposal, including those associated with air quality, noise and vibration, and social impacts, during the construction and operation of the proposal, and the Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards (enHealth, 2012) and Air Quality in and Around Traffic Tunnels (NHMRC,2008).	**Section 11.3** and **Section 11.4** **Section 11.1**

11.1 Assessment methodology

The methodology for the human health risk assessment is based on defining and assessing potential risks to human health from the construction and operation of the project. The human health assessment focused on key impacts to air quality, noise and vibration, and social changes.

11.1.1 Method of assessment

The human health risk assessment was carried out in accordance with national and international guidance that is endorsed or accepted by Australian health and environmental authorities, and includes:

- *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards* (enHealth, 2012a)
- *Health Impact Assessment Guidelines* (enHealth, 2001)
- *Australian Exposure Factor Guidelines* (enHealth, 2012b)
- *Health Impact Assessment Guidelines* (Harris, 2007)
- *National Environment Protection Council (NEPC) Schedule B(8) Guideline on Community Consultation and Risk Communication, National Environment Protection (Assessment of Site Contamination) Measure* (NEPC, 2013)

- *NEPC National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure* (NEPC, 2003)
- *United States Environment Protection Agency (USEPA) Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)*, EPA-540-R-070-002 (USEPA, 2009).

More specifically in relation to the assessment of health impacts associated with exposure to particulates, additional guidelines available from the NEPC, World Health Organisation and USEPA have been used as required.

This chapter considers the following issues in relation to the assessment of human health impacts:

- Existing conditions (in relation to air quality and noise)
- How the design of the project minimises adverse health impacts
- Human health risks and costs associated with the project, including those associated with air quality, noise and vibration as well as social impacts during the construction and operation of the project, and an estimation of short-term (acute) and long-term (chronic) impacts during construction and operation of the project
- Human health impacts to users of the tunnel and external receivers from the operation of the tunnel under a range of conditions, including worst case operating condition
- Consideration of cumulative impacts, and changes to exposure that are associated with the project.

Key tasks involved in the human health risk assessment included:

- A review of available information and guidelines that relate to the project design
- Reviewing outcomes from relevant technical studies undertaken in relation to air quality, noise and vibration which include assessment methodology, criteria, project goals, survey results and analysis
- Identification of populations located in the vicinity of the project that may be exposed to impacts from the project
- A toxicity assessment that enables a calculation of an increased annual risk and an increased incidence of a potential impact occurring within the population of concern, including qualitative and quantitative assessment as appropriate, and also considering the level of uncertainty associated with all aspects of the technical studies.
- A risk assessment that enabled a calculation of an increased annual risk and an increased incidence of a potential impact occurring within the population of concern, including qualitative and quantitative assessment as appropriate, and also considering the level of uncertainty associated with all aspects of the technical studies.

The detailed principles, methodology and limitations of the toxicity and risk assessment are provided in Section 3 of the Technical working paper: Human health (**Appendix I)**.

11.1.2 Study area

The study area is centred on the project alignment and comprises an area that is about 11 kilometres by seven kilometres in size. The suburbs (or part suburbs) considered as part of the human health risk assessment included:

- Roselands
- Riverwood
- Narwee and Beverly Hills
- Lakemba and Wiley Park
- Hurstville
- Penshurst
- Canterbury
- Belmore
- Campsie and Clemton Park
- Kingsgrove North and Earlwood
- Kingsgrove South, Bexley North and Bardwell Park
- Bexley
- Arncliffe, Turrella and Bardwell Valley
- Rockdale and Banksia
- Wolli Creek
- Monterey, Brighton-Le-Sands and Kyeemagh
- Sydenham, Tempe and St Peters
- Marrickville
- Erskineville and Alexandria
- Newtown
- Botany
- Mascot.

The assessment of potential impacts on the surrounding community, particularly in relation to air quality, has considered the location where peak impacts from the project may occur.

Impacts to sensitive community receivers in suburbs close to the study area have also been identified. Community receivers are locations in the local community where more sensitive members of the population, such as infants, young children, the elderly or those with existing health conditions or illnesses, may spend a significant period of time. These locations comprise hospitals, child care facilities, schools and aged care homes / facilities. **Table 11-2** lists the 45 specific community receivers included in the health risk assessment.

A further 46,200 individual receivers have been modelled in the streets / suburbs located in the study area. These individual receivers represent residential homes, workplaces or recreational areas located in the surrounding community. These receivers are referred to as residential, workplace and recreational (RWR) receivers. The RWR receivers include other community receivers located in the study area, not included in **Table 11-2**. The peak impacts on all of the RWR receivers have also been evaluated in this assessment.

Table 11-2 Community receivers included in health risk assessment

Receiver name	Type of receiver	Suburb
Active Kids Beverly Hills	Child care	Beverly Hills
Active Kids Narwee	Child care	Narwee
Beverly Hills North Public School	School	Beverly Hills
Beverly Hills Girls High School	School	Beverly Hills
Barfa Bear Child Care Centre	Child care	Beverly Hills
Regina Coeli Catholic Primary School	School	Beverly Hills
Footsteps Early Learning Centre	Child care	Beverly Hills
Footsteps Early Learning Centre OOSH School Care	Child care	Beverly Hills
McCallums Hill Public School	School	Roselands
Hurstville City Council Family Day Care Scheme	Child care	Hurstville
Kingsgrove North High School	School	Kingsgrove
Kingsgrove Early Childhood Health Centre	Health	Kingsgrove
Kingsgrove World Of Learning	Child care	Kingsgrove
Kingsgrove Day Hospital	Hospital	Kingsgrove
Kings Medical Clinic	Health	Kingsgrove
Kids Oasis Childcare Centre	Child care	Kingsgrove
Clemton Park Public School	School	Clemton Park
The Salvation Army Booth College	School	Bexley North
Alloa Nursing Home	Aged care	Arncliffe
Athelstane Public School	School	Arncliffe

Receiver name	Type of receiver	Suburb
Kinderoos Childcare Centre	Child care	Arncliffe
Ladybugs Day Care	Child care	Turrella
Macedonian Community Child Care Centre	Child care	Arncliffe
Arncliffe Public School	School	Arncliffe
Tempe High School	School	Tempe
Tillman Park Child Care Centre	Child care	Tempe
St Pius' Catholic Primary School	School	Enmore
Camdenville Public School	School	Newtown
Camdenville Public School Preschool	School	Newtown
St Peters Public School	School	St Peters
Sydney Park Childcare Centre	Child care	Alexandria
Sydney Park Childcare Centre	Child care	Alexandria
Lady Gowrie Child Centre	Child care	Erskineville
Active Kids Mascot	Child care	Mascot
Building Blocks Early Childhood Learning	Child care	Alexandria
Rosemore Aged Care	Aged care	Belmore
Fairmont Aged Care	Aged care	Bexley
Prestige Nursing Agency	Aged care	Varsity Lakes, Campsie
Lakemba Masonic Caring Centre	Aged care	Lakemba
Jenny-Lyn Aged Care Centre	Aged care	Brighton-Le-Sands
Menaville Nursing Home	Aged care	Rockdale
Chow Cho-Poon Nursing Home	Aged care	Earlwood
Moorefields Masonic Village	Aged care	Roselands
Glen Village	Aged care	Bardwell Valley
Macquarie Lodge Retirement Village	Aged care	Arncliffe

11.1.3 Field survey and analysis

Seven air quality monitoring stations were established in the study area to support the development and assessment of the project. The monitoring stations have been designed to supplement the existing Office of Environment and Heritage (OEH) and Roads and Maritime stations so that representative data can be established and long-term air quality data near the project can be provided. Background air quality data relevant to the assessment of carbon monoxide (CO), nitrogen dioxide (NO_2) and particulate matter was collated from these monitoring stations. Data analysis used an air dispersion model (GRAL) to predict changes in ambient air quality associated with a range of emissions scenarios for the operational years 2021 and 2031. More detail regarding the air quality assessment is provided in **Chapter 10** (Air quality).

Existing ambient noise was measured at 27 locations (refer to the Technical working paper: Human health in (**Appendix I**) for locations) during four noise monitoring periods that were conducted in May / June 2014, December 2014, March 2015 and June 2015. The background noise levels established for use in the noise assessment relates to specific time periods in the *Interim Construction Noise Guideline* (DECC, 2009) and *Road Noise Policy Guideline* (DECCW, 2011).

Attended noise monitoring was also undertaken at a number of locations to supplement ambient noise monitoring. Construction noise was assessed using the CONCAWE model (within SoundPLAN 7.1). Operational noise impacts have been assessed for the years 2021 (representing the year of opening of the project) and 2031 (10 years after opening of the project). Operational noise modelling has considered noise impacts in the community both with and without the project. Details of noise monitoring stations, monitoring locations, noise criteria and modelling are discussed in **Chapter 12** (Noise and vibration).

11.2 Existing environment

11.2.1 Population profile

The composition of the populations located within the suburbs considered in this assessment are available from the Australian Bureau of Statistics for the census year 2011 and are summarised in Table 4.2 and Table 4.3 of the Technical working paper: Human health (**Appendix I**).

The suburbs included in the human health risk assessment are located in six local government areas; Canterbury, Hurstville, Rockdale, Marrickville, Sydney and Botany Bay. The estimated population growth from 2011 to 2013 in each of these local government areas is:

- Canterbury: 23.3 per cent growth in population, including a 26.4 per cent increase in the number of children aged under 15 years and a 62.9 per cent increase in the population aged 65 years and older
- Hurstville: 28.1 per cent growth in population, including a 31.7 per cent increase in the number of children aged under 15 years and 59.3 per cent increase in the population aged 65 years and older
- Rockdale: 30.7 per cent growth in population, including a 36.0 per cent increase in the number of children aged under 15 years and a 58.3 per cent increase in the population aged 65 years and older
- Marrickville: 19.8 per cent growth in population, including a 36.1 per cent increase in the number of children aged under 15 years and a 50.0 per cent increase in the population aged 65 years and older
- Sydney: 58.3 per cent growth in population, including a 95.8 per cent increase in the number of children aged under 15 years and a 136.5 per cent increase in the population aged 65 years and older
- Botany Bay: 43.2 per cent growth in population, including a 49.9 per cent increase in the number of children aged under 15 years and a 75.5 per cent increase in the population aged 65 years and older.

Section 4 of the Technical working paper: Human health (**Appendix I**) provides a detailed description of the social characteristics and economic status of the six local government areas relevant to the project. **Table 11-2** provides a list of the sensitive receivers, termed community receivers, included in this assessment. The locations of the social and economic receivers are shown on **Figure 11-1**.

(blank page)

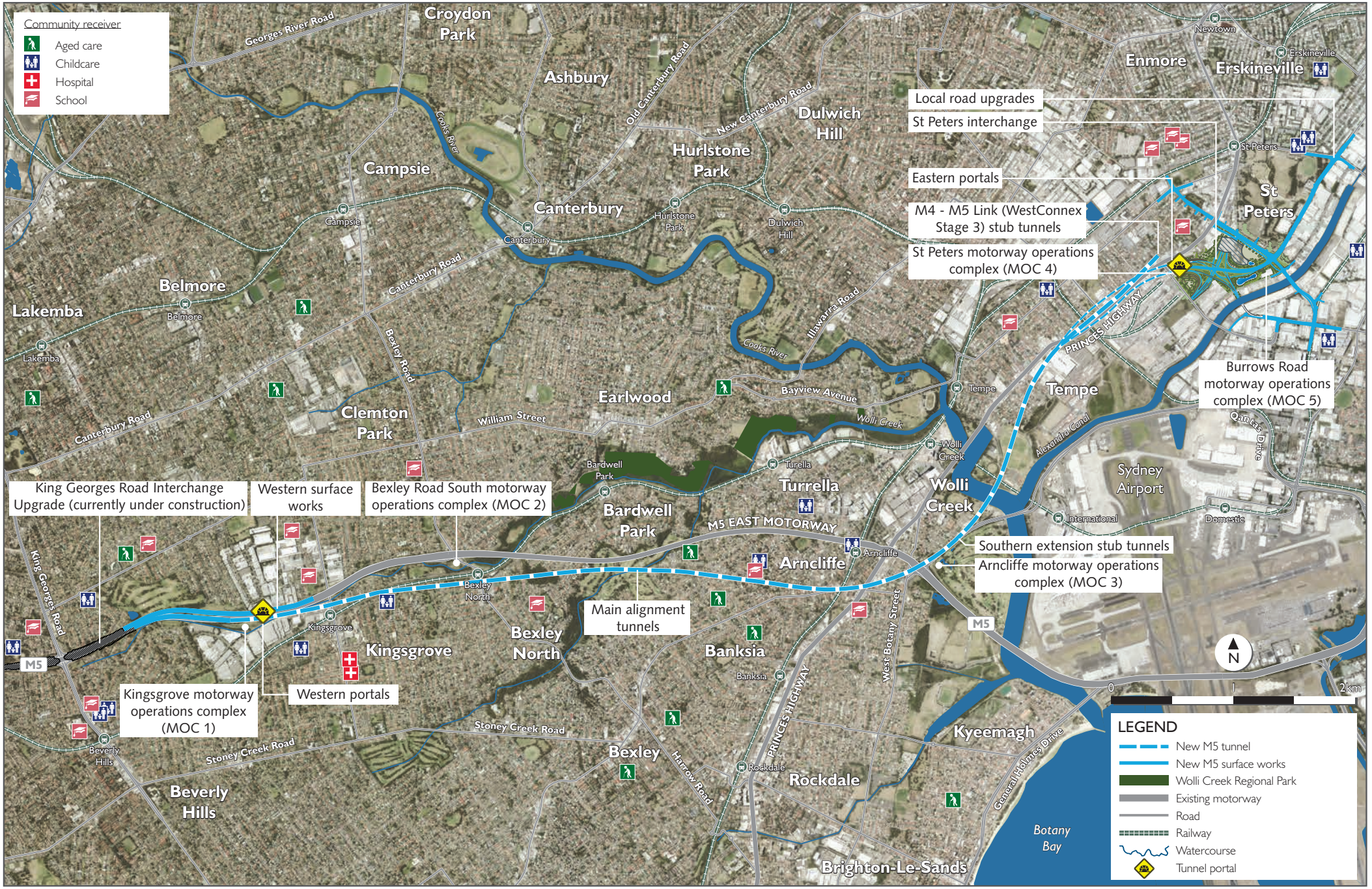


Figure 11-1 Community receivers evaluated in human health risk assessment

(blank page)

11.2.2 Health of existing population

The health of the community within the study area is influenced by a complex range of interacting factors including age, socio-economic status, social capital, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care.

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) are available for large health population areas in Sydney and NSW. This includes risky alcohol drinking, smoking, consumption of fruit and vegetables, being overweight and obese and adequate physical activity.

The population of the study area is largely located within the Sydney Area Health Service and the South Eastern Sydney Area Health Service. The incidence of health-related behaviours in this area, compared with other health areas in NSW and the state of NSW (based on data from 2014) generally indicates that the population in the Sydney and South Eastern Sydney areas:

- Have similar rates of risky alcohol drinking and smoking and similar intakes of recommended consumption of fruit and vegetables compared with NSW
- Have higher rates of adequate physical activity and lower rates of being overweight and obese compared with NSW.

A review of the data obtained from Health Statistics New South Wales (refer Table 4.4 in the Technical working paper: Human health (**Appendix I**) generally indicates that for the population in the study area, the health statistics (including mortality rates and hospitalisation rates for most categories) are variable but generally similar to those reported in the larger area health services of Sydney and South Eastern Sydney, the wider Sydney metropolitan area and the whole of NSW.

Section 4.5 of the Technical working paper: Human health (**Appendix I**) provides further details on health related behaviours and health indicators for the study area.

11.2.3 Existing air quality

The project is situated within an urbanised area of Sydney. In large urban areas there is usually a complex interaction of pollution sources, substantial concentration gradients, short-term meteorological conditions and local topography all affecting the quality of the air.

Air quality in the Sydney region has improved over the last few decades. The improvements have been attributed to initiatives which aim to reduce emissions from industry, motor vehicles, businesses and residences. While levels of NO_2, SO_2 and CO continue to be below national standards, levels of ozone and particulate matter ($PM_{2.5}$ and PM_{10}) can occasionally exceed the standards. For these pollutants there are a large number of sources in the study area including combustion sources other than from the project, other local construction / earthworks and personal exposures (such as smoking) and risk taking behaviours that have the potential to affect the health of any population.

A full description of existing air quality near the project is provided in **Chapter 10** (Air quality).

11.2.4 Existing noise and vibration

The noise levels at attended monitoring locations showed a typical daily trend with lower noise levels during the night-time compared to the daytime and evening periods. This is characteristic of urban and suburban areas where the ambient noise environment is primarily influenced by road traffic.

The data is also consistent with observed traffic flows on the adjacent major roads which have a relatively small reduction in traffic volumes during the evening compared to the daytime period, and a more significant reduction in volumes during the night-time.

The measured noise levels have been used with consideration of the existing road traffic flows to calibrate the operational noise model and also to establish construction noise management levels for the project.

Background noise levels for construction have been established for the day (7am to 6pm, varying from 45 to 68 decibels (dB(A)), evening (6 to 10pm, varying from 43 to 67 dB(A)) and night-time (10pm to 7am, varying from 32 to 51 dB(A)) periods as rating background level (RBL) values determined on the basis adopted guidelines.

Background noise levels for operations have been established for the day (7am to 10pm varying from 54 to 73 dB(A)) as $L_{Aeq(15\ hour)}$ and night-time (10pm to 7am varying from 50 to 70 dB(A)) as $L_{Aeq(9\ hour)}$.

A full description of the existing noise environment is provided in **Chapter 12** (Noise and vibration).

11.3 Assessment of potential impacts

11.3.1 Construction

Air quality

Chapter 10 (Air quality) has considered impacts to air quality that may occur during construction as a result of tunnelling activities and surface works. The assessment of construction air quality was carried out using a qualitative assessment approach. For almost all construction activities, significant impacts to receivers would be avoided through project design and the implementation of effective mitigation measures. However, dust management measures may not be effective all of the time. In situations where the construction air quality management measures are not fully effective, impacts to receivers would be temporary and short-term and are not considered to be significant. A construction air quality management plan would be developed and implemented for all construction activities of the project (refer to **Chapter 10** (Air quality) for more information).

Noise and vibration

As described in **Chapter 12** (Noise and vibration), a worst case noise and vibration assessment (assuming no additional mitigation measures are implemented) was carried out in accordance with the *Interim Construction Noise Guidelines* (DECC, 2009). For each area assessed, the noise levels at the most affected receiver have been used to represent the whole area.

Construction noise

Potential construction noise which exceeds the applicable construction noise management levels have been identified at a number of receivers during site establishment works, road and intersection modifications (including traffic controls), works within the various construction compounds, construction of surface roadways and other local road works (as part of the local road upgrades), M5 East Motorway road widening and realignment (as part of the western surface works), construction of tunnel portals and interchanges, tunnelling works, demolition of existing structures and construction of fixed facilities. A range of mitigation measures (including temporary construction noise attenuation structures) have therefore been identified to mitigate and manage these potential impacts.

During construction it is likely that the screening criterion for sleep disturbance would be exceeded during some night time works adjacent to residential receivers for most works scenarios, with the greatest impact predicted during local road works and road works for the construction of toll infrastructure. The level of noise predicted for the project is typical for construction works using noise intensive equipment in urbanised areas. Where possible, construction works would be undertaken during the daytime. The need for additional noise mitigation measures for works during night time would be considered during detailed design works for the project.

Construction traffic

Potential increases in noise at sensitive receivers due to construction traffic have been assessed separately from the assessment of noise from other construction activities.

The majority of construction traffic flows would occur on major roads. Construction compound locations have been selected to minimise the use of local roads; however, construction vehicles may use local roads that do not form part of the construction compound vehicle routes to access construction areas (such as along local roads that are subject to construction activities). The construction traffic noise associated with access and use of local roads has been evaluated in **Chapter 12** (Noise and vibration). The assessment found that Wirega Avenue and West Botany Street (north of the M5 East Motorway) were the most affected local roads proposed to carry heavy construction vehicles. Other local roads around the temporary construction compounds would be less affected.

Ground-borne noise

Detailed three-dimensional modelling was undertaken for the project to predict potential elevated noise levels due to ground-borne noise. Ground-borne noise occurs when works are being undertaken under the ground surface or in some other fashion that results in vibrations being generated from noise moving through the ground rather than the air.

The three-dimensional modelling addressed the worst case scenario, where tunnelling occurs immediately beneath a sensitive receiver. The tunnelling equipment would move at about seven metres per day so would be directly underneath a sensitive receiver for a relatively short period of time (around five days for most receivers). However, tunnelling advance rates may reduce to between two and five meters a day around tunnel portals, which may increase the duration of exposure for sensitive receivers at these locations.

The worst-case ground-borne noise levels are predicted to be compliant with the more stringent 35 dB(A) $L_{Aeq(15minute)}$ night-time criterion at the majority of receivers which are potentially affected by ground-borne noise from tunnelling works.

At some locations where the tunnel rises to meet surface roads (for example St Peters interchange) and where cross passages would be constructed (for example at Kingsgrove, Bardwell Park, Bexley North and St Peters), exceedances of evening noise criteria may occur. Some 369 receivers may also experience exceedances of the more stringent night-time criteria throughout the study area, including the suburbs of Kingsgrove, Bexley North, Bardwell Park, Tempe, and St Peters.

Vibration impacts

Some of the equipment which would be used during construction would have the potential to cause unacceptable levels of vibration. Managing the potential for such vibration to actually cause discomfort or structural damage at sensitive receiver locations is based on ensuring suitable separation distances between construction plant and equipment and the sensitive receiver locations.

The vibration assessment undertaken indicates about 163 receivers would experience exceedances of the preferred night-time human comfort criteria during tunnelling works. The maximum night-time criteria are not anticipated to be exceeded.

Receivers adjacent to construction areas have been identified as likely to perceive vibration impacts at times during construction works. This is expected to be primarily as a result of works associated with rock breakers and other high vibration plant items such as heavy vibratory rollers. In practice, vibration impacts from most construction activities would be throughout the duration of construction and generally tend to move along the alignment such that impacts at any given receiver are for a far shorter duration. The required locations for vibration intensive equipment would be reviewed during detailed design when more specific information is available.

Blasting

Blasting would be carried out along the length of the tunnel alignment during excavation and would be carefully planned to ensure blast limits are satisfied. Each blast event would be tailored to site conditions and site constraints at each blast location as tunnelling activities progress. Impacts resulting from blasting are largely dependent on the blast methodology. The size of the charge, space between charges and timing between charges results in a large variability in the vibration generated by a blast. This variability necessitates a specialised blast consultant to design blasts to ensure compliance with the applicable vibration criteria. Further detailed assessment and a blast trial process would be described in a Blast Management Strategy, which would be prepared during the detailed design of the project.

11.3.2 Operation

Air quality

The assessment of impacts to air quality associated with operation of the project has considered a range of scenarios that include the existing situation and operation for the future years 2021 and 2031; with and without the project, outside of the main alignment tunnels. The operational air quality assessment has focused on the following key pollutants associated with vehicle emissions:

- Volatile organic compounds (VOC)
- Polycyclic aromatic hydrocarbons (PAH)
- CO
- NO_2
- Particulate matter ($PM_{2.5}$ and PM_{10}).

Emissions associated with the operation of the tunnel relate to the discharge of air from within the tunnel to atmosphere via three ventilation facilities located at Kingsgrove (venting emissions from west-bound traffic), Arncliffe (venting emissions from east-bound traffic) and St Peters (venting emissions from east-bound traffic).

There are in-tunnel air quality limits that are required to be met under all operational circumstances (except emergencies such as fire). The tunnel ventilation system and tunnel operational parameters are designed to ensure the in-tunnel concentration limits are not exceeded and to limit the discharge of pollutants to the external environment. Additional details on the operational air quality assessment scenarios, locations of air quality monitoring stations and the emission sources and limits considered are provided in **Chapter 10** (Air quality).

Vehicle emissions

Emissions from vehicles using the main alignment tunnels have been estimated based on published emission factors relevant to vehicle fleets in the year 2020. These emissions factors have been assumed to remain the same for assessing impacts in 2021 and 2031. This is a conservative approach because it does not take into account improvement in fuel and vehicle efficiencies that are likely to occur over this period.

Volatile organic compounds and polycyclic aromatic hydrocarbons

VOCs and PAHs are associated with emissions from vehicles using the main alignment tunnels and the local surface road network, with levels dependent on the mix of vehicles.

Most of the VOC emissions comprise a range of hydrocarbons. From a toxicity perspective, the key VOCs that have been considered for the vehicle emissions are benzene, toluene, ethylbenzene, and xylenes (BTEX), 1,3-butadiene, acetaldehyde and formaldehyde (consistent with those identified and targeted in studies conducted in Australia on vehicle emissions (Department of the Environment, 2003; EPA, 2012b)).

The predicted (incremental) increase in concentration of individual VOCs and PAHs associated with the project (based on the speciation outlined above) have been reviewed against published peer-reviewed health based guidelines that are relevant to acute and chronic exposures (where relevant). The health based guidelines adopted (enHealth, 2012a) are relevant to exposures, both acute and chronic, that may occur to all members of the general public (including sensitive individuals) with no existing adverse health effects. The proportion of each of the key VOCs considered are derived from the 2008 Air Emissions Inventory for the Greater Metropolitan Region in NSW (EPA, 2012b).

A summary of the speciation profile of VOCs for the different vehicle types considered in the project as well as the weighted mass fraction for the VOCs considered for the project is presented in the Technical working paper: Human health (**Appendix I**)**.**

Table 11-3 and **Table 11-4** 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 (HI) which is the ratio of the maximum predicted concentration to the guideline. Each individual HI is added to obtain a total HI for all threshold VOCs and PAHs considered. The total HI 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:

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

The following evaluation is based on the maximum predicted change (incremental) in concentration in air for 2021, 2031 and the cumulative scenario as modelled as part of the air quality assessment (refer to **Appendix H**). Concentrations in all other areas of the surrounding community are lower than evaluated in this assessment. In most locations the project results in a lowering of VOCs and PAHs concentrations in air (ie a beneficial effect).

For the assessment of acute exposures to VOCs (**Table 11-3**), the calculated HI associated with exposure to the maximum concentrations predicted is less than one for 2021, 2031 and the cumulative scenario. On this basis there are no acute risk issues in the local community associated with the project.

Table 11-3 Assessment of acute exposures to VOCs – maximum impacts in community associated with project

Key VOC	Maximum predicted 1-hour average concentration associated with project and calculated HI					
	2021		2031		Cumulative - 2031	
	Maximum concentration ($\mu g/m^3$)	HI	Maximum concentration ($\mu g/m^3$)	HI	Maximum concentration ($\mu g/m^3$)	HI
Total VOCs	**244**		**171**		**146**	
Toluene	19.5	0.0043	12.4	0.0028	11.7	0.0026
Xylenes	16.1	0.0073	10.2	0.0046	9.7	0.0044
1,3-Butadiene	2.8	0.0042	1.8	0.0027	1.7	0.0025
Formaldehyde	6.0	0.40	5.7	0.38	3.6	0.24
Acetaldehyde	3.2	0.0067	2.6	0.0055	1.9	0.0040
Total HI	**0.4**		**0.4**		**0.2**	

For the assessment of chronic exposures to VOCs and PAHs (**Table 11-4**), the calculated HI associated with exposure to the predicted maximum concentrations is less than or equal to one for 2021, 2031 and the cumulative scenario. The calculated lifetime cancer risks associated with the maximum change in benzene and carcinogenic PAHs (as benzo(a)pyrene Toxic Equivalence Quotient (TEQ)) are equal to $1x10^{-5}$ and are considered to be tolerable.

Table 11-4 Assessment of chronic exposures to VOCs and PAHs – maximum impacts in community associated with project

Key VOCs and PAHs	Maximum predicted annual average concentration associated with project and calculated HI					
	2021		2031		Cumulative - 2031	
	Maximum concentration ($\mu g/m^3$)	HI	Maximum concentration ($\mu g/m^3$)	HI	Maximum concentration ($\mu g/m^3$)	HI
Total VOCs	**6.3**		**4.8**		**5.5**	
Toluene	0.51	0.00010	0.35	0.000070	0.44	0.000088
Xylenes	0.42	0.0019	0.29	0.0013	0.36	0.0017
1,3-Butadiene	0.072	0.24	0.051	0.17	0.063	0.21
Formaldehyde	0.15	0.047	0.16	0.048	0.13	0.041
Acetaldehyde	0.082	0.0091	0.072	0.008	0.072	0.007
Total PAHs	**0.042**		**0.032**		**0.036**	
Naphthalene	0.027	9×10^{-3}	0.021	7×10^{-3}	0.024	8×10^{-3}
Acenaphthylene	0.0022	1×10^{-5}	0.0017	9×10^{-6}	0.0020	1×10^{-5}
Acenaphthene	0.00058	3×10^{-6}	0.00044	2×10^{-6}	0.00051	2×10^{-6}
Fluorene	0.0029	2×10^{-5}	0.0022	2×10^{-5}	0.0025	2×10^{-5}
Phenanthrene	0.0057	4×10^{-5}	0.0043	3×10^{-5}	0.0050	4×10^{-5}
Anthracene	0.00046	5×10^{-7}	0.00035	3×10^{-7}	0.00040	4×10^{-7}
Fluoranthene	0.00033	2×10^{-6}	0.00025	2×10^{-6}	0.00029	2×10^{-6}
Pyrene	0.00058	6×10^{-6}	0.00044	4×10^{-6}	0.00051	5×10^{-6}
Total HI	**0.3**		**0.2**		**0.3**	

Table 11-5 presents a summary of the calculated incremental lifetime carcinogenic risk (ILCR) associated with exposure to the maximum predicted concentrations of benzene and carcinogenic PAHs (as benzo(a)pyrene TEQ). The calculated risks are considered in conjunction with what are considered negligible, tolerable/acceptable and unacceptable risks as outlined in the risk assessment within the Technical working paper: Human health in **Appendix I**.

Table 11-5 Assessment of incremental lifetime carcinogenic risk – maximum impacts in community associated with project

Key VOC	Maximum predicted 1-hour average concentration associated with project and calculated HI					
	2021		2031		Cumulative - 2031	
	Maximum concentration ($\mu g/m^3$)	ILCR	Maximum concentration ($\mu g/m^3$)	ILCR	Maximum concentration ($\mu g/m^3$)	ILCR
Benzene	0.27	6×10^{-7}	0.19	5×10^{-7}	0.24	6×10^{-7}
Benzo(a)pyrene TEQ	0.00037	1×10^{-5}	0.00029	1×10^{-5}	0.00033	1×10^{-5}
Total carcinogenic risk	1×10^{-5}		1×10^{-5}		1×10^{-5}	

ILCR = incremental lifetime carcinogenic risk

The results shown in **Table 11-3**, **Table 11-4** and **Table 11-5** indicate that there would be no chronic health risk issues in the local community associated with the project. It is noted that the calculations undertaken for PAH are based on a conservative estimate of the fraction of emissions from vehicles that comprises PAH (as a percentage of total VOCs). The approach adopted is expected to overestimate concentrations of PAH in air. Hence the calculations presented are considered to be a conservative upper limit estimate.

Carbon monoxide

Adverse health effects of exposure to CO are linked with carboxyhaemoglobin (COHb) in blood. Association between exposure to CO and cardiovascular hospital admissions and mortality; especially in the elderly, for cardiac failure, myocardial infraction and ischemic heart disease as well as some birth outcomes (such as low birth weights) have been identified (NEPC, 2010). Guidelines are available in Australia from NEPC (NEPC, 2003) and the NSW EPA (OEH) that are based on the protection of adverse health effects associated with CO. These guidelines consider exposures to CO from a 'lowest observed adverse effect level' and 'no observed adverse effect level'.

A guideline level of CO of nine parts per million by volume (ppmv) (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 EPA guideline is protective of adverse health effects in all individuals, including more susceptible groups of individuals. The NSW EPA has also established a guideline one-hour average (30 milligrams per cubic metre) concentrations of CO in ambient air based on criteria established by the WHO (WHO, 2000a).

Table 11-6 presents a summary of the maximum predicted cumulative one-hour average and eight-hour average concentrations of CO for the assessment years 2021 and 2031, both without and with the project.

Table 11-6 Review of potential acute and chronic health impacts – carbon monoxide

Scenario	Maximum 1-hour average concentration of carbon monoxide (mg/m^3)		Maximum 8-hour average concentration of carbon monoxide (mg/m^3)	
	Without project	With project	Without project	With project
2021				
Maximum	8.0	8.7	5.5	6.0
2031				
Maximum	7.7	8.5	5.3	5.8
Cumulative - 2031				
Maximum	--	7.8	--	5.4
Relevant health based guideline	30		10	

All the concentrations of CO presented in the above table are well below the relevant health based guidelines. Hence, there are no adverse health effects expected in relation to exposures (acute or chronic) to CO in the local area surrounding the project.

Nitrogen dioxide

Motor vehicles, along with industrial, commercial and residential (for example gas heating or cooking) combustion sources, are primary producers of nitrogen oxides, including NO_2. In Sydney, it was estimated that on-road vehicles account for about 62 per cent of emissions of nitrogen oxides, industrial facilities account for 12 per cent, other mobile sources account for about 22 per cent with the remainder from domestic / commercial sources (EPA, 2012b).

NO_2 is the only oxide of nitrogen that may be of concern to health (WHO 2000b). 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. 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 2003) 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.

Potential health effects associated with NO_2 consider both comparison with guidelines for cumulative exposure (acute and chronic) and an assessment of incremental impacts on health (associated with changes in air quality from the project).

Cumulative nitrogen dioxide

The guideline for the assessment of acute (short-term) exposure is 246 micrograms per cubic metre ($\mu g/m^3$) (or 120 parts per billion by volume (ppbv)) and chronic (long-term or lifetime) exposures of 62 $\mu g/m^3$ (or 30 ppbv) is protective of adverse health effects in all individuals, including sensitive individuals.

Table 11-7 presents a summary of the maximum predicted cumulative annual average concentration of NO_2 for the modelled scenarios.

Table 11-7 Review of potential acute health impacts – NO_2

Location and scenario	Maximum 1-hour average concentration of NO_2without the project ($\mu g/m^3$)	Maximum 1-hour average concentration of NO_2 with the project ($\mu g/m^3$)
2021		
Maximum residential	473	424
Maximum commercial	452	458
2031		
Maximum residential	477	383
Maximum commercial	388	331
Cumulative - 2031		
Maximum residential	--	312
Maximum commercial	--	298
Acute health based guideline	**246**	**246**

The maximum cumulative concentrations of NO_2 presented in the above table are above the acute NEPC guideline of 246 micrograms per cubic metre, principally due to the contribution of NO_2 from the surface roads that are predicted to exceed the short-term criteria even without the construction of the project.

The maximum cumulative concentrations of NO_2 are equal to or lower with operation of the project (particularly in 2031 and with consideration of all the WestConnex projects), which indicates that the project provides some benefit (ie an improvement) in lowering concentrations of NO_2 within the local community (compared with the situation where the project was not constructed).

To further address potential risks to human health that may be associated with localised changes in short-term exposures to NO_2 that relate to the project, incremental risk calculations have been undertaken and are presented in Section 6.8 of the Technical working paper: Human health in **Appendix I**.

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 (cumulative) annual average concentration in air.

The guideline of 62 µg/m^3 (or 30 ppbv) is based on a lowest-observed-adverse-effect level (LOAEL) of the order of 40–80 ppbv (around 75–150 µg/m^3) during early and middle childhood years. These exposures can lead to the development of recurrent upper and lower respiratory tract symptoms, such as recurrent 'colds', a productive cough and an increased incidence of respiratory infection with resultant absenteeism from school.

An uncertainty factor of two was applied to the LOAEL to account for susceptible people within the population resulting in a guideline of 20-40 ppbv (38–75 µg/m^3) (NEPC 1998). On this basis the NEPC (and OEH) chronic guideline is protective of adverse health effects in all individuals, including sensitive individuals.

Table 11-8 presents a summary of the maximum predicted cumulative annual average concentration of NO_2 for the modelled scenarios.

Table 11-8 Review of potential chronic health impacts – NO_2

Location and scenario	Maximum annual average concentration of NO_2 (µg/m^3)	
	Without the project	With the project
2021		
Maximum residential	45.2	42.9
Maximum commercial	47.4	43.0
2031		
Maximum residential	39.4	39.8
Maximum commercial	43.4	38.9
Cumulative – 2031		
Maximum residential	--	36.5
Maximum commercial	--	36.8
Chronic health based guideline	**62**	

All the concentrations of NO_2 presented in **Table 11-8** are well below the chronic NEPC guideline of 62 µg/m^3. No adverse health effects are therefore expected in relation to chronic exposures to NO_2 in the local area surrounding the project.

The maximum concentrations of NO_2 are equal to or lower in the local community for the situation where the project (and all of the WestConnex projects) is operating. This indicates that that the operation of the project provides some benefit (ie an improvement) in lowering the concentrations of NO_2 in the local community.

Incremental nitrogen dioxide

Table 11-9 presents a summary of the health endpoints considered in this assessment, the β coefficient relevant to the calculation of a relative risk (refer to Appendix A in the Technical working paper: Human health (**Appendix I**) 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 undertaken for the current review of health impacts of air pollution undertaken by NEPC (Golder, 2013) and are considered to be robust.

Table 11-9 Adopted exposure-responses relationships for assessment of changes in nitrogen dioxide concentrations

Health endpoint	Exposure period	Age group	Adopted β coefficient (as %) for 1 µg/m^3 increase in NO_2	Reference
Mortality, all causes (non-trauma)	Short-term	30+	0.00188 (0.19%)	Relationship derived from modelling undertaken for five cities in Australia and one day lag (EPHC 2010; Golder 2013)
Mortality, respiratory	Short-term	All ages*	0.00426 (0.43%)	Relationship derived from modelling undertaken for five cities in Australia and one day lag (EPHC 2010; Golder 2013)
Asthma emergency department admissions	Short-term	1–14 years	0.00115 (0.11%)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Golder 2013; Jalaludin et al. 2008)

* Relationships established for all ages, including young children and the elderly
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/m^3 increase in particulate matter exposure.

Table 11-10 presents the change in individual risk associated with changes in NO_2 at the maximum impacted receiver (regardless of the land use), the maximum impacts to residential and workplace receivers in the surrounding community, as well as the community receivers, for the operational years 2021 and 2031, including the cumulative scenario (refer to the Technical working paper: Human health (**Appendix I**) for the method of calculating individual risks).

The maximum impacted receiver was included and evaluated for potential exposures by residents to address future changes in land use that may occur during redevelopment. These calculations reflect the maximum population risk in the community from changes in NO_2 concentrations associated with the project. Risks for all other receivers (including other sensitive receivers) would be lower than the maximums presented.

For this project, all maximum impacted locations lie in the range $3x10^{-6}$ to $9x10^{-5}$ and are considered to be tolerable / acceptable. Risks at all community receivers vary from $-6x10^{-6}$ to $2x10^{-5}$ with a number of the calculated risks for community receivers calculated to be negative, indicating that the project is expected to result in a lower level of risk at these locations. Where an increase in risk was calculated at the community receivers, they are all considered to be tolerable / acceptable.

These conclusions remain unchanged where risks associated with cumulative impacts from the operation of all WestConnex projects are considered.

Table 11-10 Maximum calculated risks associated with short-term exposure to changes in NO_2 concentrations with operation of the project

Scenario and Receiver	Maximum change in individual risk from short-term exposure to NO_2 for the following health endpoints[(a)]		
	Mortality: All causes (ages 30+)	Mortality: Respiratory (all ages)	Asthma ED Admissions (1–14 years)
2021			
Maximum	6×10^{-6}	1×10^{-5}	8×10^{-5}
Maximum residential	5×10^{-6}	1×10^{-5}	6×10^{-5}
Maximum workplace	6×10^{-6}	1×10^{-5}	8×10^{-5}
Childcare centres	9×10^{-7}	2×10^{-6}	1×10^{-5}
Hospitals	7×10^{-7}	1×10^{-6}	9×10^{-6}
Schools	8×10^{-7}	2×10^{-6}	1×10^{-5}
Aged care	1×10^{-6}	3×10^{-6}	2×10^{-5}
2031			
Maximum	4×10^{-6}	9×10^{-6}	6×10^{-5}
Maximum residential	4×10^{-6}	7×10^{-6}	5×10^{-5}
Maximum workplace	4×10^{-6}	9×10^{-6}	6×10^{-5}
Childcare centres	5×10^{-7}	1×10^{-6}	6×10^{-6}
Hospitals	-5×10^{-7}	-1×10^{-6}	-6×10^{-6}
Schools	1×10^{-7}	2×10^{-6}	1×10^{-5}
Aged care	6×10^{-7}	1×10^{-6}	8×10^{-6}
Cumulative - 2031			
Maximum	7×10^{-6}	1×10^{-5}	9×10^{-5}
Maximum residential	3×10^{-6}	7×10^{-6}	4×10^{-5}
Maximum workplace	7×10^{-6}	1×10^{-5}	9×10^{-5}
Childcare centres	6×10^{-7}	1×10^{-6}	8×10^{-6}
Hospitals	-3×10^{-7}	-6×10^{-7}	-4×10^{-6}
Schools	9×10^{-7}	2×10^{-6}	1×10^{-5}
Aged care	5×10^{-7}	1×10^{-6}	6×10^{-6}
Negligible risks	$< 1 \times 10^{-6}$		
Tolerable/acceptable risks	$\geq 1 \times 10^{-6}$ and $\leq 1 \times 10^{-4}$		
Unacceptable risks	$> 1 \times 10^{-4}$		

(a) Negative value indicates that risks have decreased with operation of the project

Particulate matter

Particulate matter is a widespread air pollutant with a mixture of physical and chemical characteristics that vary by location source and substance. Particulates can be derived from natural sources such as soil dust, pollen and moulds, and other sources that include combustion and industrial processes.

Secondary particulate matter 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).

Particulate matter 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 particulate matter vary widely (with the respiratory and cardiovascular systems most affected) and include mortality and morbidity effects. The potential for particulate matter to result in adverse health effects is dependent on the size and composition of the particulate matter.

The particle size addressed in the human health risk assessment relate to the particulates most commonly measured in the urban air environment studies, including

- PM_{10} (particulate matter below 10 micrometres in diameter)
- $PM_{2.5}$ (particulate matter below 2.5 micrometres in diameter).

Table 11-11 presents a summary of the current NEPC and EPA air quality goals and guidelines for particulate matter.

Table 11-11 Ambient air quality goals for particulates

Pollutant	Averaging period	Criteria (µg/m^3)	Reference
PM_{10}	24-hour	50 Maximum of five days exceedance per year	(DEC 2005; NEPC 2003)
	Annual	30	(DEC 2005)
$PM_{2.5}$	24-hour	25	Advisory reporting standards(NEPC 2003)
	Annual	8	

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. 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 ten-fold margin of safety was 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 evaluated health effect that are less than one case per year are considered negligible.

Calculated risks and population incidence – cumulative scenario

Table 11-12 presents the calculated individual risk associated with changes in $PM_{2.5}$ and PM_{10} concentrations at the maximum impacted receiver (regardless of land use), maximum impacted residential and workplace receivers, as well as community receivers, for the cumulative scenario (ie operation of the complete WestConnex program of works) in the year 2031. The change in $PM_{2.5}$ and PM_{10} concentration considered in the risk calculations are also included.

A review of the calculated changes in risk indicates the following in relation to impacts in the study area associated with the operation of WestConnex in 2031:

- Most of the calculated individual risks are in the range $2x10^{-7}$ to $1x10^{-4}$ and are considered to range from negligible to tolerable/acceptable
- As with the assessment of the New M5 in 2021 and 2031, where the cumulative impacts of the WestConnex program of works are considered, there are a number of locations where the project results in lower particulate matter concentrations and other locations where there are some increases in the particulate matter concentrations. This is due to the redistribution of traffic on surface roads in the area
- The greatest increases in $PM_{2.5}$ occur in existing commercial / industrial areas of St Peters, Alexandria and Tempe. In relation to residential areas, the greatest increases occur in the area of Rockdale (Bay Street) and Alexandria (Campbell Road adjacent to Sydney Park). Impacts associated with the Southern extension are based on a strategic concept only. Risks associated with the operation of the Southern extension are therefore indicative only, would be subject to further design, as well as separate planning and approval.

Table 11-12 Calculated individual risk associated with changes in $PM_{2.5}$ and PM_{10} concentrations – cumulative scenario in 2031

Health Endpoint	Maximum calculated change in individual risk for key locations in community[(a)]						
	Maximum	Maximum residential	Maximum workplace	Childcare centres	Hospitals	Schools	Aged care
Change in annual average concentration							
$PM_{2.5}$ (µg/m^3)	1.9	0.87	1.9	0.18	-0.07	0.2	0.12
PM_{10} (µg/m^3)	3.0	1.3	3.0	0.23	0.016	0.37	0.14
Primary health indicators: $PM_{2.5}$							
Mortality all causes (long-term effects, ages 30+)	1×10^{-4}	5×10^{-5}	1×10^{-4}	1×10^{-5}	-4×10^{-6}	1×10^{-5}	7×10^{-6}
Cardiovascular hospitalisations (short-term effects, ages 65+)	1×10^{-4}	6×10^{-5}	1×10^{-4}	1×10^{-5}	-5×10^{-6}	1×10^{-5}	9×10^{-6}
Respiratory hospitalisations (short-term effects, ages 65+)	3×10^{-5}	1×10^{-5}	3×10^{-5}	3×10^{-6}	-1×10^{-6}	3×10^{-6}	2×10^{-6}
Secondary health indicators: $PM_{2.5}$							
Mortality all causes (short-term effects, all ages)	9×10^{-6}	4×10^{-6}	9×10^{-6}	9×10^{-7}	-3×10^{-7}	1×10^{-6}	6×10^{-7}
Mortality, cardiopulmonary (long-term effects, ages 30+)	1×10^{-4}	4×10^{-5}	1×10^{-4}	9×10^{-6}	-4×10^{-6}	1×10^{-5}	6×10^{-6}
Mortality, cardiovascular (short-term effects, all ages)	3×10^{-6}	1×10^{-6}	3×10^{-6}	3×10^{-7}	-1×10^{-7}	3×10^{-7}	2×10^{-7}
Mortality, respiratory (short-term effects, all ages)	2×10^{-6}	9×10^{-7}	2×10^{-6}	2×10^{-7}	-7×10^{-8}	2×10^{-7}	1×10^{-7}
Asthma emergency department hospitalisations (1–14 years)	3×10^{-5}	2×10^{-5}	3×10^{-5}	3×10^{-6}	-1×10^{-6}	4×10^{-6}	2×10^{-6}
Secondary health indicators: PM_{10}							
Mortality all causes (short-term effects, all ages)	9×10^{-6}	4×10^{-6}	6×10^{-6}	7×10^{-7}	5×10^{-8}	1×10^{-6}	4×10^{-7}
Diesel particulate matter							
Lung cancer	3×10^{-5}	1×10^{-5}	3×10^{-5}	2×10^{-6}	-1×10^{-6}	3×10^{-6}	2×10^{-6}
Negligible risks	$< 1 \times 10^{-6}$						
Tolerable risks	$\geq 1 \times 10^{-6}$ and $\leq 1 \times 10^{-4}$						
Unacceptable risks	$> 1 \times 10^{-4}$						

(a) Negative value indicates that risks have decreased with operation of the project

Elevated Receivers

Further assessment of elevated receivers was undertaken in relation to potential health impacts at both 10 metres and 30 metres above the ground level, representative of potential exposures that may occur in multi-storey buildings.

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 at 10 metres and 30 metres height has focused on the worst-case scenario, being the 2031 cumulative case, associated with impacts from all components of the WestConnex program. The maximum change in $PM_{2.5}$ relevant to this scenario was evaluated, which does not relate to any existing multi storey building, rather the maximum value change anywhere in the study area.

Table 11-13 presents the calculated risks associated with the maximum predicted change in $PM_{2.5}$ concentrations at a height of 10 metres and 30 metres above ground level. Calculations are presented in Appendix F of the Technical working paper: Human health (**Appendix I**).

The calculations presented in **Table 11-13** indicate the following:

- At a height of 10 metres within the study area, the maximum change in $PM_{2.5}$ is lower than at ground level and results in risks that are considered to range from negligible to tolerable / acceptable
- At a height of 30 metres within the study area, the maximum change in $PM_{2.5}$ is significantly greater than at ground level and at 10 metres height, and results in risks that are considered to be unacceptable. Further review of the impacts predicted at 30 metres height indicates the following:
  - The impacts identified at 30 metres height are localised around the ventilation outlets, with the maximum increases more specifically located adjacent to the future Southern extension ventilation facility (not part of the New M5 project)
  - The maximum increase in $PM_{2.5}$ away from the immediate vicinity of the ventilation outlets is less than 0.8 µg/m^3 which is associated with small changes in risk that are considered to be tolerable / acceptable
  - There are currently no multi-storey buildings located close to the proposed ventilation facilities associated with the New M5 or the potential location of the future Southern extension ventilation facility, hence the maximum risks calculated are hypothetical at this stage
  - For the New M5, future development of land (including re-zoning) near the ventilation facilities that may involve multi-storey buildings would need to consider the air dispersion performance of the New M5 facilities. The future Southern extension and future M4-M5 Link ventilation facilities are subject to further design development and planning approvals. Any future EIS for these projects would as a minimum assess potential air quality impacts and human health risks associated with these projects, including potential impacts on elevated receivers.

Table 11-13 Calculated individual risk associated with changes in PM2.5 concentrations – cumulative scenario in 2031 for elevated receivers

Health Endpoint	Maximum calculated	
	10 m height	30 m height
Change in annual average concentration		
$PM_{2.5}$ (µg/m^3)	0.73	24.2
Primary health indicators: $PM_{2.5}$		
Mortality all causes (long-term effects, ages 30+)	4×10^{-5}	1×10^{-3}
Cardiovascular hospitalisations (short-term effects, ages 65+)	5×10^{-5}	2×10^{-3}
Respiratory hospitalisations (short-term effects, ages 65+)	1×10^{-5}	4×10^{-4}
Secondary health indicators: $PM_{2.5}$		
Mortality all causes (short-term effects, all ages)	4×10^{-6}	1×10^{-4}
Mortality, cardiopulmonary (long-term effects, ages 30+)	4×10^{-5}	1×10^{-3}
Mortality, cardiovascular (short-term effects, all ages)	1×10^{-6}	4×10^{-5}
Mortality, respiratory (short-term effects, all ages)	7×10^{-7}	2×10^{-5}
Asthma emergency department hospitalisations (1–14 years)	1×10^{-5}	4×10^{-4}
Negligible risks	$< 1 \times 10^{-6}$	
Tolerable/acceptable risks	$\geq 1 \times 10^{-6}$ and $\leq 1 \times 10^{-4}$	
Unacceptable risks	$> 1 \times 10^{-4}$	

Shaded cells indicate calculated risks that are considered unacceptable

Assessment of regulatory worst case scenario

Regulatory worst-case scenarios have been evaluated in the Technical working paper: Air Quality (**Appendix H**). These scenarios are based on the situation where emissions to air from the tunnel ventilation outlets occur at the maximum discharge limits. 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 to less than a day. The scenarios considered in the Technical working paper: Air Quality (**Appendix H**) assume that such an event may last for a 24-hour period.

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

In relation to impacts on human health, a worst-case scenario results in short-term changes in air quality. As a result, health effects identified and evaluated in this assessment that relate to changes in short-term concentrations of NO_2 and $PM_{2.5}$ require further assessment. The assessment of short-term human health impacts has utilised the methodology outlined in Appendix A of the Technical working paper: Human health (**Appendix I**) 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 the following scenarios:

- Short-term change in air concentrations associated with maximum emissions from the ventilation outlets from the project tunnel
- Short-term changes in air concentrations associated with maximum emissions from the ventilation outlets for the project tunnel and the future M4–M5 link.

Risk calculations can be undertaken 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, hence for the purpose of this assessment some conservative assumptions have been adopted. **Table 11-14** presents the calculated change in individual risk associated with exposure to worst-case emissions of NO_2. The table includes the assumptions adopted for the assessment.

Table 11-15 presents the calculated change in individual risk associated with exposure to worst-case emissions of $PM_{2.5}$. The table includes the assumptions adopted for the assessment.

A review of the maximum calculated changes in risk associated with short-term changes in NO_2 (**Table 11-14**) and $PM_{2.5}$ (**Table 11-15**) concentration under the worst-case scenarios evaluated indicates the following:

- 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 (and the maximum changes impact occurs at the same receiver 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 human health risks identified in the community surrounding the project
- The calculated maximum individual risks are in the range of $1x10^{-6}$ 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 11-14 Maximum calculated risks associated with short-term exposure changes in NO_2 concentrations: regulatory worst case

Scenario	Maximum change in individual risk for the following health endpoints		
	Mortality: All causes (ages 30+)	Mortality: Respiratory (all ages)	Asthma ED admissions (1–14 years)
The project			
Maximum annual risk – expected operations (2021)	6×10^{-6}	1×10^{-5}	8×10^{-5}
Increase in risk for 1 day of worst-case emissions (assuming event lasts for 4 hours)*	1×10^{-8}	2×10^{-8}	2×10^{-7}
Increase in risk assuming worst-case event occurs 1 day each week (52 days per year)*	6×10^{-7}	1×10^{-6}	8×10^{-6}
Maximum annual risk – expected conditions plus worst-case event**	7×10^{-6}	1×10^{-5}	9×10^{-5}
The project and future M4–M5 Link (cumulative)			
Maximum annual risk – expected operations	7×10^{-6}	1×10^{-5}	9×10^{-5}
Increase in risk for 1 day of worst-case emissions (assuming event lasts for 4 hours)*	1×10^{-8}	3×10^{-8}	2×10^{-7}
Increase in risk assuming worst-case event occurs 1 day each week (52 days per year)*	7×10^{-7}	1×10^{-6}	9×10^{-6}
Maximum annual risk – expected conditions plus worst-case event**	8×10^{-6}	1×10^{-5}	1×10^{-4}
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 for four hours, and occurs at the same location (receiver) every day the worst-case event occurs. With changes in meteorology in the local area the one-hour maximum concentration is expected to change in concentration and location throughout any one day and over different days. Hence this assumption is conservative.

** Assumes the maximum annual average impact and maximum short-term change occur that the same location (receiver).

Table 11-15 Maximum calculated risks associated with short-term exposure changes in $PM_{2.5}$ concentrations: regulatory worst case

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	8×10^{-5}	2×10^{-5}	6×10^{-6}	2×10^{-6}	1×10^{-6}	2×10^{-5}
Increase in risk for 1 day of worst-case emissions	8×10^{-7}	2×10^{-7}	5×10^{-8}	2×10^{-8}	1×10^{-8}	2×10^{-7}
Increase in risk assuming worst-case event occurs 1 day each week (52 days per year)*	4×10^{-5}	9×10^{-6}	3×10^{-6}	8×10^{-7}	5×10^{-7}	1×10^{-5}
Maximum annual risk – expected conditions plus worst-case event**	1×10^{-4}	3×10^{-5}	9×10^{-6}	3×10^{-6}	1×10^{-6}	3×10^{-5}
The project and M4–M5 (cumulative)						
Maximum annual risk – expected operations***	6×10^{-5}	1×10^{-5}	4×10^{-6}	1×10^{-6}	9×10^{-7}	2×10^{-5}
Increase in risk for 1 day of worst-case emissions	9×10^{-7}	2×10^{-7}	6×10^{-8}	2×10^{-8}	1×10^{-8}	2×10^{-7}
Increase in risk assuming worst-case event occurs 1 day each week (52 days per year)*	5×10^{-5}	1×10^{-5}	3×10^{-6}	9×10^{-7}	6×10^{-7}	1×10^{-5}
Maximum annual risk – expected conditions plus worst-case event**	1×10^{-4}	2×10^{-5}	7×10^{-6}	2×10^{-6}	1×10^{-6}	3×10^{-5}
Negligible risks	$< 1 \times 10^{-6}$					
Tolerable/acceptable risks	$\geq 1 \times 10^{-6}$ and $\leq 1 \times 10^{-4}$					
Unacceptable risks	$> 1 \times 10^{-4}$					

* Assumes that the maximum predicted impact occurs at the same location (receiver) 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 (receiver)

*** Maximum change in risk for the cumulative scenario relates to the maximum change at a residential location. The maximum change predicted within the study area is predicted to occur in a commercial/industrial area that is located within the footprint of the proposed Southern extension and is not considered representative of a realistic community receiver for evaluating cumulative impacts (as the Southern extension would be constructed for the cumulative case)

Assessment of in-tunnel air quality impacts

The in-tunnel air quality was evaluated for the following reasons:

- To design and control ventilation systems - tunnel construction and operation has been designed with the aim to minimise the significant costs involved in providing active ventilation. As a result, systems are designed, constructed and operated to provide sufficient ventilation to maintain acceptable air quality in the main alignment tunnel, at reasonable cost (NHMRC, 2008)
- To manage in-tunnel exposure to air pollution
- To manage external air pollution.

In-tunnel air quality limits, based on the conditions of approval for NorthConnex, have been considered in the human health assessment and are presented in **Table 11-16**. 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.

Table 11-16 In-tunnel average limits along length of tunnel

Pollutant	Concentration limit	Averaging period
CO	87 ppm	Rolling 15-minute average
CO	50 ppm	Rolling 30-minute average
CO	200 ppm	Rolling 3-minute average
NO_2	0.5 ppm	Rolling 15-minute average

Another important consideration for tunnel ventilation design is visibility. Consideration of visibility criteria in the design of the tunnel ventilation system is required due to the need for visibility levels that exceed the minimum vehicle stopping distance at the design speed. Visibility is reduced by the scattering and absorption of light by particulate matter suspended in the air. The amount of light scattering or absorption is dependent upon the particle composition (dark particles, such as soot, are particularly effective), diameter (particles need to be larger than around 0.4 µm), and density.

Particles which result in a loss of visibility also have an effect on human health, and so monitoring visibility also provides the potential for an alternative assessment of the air quality and human health risk within a tunnel. However, such an assessment is limited by the short duration of exposure in tunnels compared with longer exposure times (24 hours and one year) for which the health effects of ambient particles have been established. Further, 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 main alignment tunnels have not been further evaluated.

Concentrations in the main alignment 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 10 times (depending on the particular pollutant and location within the main alignment tunnels) from periods of low traffic to peak traffic
- Location within the main alignment tunnels and ventilation facilities - concentrations of pollutants would gradually increase from the tunnel entrance to the next offtake to a ventilation outlet. The average exposure for a motorist would be around half of the maximum concentration within the tunnel.

The assessment of potential exposures that may occur in the main alignment tunnels was undertaken with consideration of these factors. In addition, the following has also been considered:

- The time spent within the main alignment tunnels would be limited, taking around six to seven minutes to travel the full distance of the tunnel (when travelling at 80 kilometres per hour). During peak times, the time of travel may be slightly longer depending on the speed of traffic flow. Concentrations are not the same in all parts of the tunnel, with concentrations increasing with distance from the start. As a result, the amount of time exposed to the maximum concentration would be much lower (around one minute). The average exposure through the whole tunnel would be lower than half the maximum (at the end of the tunnel).
- The concentration of pollutants within the vehicle itself, 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 Motorway Tunnel (NSW Health, 2003) identified that closing car windows and switching the ventilation to recirculation can reduce exposures by approximately 70-75 per cent for CO and NO_2, 80 per cent for fine particulates and 50 per cent for VOCs.

The following provides further discussion on the range of concentrations predicted within the main alignment tunnels.

Carbon monoxide

The maximum one-hour average concentration of CO in the tunnel is predicted to be approximately 7 ppm eastbound, and 13 ppm westbound. 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 internationally. 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 the human health risk 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 ppm to 38 ppm (NHMRC, 2008). The predicted hourly average concentration in the project tunnel is within the range reported in other tunnels.

The tunnel is designed to meet in-tunnel limits for CO. While actual concentrations in the tunnel are expected to be lower than these limits, where the limits are met the following can be noted:

- The in-tunnel limit for CO of 87 ppm as a 15-minute average is equivalent 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 30-minute average is the same as the health based guideline of 50 ppm (30-minute average) established by the WHO (WHO, 2000a).

On the basis of the above, where the in-tunnel limits are met there are no health issues of concern related to in-tunnel exposures to CO.

Nitrogen dioxide

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

- The maximum concentrations in the tunnel vary throughout the day, with the maximum concentration predicted at any time of the day and at the lowest speed less than 1.0 ppm. The average concentration in the tunnel is expected to be (at most) approximately 0.5 ppm, equal to the in-tunnel limit
- The maximum in-tunnel concentrations of NO_2 estimated for travelling at 80 kilometres per hour through the tunnel varies from close to 0 ppm at the start to approximately 0.5 ppm both eastbound and westbound. These concentrations are equal to the in-tunnel limit of 0.5 ppm (set as a 15-minute average). Actual exposures would only occur for approximately six to seven minutes at an average concentration of approximately (but likely less than) 0.25 ppm (with windows down). Lower concentrations of approximately 0.06 ppm may occur with windows up and ventilation on recirculation
- The NHMRC (2008) has published measured concentrations of NO_2 from a range of tunnels in Sydney and internationally. 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, the NHMRC (2008) have reported a range of average concentrations of NO_2 in tunnels that range from 0.05 ppm to 0.3 ppm with levels up to 0.4 ppm reported during peak periods. These levels are based on data with averaging times that vary from 30 seconds during travel through a tunnel, six minute averages, to long term data with (unspecified averaging times). At the downstream end of a tunnel (where exposure is very short, ie minutes) levels up to 0.8 ppm have been reported.

- There are very few studies that have evaluated health effects associated with very short duration exposures to NO_2. A study conducted in Stockholm (Svartengren et al. 2000) involved exposing 20 adults with mild asthma to air quality inside a car in a tunnel for 30 minutes, where levels of NO_2 ranged from 0.1 ppm to 0.24 ppm (noting exposure to particulate matter and other pollutants inside the tunnel occurred at the same time). The study showed an increase in bronchial response to allergens several hours after exposure for individuals with allergic asthma. These results are similar to other studies where individuals with mild asthma were exposed to 0.26 ppm NO_2 for 30 minutes (Barck et al. 2002; Strand et al. 1998), a range of concentrations from zero ppm to 0.53 ppm for 30 minutes (Bylin et al. 1988) or for 15 minutes on one day and then repeated twice in the following day (Barck et al. 2005), followed by an allergen inhalation challenge. None of the available studies have considered individuals with moderate or severe asthma. The data suggest that exposure to elevated concentrations of NO_2 in a congested tunnel is associated with an increased risk of adverse effects for those with asthma (NHMRC 2008).

There are no guidelines in Australia for levels of NO_2 in tunnels. Guidelines for in-tunnel levels of NO_2 are available from Belgium (0.5 ppm for exposures <20 minutes), France (0.4 ppm for a 15 minute average exposure period), Norway (Norwegian Public Road Admiration (NPRA) guidelines of 0.75 ppm at the tunnel midpoint and 1.5 ppm at the tunnel ends, based on a 15-minute average), Hong Kong (1 ppm as a five minute average) and New Zealand (1 ppm as a 15 minute average) (Longley, 2014). The PIARC has proposed a level of 1 ppm (as a threshold limit for healthy people). The average expected exposures, including the average during high traffic low speed situations are the same as or lower than the available short term (15 –20 minute average) guidelines.

Particulate matter

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

The maximum concentration of PM_{10} in the tunnel ranges from approximately 0.01 milligrams per cubic metre to 0.55 milligrams per cubic metre. The average concentration in the tunnel may be approximately 0.005 milligrams per cubic metre to 0.27 milligrams per cubic metre. Motorists may be exposed to these levels where widows are open. The average exposure concentration is lower (ranging from 0.001 to 0.05 milligrams per cubic metre) with windows closed and ventilation on recirculation

Recent review (WHO, 2013) 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 particulate matter can lead to adverse physiological changes in the respiratory and cardiovascular system, in particular exacerbation of existing disease. This is generally consistent with the outcome of studies reviewed and considered by the USEPA (USEPA 2009a)
- The studies available do not cover a range of exposure concentrations, nor do they adequately address other variables such as co-pollutants (gases) or repeated short-duration exposures
- The studies have not determined if a one-hour exposure would lead to a different response than a similar dose spread over 24-hours, or if an exposure-response can be determined
- Exposures that occur during the use of various transportation methods (such as in-vehicles) have been found to contribute to and affect 24-hour personal exposures.

The urban epidemiology studies (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 particulate matter (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 human health effects to regional ambient (urban) air concentrations. They have not measured daily or longer term personal exposures to particulate matter, but such fluctuations would occur within the population exposed and would be expected to be accounted for within the human 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 therefore important to consider if exposures to $PM_{2.5}$ in the project tunnel 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 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.

Overall assessment of in-tunnel impacts

The duration of exposure to vehicle emissions within the project tunnel is limited (minutes, rather than hours, only) and where guidelines are available for short duration exposures in tunnels, the likely exposure concentrations (representative of the average concentrations from start to end) are generally within or below these guidelines.

Short-duration exposure guidelines are not available for NO_2 or particulate matter (assessed as $PM_{2.5}$). In relation to NO_2, the published exposures studies suggest in situations of congested traffic (including delayed traffic in a tunnel) there is an increased risk of adverse health effects amongst individuals with asthma. Particulate matter exposures within the tunnel are estimated to be similar to those expected within other vehicle tunnels and are of limited duration (minutes). Particulate exposures vary throughout a day depending on the activities undertaken. Exposures that may occur within the tunnel are consistent with expected variability of exposure to particulate matter throughout any day where a range of activities are undertaken.

For regular users of tunnels in Sydney, and regular commuters in heavy traffic, repeated short duration exposures to elevated concentrations of pollutants from vehicle emissions would contribute to a higher level of overall (daily) exposure and may be associated with increased risks for asthmatics. Drivers who regularly use tunnels or drive in congested traffic in Sydney can minimise exposure to vehicle emissions by keeping windows up and air conditioning on recirculation when in tunnels or heavy traffic conditions. Keeping windows closed and switching ventilation to recirculation has been shown to reduce exposures inside the vehicle by up to 80 per cent.

Noise and vibration

Environmental noise was identified as a growing concern in urban areas because it has negative effects on quality of life and well-being and it has the potential for causing harmful physiological health effects. With increasingly urbanised societies, the impacts of environmental noise has the potential to increase within the community. 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 could include:

- Sleep disturbance (sleep fragmentation that can affect psychomotor performance, memory consolidation, creativity, risk-taking behaviour and risk of accidents)
- Annoyance
- Hearing impairment
- Interference with speech and other daily activities

- Children's school performance (through effects on memory and concentration)
- Cardiovascular health
- Possible effects on mental health (usually in the form of exacerbation of existing issues for vulnerable populations rather than direct effects)
- Possible tinnitus (which can also result in sleep disturbance, anxiety, depression, communication and listening problems, frustration, irritability, inability to work, reduced efficiency and a restricted participation in social life)
- Possible cognitive impairment in children (including deficits in long term memory and reading comprehension)
- Possible indirect effects such as impacts on the immune system.

Annoyance can be a 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.

The criteria developed for use in the assessment for control of noise come from policy documents developed by the NSW Government including the *NSW Industrial Noise Policy* (NSW, DECC 2009), the *NSW Interim Construction Noise Guideline* (NSW DECCW, 2011), and the N*SW Road Noise Policy* (NSW EPA, 2000).

Noise impacts during operation of the project have been assessed for the years 2021 and 2031. In relation to noise impacts from the operation of the project, the assessment identified the following:

- The project would alter traffic volumes on the existing M5 East Motorway and hence result in an appreciable reduction in noise levels between Beverly Hills and Kingsgrove
- In the western portion of the project, road traffic noise levels are predicted to exceed the adopted daytime criteria at 53 residential receivers and one school receiver, with one residential receiver identified for consideration of additional noise mitigation measures. Noise levels are predicted to exceed the adopted night-time criteria at 65 residential receivers, with one residential receiver identified for consideration of additional noise mitigation measures. The receiver identified for additional noise mitigation is located in Beverly Hills
- Around the St Peters interchange and local road upgrades traffic noise levels are predicted to exceed the adopted daytime criteria at 386 receivers, with 146 receivers (143 residential, 2 school receivers and one recreation area) identified for consideration of additional noise mitigation measures. Noise levels are predicted to exceed the adopted night-time criteria at 382 receivers, with 157 residential receivers identified for consideration of additional noise mitigation measures. The receivers identified for additional noise mitigation include residential homes in Alexandria and St Peters, St Peters Public School and parts of Sydney Park
- The redistribution of traffic on local roadways has the potential to impact on noise levels. The traffic noise assessment concluded that the changes in noise levels on parallel routes would be indiscernible.
- The maximum noise events are predicted to occur between 10pm and 12 midnight and after 6am in the Beverly Hills area. This is likely to be linked to increased heavy vehicle movements. In the St Peters area there are currently a number of maximum noise events and these are likely to increase over time as the percentage of heavy vehicles increases.
- Noise impacts from fixed facilities have also been assessed. The predicted noise levels demonstrate that during both normal traffic conditions and low speed traffic conditions the operational noise criteria would not be exceeded.

Mitigation measures have been considered to reduce noise levels in those locations where it would be above guidance values.

The hierarchy of noise mitigation is firstly to consider at-source noise mitigation measures such as road design and traffic management, then the use of quieter pavements. If these measures cannot be designed to meet the noise criteria, the use of 'in-corridor' mitigation measures would be considered, which are generally noise barriers and mounds. Finally, if the applicable noise criteria cannot be met by using a combination of all these methods, at-receiver mitigation measures can be considered such as architectural treatments and property boundary walls.

For properties where exceedances are up to 10 dB(A), fresh air ventilation, sealing of wall vents and upgraded window and door seals are generally considered appropriate (Architectural treatment type 1). Where exceedances are over 10 dB(A) additional upgrade of windows and doors may be considered (Architectural treatment type 2). One property in Bevery Hills and 157 properties in the Alexandria / St Peters area have been identified as being eligible for consideration of architectural treatments (of varying levels). The properties identified in the Alexandria / St Peters area that are eligible for consideration of noise mitigation are presented in Figure 5-1 to Figure 5-4 of the Technical working paper: Human health (**Appendix I**).

Contamination

The project includes a range of works that are in areas where contamination, derived from former uses of these areas, is known to be present. Contamination may be present as a result of the presence of former landfills, contaminated soil or contaminated groundwater. This includes St Peters interchange and the Arncliffe construction compound.

Intrusive leachate, ground gas, soil, fill and groundwater investigations would be undertaken in specific areas of environmental concern, as outlined in Technical working paper: Contamination (**Appendix O**).

Subject to the nature of the activities proposed to be carried out on the relevant properties, sampling activities would be undertaken prior to disturbance of these areas to minimise the potential for identifying unexpected finds with respect to contaminated land. The investigations would be undertaken in accordance with ASC NEPM (NEPC 1999 amended 2013) guidelines. These guidelines are risk-based guidelines, aimed at protecting the health of the community and workers who may be present on or adjacent to the site. The guidelines are designed to be protective of exposures that may occur as a result of direct contact as well as inhalation. The findings of the investigation would be used to inform appropriate remediation and management options (if required) for the project. Such measures would be protective of the health of all members of the public for both direct contact (where relevant) and inhalation exposures.

The Construction Environmental Management Plan (CEMP) would incorporate an unexpected finds procedure, which would be implemented to manage potentially contaminated materials that may be encountered in areas not identified in the Technical working paper: Contamination (**Appendix O**). The procedure would outline the process for the identification and assessment of potentially contaminated material in the event that previously unidentified contamination is discovered during construction or excavation activities. The procedure would include requirements for inspections and testing of suspected contamination by an appropriately qualified hygienist and/or contaminated lands consultant.

11.3.3 Assessment of social impacts on health

General

The World Health Organisation 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 **Chapter 10** (Air quality) and **Chapter 12** (Noise and vibration) respectively) addressed key aspects that have the potential to directly affect health.

There are, however, a range of other impacts associated with the project that can affect the health and well-being of the community in a more indirect way. Changes within a community that may be associated with the project may be differentially distributed. This may affect population groups that

may be advantaged or disadvantaged based on age, gender, socio-economic status, geographic location, cultural background, aboriginality, and current health status and existing disability. This aspect relates to the equity of the impacts in the local community.

This section specifically evaluates changes that have the potential to indirectly affect the health and well-being of the community. In addition, this section 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 section refers to the social impact assessment which is summarised in **Chapter 15** (Social and economic).

Changes in traffic

The study area includes the local road network associated with the existing M5 East Motorway corridor and the area around the St Peters interchange and local road upgrades.

The existing M5 East Motorway corridor provides the main passenger, commercial and freight connection between South West Sydney and the Sydney CBD, Sydney Airport and Port Botany. It is the main east-west freight, commercial and passenger vehicle corridor in southern Sydney, and is of local and regional transport importance in terms of its function. It also connects to the Sydney orbital network and interstate transport routes. The corridor forms part of the AusLink National Land Transport Network (National Road Network) and the Sydney orbital network.

The M5 East Motorway corridor is subject to high levels of congestion, particularly during peak periods. In addition, arterial roads connecting to the M5 East Motorway, including King Georges Road, Canterbury Road, Stoney Creek Road, the Princes Highway and General Holmes Drive, are experiencing greater volumes of traffic than they were originally designed for, particularly heavy vehicle movements. The additional vehicles along these roads are causing underperformance of the M5 East Motorway by increasing congestion, travel time variability and a higher risk of crashes.

The area around the St Peters interchange and local road upgrades spans the Sydney, Marrickville and Botany local government areas. The key roads at this location include the Princes Highway, Campbell Street, Campbell Road, Euston Road, Bourke Road and Gardeners Road. Intersections along main roads in the area are currently congested and include a high percentage of heavy vehicles.

Construction

Changes to local roads are proposed during construction of the project. While it is expected that access to properties on the local roads would be maintained during construction, some permanent and temporary closures or reduced capacity of some local roads may affect the movement of local traffic through the area.

There are 14 construction compounds used during construction that may result in impacts to local traffic, property access, pedestrian and cyclists movements, and bus stop locations. More significant impacts associated with changes in road access are expected to occur around Arncliffe and St Peters. Some temporary road closures would be required along the M5 East Motorway at night to facilitate the installation, relocation and removal of traffic barriers, the installation of tolling infrastructure, and for works associated with the M5 East Motorway corridor integration works.

The project would result in the generation of additional heavy and light vehicle movements for the removal of spoil, generally along the M5 East Motorway and M5 South West Motorway, deliveries and other movements associated with construction activities. Construction traffic would use the existing motorway and arterial road network as much as possible to minimise impacts on local roads. Construction traffic has the potential to add to existing high levels of congestion in the area increasing traffic delays at some intersections.

It is expected that during construction there would be some impact to the local community as a result of increased travel times for vehicles, cyclists and bus passengers; reduced pedestrian roadside safety due to an increase in traffic, as well as a reduction in pedestrian and cyclist amenity.These changes have the potential to result in increased levels of stress and anxiety in the local community. These impacts, however, are expected to occur during the period of construction only.

Operations

Once the project is complete it is expected to result in reductions in vehicle delays in a number of areas, including the M5 East Motorway. The project would result in changes to localised traffic volumes within the M5 East Motorway corridor due to traffic switching to the New M5 and other parallel arterial roads, such as Stoney Creek Road. It is expected that traffic switching to parallel arterial roads may be partly a result of the introduction of tolls onto the M5 East Motorway.

Changes to public transport and pedestrian cycle infrastructure

Public transport

No pedestrians or regular bus services use the existing M5 East Motorway corridor. Intercity and regional bus services which depart from the Sydney CBD use the M5 East Motorway and the M5 South West Motorway; however there are no operational bus stops along the M5 East Motorway.

The Sydney and Marrickville local government areas are serviced by four railway lines, with the closest railway stations located at St Peters and Mascot. The St Peters and Mascot area also has a comprehensive bus network which provides access to the surrounding activity and employment centres as well as the Sydney central business district.

The project would result in the temporary relocation of one bus stop (on Euston Road Alexandria) and the temporary closure of four bus stops, Princes Highway St Peters, two on Bourke Street Mascot and on Gardeners Road in Mascot). The bus stops that are temporarily relocated or closed would be reinstated at the completion of construction.

The bus stop on the southbound side of Canal Road near the intersection of the Princes Highway would be permanently relocated further south along Canal Road to accommodate construction vehicles accessing the Canal Road construction compound. The final location of this bus stop would be determined during detailed design and in consultation with Transport for NSW.

During construction, delays in local traffic would also affect bus travel times. Once the project is completed there would be some changes in bus travel times, with some routes taking additional time and other taking less time (refer to **Chapter 9** (Traffic and transport)).

The project would not impact on the operation of passenger rail services on the Sydney metropolitan rail network.

Pedestrian and Cycle Access

There is currently a network of cycle paths in the area, comprising a mixture of separated cycleways and on road paths in areas of low to medium traffic. Following the commencement of construction of the King Georges Road Interchange upgrade, cyclists can no longer use the M5 East Motorway between this interchange and Bexley Road. An alternative route is provided through the M5 Linear Park between King Georges Road and Bexley Road.

The major cycle path in the area is the Bourke Road cycleway, which provides a separated cycle path along Bourke Road between Gardeners Road and the Green Square railway station. Additional separated cycleways are located in Sydney Park, and these connect to on-road cycle paths on surrounding roads.

Construction of the project would require modifications to pedestrian and cycling facilities around the western surface works, Kingsgrove Road surface works and Bexley Road surface works. This includes realignment of existing pathways to maintain access during construction, temporary closure of some pathways with diversions in place during construction, removal of cyclists from the M5 East Motorway and diversion onto local/surrounding roads.

Roads and Maritime is proposing to widen Marsh Street to three lanes in each direction as part of the Airport West Precinct component of the WestConnex enabling works around Sydney Airport. As part of these works, a dedicated cycleway would be constructed along the westbound carriageway of Marsh Street. Signalised pedestrian crossing facilities are also proposed at the Flora Street / Marsh Street intersection as part of the Airport West Precinct works. Modifications to the Flora Street / Marsh Street intersection would integrate with the Airport West Precinct, and would be constructed in consultation with Roads and Maritime.

The local road upgrades would include new and upgraded pedestrian and cycle infrastructure. This infrastructure has been designed to maintain and enhance pedestrian and cyclist accessibility and connectivity, particularly around the St Peters interchange and Sydney Park. The most significant new infrastructure would be the construction of the Campbell Road pedestrian and cycle bridge which would provide connections between Sydney Park and Mascot. This would provide east-west connectivity across Alexandra Canal connecting the Bourke Road cycleway to St Peters at Unwins Bridge Road. A separated cycleway would also be constructed along Campbell Street. The upgrades to pedestrian and cycle infrastructure would provide for a safe cyclist and pedestrian environment by minimising the interface of cyclists and pedestrians with vehicular traffic, and would also provide a regional cycle connection between Mascot and Marrickville.

The shared path within Beverly Grove Park would be reinstated to the north and south to accommodate the western surface works and the Kingsgrove motorway operations complex. The realignment of this shared path would not restrict its use.

On-road cyclists may experience delays at intersections and increased travel times when accessing and using detours and changes in cycle routes. A strategy for the maintenance of pedestrian and cyclist access during construction would be provided as part of the Construction Traffic Management and Safety Plan(s) for the project.

Improved urban amenity and cycling infrastructure could likely attract more people to both recreational and commute cycling, with consequent positive health benefits.

Changes in air quality

The project would result in improved air quality (ie decrease in total pollutant concentrations) within much of the local community. The redistribution of surface traffic in the area would result in an increase in pollutants at some locations. The calculated risks to health posed by these changes range from negligible to tolerable / acceptable.

A review of the changes in air quality associated with the project has not identified impacts that significantly affect specific areas of disadvantage (refer to Figure 6.4 in the Technical working paper: Human health in (**Appendix I**) for the distribution of changes in $PM_{2.5}$ concentrations in the community).

In relation to changes in air quality impacts associated with the operation of the project, changes in $PM_{2.5}$ are of most relevance. The areas where increases in $PM_{2.5}$ concentrations are predicted are adjacent to existing roadways, where changes in traffic volumes associated with the project are predicted to result in a small increase in $PM_{2.5}$ exposure. Some of the roadways where increases are predicted are roads that are likely to be used by traffic avoiding the tolling of the M5 East Motorway and these roads run through existing residential areas.

An increase in $PM_{2.5}$ is predicted on Campbell Road in Alexandria adjacent to Sydney Park. While the risks associated with changes in $PM_{2.5}$ concentrations in air are considered to be tolerable / acceptable, properties at this location have also been identified as homes that may require treatment to mitigate increases in noise associated with the operation of the project. While it is not possible to quantify the cumulative risk to health from air quality and noise sources, it is important that measures identified for the effective mitigation of noise are implemented in these areas.

Suburbs in the human health risk assessment study area that, based on the 2011 Census Data, are slightly more disadvantaged (in relation to the Socio-Economic Index for Areas (SEIFA)) include Lakemba, Wiley Park, Punchbowl/Canterbury, Campsie, Hurstville and Arncliffe. Lakemba, Wiley Park and Campsie in particular are noted to have high unemployment and lower household incomes when compared with other suburbs in the study area and Sydney. Some of the predicted increases in $PM_{2.5}$ relate to roadways that run along the boundary of Hurstville and Lakemba. Some roadways that run through Lakemba and Campsie are predicted to have a small decrease on $PM_{2.5}$ concentrations. Within Arncliffe both small increases and small decreases in $PM_{2.5}$ are predicted in some areas. For most of these suburbs, however, there is no predicted change in air quality as a result of the project.

Overall, the changes in air quality associated with the project are not considered to adversely affect areas of socio-economic disadvantage.

The median house prices in the human health risk assessment 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.

Changes in noise

The project would result in lower noise levels in many areas, with only some areas located close to new road infrastructure experiencing an increase in noise. Where no mitigation measures are implemented, the predicted change in noise levels associated with various construction activities are likely to result in adverse health impacts. These impacts may include disturbance of sleep, reduced capacity for concentration, interference with speech and other activities, and the loss of the use of outdoor space. These impacts may have potential for effects on cardiovascular health if the elevated noise at a particular location occurs for extended periods. Annoyance and increased stress levels would also occur. Consequently, mitigation of noise and vibration impacts would be implemented during construction of the project to avoid or minimise potential impacts on the health and wellbeing of the local community.

Predicted changes in road noise as a result of the project would require the implementation of mitigation measures (low noise pavement and some noise barriers) with some properties also requiring treatment to lower noise levels inside the home to a level where health impacts are minimised.

Noise levels were predicted at every façade of every building within 600 metres of the project. The use of each receiver was identified through a visual inspection. The receiver was assessed against the EPA's Road Noise Policy (RNP) criteria, which was specifically developed to minimise adverse health impacts for affected receivers. Where exceedances of criteria were identified, noise mitigation was clearly identified and committed to in accordance with the Roads and Maritime Noise Criteria Guideline and Noise Management Guideline to ensure that adequate noise mitigation is provided to those receivers affected.

The EPA's RNP criterion for residential receivers represents an external noise criterion. The impact of open windows does not impact the noise criteria for this type of sensitive receivers. For other types of sensitive noise receivers (such as schools, hospitals and child care), an internal noise criterion applies which is measured from the centre of the habitable room that has the greatest exposure to road noise with open windows.

For properties where noise treatment is identified, these measures are effective in minimising impacts of noise on health if they are taken up by the property owner. Where this does not occur there is the potential for health impacts to occur as a result of increased road noise (particularly in the evening and at night-time).

In addition, it is noted that for these properties, comfortable use of outdoor areas may change due to increased noise impacts and may affect the access and use of outdoor garden areas. Where alternative quite outdoor areas are accessible such impacts would not be significant; however, for some members of the community it may not be possible or practical to travel to other outdoor areas. Where this is the case, the change in property use (as a result of noise impacts) may result in increased levels of stress and anxiety and decreased wellbeing.

Properties where noise mitigation measures are required for the operation of the project are primarily located in the Alexandria / St Peters area. Most of these properties are not located adjacent to existing major roadways.

The location of properties where noise mitigation is required is generally in an area of low socio-economic disadvantage. It is noted however that some of the individual properties impacted include public housing.

Changes in community

Changes in the urban environment have the potential to result in impacts to health, primarily due to increased levels of stress and anxiety associated with rapid changes in the community. In relation to

this project, many of the changes relate to property acquisitions, access to community facilities, visual impacts and changes in community cohesion.

Property acquisitions and access

The design of the project has been developed to minimise the need for surface property acquisition and impacts on other residential and open space areas. There would, however, be a number of property acquisitions as well as other temporary and permanent impacts on land use associated with the project.

Impacts during construction would include full and partial acquisitions, temporary alterations or disruptions, temporary occupation of land and the settlement of the ground surface as a result of tunnelling. The surface works for the project would impact 159 properties, of which 109 properties are not owned by Roads and Maritime or other NSW Government agencies, and would require acquisition or temporary occupation of the land for project works at the surface.

In relation to impacts to publicly accessible areas, the following areas are expected to be affected:

- M5 Linear Park – the majority of the M5 Linear Park is owned by Roads and Maritime with the remainder owned by Canterbury City Council. Around 10.7 hectares of the M5 Linear Park would be permanently impacted by the project with around 2.6 hectares temporarily impacted. Land required temporarily for construction would be returned to recreational purposes following the completion of construction
- Kogarah Golf Course – The project would occupy a portion of the Kogarah Golf Course during construction and operation. The construction footprint has been minimised so that nine holes would remain open during construction and reduce impacts on the recreation value of the land. The footprint of the permanent facilities has been restricted and appropriately sited to minimise impacts to the future use or development potential of the golf course site
- Sydney Park - currently used for public recreation. Around 0.2 hectares of City of Sydney land adjacent to the road corridor within Sydney Park would be permanently acquired, which represents around 0.56 per cent of the total area of Sydney Park. An additional 0.55 hectares would be temporarily occupied or leased for construction purposes from City of Sydney and returned to recreational uses following the completion of construction
- May Street Reserve - this would be partially impacted by the upgrade of Campbell Street and the intersection of Unwins Bridge Road / Campbell Street / May Street / Bedwin Road. Part of the park is owned by Roads and Maritime with around 0.015 hectares owned by Marrickville Council that would be acquired. Around 0.06 hectares of land not required for the project would be landscaped to reconfigure the May Street Reserve
- Camdenville Park - around 1.1 hectares of Camdenville Park would be impacted as a result of the widened road and works associated with the existing drainage basin. Land not required for road infrastructure (around 0.86 hectares) would be leased or temporarily acquired from Marrickville Council
- Existing industrial areas (including areas used for the Commercial Road construction compound and areas in Mascot) that would be acquired. Residual industrial / commercial land, being land in excess of operational requirements, would be rehabilitated at the end of the construction period and returned for permissible uses under land use zoning provisions.

The construction and / or operation of the project has the potential to restrict local access and connectivity between the various land uses around the surface components of the project. Restrictions are most likely to occur at the western surface works, St Peters interchange and local roads upgrades and include the following:

- The western surface works would be located within a linear infrastructure corridor, which already contains the M5 East Motorway. The main impacts of the project on connectivity of land would be along the corridor during construction. This would largely be a result of roadworks and local road upgrades requiring temporary diversion of existing pedestrian and cyclist facilities. At the completion of construction, the pedestrian and cycle paths would be reinstated. As a result the project is unlikely to generate connectivity impacts at the western surface works during operation

- The project has the potential to restrict access and connectivity around the St Peters interchange and local road upgrades during construction. The project has been designed to enhance pedestrian and cyclist access around the St Peters interchange and would connect with existing cycle and pedestrian paths to Sydney Park via a bridge over Campbell Road
- In eastern parts of the project, new areas of open space would be created around the St Peters interchange. A master plan solution was developed, encompassing the entire interchange site and ensuring its integration with surrounding areas. The majority of the open space to be provided by the master plan would be completed as part of the project. The project would extend the parklands of Sydney Park further south, providing much needed open space for a growing population. Featuring landscape mounds, the design of the interchange parklands would continue the features of Sydney Park. This space would be accessed from shared paths in the east connecting to Sydney Park or via a dedicated entrance at the corner of Canal Road and Princes Highway
- The project would provide the following improved and upgraded connectivity for cyclists and pedestrians:
  - In the western reaches of the project, the existing M5 Linear Park shared path would be updated to provide a three metre wide surface for the majority of its length. This would be complemented by new landscaping along the length of the Linear Park
  - In the east of the project a number of amendments along local roads would provide the opportunity to improve pedestrian and cyclist connectivity around the St Peters interchange. Bridges over the Alexandra Canal would also provide new connections between Mascot, Alexandria and St Peters. These connections would increase access for a growing residential population to Sydney Park and the additional parklands to be created as part of the project
  - Pedestrian access to Sydney Park and the open space created by the project would also be improved
- The property adjustments required for the local road upgrades consist typically of driveway adjustments / extensions to suit the realignment of Euston Road, Campbell Street / Campbell Road and Gardeners Road. Where the works have an impact on a structure such as a residential or commercial building, the entire property has been acquired in most instances. The exception is along Euston Road and Gardeners Road at St Peters where the partial demolition of buildings would be required on some properties. At these locations, access would be modified but maintained during construction.

The operational surface footprint of the project has been generally located along existing roads, and within existing infrastructure corridors so that the new infrastructure would generally be consistent with the surrounding land use.

Closure of the former Alexandria Landfill site as part of the project, would result in a positive land use change by re-using the site as the St Peters interchange. The redevelopment of this site would also enhance pedestrian and cycle path connectivity between Sydney's south and Sydney Park as well as providing an opportunity to create additional public open space.

The project has the potential to affect development patterns in the area as a result of changes in traffic congestion and desirability of different areas for residential and commercial use. Urban development has the potential to result in increased levels of stress and anxiety within the existing community.

Moving house is known to be a significant stressor that can have a negative short-term impact on the health of individuals. Sydney Motorway Corporation, on behalf of Roads and Maritime is providing access for affected households to a counselling service, WestConnex Assist, to support them in negotiating the land acquisition process.

WestConnex Assist was established to provide support to people facing significant change as a result of the project. WestConnex Assist provides independent and confidential phone or face-to-face counselling, across a range of locations and a diverse team of professionals, including psychologists, social workers and qualified counsellors can be matched to the needs of each individual.

Roads and Maritime is also providing an independent service to vulnerable households, such as the elderly and those suffering an illness, to help assist with their relocation. This service aims to provide assistance with tasks such as finding a new property (either to rent or purchase), arranging removalists, service connections (electricity, gas etc.), attending appointments with solicitors and other tasks associated with relocating.

These services will assist in minimising health impacts associated with property acquisitions.

Visual changes

The existing environment of the study area contains a mixed level of visual amenity. This is due to a variety of factors, most significantly the fact that road and rail transport corridors already exist through much of the study area. Furthermore, there are few iconic views available within the study area, and some sections of the study area (such as the existing Alexandria landfill) do not currently provide a high level of visual amenity.

Changes in visual amenity are predicted to occur during construction for a number of residents where the property overlooks a construction compound or work site. In addition, the quality of the view for recreational users in a number of areas would be impacted by the construction works. There is the potential for moderate to high impacts to residents as a result of the use of night lighting at the Kingsgrove North construction compound, Bexley Road North construction compound, Bexley Road East construction compound and the Campbell Road construction compound.

Once completed there would be a range of new road infrastructure that includes ventilation facilities, ramps, tunnel facilities and noise barriers. The areas where new infrastructure and facilities would be present include the Kingsgrove motorway operations complex, M5 Motorway corridor, Bexley North, Bexley Road South motorway operations complex, Arncliffe motorway operations complex, St Peters interchange and motorway complex, and the Burrows Road Motorway Control Complex.

Visual impacts during construction would be managed through the use of landscaping. Designs for temporary noise barriers and hoarding would include painted surfaces and project information, prompt removal of graffiti, use of toned colours and materials on acoustic sheds, use of cut-off and directed lighting to minimise light spill and minimising visual impacts of construction works by maximising separation distances to residential areas.

Visual impacts associated with the operation of the project would be managed through the use of a range of measures that include appropriate building designs for the local areas, landscaping, use of appropriate fencing materials in parks and public spaces, and the use of lighting designs to minimise light spill into surrounding areas.

Changes to noise barriers to minimise visual amenity impacts (such as heights and construction materials) would be undertaken in consultation with specialist noise consultants to ensure the effectiveness of the noise mitigation measures remain. It is important for the protection of human health that the integrity and effectiveness of the noise mitigation measures adopted remains unchanged.

Changes to the amenity of a street or suburb can adversely impact a sense of belonging and identity of its residents and consequently their community cohesion. Project design and landscaping plans aim to minimise visual intrusion of project elements and respect and respond to the existing character of these areas.

Changes to health and emergency services

The M5 East Motorway, 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.

The Construction Traffic Management Plan(s) for the project would be developed in consultation with relevant emergency services, ensuring that procedures are in place to maintain safe, priority access for emergency vehicles through construction zones. Additionally, local emergency services would be periodically updated on the staging and progress of construction works.

The project would not impact access to health or emergency services.

11.3.4 Assessment of cumulative impacts

Within an urban environment there are a wide range of complex factors (acting and interacting at different scales) that can affect human health and wellbeing. This is conceptualised in the Technical working paper: Human health (**Appendix I**). The factors identified may result in either positive or negative impacts on health and wellbeing. It is noted that no single element or determinant acts in isolation. Health and wellbeing in the urban environment depends on the sum of the total interactions between many factors. Where negative impacts have been identified, these impacts are either short-term (during construction only) and / or appropriate mitigation or management measures have been identified which would minimise impacts on the community.

11.4 Environmental management measures

Environmental management measures to minimise impacts to human health during construction and operation of the project are provided in **Table 11-17**. Additional management measures to avoid or minimise impacts to human health are provided in the following chapters:

- Transport and travel management measures - **Chapter 9** (Traffic and transport)
- Air quality management measures - **Chapter 10** (Air quality)
- Noise and vibration impact management measures - **Chapter 12** (Noise and vibration)
- Social impact management measures - **Chapter 15** (Social and economic)

Table 11-17 Environmental management measures – human health

Impact	No.	Environmental management measure	Timing
Construction			
Moving house as a result of property acquisition	HH1	Affected households would be provided access to a free counselling service; WestConnex Assist, to support them in the land acquisition process and relocation.	Pre-construction

(blank page)

12 Noise and vibration

A Technical working paper: Noise and vibration (**Appendix J**) has been prepared to assess the potential noise and vibration impacts of the project. This chapter provides a summary of the technical working paper and outlines the potential noise and vibration impacts associated with the new M5 (the project).

Table 12-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to noise and vibration and where in the environmental impact statement (EIS) these have been addressed.

Table 12-1 SEARs – Noise and vibration

SEARs	Where addressed
An assessment of the noise impacts of the proposal during operation, consistent with the *Road Noise Policy* (EPA, 2011) and *NSW Industrial Noise Policy* (EPA, 2000). The assessment must address:	This chapter and Technical working paper: Noise and vibration (**Appendix J)**.
• the redistribution of traffic	Road traffic noise impacts generated by redistributed traffic are considered in **Section 12.4.2**.
• impacts to receivers (dwellings, child care centres, educational establishments, hospitals, motels, nursing homes, or places of worship)	Operation noise impacts are considered in **Section 12.4.2**.
• sleep disturbance	Operation related sleep disturbance is considered in **Section 12.4.2**.
• the characteristics of noise (eg low frequency noise).	The characteristics of project noise sources, including frequency, are provided in Technical working paper: Noise and vibration (**Appendix J**).
An assessment of construction noise and vibration impacts, consistent with the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and *Assessing Vibration: a technical guideline* (DEC, 2006). The assessment must address: • the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant) • the intensity and duration of noise and vibration impacts (both air and ground borne) • the nature, sensitivity and impact to receivers • the need to balance timely conclusion of noise and vibration generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management) • an indication of potential for works outside standard construction hours, including predicted levels, exceedances and number of potentially affected receivers, justification for the activity in terms of the ICNG.	This chapter and Technical working paper: Noise and vibration (**Appendix J**). Construction noise impacts, including the nature of construction activities, the intensity and duration of noise and vibration, affected receivers, and the need for and timing of construction activities, particularly outside standard construction hours, is included in **Section 12.4.1**
Cumulative assessment of potential construction noise and vibration impacts due to other developments in the vicinity, including future stages of WestConnex.	Cumulative construction noise impacts are considered in **Section 12.4.1 and Section 12.4.2**.

12.1 Assessment methodology

The assessment methodology for noise and vibration impacts has generally involved:

- Identification of the study area
- Identification and classification of sensitive receivers
- Noise monitoring
- Calibration of noise models using noise monitoring data
- Modelling of construction and operational noise
- Assessment of noise model predictions against relevant noise criteria for construction works, construction and operational traffic, and operational infrastructure
- Identification of feasible and reasonable mitigation and management measures.

Where guidelines require consideration of 'feasible' and 'reasonable' noise mitigation and management measures, the *Interim Construction Noise Guidelines* (ICNG) (DECC, 2009) describes these terms as:

- Feasible – a work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements
- Reasonable – selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

12.1.1 Study area

The noise and vibration study area is shown in **Figure 12-1** and was identified in two parts:

- The study area relevant to construction and operational sites
- The study area relevant to construction and operational traffic.

The study area has been identified through consideration of potential noise impacts, noting that the area affected by noise is usually larger than the area that may be affected by vibration.

The study area for the construction and operational sites was determined by:

- Identifying construction activities and sites, and operational sites, with the potential to generate noise, including each of the surface works areas: the western surface works area, the Bexley Road surface works area, the Kingsgrove surface works area, the Arncliffe surface works area, and the St Peters interchange and local road upgrades surface works area
- Identifying noise sensitive receivers around each activity and site with the potential to generate noise. Noise sensitive receivers were identified through aerial photography and all structures in the project area, except for those to be acquired and demolished, were subject to visual groundtruthing. This exercise, in conjunction with cadastral information, was used to determine the classification of buildings into residential, commercial, industrial, educational, recreational and other uses (such as sheds and the like)
- Grouping receivers into a series of 30 noise catchment areas (NCAs) based on location, the nature of the receivers and local conditions (such as topography and proximity to other major noise sources). The extent of each NCA was established based on the anticipated extent of discernible noise impacts around each construction and operational activity/ site
- The 30 NCAs together form the noise study area for construction and operational sites.

The study area for the construction and operational traffic noise was determined by:

- Identifying traffic routes for construction and operational phases of the project:
  - For construction traffic, proposed construction traffic routes to and from each construction compound are described in **Chapter 9** (Traffic and transport). Access and egress arrangements for each construction compound are summarised in **Table 6-24** in **Chapter 6**.
  - For operation traffic, relevant traffic routes were those new or upgraded roads within the scope of the project. Relevant operational traffic routes were broadly located around the western surface works area (associated with the M5 East Motorway tie-in works) and around the St Peters interchange and local road upgrades.
- An initial study area of 600 metres around each of the construction and operational traffic routes was identified, consistent with the requirements of the *NSW Road Noise Policy* (DECCW, 2001)
- The roads captured in the 600 metre zone were refined considering:
  - Other major roads and road traffic noise sources within the 600 metre study area. In some cases, the study area was reduced in these locations consistent with the guidance provided in the *Noise Criteria Guideline* (RMS, 2015a)
  - This process of study area refinement involved considering the contribution of traffic noise attributable to the project. Parts of the initial study area where the project was identified as contributing no more than 2.0 dB(A) to the total traffic noise were excluded from the final study area.
- Identifying receiver locations within the study area for construction and operational traffic noise, which was characterised and ground-truthed in the same manner as for the study area for construction and operational sites
- Identifying parallel routes and undertaking road traffic modelling for areas in the existing road network around the project which have been identified as experiencing increases in traffic volumes as a result of traffic redistribution, based on the operational traffic assessment carried out for the project (refer to **Chapter 9** (Traffic and transport)).

The combined noise and vibration study area is predominantly a suburban noise environment in the west and an urban noise environment in the east, incorporating a mix of noise and vibration sensitive receivers (ie residential properties, educational establishments, hospitals and recreational areas), commercial and industrial properties, as well as major motorways and roads.

(blank page)



Figure 12-1 Noise and vibration study area relevant to construction and operational sites

(blank page)

12.1.2 Background noise monitoring

Monitoring approach and locations

Unattended background noise monitoring has been carried out to inform the noise impact assessment at 27 locations throughout the study area, over five noise monitoring periods between May 2014 and September 2015. Noise monitoring locations are shown in **Figure 12-2** to **Figure 12-10**, and are described in detail in **Section 3.4** of the Technical working paper: Noise and vibration (**Appendix J**).

The locations for the noise logging were chosen through examination of aerial photography and site inspections. Attended noise measurements were also undertaken to determine the nature of the local noise environment and confirm road traffic was the controlling noise source (for the validation of the operational noise model). Noise logger locations were chosen to be representative of the noise sensitive receivers most likely to be adversely affected by the works.

Two types of noise monitoring have been carried out:

- Noise monitoring at representative locations within each NCA. This monitoring data was used to:
  - Establish existing background noise levels for receiver locations in each NCA
  - Calculate construction noise management levels for construction activities in accordance with the *Interim Construction Noise Guideline* (DECC, 2009). These construction noise management levels were used to assess the noise performance of construction sites
  - Operational noise criteria for fixed facilities in accordance with the *Industrial Noise Policy* (EPA, 2000). These operational noise criteria were used to assess the noise performance of operational sites.
- Traffic noise monitoring at representative locations along operational traffic routes. This monitoring included concurrent traffic noise and traffic volume monitoring to identify the relationship between traffic numbers and traffic noise at each location. This data was used to:
  - Establish existing background traffic noise levels for receiver locations along each construction and operational traffic route
  - Validate the traffic noise model. This validation involved ensuring that traffic noise modelled for a specific traffic volume reflected concurrent traffic noise and traffic volume monitoring data.

Noise monitoring was not required for the assessment of construction traffic noise because construction traffic noise has been evaluated based on the change in traffic flows with and without any additional construction traffic.

(blank page)

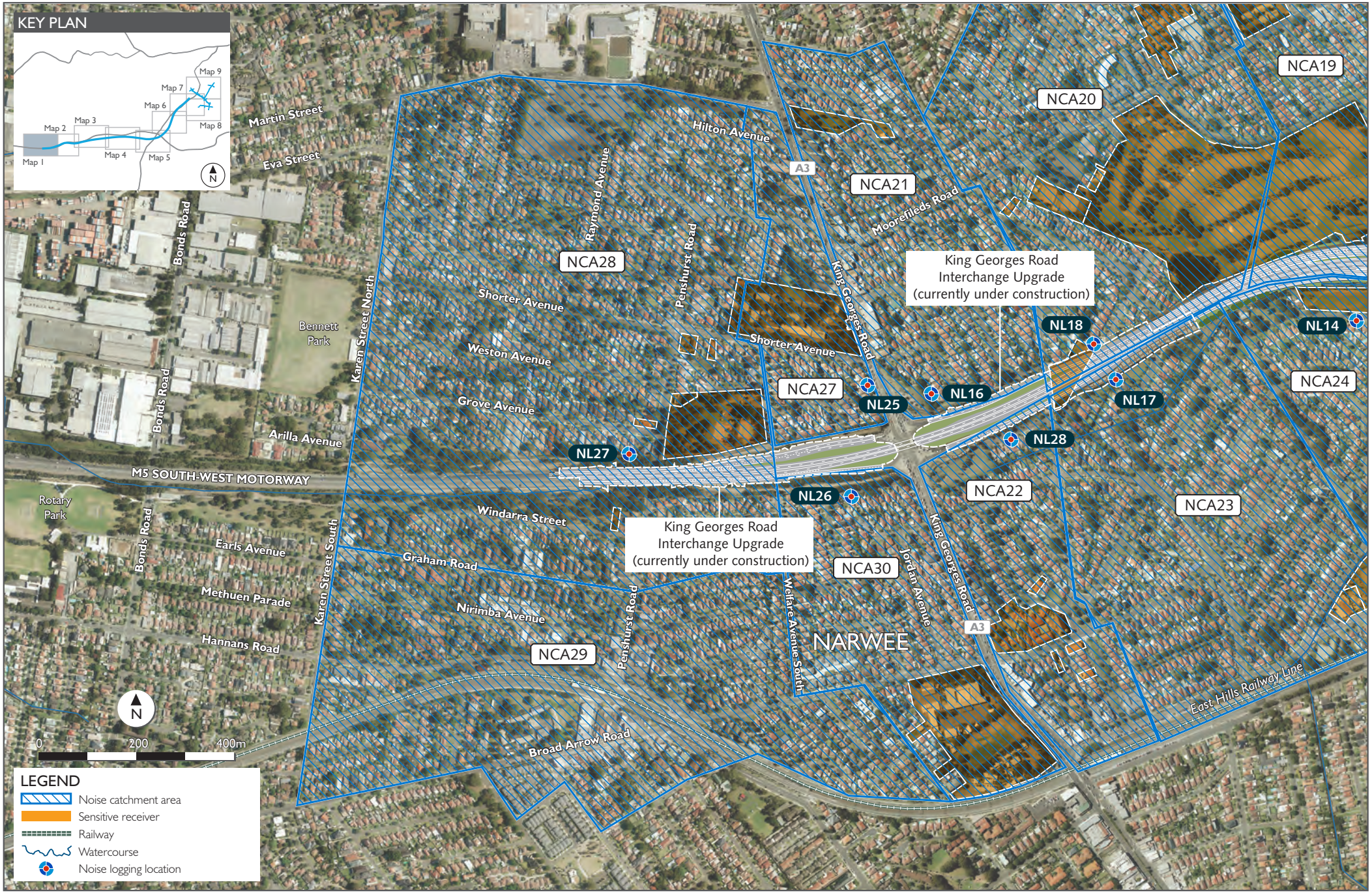


Figure 12-2 Noise monitoring locaitons - map 1

(blank page)

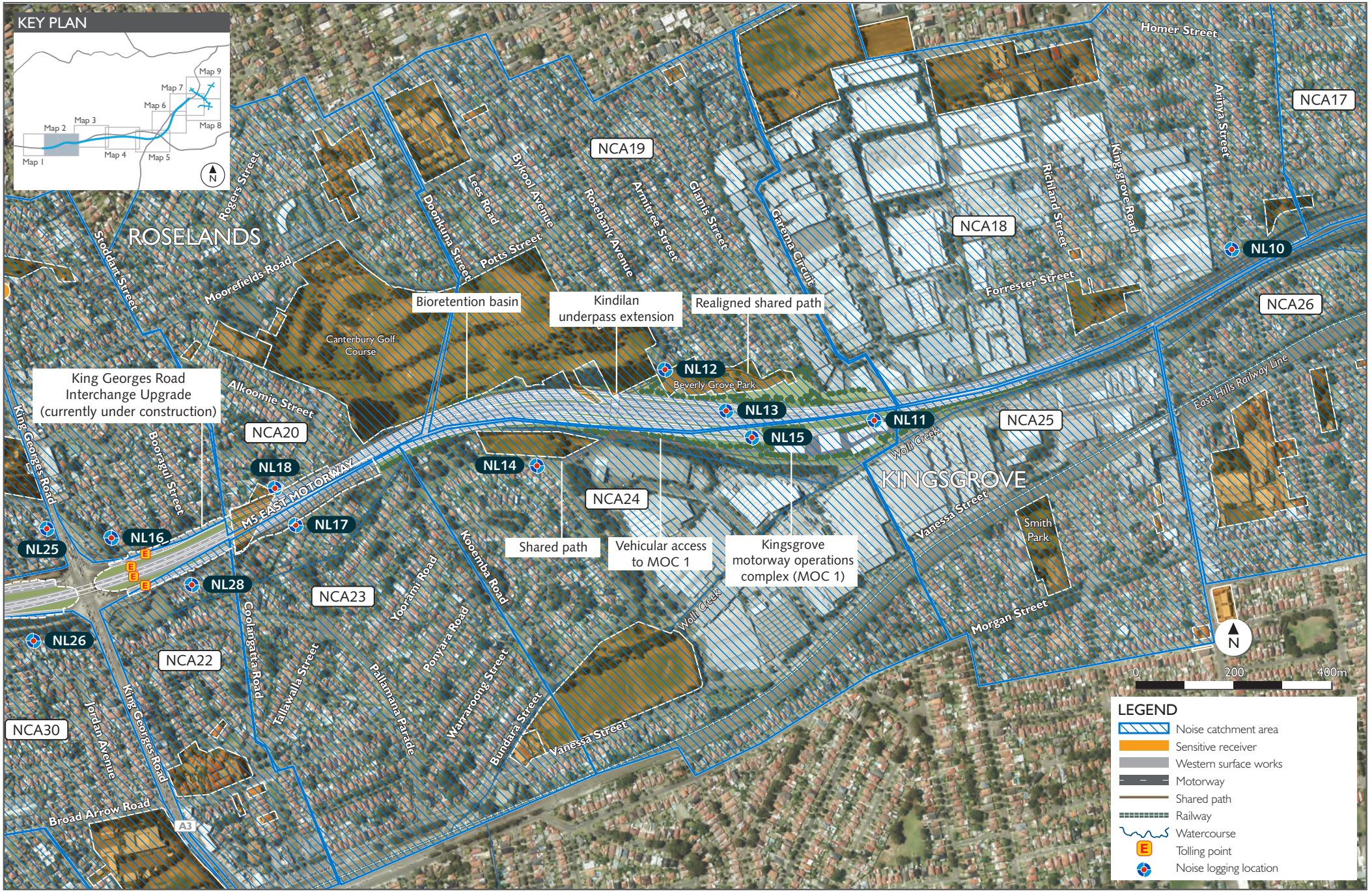


Figure 12-3 Noise monitoring locations - map 2

(blank page)



Figure 12-4 Noise monitoring locations - map 3

(blank page)



Figure 12-5 Noise monitoring locations - map 4

(blank page)



Figure 12-6 Noise monitoring locations - map 5

(blank page)



Figure 12-7 Noise monitoring locations - map 6

(blank page)



Figure 12-8 Noise monitoring locations - map 7

(blank page)

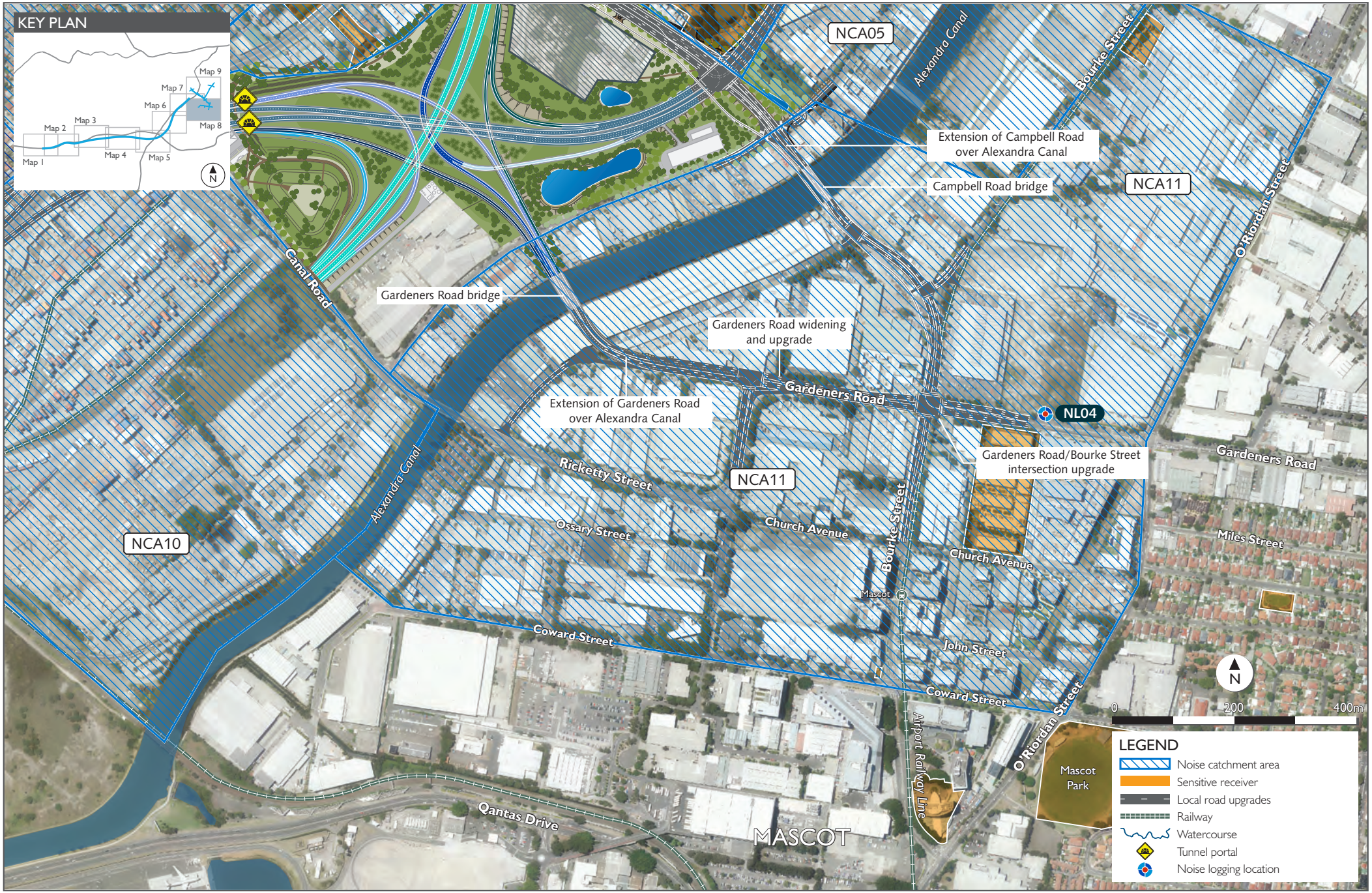


Figure 12-9 Noise monitoring locations - map 8

(blank page)



Figure 12-10 Noise monitoring locations - map 9

(blank page)

12.1.3 Policy framework

The following guidelines have been used in the noise and vibration assessment:

- Construction noise:
  - ICNG (DECC, 2009)
  - *Construction Noise Strategy* (Transport for NSW, 2012c)
- Construction vibration:
  - Assessing Vibration: A Technical Guideline (DEC, 2006a)
  - *Structural vibration – Effects of vibration on structures* (German Standard (DIN) 4150 Part 3-1999)
  - *Evaluation and Measurement for Vibration in Buildings Part 2,* (British Standard (BS) 7385:Part 2-1993)
  - *Explosives − Storage and Use − Part 2: Use of Explosives* (Australian Standard (AS) 2187: Part 2-2006)
  - Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Council, 1990)
- Construction and operational traffic noise:
  - NSW Road Noise Policy (DECCW, 2011)
  - *Noise Criteria Guideline* (Roads and Maritime, 2015a)
  - *Noise Mitigation Guideline* (Roads and Maritime, 2015b)
- Noise from operational ancillary facilities:
  - Industrial Noise Policy (EPA, 1999)
- Sleep disturbance during construction and operation:
  - NSW Road Noise Policy (DECCW, 2011)
  - Preparing an Operational Noise and Vibration Assessment (Roads and Maritime, 2011b)
  - Practice Note 3 of the *Environmental Noise Management Manual* (RTA, 2001).

12.2 Existing environment

The existing noise environment across the study area is characterised by high levels of road traffic noise. The most dominant sources of noise include the M5 East Motorway, Bexley Road, Kingsgrove Road, King Georges Road, the Princes Highway, Canal Road and Campbell Road.

There are also noise contributions from local roads. The existing noise environment within the study area is generally dependent on the proximity of receiver location to existing major road corridors. Other key noise sources in the study area include the East Hills, Airport, Inner West and Illawarra Railways and Sydney Airport.

Land use and existing development within and around the project corridor is predominately urban and suburban in nature, containing a mix of residential, commercial, industrial and open space uses.

The results of the background noise monitoring are provided in **Table 12-2**. Noise monitoring locations are shown in **Figure 12-1** and described in detail in the Technical working paper: Noise and vibration (**Appendix J**)**.**

The noise monitoring results in **Table 12-2** are typical of noise levels experienced in suburban environments with daytime noise levels generally around 45 dB(A) to 65 dB(A), and in most cases several decibels quieter during the evening period. Night time background noise levels are variable, from around 30 dB(A) to 45 dB(A) depending on the proximity of receiver locations to 24 hour noise sources such as major transport corridors and industrial developments.

Background traffic noise is strongly influenced by proximity to existing major road corridors, with daytime traffic noise between around 54 dB(A) and 73 dB(A). Monitoring data indicates greater variability in background traffic noise during the night-time, with monitored values between around 50 dB(A) and 70 dB(A).

Table 12-2 Background noise monitoring results

Noise Monitoring location	Rating background level, dB(A) [1]			Rating background level, dB(A) [2]	
	Day (7am to 6pm) $L_{A90,15\ minute}$	Evening (6pm to 10pm) $L_{A90,15\ minute}$	Night (10pm to 7am) $L_{A90,15\ minute}$	Day (7 am – 10 pm) ($L_{Aeq,\ (15\ hour)}$)	Night (10 pm – 7am) ($L_{Aeq,\ (9\ hour)}$)
NL01	57	51	40	66	62
NL02	50	46	39	68	64
NL03	54	45	40	67	62
NL04	58	52	42	68	64
NL05	52	50	44	64	58
NL06	58	56	49	70	64
NL07	54	54	40	63	59
NL08	49	46	41	54	50
NL09	48	48(49)[3]	43	54	51
NL10	Equipment failure[5]				
NL11	68	67	49	73	70
NL12	45	45(47)[3]	43	54	51
NL13	67	67	51	72	69
NL14	50	50	42	56	52
NL15	67	64	49	72	69
NL16	47	46	40	-	-
NL17	49	49	42	-	-
NL18	50	49	40	-	-
NL19	60	54	43	-	-
NL20	55	55(56)[3]	45	-	-
NL21	49	48	42	-	-
NL22	47	47(48)[3]	39	-	-
NL23	51	51	43	-	-
NL24	47	47(49)[3]	41	-	-
NL25[4]	60	58	46	-	-
NL26	53	52	44	-	-
NL27	52	51	39	-	-

Note 1: ICNG governing periods – Day: 7.00 am to 6.00 pm Monday to Saturday, 8.00 am to 6.00 pm Sunday; Evening: 6.00 pm to 10.00 pm; Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday.
Note 2: *NSW Road Noise Policy* assessment time periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am (weekly data).
Note 3: Application notes to the *Industrial Noise Policy* indicate that the community generally expects a greater control of noise during the evening and night as compared to the day time. Therefore, the evening is set to no more than that for the daytime and the night-time to no more than the evening. Monitoring results for these instances are shown in brackets.
Note 4: Monitoring location near to building facade. Measured LAeq noise levels considered to represent façade reflected noise levels which are up to 2.5 dB(A) higher than the equivalent free-field condition.
Note 5: Noise levels at location NL09 were deemed to be representative of those at location NL10, and were therefore adopted.

12.3 Assessment criteria

The following noise and vibration assessment criteria are relevant to the construction of the project:

- Noise management levels applied to the assessment of surface construction activities and construction sites (airborne noise)
- Sleep disturbance criteria applied to the assessment of construction activities that may be carried out during the night time (10pm to 7am)
- Ground borne noise goals for tunnelling and associated tunnel construction activities
- Noise assessment levels for construction traffic noise
- Vibration assessment standards for construction activities that may generate vibration
- Vibration and overpressure standards for blasting activities during tunnelling.

12.3.1 Construction noise assessment criteria

Construction noise management levels – airborne construction noise

The risk of adverse impact of construction noise on a community is determined by the extent of its emergence above the existing background noise level, the duration of the event and the characteristics of the noise.

Residential receivers

Noise management levels for residential receivers are calculated relative to existing background noise levels, and take into account whether construction activities are carried out during or outside standard construction hours. The *Interim Construction Noise Guideline* (DECC, 2009) also identifies the level at which a residential receiver is considered to be 'highly noise affected'.

The method for calculating construction noise management levels from existing noise levels (rating background levels) for residential receivers is summarised in **Table 12-3**. Further details of this calculation are provided in the Technical working paper: Noise and vibration (**Appendix J**) and in the *Interim Construction Noise Guideline* (DECC, 2009).

This calculation method has been applied to the existing noise levels (rating background levels) identified through noise monitoring in each NCA. The resulting construction noise management levels for residential receivers in each NCA are provided in **Table 12-4**.

Table 12-3 Calculating construction noise management levels for residential receivers

Time of day	Noise management level ($L_{Aeq(15\text{-}minute)}$) (dB(A))	Application
During standard construction hours: • Monday to Friday 7am to 6pm • Saturday 8am to 1pm • No work on Sundays or public holidays	Noise affected receivers Rating background level plus 10 dB(A)	The 'noise affected' level represents the point above which there may be some community reaction to noise. Where the predicted or measured construction noise is above this noise management level, all feasible and reasonable noise mitigation measures should be identified and applied. Receivers affected by noise above this noise management level should also be notified of the nature of works to be carried out, the expected noise levels and duration, and provided with contact details.
	Highly noise affected receivers 75 dB(A)	The 'highly noise affected' level represents the point above which there may be strong community reaction to noise. Where predicted or measured construction noise is above this level, additional restrictions may be required. These may include respite periods and restrictions on hours for noisy works taking into account: • Times when the community may be less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) • Community acceptance of a longer construction period in exchange for restricted construction times.
Outside standard construction hours	Noise affected receivers Rating background level plus 5 dB(A)	A strong justification is required for construction works outside standard construction hours. Construction outside standard construction hours required the identification and application of all feasible and reasonable noise mitigation measures. Where noise is more than 5 dB(A) above the noise management level, even after the application of all feasible and reasonable noise mitigation measures, further consultation and negotiation with the community should be carried out.

Note: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 12-4 Construction noise management levels for residential receivers in each NCA

NCA	Noise monitoring locations	Period	Rating background level (dB(A))[1]	Construction noise management level (NML)[2,3]
Western surface works area				
NCA18	NL09	Day	48	58
		Evening	48[I]	53
		Night	43	48
NCA19	NL12	Day	45	55
		Evening	45[I]	55
		Night	43	48
NCA20	NL18	Day	50	60
		Evening	49	54
		Night	40	45
NCA21	NL16	Day	47	57
		Evening	46	51
		Night	40	45
NCA22	NL16	Day	47	57
		Evening	46	51
		Night	40	45
NCA23	NL17	Day	49	59
		Evening	49	54
		Night	42	47
NCA24	NL14	Day	50	60
		Evening	50	55
		Night	42	47
NCA25	NL24	Day	47	57
		Evening	47[I]	53
		Night	41	46
NCA26	NL24	Day	47	57
		Evening	47[I]	53
		Night	41	46
NCA27	NL25	Day	60	70
		Evening	58	63
		Night	46	51
NCA28	NL27	Day	52	62
		Evening	51	56
		Night	39	44
NCA29	NL24	Day	47	57
		Evening	47[I]	53
		Night	41	46
NCA30	NL26	Day	53	63
		Evening	52	57
		Night	44	49
Bexley Road surface works area				
NCA15	NL23	Day	51	61
		Evening	51	56
		Night	43	48
NCA16	NL07	Day	54	64
		Evening	54	59
		Night	40	45
NCA17	NL09	Day	48	58
		Evening	48[I]	53
		Night	43	48

NCA	Noise monitoring locations	Period	Rating background level (dB(A))[1]	Construction noise management level (NML)[2,3]
Arncliffe surface works area				
NCA12	NL20	Day	55	65
		Evening	55	60
		Night	45	50
NCA13	NL21	Day	49	59
		Evening	48	53
		Night	42	47
NCA14	NL22	Day	47	57
		Evening	47	52
		Night	39	44
St Peters interchange and local road upgrade surface works area				
NCA01	NL01	Day	57	67
		Evening	51	56
		Night	40	45
NCA02	NL02	Day	45	55
		Evening	43	48
		Night	32	37
NCA03	NL02	Day	45	55
		Evening	43	48
		Night	32	37
NCA04	NL01	Day	57	67
		Evening	51	56
		Night	40	45
NCA05	NL01	Day	57	67
		Evening	51	56
		Night	40	45
NCA06	NL02	Day	45	55
		Evening	43	48
		Night	32	37
NCA07	NL05	Day	52	62
		Evening	50	55
		Night	44	49
NCA08	NL03	Day	54	64
		Evening	45	50
		Night	40	45
NCA09	NL19	Day	60	70
		Evening	54	59
		Night	43	48
NCA10	NL06	Day	58	68
		Evening	56	61
		Night	49	54
NCA11	NL04	Day	58	68
		Evening	52	57
		Night	42	47

Note 1: The community generally expects a greater control of noise during the evening and night compared to the day time. Therefore the rating background level for the evening has been set to no more than that for the daytime and the night-time to no more than the evening.
Note 2: Day time construction noise management levels = rating background level plus 10 dB(A)
Note 3: Evening / night time construction noise management levels = rating background level plus 5 dB(A)

Other sensitive land uses

Noise management levels for other sensitive receiver locations, including schools, hospitals and places of worship, are generally specified as internal noise levels (ie inside the school, hospital or place of worship). The *Interim Construction Noise Guideline* (DECC, 2009) also specifies external noise management levels of outside areas, such as parks and recreation areas. Hotels have been considered as a commercial receiver.

Construction noise management levels recommended by the *Interim Construction Noise Guideline* (DECC, 2009) for other sensitive receivers are summarised in **Table 12-5**.

Table 12-5 Construction noise management levels – other sensitive receivers

Other sensitive receiver type	Construction noise management level ($L_{Aeq(15\text{-}minute)}$) (dB(A))
Classrooms at schools and other educational institutions	Internal noise level of 45 dB(A) when the property is in use.
Hospital wards and operating theatres	Internal noise level of 45 dB(A) when the property is in use.
Places of worship	Internal noise level of 45 dB(A) when the property is in use.
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level of 65 dB(A) when the property is in use.
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level of 60 dB(A) when the property is in use.
Community centres	Depends on the intended use of the centre, and applies when the property is in use. Refer to the recommended "maximum" internal levels in AS2107 for specific uses.
Aged care facilities	Residential land use noise assessment criteria applied to these facilities.

Commercial and industrial premises

The *Interim Construction Noise Guideline* (DECC, 2009) specifies external noise management levels for less sensitive receiver locations, such as businesses and industry. For these types of receivers an external noise management level of 70 dBA $LA_{eq(15minute)}$ has been adopted for commercial premises, while a noise management level of 75 dBA $LA_{eq(15minute)}$ has been adopted for industrial premises.

Construction noise sleep disturbance criteria

The potential for sleep disturbance as a result of construction activities that may be conducted at night is assessed based on two criteria:

- A sleep disturbance screening criterion, to identify situations where there is potential for sleep disturbance
- A sleep disturbance awakening reaction criterion, below which an awakening reaction is unlikely to occur.

The sleep disturbance screening criterion is the noise level (measured as $L_{A1(one\text{-}minute)}$ at the bedroom window during the night time period) that is 15 dB(A) above the background noise level (rating background level). Where night time noise is anticipated to exceed this screening criterion, the NSW EPA recommends a more detailed analysis to identify the magnitude of maximum noise levels above background noise levels, and the number of times the screening criterion is anticipated to be exceeded during any night.

The sleep disturbance awakening reaction criterion is the threshold at which an awakening reaction is likely to occur based on night time noise.

Research conducted to inform the preparation of the *NSW Road Noise Policy* (DECCW, 2011) has concluded that this threshold is around 50-55 dB(A) when measured inside a bedroom.

An open window provides around 10 dB(A) of noise attenuation, and therefore the sleep disturbance awakening reaction criterion when measured outside a bedroom window is 60-65 dB(A). Below this criterion, an awakening reaction is unlikely to occur.

The sleep disturbance screening criterion and the sleep disturbance awakening reaction criterion for each NCA are provided in **Table 12-6**.

Table 12-6 Construction noise sleep disturbance criteria

NCA	Noise monitoring location	Background noise level (rating background level) (dB(A))	Sleep disturbance screening criteria ($L_{A1(1min)}$) (dB(A))	Sleep disturbance awakening reaction criteria ($L_{A1(1min)}$) (dB(A))
Western surface works area				
NCA18	NL09	43	58	65
NCA19	NL12	43	58	65
NCA20	NL18	40	55	65
NCA21	NL16	40	55	65
NCA22	NL16	40	55	65
NCA23	NL17	42	57	65
NCA24	NL14	42	57	65
NCA25	NL24	41	56	65
NCA26	NL24	41	56	65
NCA27	NL25	46	61	65
NCA28	Nl27	39	54	65
NCA29	NL24	41	56	65
NCA30	NL26	44	59	56
Bexley Road surface works area				
NCA15	NL23	43	58	65
NCA16	NL07	40	55	65
NCA17	NL09	43	58	65
Arncliffe surface works area				
NCA12	NL20	45	60	65
NCA13	NL21	42	57	65
NCA14	NL22	39	54	65
St Peters interchange and local road upgrade surface works area				
NCA01	NL01	40	55	65
NCA02	NL02	32	47	65
NCA03	NL02	32	47	65
NCA04	NL01	40	55	65
NCA05	NL01	44	59	65
NCA06	NL02	32	47	65
NCA07	NL05	44	59	65
NCA08	NL03	41	56	65
NCA09	NL19	43	58	65
NCA10	NL06	49	64	65
NCA11	NL04	42	57	65

Construction ground-borne noise goals

Some construction activities, such as tunnelling, can generate vibrations which travel through the ground to the surface where the vibrations can 'break out' as audible noise for surface receivers. This effect is often referred to as ground-borne noise or regenerated noise. Ground-borne noise is typically low frequency, and if audible is perceived as a 'rumble'.

Ground-borne noise is generally only a relevant issue where the ground-borne noise level is higher than airborne noise from surface construction activities and other background sources. In many cases, ground-borne noise is masked by airborne noise levels. For this reason, ground-borne noise is usually only an issue during the evening and night time periods, when ambient noise levels are lower.

Recommended ground-borne noise goals for the project, as detailed in the *Interim Construction Noise Guideline* (DECC, 2009), applicable for residences are:

- Evening: 40 dBA $L_{Aeq(15minute)}$
- Night-time: 35 dBA $L_{Aeq(15minute)}$

The *Interim Construction Noise Guideline* (DECC, 2009) does not provide guidance in relation to acceptable ground-borne noise levels for commercial receivers. An internal NML of 60 dBA $L_{Aeq(15minute)}$ has been adopted in order to identify potential impacts.

Criteria for vibration from blasting are discussed in **Section 12.3.2**.

Construction road traffic noise criterion

The *Interim Construction Noise Guideline* (DECC, 2009) does not provide specific criterion to assess the noise arising from construction traffic on public roads. However, it does refer to the *Environmental Criteria for Road Traffic Noise*, now superseded by the *NSW Road Noise Policy* (DECCW, 2011), for the assessment of noise arising from construction traffic on public roads.

In relation to assessing feasible and reasonable noise mitigation measures, the *NSW Road Noise Policy* (DECCW, 2011) suggests that noise increases of up to 2 dB(A) are barely perceptible to the average person, Therefore, 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 2 dB(A).

12.3.2 Construction vibration assessment criteria

Vibration generated by construction activities may result in:

- Potential structural damage of buildings and/or cosmetic damage (eg superficial cracking in cement render or plaster). Vibration standards for the protection of structural integrity are provided in *German Standard DIN 4150 Structural Vibration, Part 3: Effects of Vibration on structures*.
- Human comfort effects, where human receivers are inconvenienced or possibly disturbed by vibration. Vibration standards for the protection of human comfort are provided in *Assessing Vibration: a technical guideline* (DEC, 2006a).

Vibration and overpressure effects from blasting, and applicable assessment standards, are detailed in the following section.

Construction vibration assessment standards

Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration. The German Standard *Structural Vibration, Part 3: Effects of Vibration on structures (DIN 4150-3*) provides recommended maximum levels of vibration to reduce the likelihood of building damage caused by vibration.

Recommended vibration limits specified in DIN 4150-3 are summarised in **Table 12-7.** The standard recognises that these limits are precautionary and vibration levels above these limits do not necessarily mean that damage to a structure would occur.

In addition to these recommended vibration limits, Roads and Maritime also applies a two millimetres per second vibration standard at property boundaries as part of its environmental procedures.

Table 12-7 Recommended structural damage vibration limits

Type of structure	Vibration velocity (mm/s)			
	Frequency at foundation			Horizontal plane of the highest floor All frequencies
	Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that (because of their particular sensitivity to vibration) do not correspond to those listed above, but have intrinsic value (eg buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Human comfort (tactile vibration)

Assessing Vibration: a technical guideline (DEC, 2006a) provides preferred and maximum vibration dose values for different types of vibration. The guideline provides that:

- There is a low probability of adverse comment or disturbance to building occupants for vibration below preferred values
- Activities should be designed to meet preferred values for receivers that are not currently affected by vibration
- Vibration above preferred values and up to the maximum values may be justified if all feasible and reasonable vibration mitigation measures are applied
- Negotiated agreements with the affected parties should be pursued where maximum values are exceeded.

The three types of vibration covered by *Assessing Vibration: a technical guideline* (DEC, 2006a) are:

- Intermittent vibration. This occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, or jack hammers.
- Continuous vibration. This vibration continues uninterrupted for a defined period and its sources include machinery and continuous construction activities
- Impulsive vibration. This vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, typically lasting less than two seconds and no more than three occurrences in an assessment period. Its sources may include occasional dropping of heavy equipment or loading activities

The assessment of intermittent vibration is based on vibration dose values. A vibration dose value represents the total cumulative vibration received over the day time or the night time period. The preferred and maximum vibration dose values for intermittent vibration from construction activities are summarised in **Table 12-8.**

These vibration dose values are based on the likelihood that a person would be annoyed by the level of vibration over the entire day time or night time period.

Table 12-8 Preferred and maximum vibration dose values for intermittent vibration during construction activities

Receiver type	Day time (7am to 10pm)		Night time (10pm to 7am)	
	Preferred value ($m/s^{1.75}$)	Maximum value ($m/s^{1.75}$)	Preferred value ($m/s^{1.75}$)	Maximum values ($m/s^{1.75}$)
Critical areas (such as hospital operating theatres and precision laboratories)	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

Acceptable levels of human exposure to continuous and impulsive vibration are dependent on the time of day and the sensitivity of the receiver type. Preferred values for continuous and impulsive vibration are summarised in **Table 12-9**, and relate to three axes:

- x axis – back to chest
- y axis – right side to left side
- z axis – foot to head.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values in **Table 12-9**.

Vibration above the preferred values may also be acceptable, particularly for temporary disturbances and infrequent, short events.

Assessing Vibration: a technical guideline (DEC, 2006a) also presents acceptable levels of human exposure to continuous or impulsive vibration in terms of 'peak velocity' of the vibration. Preferred and maximum peak velocity values are summarised in **Table 12-10**.

Table 12-9 Preferred and maximum values for continuous and impulsive vibration (1-80 Hz)

Receiver type	Time of day	Preferred (m/s^2)		Maximum (m/s^2)	
		z axis	x axis and y axis	z axis	x axis and y axis
Continuous vibration					
Critical areas (such as hospital operating theatres and precision laboratories)	When in use	0.005	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	When in use	0.020	0.014	0.040	0.028
Workshops	When in use	0.040	0.029	0.080	0.058
Impulsive vibration					
Critical areas (such as hospital operating theatres and precision laboratories)	When in use	0.005	0.0036	0.010	0.0072
Residences	Day	0.300	0.21	0.60	0.42
	Night	0.100	0.071	0.20	0.14

Receiver type	Time of day	Preferred (m/s^2)		Maximum (m/s^2)	
		z axis	x axis and y axis	z axis	x axis and y axis
Offices, schools, educational institutions and places of worship	When in use	0.640	0.46	1.28	0.92
Workshops	When in use	0.640	0.46	1.28	0.92

Table 12-10 Criteria for exposure to continuous and impulsive vibration (peak velocity)

Receiver type	Time of day	Preferred (mm/s)	Maximum (mm/s)
Continuous vibration			
Critical areas (such as hospital operating theatres and precision laboratories)	When in use	0.14	0.28
Residences	Day	0.28	0.56
	Night	0.20	0.40
Offices, schools, educational institutions, places of worship	When in use	0.56	1.1
Workshops	When in use	1.1	2.2
Impulsive vibration			
Critical areas (such as hospital operating theatres and precision laboratories)	When in use	0.14	0.28
Residences	Day	8.6	17.0
	Night	2.8	5.6
Offices, schools, educational institutions, places of worship	When in use	18.0	36.0
Workshops	When in use	18.0	36.0

Safe working distances

The *Construction Noise Strategy* (Transport for NSW, 2012c) provides indicative safe working distances for different types of construction equipment based on achieving vibration standards for structural integrity and human comfort. These safe working distances are provided in **Table 12-11.**

Where specified construction equipment is used at greater distances from receiver locations than the specified safe working distance, there is negligible risk of structural damage or impacts to human comfort. Where safe working distances are not met, more detailed consideration of potential vibration impacts is warranted.

Table 12-11 Safe working distances for common construction equipment

Construction equipment	Rating/ description	Safe working distance (m)	
		Cosmetic structural damage	Human comfort
Vibratory roller	<50 kN (typically 1-2 tonnes)	5	15 to 20
	<100 kN (typically 2-4 tonnes)	6	20
	<200 kN (typically 4-6 tonnes)	12	40
	<300 kN (typically 7-13 tonnes)	15	100
	>300 kN (typically 13-18 tonnes)	20	100
	>300 kN (typically 18 tonnes)	25	100
Small hydraulic hammer	300kg – 5-12 tonne excavator	2	7
Medium hydraulic hammer	900kg – 12-18 tonne excavator	7	23
Large hydraulic hammer	1600kg – 18-34 tonne excavator	22	73
Vibratory pile driver	Sheet piles	2 to 20	20
Pile boring	≤800 mm	2 (nominal)	N/A
Jackhammer	Handheld	1 (nominal)	Avoid contact with structure

Blasting criteria

Blasting would be required during tunnelling activities. Blasting has been considered as an excavation method for the tunnels because the vibration caused by a single blast (airblast) is much shorter than the continuous vibration and ground-borne noise resulting from mechanical exaction equipment such as roadheaders.

Blasting can generate two types of effects, both of which have the potential to cause damage to structures and discomfort to human receivers:

- Airblast – the pressure wave transmitted through the air as a result of the blast
- Vibration – the energy transmitted through the ground as a result of the blast.

Guidance in relation to acceptable overpressure and vibration from blasting is provided in the *Interim Construction Noise Guideline* (DECC, 2009), which specifies that the assessment should be based on the levels in the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZEC, 1990), as follows:

- Airblast overpressure criteria for blasting:
  - Recommended maximum level of 115 dBA (linear peak). This may be exceeded on up to five per cent of the total number of blasts over a period of 12 months
  - A maximum level of 120 dBA (linear peak) should not be exceeded at any time
- Ground vibration criteria for blasting:
  - Recommended maximum level of five millimetres per second (peak particle velocity). This may be exceeded on up to five per cent of the total number of blasts over a period of 12 months
  - A maximum level of 10 millimetres per second (peak particle velocity) should not be exceeded at any time.

These criteria relate to sensitive sites, which include houses and low rise residential buildings, theatres, schools and other similar buildings occupied by people.

The blast vibration criteria identified in the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZEC, 1990) are considered conservative and were originally developed to protect communities exposed to long-term blasting operations such as at mining sites. For projects such as this, with a shorter duration of blasting of 12 months or less, a higher vibration criterion may be reasonable. For this project, the location of the blast moves along the alignment such that any one receiver is affected for only a short period of time.

Table J4.5(A) in Appendix J of *Explosives – Storage, Transport and Use (*AS2187) presents vibration limits designed to safeguard human comfort in relation to blasting that have been used by some authorities, as it defines clearer vibration limits which are dependent on the specific duration of the project. Based on the limitations of the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZEC, 1990) and further guidance in AS2187, a human comfort vibration limit of 10 millimetres per second (peak particle velocity) for blasting operations lasting less than 12 months has been adopted for this project.

Control of damage

In relation to damage from airblast, AS2187 notes that from Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dB.

It should be noted that BS7385 states that 'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive'. Nominating appropriate criteria for heritage buildings generally requires site inspections; this would be confirmed during detailed design.

12.3.3 Operational noise assessment criteria

The following noise and vibration assessment criteria are relevant to operation of the project:

- Noise criteria applied to the assessment of fixed operational facilities and sites
- Sleep disturbance criteria applied to the assessment of fixed operational facilities and sites that may generate noise during the night time (10pm to 7am)
- Noise assessment levels for operational traffic noise, including potential sleep disturbance from road traffic noise.

Operation of the project would not generate vibration with the potential to affect structural integrity or human comfort.

Noise criteria for operational fixed facilities

The *Industrial Noise Policy* (EPA, 2000) specifies noise criteria applicable to the project's operational fixed facilities, including:

- The Kingsgrove motorway operations complex (MOC1), including the operation of the Kingsgrove ventilation facility and jet fan break out noise from the western portals
- The Bexley Road South motorway operations complex (MOC2), including operation of the emergency smoke extraction facility
- The Arncliffe motorway operations complex (MOC3), including operation of the Arncliffe ventilation facility, emergency smoke extraction facility and water treatment plant
- The St Peters motorway operations complex (MOC4), including operation of the St Peters ventilation facility and jet fan break out noise from the eastern portals
- The Burrows Road motorway operations complex (MOC5), including the motorway control centre.

The *Industrial Noise Policy* (EPA, 2000) provides two types of noise criteria, with the most stringent adopted in each case:

- An intrusive criterion, which seeks to limit the increase in noise levels from a single source. The intrusive criterion is set at 5 dB(A) above existing background noise levels (rating background levels)
- An amenity criterion, which seeks to limit 'noise creep' over time with the addition of multiple noise sources. Amenity criteria are set noise levels specified as acceptable and recommended maximum noise levels for different receiver types (eg residential, commercial, industrial receivers).

The amenity criteria for different receiver types specified in the *Industrial Noise Policy* (EPA, 2000) are summarised in **Table 12-12**.

Table 12-12 Amenity criteria for different receiver types

Receiver type	Time of day	Amenity criteria (dB(A))	
		Acceptable	Recommended maximum
Residence (suburban)	Day[1]	50	60
	Evening[2]	45	50
	Night[3]	40	45
Residence (urban)	Day[1]	60	65
	Evening[2]	50	55
	Night[3]	45	50
School classroom (internal noise level)	Noisiest one-hour period	35	40
Hospital ward (internal noise level)	Noisiest one-hour period	35	40
Hospital ward (external noise level)	Noisiest one-hour period	50	55
Place of worship (internal noise level)	When in use	40	45
Area specifically reserved for passive recreation (eg National Park)	When in use	50	55
Active recreation area (eg school playground, golf course)	When in use	55	60
Commercial	When in use	65	70
Industrial	When in use	70	75

Note 1: Day is defined as 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays.
Note 2: Evening is defined as 6pm to 10pm Monday to Sunday and Public Holidays.
Note 3: Night is defined as 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.

Table 12-13 summarises the relevant amenity criterion and intrusive criterion for each NCA during each period of the day. The amenity criteria listed in **Table 12-13** are based on the dominant receiver type in each NCA.

Based on these criteria, project specific noise criteria have been identified, being the more stringent of the amenity criterion and the intrusive criterion. The more stringent, limiting criterion is highlighted in bold in each case.

Table 12-13 Project specific noise criteria for operational fixed facilities

NCA/ NL	Time of day	Background noise level (rating background level)	Amenity criterion ($L_{Aeq(period)}$) (dB(A))	Intrusive criterion ($L_{Aeq(15\text{-}minute)}$) (dB(A))	Project specific noise criterion (dB(A))
Kingsgrove motorway operations complex (MOC1), including Kingsgrove ventilation facility and western portals					
NCA18/ NL09	Day	48	**50**	53	50
	Evening	49	**45**	54	45
	Night	43	**40**	48	40
NCA19/ NL12	Day	45	**50**	50	50
	Evening	45[1]	**45**	50	45
	Night	43	**40**	48	40
NCA24/ NL14	Day	50	**50**	55	50
	Evening	50	**45**	55	45
	Night	42	**40**	47	40

NCA/ NL	Time of day	Background noise level (rating background level)	Amenity criterion ($L_{Aeq(period)}$) (dB(A))	Intrusive criterion ($L_{Aeq(15\text{-}minute)}$) (dB(A))	Project specific noise criterion (dB(A))
NCA25/ NL24	Day	47	**50**	52	50
	Evening	47[1]	**45**	52	45
	Night	41	**40**	46	40
NCA26/ NL24	Day	47	**50**	52	50
	Evening	47[1]	**45**	52	45
	Night	41	**40**	46	40
Bexley Road South motorway operations complex (MOC2), including the emergency smoke extraction facility					
NCA15/ NL23	Day	51	**50**	56	50
	Evening	51	**45**	56	45
	Night	43	**40**	48	40
NCA16/ NL07	Day	54	**50**	59	50
	Evening	54	**45**	59	45
	Night	40	**40**	45	40
NCA17/ NL09	Day	48	**50**	53	50
	Evening	48[1]	**45**	53	45
	Night	43	**40**	48	40
Arncliffe motorway operations complex (MOC3), including the Arncliffe ventilation facility and emergency smoke extraction facility					
NCA12/ NL20	Day	55	**60**	**60**	60
	Evening	56	**50**	61	50
	Night	45	**45**	50	45
NCA13/ NL21	Day	49	60	**54**	54
	Evening	48	**50**	53	50
	Night	42	**45**	47	45
NCA14/ NL22	Day	47	**50**	52	50
	Evening	47	**45**	52	45
	Night	39	**40**	44	40
St Peters motorway operations complex (MOC4), including the St Peters ventilation outlet and eastern portals					
NCA06/ NL02	Day	45	**50**	**50**	50
	Evening	43	**45**	48	45
	Night	32	40	**37**	37
NCA07/ NL05	Day	52	60	**57**	57
	Evening	50	**50**	55	50
	Night	44	**45**	49	45
NCA10/ NL06	Day	58	**60**	63	60
	Evening	56	**50**	61	50
	Night	49	**45**	54	45
Burrows Road motorway operations complex (MOC5)					
NCA04/ NL01	Day	57	**60**	62	60
	Evening	51	**50**	56	50
	Night	40	**45**	**45**	45
NCA05/ NL01	Day	57	**60**	62	60
	Evening	51	**50**	56	50
	Night	40	**45**	**45**	45
NCA11/ NL04	Day	58	**60**	63	60
	Evening	52	**50**	57	50
	Night	42	**45**	47	45

The *Industrial Noise Policy* (EPA, 2000) requires the application of modifying factors where fixed facility noise sources include 'annoying characteristics' such as tonal, impulsive or low frequency noise. The project's operational infrastructure, including motorway operations complexes, ventilation facilities, emergency smoke extraction facilities, substations, jet fans and axial fans do not exhibit 'annoying characteristics' and therefore no modification of applicable project specific noise criteria has been applied. This is due to the motorway operations complexes being located in close proximity to major roads. The relatively high levels of road traffic noise effectively mask any tonal or low frequency characteristics.

Operational noise sleep disturbance criteria

The potential for sleep disturbance as a result of operational noise from fixed facilities that operate at night is assessed based on two criteria:

- A sleep disturbance screening criterion to identify situations where there is potential for sleep disturbance
- A sleep disturbance awakening reaction criterion, below which an awakening reaction is unlikely to occur.

The sleep disturbance screening criterion is the noise level (measured as $L_{A1(one\text{-}minute)}$ at the bedroom window during the night time period) that is 15 dB(A) above the background noise level (rating background level).

Where night time noise is anticipated to exceed this screening criterion, the EPA recommends a more detailed analysis to identify the magnitude of maximum noise levels above background noise levels, and the number of times the screening criterion is anticipated to be exceeded during any night.

The sleep disturbance awakening reaction criterion is the threshold at which an awakening reaction is likely to occur based on night time noise.

Research conducted to inform the preparation of the *Road Noise Policy* (DECCW, 2011) has concluded that this threshold is around 50-55 dB(A) when measured inside a bedroom. An open window provides around 10 dB(A) of noise attenuation, and therefore the sleep disturbance awakening reaction criterion when measured outside a bedroom window is 60-65 dB(A). Below this criterion, an awakening reaction is unlikely to occur.

The sleep disturbance screening criterion and the sleep disturbance awakening reaction criterion for each NCA relevant to operational fixed facilities are provided in **Table 12-14**.

Table 12-14 Operational noise sleep disturbance criteria

Noise catchment area (NCA)	Noise monitoring local (NL)	Background noise level (rating background level) (dB(A))	Sleep disturbance screening criteria ($L_{A1(1min)}$) (dB(A))	Sleep disturbance awakening reaction criteria ($L_{A1(1min)}$) (dB(A))
Kingsgrove motorway operations complex (MOC1), including the Kingsgrove ventilation facility and western portals				
NCA18	NL09	43	58	65
NCA19	NL12	43	58	65
NCA24	NL14	42	57	65
NCA25	NL24	41	56	65
NCA26	NL24	41	56	65
Bexley Road South motorway operations complex (MOC2), including the emergency smoke extraction facility				
NCA15	NL23	43	58	65
NCA16	NL07	40	55	65
NCA17	NL09	43	58	65

Noise catchment area (NCA)	Noise monitoring local (NL)	Background noise level (rating background level) (dB(A))	Sleep disturbance screening criteria ($L_{A1(1min)}$) (dB(A))	Sleep disturbance awakening reaction criteria ($L_{A1(1min)}$) (dB(A))
Arncliffe motorway operations complex (MOC3), including the Arncliffe ventilation facility and emergency smoke extraction facility				
NCA12	NL20	45	60	65
NCA13	NL21	42	57	65
NCA14	NL22	39	54	65
St Peters motorway operations complex (MOC4), including the St Peters ventilation facility and eastern portals				
NCA06	NL02	32	47	65
NCA07	NL05	44	59	65
NCA10	NL06	49	64	65
Burrows Road motorway operations complex (MOC5)				
NCA04	NL01	40	55	65
NCA05	NL01	40	55	65
NCA11	NL04	42	57	65

Operational road traffic noise criteria

The operational road noise assessment has been carried out in accordance with the *Noise Criteria Guideline* (RMS, 2015a). The guideline provides guidance on how to implement the *NSW Road Noise Policy* (DECCW, 2011) for Roads and Maritime projects.

The timeframes for assessment of road projects against the applicable road traffic noise criteria are in the year of opening and 10 years after opening.

The assessment area extends to where noise levels are dominated by other roads that are not being assessed as part of this project as defined in the *Noise Criteria Guideline* (RMS, 2015).

This is up to a maximum distance of 600 metres from the project works for urban areas. The project assessment area is shown in **Figure 12-1** and in the Technical working paper: Noise and vibration (**Appendix J)**.

Road traffic noise criteria are based on the road development type (a new road or a redeveloped road) affecting each affected residential receiver.

Further protection against large increases in road traffic noise levels is provided through the application of 'relative increase' criteria.

Receivers may be assigned new, redeveloped or relative increase criteria depending on how the project will influence road traffic noise levels at the receiver. For each façade of the receiver, the most stringent applicable criteria have been used in the assessment.

Road traffic noise assessment criteria for residential land uses are summarised in **Table 12-15** and for sensitive non-residential land uses in **Table 12-16**.

Table 12-15 Road traffic noise assessment criteria for residential land use

Road category	Type of project/land use	Assessment criteria dB(A)	
		Day (7 am – 10 pm)	Night (10 pm – 7 am)
Freeway/ arterial/sub -arterial	Existing residences affected by noise from **new** freeways/arterial/sub-arterial road corridors	55 dB(A) (external) $L_{Aeq\ (15\text{-}hour)}$	50 dB(A) (external) $L_{Aeq\ (9\text{-}hour)}$
	Existing residences affected by noise from **redevelopment** of existing freeways/arterial/sub-arterial roads Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments Existing residences affected by noise from existing freeway/arterial/sub-arterial roads where no redevelopment is taking place[1]	60 dB(A) (external) $L_{Aeq\ (15\text{-}hour)}$	55 dB(A) (external) $L_{Aeq\ (9\text{-}hour)}$
	Existing residences affected by increases in traffic noise of 12dBA or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq,\ (15\ hour)}$ 42-55 (external)	Between $L_{Aeq,\ (15\ hour)}$ 42-50 (external)

Note 1: The criteria assigned to a façade depend on the proportion of noise coming from the existing road. See Roads and Maritime Noise Criteria Guideline for further information.
Note 2: The criteria at each façade are determined from the existing traffic noise level plus 12 dB(A).

Table 12-16 Road traffic noise assessment criteria for non-residential land use

Existing non-residential land use	Assessment criteria (dB(A))	
	Day (7am – 10pm)	Night (10pm – 7am)
School classrooms	40 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$	-
Hospital wards	35 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$	35 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$
Places of worship	40 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$	40 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$
Open space (active use)	60 dB(A) $L_{Aeq\ (15\text{-}hour)}$	-
Open space (passive use)	55 dB(A) $L_{Aeq\ (15\text{-}hour)}$	-
Child care facilities	Sleeping rooms: 35 dB(A) $L_{Aeq\ (1\text{-}hour)}$ Indoor play areas: 40 dB(A) (internal) $L_{Aeq\ (1\text{-}hour)}$ Outdoor play areas: 55 dB(A) (external) $L_{Aeq\ (1\text{-}hour)}$ 55	
Aged care facilities	Residential land use noise assessment criteria applied to these facilities.	

To manage potential sleep disturbance, the *NSW Road Noise Policy* (DECCW, 2011) also requires assessment of maximum road traffic noise levels during the night time.

A maximum road traffic noise level is typically defined as a 'passby' for which the L_{Amax} noise level is equal to or greater than 15 dB(A) above the average hourly road traffic noise ($L_{A(1\text{-}hour)}$). The maximum road traffic noise assessment is used to help prioritise and rank road traffic noise mitigation measures, and is not intended to be a decisive criterion for assessment.

12.4 Assessment of potential impacts

12.4.1 Construction noise and vibration assessment

The construction noise and vibration assessment has considered impacts based on the following:

- Whether the construction activities would be conducted:
  - Within standard construction hours
  - Outside standard construction hours.
- Within each of these time periods, the location of the construction activities:
  - Within the western surface works area, and associated construction traffic routes
  - Within the Bexley Road surface works area, and associated construction traffic routes
  - Within the Arncliffe surface works area, and associated construction traffic routes
  - Within the St Peters interchange and local road upgrades surface works area, and associated construction traffic routes.

The Technical working paper: Noise and vibration (**Appendix J**) includes a detailed assessment of construction noise impacts in these areas. A summary of the assessment is provided in the following sections.

Construction activities within standard construction hours – airborne noise

Western surface works area

Construction activities that would be carried out in the western surface works area, and impact NCA 18 to NCA 30, during standard construction hours would include:

- Surface works
- Activities within construction compounds (the Kingsgrove North (C1), Kingsgrove South (C2) and Commercial Road (C3) construction compounds)
- Construction of permanent operation facilities
- Tunnelling support activities (including spoil handling).

Key construction noise mitigation measures to be employed within the surface works area include:

- A 2.5 metre noise barrier along the northern and eastern boundaries of the Kingsgrove North construction compound (C1), at the interface with adjacent residential receivers. Noise barriers are not proposed at the Kingsgrove South (C2) and Commercial Road (C3) construction compounds because adjacent and surrounding receivers are generally non-residential
- Acoustic sheds would be installed over the tunnel shaft and spoil stockpile areas within the Kingsgrove North (C1) and Commercial Road (C3) construction compounds.

Existing noise barriers along the M5 East Motorway in the vicinity of the western surface works area would be retained, or relocated immediately outside the area required for construction and operation. Noise barrier relocations would be carried out as early as feasible in the construction program to provide additional construction noise mitigation.

Further consideration of construction noise mitigation and management measures is provided in **Section 12.5.**

Potential construction noise impacts in and around the western surface works area have been assessed (with noise mitigation incorporated), including:

- The predicted maximum noise impact in each NCA
- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs, and the number of receivers identified as 'highly noise affected' (ie experience construction noise levels above 75 dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Surface construction works, including:
  - Surface works (outside construction compound sites), including earthworks, vegetation clearing and surface road works(refer to **Table 12-17**)
  - Cut and cover portal construction (western portals) (refer to **Table 12-18**)
  - M5 East Motorway widening and realignment activities (refer to **Table 12-19**)
  - Installation of toll gantries (refer to **Table 12-21**)
  - Utility installation and relocation (refer to **Table 12-23**)
- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Kingsgrove North (C1), Kingsgrove South (C2) and Commercial Road (C3) construction compounds) (refer to **Table 12-24**)

Construction of the Kingsgrove South motorway operations complex (MOC1) (refer to **Table 12-25**)

- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-26**)
  - General construction compound and carpark activities during tunnelling (refer to **Table 12-27**)
  - Tunnelling and support activities (refer to **Table 12-28** and **Table 12-29**).

Bexley Road surface works area

Construction activities that would be carried out in the Bexley Road surface works area, and impact NCA 15 to NCA 17, during standard construction hours would include:

- Surface works
- Activities within construction compounds (the Bexley Road North (C4), Bexley Road South (C5) and Bexley Road East (C6) construction compounds)
- Construction of permanent operation facilities
- Tunnelling support activities (including spoil handling).

Key construction noise mitigation measures to be employed within the surface works area include:

- A 4.5 metre noise barrier along the entire boundary of the Bexley Road North construction compound (C4)
- A 4.5 metre noise barrier along the majority of the boundary of the Bexley Road South construction compound (C5)
- A 4.5 metre noise barrier along the northern and eastern boundaries of the Bexley Road East construction compound (C6)
- Acoustic sheds would be installed over the tunnel shaft and spoil stockpile areas within the Bexley Road North (C4) and Bexley Road South (C5) construction compounds.

Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential construction noise impacts in and around the Bexley Road surface works area have been assessed (with noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NML
- The number of receivers identified as 'highly noise affected' (ie experience construction noise levels above 75 dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Surface construction works, including:
  - Installation of M5 East Motorway toll gantries (refer to **Table 12-21**)
- Construction compound activities (non-tunnelling), including:

Construction of the Bexley Road motorway operations complex (MOC2) (refer to **Table 12-25**)

- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-26**)
  - General construction compound and carpark activities during tunnelling (refer to **Table 12-27**)
  - Tunnelling and support activities (refer to **Table 12-28** and **Table 12-29**).

Arncliffe surface works area

Construction activities that would be carried out in the Arncliffe surface works area, and impact NCA 12 to NCA 14, during standard construction hours would include:

- Activities within construction compounds (the Arncliffe construction compound (C7))
- Construction of permanent operational facilities
- Tunnelling support activities (including spoil handling).

Key construction noise mitigation measures to be employed within the surface works area include:

- A three metre noise barrier along the northern, western and southern boundaries of the Arncliffe construction compound (C7)
- An acoustic shed installed over the tunnel shaft and spoil stockpile areas within the Arncliffe construction compound (C7).

Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential construction noise impacts in and around the Arncliffe surface works area have been assessed (with noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected' (ie experience construction noise levels above 75 dB(A).

Details of the predicted exceedances of are presented in the following tables including in relation to:

- Construction compound activities (non-tunnelling), including:
- Construction of the Arncliffe motorway operations complex (MOC3) (refer to **Table 12-25**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-26**)
  - General construction compound and carpark activities during tunnelling (refer to **Table 12-27**)
  - Tunnelling and support activities (refer to **Table 12-28** and **Table 12-29**).

St Peters interchange and local road upgrades surface works area

Construction activities that would be carried out in the St Peters interchange and local road upgrades surface works area, and impact NCA 1 to NCA 11, during standard construction hours would include:

- Surface works
- Activities within construction compounds (the Canal Road (C8), Campbell Road (C9), Landfill closure (C10), Burrows Road (C11), Alexandra Canal bridge (C12), Gardeners Road bridge (C13) and Sydney Park (C14) construction compounds)
- Construction of permanent operation facilities
- Tunnelling support activities (including spoil handling).

Key construction noise mitigation measures to be employed within the surface works area include:

- A 2.5 metre noise barrier along the Canal Road and Princes Highway boundaries of the Canal Road construction compound (C8)
- A 2.5 metre noise barrier along Campbell Road adjacent to the hard stand and laydown area of the Campbell Road construction compound (C9)

Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential construction noise impacts in and around the St Peters interchange and local road upgrades surface works area have been assessed (with noise mitigation incorporated), including :

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected' (ie experience construction noise levels above 75 dB(A))..

Details of the predicted exceedances of are presented in the following tables including in relation to:

- Surface construction works, including:
  - Earthworks (refer to **Table 12-22**)
  - Cut and cover portal construction (eastern portals) (refer to **Table 12-18**)
  - Construction of the St Peters interchange (refer to **Table 12-20**)
  - Construction of local road upgrades, including bridges across Alexandra Canal (refer to **Table 12-22**)
  - Utility installation and relocation (refer to **Table 12-23**)
  - Camdenville Park basin works (refer to **Table 12-22**)
- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Canal Road (C8), Campbell Road (C9), landfill closure (C10), Burrows Road (C11), Alexandra Canal bridge (C12), Gardeners Road bridge (C13) and Sydney Park (C14) construction compounds) (refer to **Table 12-24**)
  - Construction of the St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5) (refer to **Table 12-25**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-26**)
  - General construction compound and carpark activities during tunnelling (refer to **Table 12-27**)
  - Tunnelling and support activities (refer to **Table 12-28** and **Table 12-29**).

Table 12-17 Construction noise (standard construction hours) – Surface works (earthworks)

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Power generator	NCA19	36	37	15	3
	Total			**15**	**3**
Installation of environmental controls	NCA6	38	2	3	0
	NCA7	48	3	2	0
	NCA8	50	1	1	0
	NCA19	42	36	53	17
	Total			**59**	**17**
Demolition of existing structures (No rock hammering)	NCA19	37	11	5	0
	Total			5	0
Demolition of existing structures (Rock hammering only)	NCA4	84	19	16	16
	NCA6	50	13	34	0
	NCA7	53	15	15	2
	NCA8	62	8	7	0
	NCA10	54	4	5	0
	NCA19	49	31	164	5
	NCA25	58	20	124	1
	Total			**365**	**24**
Crushing and screening	NCA3	36	1	1	0
	NCA4	70	4	14	0
	NCA6	47	13	40	0
	NCA7	57	14	19	1
	NCA8	61	12	11	1
	NCA18	53	5	8	0
	NCA19	52	47	146	28
	NCA24	50	1	1	0
	NCA25	49	11	20	0
	NCA26	43	3	2	0
	Total			**262**	**30**
Vegetation clearing	NCA3	36	1	1	0
	NCA4	70	4	14	0
	NCA6	47	13	40	0
	NCA7	57	14	19	1
	NCA8	61	12	11	1
	NCA18	53	5	8	0
	NCA19	52	47	146	28
	NCA24	50	1	1	0
	NCA25	49	11	20	0
	NCA26	43	3	2	0
	Total			**262**	**30**
Establishment of construction facilities	NCA6	37	1	2	0
	NCA7	47	2	1	0
	NCA19	42	35	51	15
	Total			**54**	**15**
Road and intersection modifications and installation of traffic controls	NCA7	37	1	1	0
	NCA19	42	37	46	16
	Total			**47**	**16**

Table 12-18 Construction noise (standard construction hours) – Surface works (construction of portals (cut and cover tunnel)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Piling; excavation of decline	NCA6	4	7	0
	NCA7	6	2	0
	NCA19	17	83	0
	Total		**92**	**0**
Earthworks	NCA6	10	26	0
	NCA7	14	11	1
	NCA19	51	196	29
	NCA24	10	28	0
	NCA25	9	17	0
	Total		**278**	**30**
Road tie-in works	NCA6	11	27	0
	NCA7	15	12	2
	NCA19	52	213	30
	NCA24	11	32	0
	NCA25	10	24	0
	Total		**308**	**32**

Table 12-19 Construction noise (standard construction hours) – Surface works (M5 East Motorway road widening and realignment)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Earthworks (No rock hammering)	NCA18	26	18	3
	NCA19	24	238	2
	NCA20	34	91	16
	NCA21	25	125	5
	NCA22	22	143	7
	NCA23	24	256	35
	NCA24	30	98	14
	NCA25	10	65	0
	NCA26	4	2	0
	NCA27	6	3	1
	NCA30	14	36	2
	Total		**1075**	**83**
Earthworks (Rock hammering only)	NCA18	31	34	4
	NCA19	29	350	21
	NCA20	39	170	35
	NCA21	30	167	18
	NCA22	27	160	36
	NCA23	29	438	61
	NCA24	35	155	35
	NCA25	15	171	0
	NCA27	11	15	3
	NCA30	19	80	8
	Total		**1740**	**221**
Road tie-in works	NCA18	23	15	2
	NCA19	21	157	2
	NCA20	31	62	13
	NCA21	22	106	2
	NCA22	19	93	4
	NCA23	21	190	13
	NCA24	27	79	5
	NCA25	7	21	0
	NCA26	1	1	0
	NCA27	3	2	0
	NCA30	11	20	0
	Total		**746**	**41**

Table 12-20 Construction noise (standard construction hours) – Surface works (construction of St Peters Interchange)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Piling; ground improvement	NCA6	7	9	0
	NCA7	8	4	0
	NCA8	6	7	0
	Total		**20**	**0**
Earthworks (No rock hammering)	NCA4	2	13	0
	NCA6	11	24	0
	NCA7	12	12	0
	NCA8	10	8	0
	Total		**57**	**0**
Earthworks (Rock hammering only)	NCA3	7	2	0
	NCA4	13	16	15
	NCA6	22	145	9
	NCA7	23	36	6
	NCA8	21	18	8
	NCA10	5	5	0
	Total		**222**	**38**
Road tie-in works	NCA3	5	1	0
	NCA4	8	15	0
	NCA6	17	62	3
	NCA7	18	26	2
	NCA8	16	11	6
	Total		**115**	**11**

Table 12-21 Construction noise (standard construction hours) – Surface works (Construction of toll infrastructure)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Site establishment	-	0	0	0
	Total		**0**	**0**
Road works	NCA15	4	12	0
	NCA16	6	3	0
	NCA17	9	31	0
	NCA18	13	42	0
	NCA26	15	101	0
	Total		**189**	**0**
Construction of toll gantries	NCA26	2	3	0
	Total		**3**	**0**

Table 12-22 Construction noise (standard construction hours) – Surface works (Local road works including construction of the Alexandra Canal Bridge and Camdenville Park basin)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Demolition of existing structures (No rock hammering)	NCA3	25	29	5
	NCA4	7	14	0
	NCA6	30	70	20
	NCA7	28	12	3
	NCA8	26	12	7
	Total		**137**	**35**
Demolition of existing structures (Rock hammering only)	NCA2	11	92	0
	NCA3	45	89	38
	NCA4	27	16	16
	NCA6	50	248	100
	NCA7	48	54	27
	NCA8	46	24	21
	NCA10	4	6	0
	NCA11	2	1	0
	Total		**530**	**202**
Earthworks (No rock hammering)	NCA1	33	23	7
	NCA2	18	33	1
	NCA3	40	85	14
	NCA4	33	16	16
	NCA6	40	161	86
	NCA7	38	38	18
	NCA8	36	21	12
	NCA11	29	12	8
	Total		**389**	**162**
Earthworks (Rock hammering only)	NCA1	43	109	29
	NCA2	28	208	12
	NCA3	50	168	55
	NCA4	43	16	16
	NCA6	50	244	138
	NCA7	48	49	35
	NCA8	46	24	21
	NCA11	39	19	15
	Total		**837**	**321**
Road tie-in works	NCA1	38	13	7
	NCA2	15	28	0
	NCA3	45	65	12
	NCA4	34	16	16
	NCA6	46	143	74
	NCA7	42	28	15
	NCA8	42	18	12
	NCA11	27	9	5
	Total		**326**	**141**

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Kerbing and drainage	NCA1	43	45	13
	NCA2	23	79	2
	NCA3	50	104	39
	NCA4	43	16	16
	NCA6	50	216	107
	NCA7	48	49	25
	NCA8	46	24	15
	NCA11	36	17	9
	Total		**550**	**226**
Pedestrian bridges at Campbell Rd	NCA3	3	1	0
	NCA4	21	15	7
	NCA6	8	8	0
	NCA7	14	19	1
	NCA8	46	23	12
	Total		**66**	**20**
Alexandra Canal bridge and Gardeners Rd bridge	-	0	0	0
	Total		**0**	**0**
Basin works	NCA2	20	97	9
	NCA3	35	63	6
	NCA6	22	120	4
	Total		**280**	**19**

Table 12-23 Construction noise (standard construction hours) – Surface works (General utility installation and relocation)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Service installation and relocation	NCA3	2	1	0
	NCA4	24	16	11
	NCA6	17	61	2
	NCA7	18	24	2
	NCA8	23	13	8
	NCA18	8	25	0
	NCA19	55	208	26
	NCA24	10	32	0
	NCA25	15	45	0
	NCA26	6	3	0
	Total		**428**	**49**

Table 12-24 Construction noise (standard construction hours) – Surface works (construction compound and car park generation operations (C1-C11))

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
General worksite and car parking	NCA19	28	7	1
	Total		**7**	**1**
Workshop; Deliveries; Maintenance Storage	NCA6	2	2	0
	NCA7	3	2	0
	NCA19	42	26	7
	Total		**30**	**0**

Table 12-25 Construction noise (standard construction hours) – Surface works (construction of motorway operations complexes)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
General worksite and car parking	-		0	0
	Total		**0**	**0**
Workshop and deliveries	NCA26	9	7	0
	Total		**7**	**0**
Construction of motorway operations complex structures	NCA6	15	76	0
	NCA7	19	19	2
	NCA8	3	1	0
	NCA10	4	6	0
	NCA12	18	79	20
	NCA13	7	42	0
	NCA14	5	29	0
	NCA15	14	63	0
	NCA19	20	273	0
	NCA24	15	71	0
	NCA25	14	111	0
	NCA26	29	233	11
	Total		**1003**	**33**

Table 12-26 Construction noise (standard construction hours) – Surface works (Tunnelling works – Site establishment)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Power generator	NCA19	27	7	1
	Total		**7**	**1**
Installation of environmental controls	NCA15	22	12	2
	NCA16	7	3	0
	NCA19	35	51	15
	NCA26	9	7	0
	Total		**73**	**17**
Demolition of existing structures (No rock hammering)	NCA19	40	41	9
	Total		**41**	**9**
Demolition of existing structures (Rock hammering)	NCA6	14	82	0
	NCA7	17	18	2
	NCA8	4	2	0
	NCA10	4	5	0
	NCA12	18	85	22
	NCA13	8	46	0
	NCA14	6	31	0
	NCA19	60	322	41
	NCA24	16	97	1
	NCA25	20	159	1
	Total		**847**	**67**
Vegetation clearing	NCA12	13	52	7
	NCA13	2	3	0
	NCA15	21	40	2
	NCA16	11	10	0
	NCA17	5	3	0
	NCA19	34	42	11
	NCA25	5	2	0
	NCA26	14	54	0
	Total		**206**	**20**
Establishment of construction facilities	NCA15	22	12	2
	NCA16	7	3	0
	NCA19	35	51	15
	NCA26	9	7	0
	Total		**73**	**17**
Road and intersection modifications and installation of traffic controls	NCA7	1	1	0
	NCA15	23	16	2
	NCA16	7	3	0
	NCA19	37	46	16
	NCA26	10	8	0
	Total		**74**	**18**

Table 12-27 Construction noise (standard construction hours) – Tunnelling support establishment

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Piling; excavation of decline	NCA6	1	2	0
	NCA7	3	2	0
	NCA15	16	35	6
	NCA16	16	18	1
	NCA17	2	5	0
	NCA19	15	15	0
	NCA25	3	2	0
	NCA26	13	41	0
	Total		**120**	**7**
Decline excavation and construction (No rock hammering)	NCA6	9	7	0
	NCA7	11	4	0
	NCA12	2	3	0
	NCA15	24	97	18
	NCA16	23	33	6
	NCA17	10	41	0
	NCA18	7	3	0
	NCA19	23	52	1
	NCA25	10	29	0
	NCA26	21	129	1
	Total		**398**	**26**
Decline excavation and construction (Rock hammering only)	NCA6	14	30	0
	NCA7	16	6	1
	NCA12	7	20	0
	NCA15	29	186	31
	NCA16	28	44	18
	NCA17	15	138	0
	NCA18	12	44	0
	NCA19	28	150	5
	NCA24	5	13	0
	NCA25	15	99	0
	NCA26	26	250	8
	Total		**980**	**63**

Table 12-28 Construction noise (standard construction hours) – Tunnelling works (Construction compound and car park general operations)

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
General worksite and car parking	NCA15	7	2	0
	NCA19	28	7	1
	Total		**9**	**1**
Maintenance storage; Workshop deliveries	NCA6	3	4	0
	NCA7	4	2	0
	NCA15	23	7	2
	NCA19	43	30	7
	Total		**43**	**9**

Table 12-29 Construction noise (standard construction hours) – Tunnelling works - Tunnelling support site

Activity	NCA	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers
Tunnelling and support	NCA15	7	11	0
	NCA16	7	2	0
	NCA19	6	4	0
	NCA26	4	1	0
	Total		**18**	**0**
Spoil handling	NCA6	1	2	0
	NCA7	3	2	0
	NCA8	6	7	0
	NCA19	21	25	1
	Total		**36**	**1**
Tunnel lining	NCA15	12	18	0
	NCA16	11	3	0
	NCA19	10	5	0
	NCA26	8	7	0
	Total		**33**	**0**

Construction activities outside of standard construction hours – airborne noise

Some construction activities would need to be undertaken outside of standard construction hours.

This would include tunnelling works which would be undertaken on a 24 hour basis. Other work may be required out of standard construction hours for health and safety reasons, to prevent traffic congestion on major roads during peak periods, or for particular construction requirements.

Out of hours works may be needed for:

- Tunnelling and tunnel support activities
- Road tie-in works including road and ramp construction
- Bridge lifting activities (where over existing roads)
- Traffic management, set-up and traffic switches
- Utility relocations (where the relocation is in proximity to traffic)
- Erection of traffic signs (where erection is in proximity to traffic)
- Pavement and temporary median works
- Use of construction compounds to support out of hours works.

Specific construction activities to be conducted outside standard construction hours are identified in **Chapter 6** (Construction work) and summarised in **Table 6-26** in **Chapter 6** (Construction works)**.** It is also noted that no activities would occur outside standard construction hours during site establishment. However, generators would operate in order to run security lighting for the sites.

The 'highly affected' criteria (**Table 12-3**) used for construction noise management levels for residential receivers apply to standard hours only. However, it has been considered in the out of hours assessment to provide additional impact information.

Other works which would be undertaken outside of standard daytime construction hours without any further approval would include any of the following circumstances:

- Works which are determined to comply with the relevant noise management level at the nearest sensitive receiver
- The delivery of materials as required by the Police or other authorities for safety reasons
- Where it is required to avoid the loss of lives, property and/or to prevent environmental harm in an emergency
- Where agreement is reached with affected receivers.

Out of hours work may also be undertaken where explicitly approved through an environment protection licence.

Western surface works area

Construction activities that would be carried out in the western surface works area, and impact NCA18 to NCA30, outside standard construction hours would include:

- Surface construction activities, including road works affecting the existing M5 East Motorway and construction of the western portals where it would be safer and less disruptive to traffic to undertake works outside standard construction hours. These works would be conducted during the evening period, where practical
- Minor surface construction activities, including installation/ relocation of utilities and installation of toll gantries where it would be safer and less disruptive to traffic to conduct these works outside standard construction hours. Because of the relatively low noise intensity of these works, they may be conducted during the evening or night time periods
- Minor support activities within construction compounds, such as car parking or low noise construction and fit out activities, where those activities do not exceed applicable NMLs
- Tunnelling and tunnelling support activities, which are required to be conducted continuously.

Noise mitigation measures to be employed within the surface works area would be the same as for activities conducted during standard construction hours. Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential night and evening construction noise impacts in and around the western surface works area have been assessed (assuming noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected'
- The number of receivers identified as being impacted by the sleep disturbance awakening criterion (greater than 65dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Surface construction works, including:
  - Site establishment (refer to **Table 12-30**)
  - Cut and cover portal construction (western portals) (refer to **Table 12-31**)
  - M5 East Motorway widening and realignment activities (refer to **Table 12-32**)
  - Utility installation and relocation (refer to **Table 12-35**)
  - Installation of toll gantries (refer to **Table 12-36**)
- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Kingsgrove North (C1), Kingsgrove South (C2) and Commercial Road (C3) construction compounds) (refer to **Table 12-37**)
  - Construction of the Kingsgrove South motorway operations complex (MOC1) (refer to **Table 12-38**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-39**)
  - Tunnelling and support activities (refer to **Table 12-40**).

Bexley Road surface works area

Construction activities that would be carried out in the Bexley Road surface works area, and impact NCA15 to NCA17, outside standard construction hours would include:

- Minor surface construction activities, including installation of M5 East Motorway toll gantries where it would be safer and less disruptive to traffic to conduct these works outside standard construction hours. Because of the relatively low noise intensity of these works, they may be conducted during the evening or night time periods
- Minor support activities within construction compounds, such as car parking or low noise construction and fit out activities, where those activities do not exceed applicable NMLs
- Tunnelling and tunnelling support activities, which are required to be conducted continuously.

Noise mitigation measures to be employed within the surface works area would be the same as for activities conducted during standard construction hours. Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential evening and night construction noise impacts in and around the western surface works area have been assessed (with noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected'

- The number of receivers identified as being impacted by the sleep disturbance awakening criterion (greater than 65dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Surface construction works, including:
  - Installation of M5 East Motorway toll gantries (refer to **Table 12-36**)
- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Bexley Road North (C4), Bexley Road South (C5) and Bexley Road East (C6) construction compounds) (refer to **Table 12-37**)
  - Construction of the Bexley Road motorway operations complex (MOC2) (refer to **Table 12-38**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-39**)
  - Tunnelling and support activities (refer to **Table 12-40**).

Arncliffe surface works area

Construction activities that would be carried out in the Arncliffe surface works area, and impact NCA12 to NCA14, outside standard construction hours would include:

- Minor support activities within construction compounds, such as car parking or low noise construction and fit out activities, where those activities do not exceed applicable NMLs
- Tunnelling and tunnelling support activities, which are required to be conducted continuously

Noise mitigation measures to be employed within the surface works area would be the same as for activities conducted during standard construction hours. Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential evening and night construction noise impacts in and around the western surface works area have been assessed (with noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected'
- The number of receivers identified as being impacted by the sleep disturbance awakening criterion (greater than 65dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Arncliffe construction compound (C7)) (refer to **Table 12-37**)
  - Construction of the Arncliffe motorway operations complex (MOC3) (refer to **Table 12-38**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-39**)
  - Tunnelling and support activities (refer to **Table 12-40**).

St Peters interchange and local road upgrades surface works area

Construction activities that would be carried out in the St Peters interchange and local road upgrades works area and impact NCA1 to NCA11, outside standard construction hours would include:

- Surface construction activities, including construction of the St Peters interchange and eastern portals where it would be safer and less disruptive to traffic to conduct these works outside

standard construction hours. These works would be conducted during the evening period, but not during the night time period

- Surface construction activities, including local road upgrade works and bridge construction where it would be safer and less disruptive to traffic to conduct these works outside standard construction hours. Because of the extent of these works, potential disruption to the local road network and potential amenity impacts, it is desirable to ensure timely completion of the works. These construction works would therefore be conducted during the evening or night time periods
- Minor surface construction activities, including installation / relocation of utilities where it would be safer and less disruptive to traffic to conduct these works outside standard construction hours. Because of the relatively low noise intensity of these works, they may be conducted during the evening and / or night time periods
- Minor support activities within construction compounds, such as car parking or low noise construction and fit out activities, where those activities do not exceed applicable NMLs
- Tunnelling and tunnelling support activities, which are required to be conducted continuously.

Noise mitigation measures to be employed within the surface works area would be the same as for activities conducted during standard construction hours. Further consideration of construction noise mitigation and management measures is provided in **Section 12.5**.

Potential evening and night construction noise impacts in and around the western surface works area have been assessed (with noise mitigation incorporated), including:

- The highest predicted exceedance of each applicable NML
- The number of receivers anticipated to experience noise levels above NMLs
- The number of receivers identified as 'highly noise affected'
- The number of receivers identified as being impacted by the sleep disturbance awakening criterion (greater than 65dB(A)).

Details of the predicted exceedances are presented in the following tables including in relation to:

- Surface construction works, including:
  - Site establishment (refer to **Table 12-30**)
  - Cut and cover portal construction (eastern portals) (refer to **Table 12-31**)
  - Construction of the St Peters interchange (refer to **Table 12-33**)
  - Construction of local road upgrades, including bridges across Alexandra Canal (refer to **Table 12-34**)
  - Utility installation and relocation (refer to **Table 12-35**)
- Construction compound activities (non-tunnelling), including:
  - General non-tunnelling construction activities (Canal Road (C8), Campbell Road (C9), landfill closure (C10), Burrows Road (C11), Alexandra Canal bridge (C12), Gardeners Road bridge (C13) and Sydney Park (C14) construction compounds) (refer to **Table 12-37**)
  - Construction of the St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5) (refer to **Table 12-38**)
- Tunnelling and tunnelling support activities, including:
  - Site establishment (refer to **Table 12-39**).
  - Tunnelling and support activities (refer to **Table 12-40**).

(blank page)

Table 12-30 Construction noise (out of hours works) – Site establishment

Activity	NCA	Predicted median $_{LAeq}$ noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median $_{LAeq}$ noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Power generation	NCA4	48	0	0	0	48	5	15	0	0
	NCA6	35	5	6	0	35	12	21	0	0
	NCA7	38	3	2	0	38	9	3	0	1
	NCA8	41	5	7	0	41	10	10	0	0
	NCA19	36	42	20	3	36	44	24	3	9
	NCA25	33	0	0	0	33	3	1	0	0
	Total			**35**	**3**			**74**	**3**	**10**

Table 12-31 Construction noise (out of hours works) – Construction of portals (cut and cover tunnel)

Activity	NCA	Predicted median LAeq noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median LAeq noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Piling; excavation of decline	NCA6	28	2	4	0	N/A	N/A	N/A	N/A	N/A
	NCA7	28	2	1	0	N/A	N/A	N/A	N/A	N/A
	NCA19	39	11	29	0	N/A	N/A	N/A	N/A	N/A
	Total			**34**	**0**			**N/A**	**N/A**	**N/A**
Earthworks	NCA6	34	7	10	0	N/A	N/A	N/A	N/A	N/A
	NCA7	37	9	2	0	N/A	N/A	N/A	N/A	N/A
	NCA19	43	11	29	0	N/A	N/A	N/A	N/A	N/A
	NCA24	42	3	4	0			**N/A**	**N/A**	**N/A**
	NCA25	41	2	1	0	N/A	N/A	N/A	N/A	N/A
	Total			**103**	**17**			**N/A**	**N/A**	**N/A**
Road tie-in works	NCA19	28	29	28	2	N/A	N/A	N/A	N/A	N/A
	Total			**28**	**2**			**N/A**	**N/A**	**N/A**

Table 12-32 Construction noise (out of hours works) – M5 East Motorway road widening and realignment

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Earthworks (No rock hammering)	NCA18	31	19	10	0	N/A	N/A	N/A	N/A	N/A
	NCA19	45	17	89	0	N/A	N/A	N/A	N/A	N/A
	NCA20	43	28	49	3	N/A	N/A	N/A	N/A	N/A
	NCA21	41	19	80	0	N/A	N/A	N/A	N/A	N/A
	NCA22	48	16	64	0	N/A	N/A	N/A	N/A	N/A
	NCA23	46	17	109	0	N/A	N/A	N/A	N/A	N/A
	NCA24	47	23	60	4	N/A	N/A	N/A	N/A	N/A
	NCA25	44	3	3	0	N/A	N/A	N/A	N/A	N/A
	NCA27	45	1	1	0	N/A	N/A	N/A	N/A	N/A
	NCA30	44	8	10	0	N/A	N/A	N/A	N/A	N/A
	Total			**475**	**7**			**N/A**	**N/A**	**N/A**
Road tie-in works	NCA18	15	3	1		N/A	N/A	N/A	N/A	N/A
	NCA19	29	1	2	0	N/A	N/A	N/A	N/A	N/A
	NCA20	27	12	5	0	N/A	N/A	N/A	N/A	N/A
	NCA21	25	3	1	0	N/A	N/A	N/A	N/A	N/A
	NCA23	30	1	2	0	N/A	N/A	N/A	N/A	N/A
	NCA24	31	7	4	0	N/A	N/A	N/A	N/A	N/A
	Total			**15**	**0**			**N/A**	**N/A**	**N/A**

Table 12-33 Construction noise (out of hours works) – Construction of St Peters Interchange

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Earthworks	NCA3	29	1	1	0	N/A	N/A	N/A	N/A	N/A
	NCA4	64	9	15	0	N/A	N/A	N/A	N/A	N/A
	NCA6	41	16	56	0	N/A	N/A	N/A	N/A	N/A
	NCA7	50	15	16	0	N/A	N/A	N/A	N/A	N/A
	NCA8	54	20	18	0	N/A	N/A	N/A	N/A	N/A
	Total			**106**	**0**			**N/A**	**N/A**	**N/A**
Road tie-in works	NCA4	22	2	13	0	N/A	N/A	N/A	N/A	N/A
	NCA6	57	9	15	0	N/A	N/A	N/A	N/A	N/A
	NCA7	34	8	4	0	N/A	N/A	N/A	N/A	N/A
	NCA8	43	13	11	0	N/A	N/A	N/A	N/A	N/A
	Total			**43**	**0**			**N/A**	**N/A**	**N/A**

Table 12-34 Construction noise (out of hours works) – Local road works including construction of the Alexandra Canal Bridge

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Road tie-in works	NCA1	55	48	77	6	55	59	163	6	67
	NCA2	48	23	82	0	48	30	265	0	30
	NCA3	56	53	107	12	56	60	170	12	75
	NCA4	> 90	44	16	16	> 90	55	17	16	16
	NCA6	47	54	218	65	47	61	259	65	156
	NCA7	65	48	45	13	65	54	49	13	39
	NCA8	74	55	24	12	74	60	24	12	23
	NCA11	61	37	19	5	61	47	27	5	19
	Total			**588**	**129**			**974**	**129**	**425**
Kerbing and drainage	NCA1	63	54	153	13	63	65	180	13	151
	NCA2	57	32	303	2	57	39	335	2	154
	NCA3	65	59	174	39	65	66	174	39	157
	NCA4	> 90	54	16	16	> 90	65	26	16	16
	NCA6	53	59	273	107	53	66	425	107	229
	NCA7	73	55	50	25	73	61	55	25	49
	NCA8	82	60	24	15	82	65	24	15	24
	NCA9	47	0	0	0	47	5	13	0	0
	NCA11	70	47	24	9	70	57	30	9	24
	Total			**1017**	**226**			**1262**	**226**	**804**
Pedestrian bridges to Campbell Rd	NCA3	37	9	1	0	27	5	1	0	0
	NCA4	68	29	16	5	58	26	16	0	13
	NCA6	42	14	24	0	32	11	11	0	0
	NCA7	52	18	22	0	42	14	19	0	6
	NCA8	72	57	24	12	62	52	24	7	15
	Total			**87**	**17**			**71**	**7**	**34**

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Alexandra Canal Bridge	NCA4	49	0	0	0	56	12	16	0	0
	NCA8	41	0	0	0	48	7	11	0	0
	NCA11	35	0	0	0	42	5	5	0	0
	Total			**0**	**0**			**32**	**0**	**0**

Table 12-35 Construction noise (out of hours works) – General utility installation and relocation

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Service installation and relocation	NCA3	33	5	1	0	21	0	0	0	0
	NCA4	68	29	16	4	56	28	16	0	11
	NCA6	45	20	106	0	33	15	50	0	2
	NCA7	54	19	28	0	42	13	12	0	2
	NCA8	64	31	20	2	52	24	14	0	8
	NCA10	47	1	1	0	35	0	0	0	0
	NCA18	50	7	10	0	38	0	0	0	0
	NCA19	50	54	190	19	38	44	57	7	26
	NCA24	49	9	26	0	37	5	8	0	0
	NCA25	48	14	33	0	36	8	6	0	0
	NCA26	40	5	3	0	28	0	0	0	0
	Total			**434**	**25**			**63**	**7**	49

Table 12-36 Construction noise (out of hours works) – Construction of tolling infrastructure

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Site establishment	NCA15	34	0	0	0	34	1	5	0	0
	NCA16	35	0	0	0	35	9	9	0	0
	NCA17	36	0	0	0	36	4	4	0	0
	NCA18	36	2	3	0	36	7	10	0	0
	NCA25	34	0	0	0	34	0	0	0	0
	NCA26	38	4	12	0	38	10	26	0	0
	Total			**15**	**0**			**54**	**0**	**0**
Road works	NCA15	47	9	57	0	46	16	140	0	49
	NCA16	46	11	11	0	45	24	47	0	17
	NCA17	47	14	74	0	46	18	156	0	36
	NCA18	47	18	60	0	46	22	113	0	43
	NCA26	50	20	260	0	49	25	394	0	101
	Total			**462**	**0**			**850**	**0**	**246**
Construction of toll gantries	NCA15	34	0	0	0	34	4	12	0	0
	NCA16	32	0	0	0	32	12	16	0	0
	NCA17	34	1	1	0	34	6	17	0	0
	NCA18	34	5	3	0	34	10	23	0	1
	NCA26	37	7	13	0	37	13	65	0	3
	Total			**17**	**0**			**133**	**0**	**4**

Table 12-37 Construction noise (out of hours works) – Construction compound and car park generation operations (C1-C11)

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
General worksite and car parking	NCA6	35	0	0	0	35	3	3	0	0
	NCA8	38	0	0	0	38	1	1	0	0
	NCA19	33	33	9	1	33	35	9	1	7
	Total			**9**	**1**			**17**	**1**	**7**
Workshop; Deliveries; Maintenance Storage	NCA6	35	9	14	0	25	6	7	0	0
	NCA7	43	8	2	0	33	4	2	0	0
	NCA8	45	10	8	0	35	5	6	0	0
	NCA19	38	45	37	7	28	37	20	2	9
	Total			**61**	**7**			**35**	**2**	**9**

Table 12-38 Construction noise (out of hours works) – Construction of motorway operations complexes

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
General worksite and car parking	NCA26	35	0	0	0	35	2	3	0	0
	Total			0	**0**			**0**	**0**	**0**

Table 12-39 Construction noise (out of hours works) – Tunnelling site establishment

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
General worksite and car parking	NCA6	35	0	0	0	35	3	3	0	0
	NCA8	38	0	0	0	38	1	1	0	0
	NCA15	35	12	3	0	35	20	4	0	3
	NCA19	33	33	9	1	33	35	9	1	7
	Total			**12**	**1**			**17**	**1**	**10**
Maintenance storage; Workshop deliveries	NCA4	54	0	0	0	45	1	8	0	0
	NCA6	35	10	15	0	26	8	10	0	0
	NCA7	44	9	3	0	35	6	2	0	0
	NCA8	46	11	10	0	37	7	7	0	0
	NCA15	36	26	8	2	27	25	8	0	4
	NCA19	39	46	42	7	30	39	22	2	9
	NCA25	37	1	1	0	28	0	0	0	0
	NCA26	38	2	1	0	29	0	0	0	0
	Total			**80**	**9**			**57**	**2**	**13**
Piling; excavation of decline (No rock hammering)	NCA6	29	2	4	0	29	9	11	0	0
	NCA7	28	2	1	0	28	8	3	0	0
	NCA12	40	0	0	0	40	2	3	0	0
	NCA15	41	13	27	0	41	21	70	0	23
	NCA16	42	13	10	0	42	27	41	0	17
	NCA17	37	0	0	0	37	4	7	0	0
	NCA18	37	0	0	0	37	1	1	0	0
	NCA19	36	12	7	0	36	14	11	0	1
	NCA25	38	0	0	0	36	6	4	0	0
	NCA26	37	10	21	0	37	16	51	0	3
	Total			**70**	**0**			**202**	**0**	**44**

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Decline excavation and construction (No rock breaking)	NCA6	31	6	7	0	31	13	28	0	0
	NCA7	30	6	2	0	30	12	6	0	2
	NCA12	44	0	0	0	44	5	11	0	0
	NCA15	44	17	35	0	44	25	108	0	34
	NCA16	46	16	18	0	46	30	48	0	20
	NCA17	40	3	6	0	40	8	19	0	0
	NCA18	40	0	0	0	40	5	3	0	0
	NCA19	40	16	16	0	40	18	20	0	5
	NCA24	41	0	0	0	41	1	1	0	0
	NCA25	40	3	2	0	40	9	19	0	0
	NCA26	40	14	42	0	40	20	109	0	12
	Total			**128**	**0**			**372**	**0**	**73**

Table 12-40 Construction noise (out of hours works) – Tunnelling support site

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
Tunnelling and support	NCA6	34	1	2	0	34	8	7	0	0
	NCA7	39	1	1	0	39	7	2	0	0
	NCA12	39	0	0	0	39	1	2	0	0
	NCA15	40	12	23	0	40	20	59	0	21
	NCA16	42	12	6	0	42	26	38	0	15
	NCA17	37	0	0	0	37	3	6	0	0
	NCA19	36	11	7	0	36	13	9	0	1
	NCA25	36	0	0	0	36	5	3	0	0
	NCA26	37	9	13	0	37	15	50	0	1
	Total			**52**	**0**			**176**	**0**	**38**
Spoil handling	NCA3	34	3	1	0	34	10	3	0	0
	NCA4	66	11	16	0	66	22	16	0	15
	NCA6	38	10	24	0	38	17	73	0	8
	NCA7	48	10	13	0	48	16	22	0	5
	NCA8	56	20	18	0	56	25	24	0	11
	NCA15	35	0	0	0	35	4	8	0	0
	NCA16	38	0	0	0	38	10	3	0	0
	Total			**72**	**0**			**149**	**0**	**57**
Tunnel lining	NCA6	31	2	2	0	31	9	7	0	0
	NCA7	37	1	1	0	37	7	2	0	0
	NCA12	41	0	0	0	41	2	3	0	0
	NCA15	40	14	25	0	40	22	62	0	24
	NCA16	43	13	4	0	43	27	39	0	12
	NCA17	37	0	0	0	37	5	6	0	0
	NCA18	36	0	0	0	36	2	1	0	0

Activity	NCA	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Predicted median L_{Aeq} noise level dB(A)	Predicted highest exceedance of the NML, dB(A)	Number of receivers where NMLs are exceeded	Number of highly noise affected receivers	Number of receivers with sleep disturbance (>65dB(A))
		Evening (6pm – 10 pm)				Night (10pm – 7am)				
	NCA19	37	12	7	0	37	14	11	0	1
	NCA25	36	0	0	0	36	5	2	0	0
	NCA26	37	10	17	0	37	16	48	0	3
	Total			**56**	**0**			**181**	**0**	**40**

Construction activities outside standard construction hours – ground-borne noise

Ground-borne noise can be generated during tunnelling activities, when vibration from tunnel construction travels through the ground as vibration and 'breaks out' into buildings on the surface in the form of audible noise.

Ground-borne noise is more likely to be experienced where surface receivers are close to the vibration source (for example, around shallow tunnelling activities).

Other factors that affect whether ground-borne noise will be generated include:

- The tunnel construction technique
- Geological ground conditions, which affect the speed of wave propagation and the damping provided by the ground
- The timing and duration of construction activities
- The nature of the building affected.

The Technical working paper: Noise and vibration (**Appendix J**) presents a conservative assessment of potential ground-borne noise impacts. The assessment has drawn on measurements taken during previous tunnelling projects using road headers in the Sydney region.

The ground-borne noise assessment is relevant to the evening and nigh time periods only, because background noise and noise contributions from other project construction activities would exceed and therefore 'mask' ground-borne noise during the day.

The ground-borne noise assessment has identified the number of receivers that may be affected by ground-borne noise above the applicable ground-borne noise goals, and the maximum exceedance of those goals. A summary of the assessment outcomes is presented in **Table 12-41**.

Table 12-41 Ground-borne noise assessment outcomes

Period	Goal (L_{Aeq}, dB(A))	Number of receivers exceeding ground-borne noise goal	Maximum exceedance of ground-borne noise goal
Evening	40 dB(A)	60	5 dB(A)
Night	35 dB(A)	369	10 dB(A)

The Technical working paper: Noise and vibration (**Appendix J**) includes figures showing the predicted extent of ground-borne noise and areas of potential exceedance of ground-borne noise goals. These areas are focused around:

- The western portals, with more pronounced impacts around the westbound exit portal
- The main alignment tunnels from the western portals to around Stotts Reverse, Bexley North, and around tunnel cross passages in this part of the project
- A small area largely beneath the Bardwell Valley Golf Course
- A small area under the Cooks River and Tempe Recreation Reserve
- The main alignment tunnels between the Botany Goods Railway line and the eastern portals
- The eastern portals, particularly around Canal Road and a small area of industrial land to the south of Canal Road.

It is anticipated that tunnelling would progress at an average rate of around seven metres per day, subject to local geology. On this basis, it is likely that any individual receiver would experience ground-borne noise for no more than around five days, with exceedances of ground-borne noise goals likely for no more than around two days (as tunnelling activities pass beneath the affected receiver). Tunnelling advance rates would reduce to two to five metres a day around the portals, which may increase the duration of exposure for receivers in these areas. As tunnelling moves towards and away from each receiver the noise levels experienced would be lower.

Construction road traffic noise

Construction road traffic noise would be generated by vehicles associated with the construction of the project, including heavy vehicles transporting spoil and light vehicle movements generated by construction workers.

For the purposes of the construction traffic impact assessment, the period of construction activity that generates the peak volume of heavy vehicles was assessed to represent the worst case scenario. This peak construction period assumes that 80 per cent of heavy vehicle volumes would be associated with spoil related activities and remaining 20 per cent would comprise of delivery vehicles associated with other activities associated with construction activities.

Construction vehicles movements would be generated by all compounds, however, the Kingsgrove South construction compound vehicles would access/depart via the Kingsgrove North construction compound. Tunnel support compounds, which would generate the majority of spoil vehicles, are located at Kingsgrove North (C1), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5), Arncliffe (C7) and Canal Road (C8) construction compounds.

The nominated construction vehicles routes to / from compounds are identified in **Chapter 6** (Construction Work) traffic flows would occur on major roads and compounds have been selected to minimise the use of local roads. However, construction vehicles may use local roads that do not form part of the construction compound vehicle routes to access construction areas (such as along local roads that are subject to construction activities). However, these would not constitute major haulage routes.

Further details of the assumptions for the construction road traffic assessment are outlined in the Technical working paper: Noise and vibration (**Appendix J**).

Construction traffic noise has been assessed during:

- The AM peak period, 6:30am to 9:30am (refer to **Table 12-42**)
- The PM peak period, 3:30pm to 7:00pm (refer to **Table 12-43**)
- An AM off-peak hour, being the lowest non-peak traffic hour between 9:30am and 3:30pm (refer to **Table 12-44**)
- A PM off-peak hour, being the lowest non-peak traffic hour between 7:00pm and 6:30am (refer to **Table 12-45**).

The following tables summarise:

- The existing forecasted traffic flow
- The expected construction traffic generated by the project
- The calculated increase in road traffic noise along construction traffic routes (resulting from construction traffic).

The calculated increase in road traffic noise attributable to the project has been analysed, and anticipated increases of 2 dB(A) have been highlighted in the table.

Mitigation measures for exceedances are provided in **Section 12.5**.

Table 12-42 Construction road traffic noise increases during the AM peak period

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Western surface works area					
Wirega Avenue	353	35	39	73	3.1
Moorefield Road, west of Wirega Avenue	1242	41	39	73	1.6
M5 East Motorway, west of the Kingsgrove North construction compound (C1)	6524	539	39	73	0.2
M5 East Motorway, east of the Kingsgrove North construction compound (C1)	6524	539	39	73	0.2
Kingsgrove Road, north of the M5 East Motorway	2671	189	39	73	0.7
Moorefield Road, east of Wirega Avenue	1505	45	39	73	1.4
Commercial Road	1038	24	39	73	2.0
Kingsgrove Road, south of the M5 East Motorway	2339	58	39	73	1.0
M5 East Motorway, east of Kingsgrove Road	6524	539	39	73	0.2
Bexley Road surface works area					
Bexley Road, between the M5 East Motorway and the motorway on-ramp	2974	98	40	36	0.4
M5 East Motorway, west of Bexley Road	6011	454	40	36	0.1
M5 East Motorway, west of King Georges Road	6524	539	40	36	0.1
Canterbury Road, between King Georges Road and Bexley Road	1884	120	40	36	0.5
Bexley Road, north of the M5 East Motorway	3103	93	40	36	0.4
Bexley Road, south of the M5 East Motorway	2974	98	40	36	0.4
Stoney Creek Road	4754	312	40	36	0.2
Arncliffe surface works area					
Marsh Street, north of Innesdale Road	4503	182	17	60	0.4
Marsh Street, between Innesdale Road and Valda Avenue	4186	177	17	60	0.4
Marsh Street, between the M5 East Motorway and West Botany Street	3111	171	17	60	0.5
West Botany Street, north of the M5 East Motorway	596	24	17	60	2.3
West Botany Street, south of the M5 East Motorway	3448	106	17	60	0.5
Wickham Street	1992	113	17	60	0.8

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Princes Highway, south of Forest Road	3548	111	17	60	0.4
St Peters interchange and local road upgrades surface works area					
Princes Highway, north of Campbell Road	2633	114	134	113	1.2
Campbell Road, west of the Canal Road construction compound (C8)	927	43	134	113	3.0
Campbell Road, east of the Canal Road construction compound (C8)	949	112	134	113	2.1
Burrows Road, northern end	782	151	134	113	1.9
Burrows Road, southern end	748	27	134	113	3.7
Canal Road	2639	119	134	113	1.2
Princes Highway, south of Canal Road	4449	182	134	113	0.8
Princes Highway, between Campbell Road and Canal Road	3006	127	134	113	1.1

Table 12-43 Construction road traffic noise increases during the PM peak period

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Western surface works area					
Wirega Avenue	321	50	39	73	2.8
Moorefield Road, west of Wirega Avenue	1129	58	39	73	1.6
M5 East Motorway, west of the Kingsgrove North construction compound (C1)	4762	655	39	73	0.2
M5 East Motorway, east of the Kingsgrove North construction compound (C1)	4762	655	39	73	0.2
Kingsgrove Road, north of the M5 East Motorway	1173	100	39	73	1.3
Moorefield Road, east of Wirega Avenue	1368	64	39	73	1.4
Commercial Road	944	34	39	73	2.0
Kingsgrove Road, south of the M5 East Motorway	1027	31	39	73	1.9
M5 East Motorway, east of Kingsgrove Road	4762	655	39	73	0.2
Bexley Road surface works area					
Bexley Road, between the M5 East Motorway and the motorway on-ramp	1306	52	40	36	0.8
M5 East Motorway, west of Bexley Road	5289	771	40	36	0.1
M5 East Motorway, west of King Georges Road	4762	655	40	36	0.1
Canterbury Road, between King Georges Road and Bexley Road	1713	170	40	36	0.5
Bexley Road, north of the M5 East Motorway	1362	49	40	36	0.8
Bexley Road, south of the M5 East Motorway	1306	52	40	36	0.8
Stoney Creek Road	2087	165	40	36	0.4
Arncliffe surface works area					
Marsh Street, north of Innesdale Road	3691	139	17	60	0.4
Marsh Street, between Innesdale Road and Valda Avenue	3431	135	17	60	0.5
Marsh Street, between the M5 East Motorway and West Botany Street	2550	131	17	60	0.6
West Botany Street, north of the M5 East Motorway	904	125	17	60	1.1
West Botany Street, south of the M5 East Motorway	2543	154	17	60	0.6
Wickham Street	1469	165	17	60	0.8

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Princes Highway, south of Forest Road	2617	162	17	60	0.5
St Peters interchange and local road upgrades surface works area					
Princes Highway, north of Campbell Road	1934	84	134	113	1.6
Campbell Road, west of the Canal Road construction compound (C8)	810	46	134	113	3.1
Campbell Road, east of the Canal Road construction compound (C8)	829	120	134	113	2.1
Burrows Road, northern end	683	162	134	113	1.9
Burrows Road, southern end	653	29	134	113	3.8
Canal Road	1938	88	134	113	1.6
Princes Highway, south of Canal Road	3268	134	134	113	1.0
Princes Highway, between Campbell Road and Canal Road	2208	94	134	113	1.4

Table 12-44 Construction road traffic noise increases during the AM off-peak period

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Western surface works area					
Wirega Avenue	229	7	52	102	6.4
Moorefield Road, west of Wirega Avenue	806	9	52	102	3.3
M5 East Motorway, west of the Kingsgrove North construction compound (C1)	3643	107	52	102	0.7
M5 East Motorway, east of the Kingsgrove North construction compound (C1)	3643	107	52	102	0.7
Kingsgrove Road, north of the M5 East Motorway	611	22	52	102	3.5
Moorefield Road, east of Wirega Avenue	977	9	52	102	2.9
Commercial Road	674	5	52	102	3.8
Kingsgrove Road, south of the M5 East Motorway	535	7	52	102	4.3
M5 East Motorway, east of Kingsgrove Road	3643	107	52	102	0.7
Bexley Road surface works area					
Bexley Road, between the M5 East Motorway and the motorway on-ramp	681	11	20	36	1.6
M5 East Motorway, west of Bexley Road	3925	229	20	36	0.2
M5 East Motorway, west of King Georges Road	3643	107	20	36	0.2
Canterbury Road, between King Georges Road and Bexley Road	1224	25	20	36	1.0
Bexley Road, north of the M5 East Motorway	710	11	20	36	1.6
Bexley Road, south of the M5 East Motorway	681	11	20	36	1.6
Stoney Creek Road	1088	36	20	36	1.0
Arncliffe surface works area					
Marsh Street, north of Innesdale Road	2275	77	15	38	0.5
Marsh Street, between Innesdale Road and Valda Avenue	2115	75	15	38	0.5
Marsh Street, between the M5 East Motorway and West Botany Street	1572	72	15	38	0.6
West Botany Street, north of the M5 East Motorway	588	28	15	38	1.6

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
West Botany Street, south of the M5 East Motorway	1598	35	15	38	0.8
Wickham Street	923	37	15	38	1.1
Princes Highway, south of Forest Road	1645	36	15	38	0.6
St Peters interchange and local road upgrades surface works area					
Princes Highway, north of Campbell Road	1065	29	120	83	2.2
Campbell Road, west of the Canal Road construction compound (C8)	158	4	120	83	7.9
Campbell Road, east of the Canal Road construction compound (C8)	161	9	120	83	6.9
Burrows Road, northern end	133	13	120	83	6.8
Burrows Road, southern end	127	2	120	83	8.9
Canal Road	1068	31	120	83	2.2
Princes Highway, south of Canal Road	1800	47	120	83	1.5
Princes Highway, between Campbell Road and Canal Road	1216	33	120	83	2.0

Table 12-45 Construction road traffic noise increases during the PM off-peak period

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Western surface works area					
Wirega Avenue	39	6	52	102	10.5
Moorefield Road, west of Wirega Avenue	137	7	52	102	7.7
M5 East Motorway, west of the Kingsgrove North construction compound (C1)	439	61	52	102	2.7
M5 East Motorway, east of the Kingsgrove North construction compound (C1)	439	61	52	102	2.7
Kingsgrove Road, north of the M5 East Motorway	54	13	52	102	8.4
Moorefield Road, east of Wirega Avenue	165	8	52	102	7.1
Commercial Road	114	4	52	102	8.7
Kingsgrove Road, south of the M5 East Motorway	47	4	52	102	11.2
M5 East Motorway, east of Kingsgrove Road	439	61	52	102	2.7
Bexley Road surface works area					
Bexley Road, between the M5 East Motorway and the motorway on-ramp	60	7	20	36	6.0
M5 East Motorway, west of Bexley Road	508	146	20	36	0.7
M5 East Motorway, west of King Georges Road	439	61	20	36	1.2
Canterbury Road, between King Georges Road and Bexley Road	207	22	20	36	2.7
Bexley Road, north of the M5 East Motorway	62	6	20	36	6.0
Bexley Road, south of the M5 East Motorway	60	7	20	36	6.0
Stoney Creek Road	96	21	20	36	3.5
Arncliffe surface works area					
Marsh Street, north of Innesdale Road	201	36	15	38	2.2
Marsh Street, between Innesdale Road and Valda Avenue	187	35	15	38	2.3
Marsh Street, between the M5 East Motorway and West Botany Street	139	34	15	38	2.5
West Botany Street, north of the M5 East Motorway	111	18	15	38	3.6
West Botany Street, south of the M5 East Motorway	243	19	15	38	2.7
Wickham Street	140	20	15	38	3.3

Route/ direction	Existing traffic (2016)		Project construction traffic		Relative noise increase from project construction traffic (dB(A))
	Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Princes Highway, south of Forest Road	250	20	15	38	2.4
St Peters interchange and local road upgrades surface works area					
Princes Highway, north of Campbell Road	233	23	120	83	4.8
Campbell Road, west of the Canal Road construction compound (C8)	59	3	120	83	10.9
Campbell Road, east of the Canal Road construction compound (C8)	61	7	120	83	9.1
Burrows Road, northern end	50	10	120	83	8.7
Burrows Road, southern end	48	2	120	83	12.1
Canal Road	234	24	120	83	4.7
Princes Highway, south of Canal Road	394	37	120	83	3.5
Princes Highway, between Campbell Road and Canal Road	266	26	120	83	4.4

Construction vibration

The project may generate vibration during construction as a result of:

- Surface works within construction compounds and surface road works
- Tunnelling activities, with vibration transmitted through the ground to surface receivers
- Blasting underground, if required during tunnelling.

Surface works

The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur within identified safe working distances. The safe working distances that reduce the risk of cosmetic/structural damage and human discomfort are presented in **Table 12-11**.

Further mitigation of vibration would not be required where the safe working distances are adhered to.

Equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the nearest sensitive receiver to reduce risk of vibration impacts.

In some circumstances, construction activity within the safe working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment.

In some of these cases, safe working distances could be encroached in proximity to residential receivers. The greatest potential for encroachment into safe working distances relates to vibration impacts on human comfort, in situations where vibration intensive equipment is used in proximity to residential receivers. Locations where this combination may occur include:

- The Kingsgrove North construction compound (C1), where it would be located adjacent to residences along its northern boundary
- The Bexley Road North construction compound (C4), where it would be located adjacent to residences along its western boundary
- The Bexley Road East construction compound (C6), where it would be located adjacent to residences along its northern boundary
- In some parts of the local road upgrades, where road upgrade works would be adjacent to residences.

If vibration intensive works are planned within the identified safe working distances, alternative equipment would be identified and vibration monitoring would be implemented. If the use of vibration intensive plant and equipment cannot be avoided within the safe working distance for cosmetic damage the following would occur as a minimum:

- Notification of the works to the affected receivers
- Works would not proceed until attended vibration measurements are undertaken
- If ongoing works are required a permanent vibration monitoring system would be installed, to warn operators (via flashing light, audible alarm, short message service (SMS) etc) when vibration levels are approaching the cosmetic damage limits.

Additionally, existing condition surveys would be carried out on properties and structures within the project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface works.

These dilapidation surveys would be used to establish the existing condition of potentially affected structures. While best efforts would be made to minimise the risk of damage, and it is expected that only minor cosmetic damage would occur in worst cases, repairs would be made to correct any damage resulting from vibration associated with construction of the project.

Tunnelling activities

Vibration associated with the use of roadheaders for the tunnelling activities has been calculated for properties located above the main tunnel alignments.

The results are provided in **Table 12-46**. The results are also provided graphically in the Technical working paper: Noise and vibration (**Appendix J**).

A total of around 163 receiver locations are anticipated to experience temporary vibration above the preferred vibration dose value during the night time, with no exceedances of the maximum vibration dose value.

Residential receivers anticipated to experience vibration at this level include:

- Those above and adjacent to the main alignment tunnels from around Kingsgrove Avenue to around Stotts Reverse, Bexley North
- Those on The Glen Road, Bardwell Valley, to the east of the Bardwell Valley Golf Course
- Those along and to the west of the Princes Highway, broadly from Reilly Lane, Sydenham to Canal Road, St Peters.

Table 12-46 Construction vibration – tunnelling activities

Human comfort vibration dose value			Number of receivers where criteria are exceeded	
	Evening	Night-time	Evening	Night time
Preferred	0.28 mm/s	0.2 mm/s	0	163
Maximum	0.56 mm/s	0.4 mm/s	0	0

As with ground-borne noise, receivers would experience elevated vibration levels only while tunnel construction activities are conducted beneath or close to residential properties.

Tunnelling would typically progress at an average of around seven metres per day, it is likely that vibration would be discernible for around five days at each affected receiver with exceedances occurring for around two days.

Tunnelling advance rates would reduce to around two to five metres per day around the portals, which may increase the duration of exposure for receivers in these areas. As tunnelling moves towards and away from each receiver the vibration experienced would be lower.

Vibration management measures, including consultation with affected receivers, are identified in **Section 12.5** and would be further detailed in the construction noise and vibration management plan(s) for the project.

Blasting

The main alignment tunnels would be constructed through a 'heading and bench' process. This process involves use of road headers to excavate the top of the main alignment tunnels, and then using relatively small scale blasting to remove the rock within the base of the tunnels (the 'bench').

Blasting is proposed as an excavation technique because the vibration impacts from blasting are of a much shorter duration for nearby sensitive receivers compared to the duration of vibration impact associated with mechanical excavation methods such as roadheaders or rockbreakers.

Blasting would be restricted to the following hours:

- 9.00 am to 5.00 pm Monday to Friday
- 9.00 am to 1.00 pm Saturday
- No blasting on Sundays and public holidays.

The use of blasting to construct the main alignment tunnels has the potential to generate airblast (the pressure wave transmitted through the air as a result of the blast) and vibration (the energy transmitted through the ground as a result of the blast).

The extent of airblast and vibration impacts would be affected by the maximum instantaneous charge (MIC) used in each blast event, the type of explosive used, and the characteristics of local geology.

Ground-borne vibration generated by blasting is likely to be the key consideration when carrying out blasting, particularly in areas where the main alignment tunnels are shallower and closer to the ground surface.

Blasting would be carefully planned to ensure blast limits are satisfied. Each blast event would need to be tailored to site conditions and site constraints at each blast location as tunnelling activities progress. To ensure that appropriate blast charges are applied, and to manage potential airblast and vibration impacts, small scale testing of blast charges would be conducted early in the tunnelling phase of the project to establish appropriate site specific propagation characteristics. This would allow for the accurate prediction of vibration once the proposed charge and blast configuration information is determined.

Data from these tests would be used to inform appropriate charge sizes for tunnel blasting, and to inform proactive identification of mitigation and management measures where airblast and vibration impacts are anticipated. Blast mats can be used to manage and reduce the impacts from airblast.

Further detailed assessment and the blast trial process would be described in the Blast Management Strategy, prepared during the detailed design

Cumulative construction noise

Cumulative construction noise would occur as a result of project construction activities occurring simultaneously and due to another project being constructed in proximity to the project.

Simultaneous noise from works within a site compound and road construction works associated with the project has the potential to increase noise levels at nearby sensitive receivers. Noise levels as a result of the cumulative impact could increase by up to 3 dB(A) higher than the maximum noise level of the site compound works and alignment works individually. In addition an increase in the frequency of potential construction noise impacts may occur. A 3 dB(A) increase is widely accepted as being “just perceptible” by receivers.

Detailed construction scheduling of the project would be completed during detailed design and prior to commencement of works and would detail which works would occur concurrently with others. However, the anticipated maximum increase of 3 dB(A) is unlikely to be reached due to the:

- Construction noise assessment being completed for the worst case scenario (ie a scenario where all equipment is operational during a fifteen minute period and in the worst possible location)
- Likelihood that that one scenario will be the dominant source at any residential receiver.

The noise mitigation measures proposed for managing impacts during construction would also be sufficient for managing cumulative impacts resulting in noise level increases of 3 dB(A) or less. This is because the potential increase resulting from simultaneous activities would be a maximum of 3 dB(A) and the increase is more likely to be less than 3 dB(A). Construction of the project is expected to be undertaken between 2016 and 2019. Based on the proposed construction program, there is the potential for construction of the project to occur concurrently with the construction of the King Georges Road Interchange Upgrade project, the M4 East and potential future M4-M5 Link projects that form part of the WestConnex program of works. Currently there are no other major projects in the direct vicinity of the project that could result in cumulative construction noise impacts. A summary of the indicative timing of these projects is provided in **Table 12-47**.

Table 12-47 Indicative timing of projects that form part of the WestConnex program of works

WestConnex project	Commencement of construction	Commencement of operation
New M5	Mid 2016	Late 2019
King Georges Road Interchange Upgrade Project	Commenced July 2015	Late 2016/ early 2017
M4 East	Mid 2016	Early 2019
M4-M5 Link	2019	2023

King Georges Road Interchange Upgrade Project

The King Georges Road interchange upgrade project would potentially overlap with construction of the project for about three to six months in 2016/2017. There is potential for receivers around the western surface works to be affected by cumulative construction noise impacts from these two projects.

Potential cumulative construction noise impacts may involve:

- Finishing works for King Georges Road Interchange Upgrade project, and potentially some road works scheduled for late in the construction program
- Early works, site establishment and potentially the initial phases of tunnelling for the Project.

Based on the nature of the potential concurrent project worksite is anticipated that most noise from the later stages of the King Georges Road interchange upgrade project would be generally below noise contributions from the project construction works.

Specific measures would be developed to coordinate mitigation and management of construction noise from concurrent construction activities based on the programmed works.

These measures would be detailed in the construction environmental management plan(s) for the project, and would include consideration of both physical and program measures (such as coordinating periods of respite).

M4 East Project

The M4 East Project would, if it proceeds, be carried out at a significant distance from the New M5. It is therefore unlikely to be any cumulative noise impact between the two projects.

M4-M5 Link

Subject to environmental planning approval (among other matters), there is the potential for construction of the future M4-M5 Link to commence in 2019 while the project is in the late stages of construction.

It is expected that peak construction of the project would be complete, and the construction activities being undertaken would largely comprise mechanical and electrical fit-out and landscaping and rehabilitation works.

There is the potential for localised cumulative construction works around the St Peters interchange, with a portion of the site potentially used for a construction compound for the M4-M5 Link.

As both projects would be outside of peak construction periods, and the local road upgrades for the New M5 project would be complete, it is expected that the potential for significant cumulative noise impacts would be limited.

During construction, ongoing consultation would be undertaken with local communities potentially affected by concurrent construction of projects that form part of the WestConnex program of works.

Consultation would also be undertaken with proponents of other nearby projects to increase the overall awareness of project timeframes and impacts.

Additional information about consultation and cumulative impacts are provided in **Chapter 7** (Consultation) and **Chapter 27** (Cumulative impacts).

12.4.2 Operational noise assessment

The operational noise assessment for the project covers two areas:

- Noise generated by 'fixed' operational facilities, such as the motorway operations complexes
- Road traffic noise associated with operation of the project, including changes to traffic noise on the surrounding road network.

The Technical working paper: Noise and vibration (**Appendix J**) includes details of the modelling and assessment of these types of noise, with key findings from the assessment provided in the following sections.

Operational noise from fixed facilities

Noise impacts from operational ancillary facilities ('fixed' facilities) have been assessed against the *NSW Industrial Noise Policy*, and include:

- The Kingsgrove motorway operations complex (MOC1) (including the Kingsgrove ventilation facility, substation, fire pump room, deluge water tanks, maintenance facility, workshop, emergency response system and car parking) and western tunnel portals
- The Bexley Road South motorway operations complex (MOC2) (including the Bexley Road emergency smoke extraction facility and substation)
- The Arncliffe motorway operations complex (MOC3) (including the Arncliffe ventilation facility, substation, water treatment plant and car parking)
- The St Peters motorway operations complex (MOC4) (including the motorway control centre, St Peters ventilation facility, substation, fire pump room, water deluge tanks and car parking)
- The Burrows Road motorway operations complex (MOC5) (including the motorway control centre, substation and car parking).

Key noise sources within these fixed facilities include:

- Axial ventilation fans housed within buildings, noise emissions would be via the external outlets
- In-tunnel jet fans noise break-out from tunnel portal openings
- Water treatment plants
- Switches within switch rooms of the substations
- Transformers within substations
- Noise associated with car parking facilities such as accelerating cars, door/boot slamming and people talking at the motorway control centre.

Further information regarding the sound power levels of equipment within each of these fixed facilities is provided in the Technical working paper: Noise and vibration (**Appendix J**).

Noise emissions during operation of the project would be influenced by the volumes of traffic using the project tunnels. Ventilation fans within the project tunnels would be operated at different speeds to maintain acceptable in-tunnel air quality, with the speed of the ventilation fans therefore related to traffic conditions within the tunnels. To take different ventilation fan operational modes into account, the fixed facility noise assessment has considered operation of the project under free flowing traffic conditions (average traffic speeds greater than 60 kilometres per hour), slow traffic conditions (average traffic speeds between 40 kilometres per hour and 60 kilometres per hour) and congested traffic conditions (average traffic speeds of less than 40 kilometres per hour). Worst case noise predictions from these scenarios are presented in the following sections.

The fixed facility operational noise assessment has taken into account different weather conditions, including 'neutral' weather, wind speeds of up to three metres per second and temperate inversion conditions (F class inversion).

Fixed facility noise under normal operating conditions

Modelled maximum operational noise impacts from fixed operational facilities are summarised in Technical working paper: Noise and vibration (**Appendix J**), **Section 5.2**. Results are presented for each NCA, with the most affected received location identified in each case.

The noise emissions from permanent operational fixed facilities and from the jet fans within the tunnels were assessed for three different weather conditions. The predicted noise levels demonstrate that during both normal traffic conditions and low speed traffic conditions the operational noise criteria would not be exceeded during neutral or adverse weather conditions.

Operational noise levels at all non-residential sensitive receivers comply with the appropriate criteria.

Fixed facility noise under emergency conditions

Under emergency conditions, the emergency smoke extraction facilities would be used to remove smoke from the main alignment tunnels. This would involve operation of axial fans in a reverse direction to normal operation under congested traffic conditions, where the facilities would be used to draw fresh air into the tunnels.

Emergency operations are not typically regulated through the application of noise limits, however the potential noise impacts of emergency operations have been predicted. The noise levels from these facilities during emergency operations are the same as the levels predicted during low speed traffic conditions which have been demonstrated to result in an acceptable noise outcome.

Noise impacts during emergency conditions would therefore be no greater than under normal operation (congested traffic conditions) and have been accommodated in the noise impact assessment for normal operations.

Operational road traffic noise

Operational road traffic scenarios

Impacts related to operational road noise as a result of the project have been assessed using a noise model developed to incorporate future traffic flows and road network alignments.

The model has been used to assess noise levels at sensitive receivers for the nominal year of opening (2021) and ten years after the nominal year of opening (2031). Noise levels for both the day time and night time periods have been assessed. The assessed scenarios are:

- Without the project:
  - This scenario was assessed for both 2021 and the design year (2031) and incorporates the existing road network and traffic flows for the applicable year. All major arterial roads within the noise and vibration study area have been included in the noise modelling
  - Both of these scenarios assume the possible future M4-M5 Link is not in operation
- With the project:
  - These scenarios incorporate the main alignment tunnels, portals, ramps and all existing major arterial roads
  - 2021 scenario assumes that the possible future M4-M5 Link is not in operation
  - Two future year scenarios (2031) have been assessed: one with the M4-M5 Link in operation, and one without.

Portal noise from road traffic within the main alignment tunnels has been included in the assessment of operational road traffic noise for ‘with project’ scenarios.

Full details of the road traffic noise modelling predictions in 2021 and 2031, for both the ‘without project’ and ‘with project’ scenarios are provided in the Technical working paper: Noise and vibration (**Appendix J**).

For the purpose of this operational road traffic noise assessment, results for the 2031 scenarios (both with and without the full WestConnex program of works) are presented in the following sections. These scenarios represent the 'worst case' traffic noise impacts because:

- No build road traffic volumes and road traffic noise would be greater in 2031 than in 2021
- Traffic volumes using the project, and project-related road traffic noise would be greater in 2031 than in 2021
- Traffic volume using the project, and project-related road traffic noise would be greater once the full WestConnex program of works is complete, than if only the project were to be implemented.

The project has the potential to generate or contribute to a traffic noise impact in the following areas:

- Around the western surface works area
- Around the St Peters interchange and local road upgrades area
- Along parallel traffic routes as a consequence of redistribution of traffic.

Potential operational road traffic noise impacts in each of these areas are considered in the following sections. Operational traffic associated with the operation of motorway operations complexes, including passenger vehicle traffic generated by employees and occasional deliveries would not significantly affect road traffic noise, due to the small traffic volumes.

Western surface works area

Technical working paper: Noise and vibration (**Appendix J**) provides details of the road traffic noise assessment carried out for the western surface works area, including figures showing predicted road traffic noise levels at surrounding receiver locations, and relative change in road traffic noise levels as consequence of the project.

Existing noise barriers along the M5 East Motorway in the vicinity of the western surface works area would be retained, or relocated immediately outside the area required for the construction and operation footprints for the project.

Where noise barriers are to be relocated, they would be reinstalled at the same height as existing noise barriers. The one exception would be at Beverly Grove Park where an existing eight to nine metre noise berm would be removed to allow for the new road construction. At this location a noise barrier with a full height 6.5 m above the proposed road alignment would provide a commensurate noise reduction to the existing berm. The construction of this barrier would be further assessed during detailed design to confirm an attenuation consistent with the *Noise Mitigation Guidelines* (RMS, 2015b) would be achieved with consideration of other factors (eg landscaping and visual).

Noise barrier relocations would be carried out as early as feasible in the construction program to provide additional construction noise mitigation. The operational road traffic noise modelling has taken into account the presence of existing and relocated noise barriers.

Road surfaces within the western surface works area would comprise open graded asphalt and have been modelled on this basis.

Road traffic noise modelling indicates that the project would result in a decrease in road traffic noise for most receivers around the western surface works area. This reduction in noise is a result of the combined effects of removing traffic from the surface (and into dive structures and the main alignment tunnels) and redistribution of traffic across the motorway corridor.

In total, the road noise criterion is predicted to be exceeded at 53 residential receivers and one school receiver in the daytime (7am to 10pm), and at 65 residential receivers in the night time (10pm to 7am) in 2031. At these properties, the assessment demonstrates that the project would not result in a significant increase in traffic noise with all receivers anticipated to experience less than a 2 dB(A) increase in noise, which is generally considered to be indiscernible.

Only one residential receiver would be likely to experience road traffic noise above the cumulative limit (ie $L_{Aeq(9\ hour)}$ noise criterion + 5 dB(A)). This is despite the receiver experiencing a net reduction in road traffic noise with project implementation, relative to existing road traffic noise levels, of around 1.1 dB(A). This receiver location is considered eligible for further consideration of feasible and reasonable noise mitigation measures (refer to **Section 12.5**).

Road traffic noise would not exceed applicable noise criteria at any non-residential sensitive receiver location, including schools, childcare centres and places of worship.

St Peters interchange and local road upgrades area

Technical working paper: Noise and vibration (**Appendix J**) includes details of the road traffic noise assessment carried out for the St Peters and local road upgrades surface works area. This includes figures showing predicted road traffic noise levels at surrounding receiver locations, and the relative change in road traffic noise levels as consequence of the project.

There are currently no noise barriers in or around the St Peters and local road upgrades surface works area. Further consideration of the potential need for noise barriers, and whether they would be feasible and reasonable is provided in **Section 12.5**.

Road surfaces within the St Peters interchange and local road upgrades surface works area would comprise dense graded asphalt, consistent with existing roads in the area, and have been modelled on this basis.

Road traffic noise modelling indicates that the project would result in a significant increase in road traffic noise in some areas, particularly around the local road upgrades, as a direct result of increased traffic volumes and removal of existing buildings which provide noise attenuation. Two local roads in particular are anticipated to experience significant road traffic noise increases:

- Receivers along Campbell Road are anticipated to experience road traffic noise increases of as much as 5 dB(A). This would be a direct result of upgrading the road from a single lane in each direction to a double lane configuration (with turning lanes in some areas) and an anticipated increase in traffic volumes from around 13,000 movements per day (AADT) currently to around 59,000 movements per day in 2031
- Receivers along Campbell Street are anticipated to experience road traffic noise increases of as much as 22 dB(A). This would be a direct result in increased traffic volumes. The significant relative increase is also a result of current relatively low traffic noise levels along this road.

The operational road traffic noise assessment around the St Peters interchange and local road upgrades surface works area demonstrates that the project would result in around 386 receivers experiencing more than a 2 dB(A) increase in road traffic noise relative to the exiting situation.

A total of 133 receivers and 145 receivers have been identified as likely to experience road traffic noise above applicable (L_{Aeq}) criteria during the day time and night time, respectively (in 2031). In addition two buildings within St Peters Public School are likely to experience noise levels which exceed the internal noise criteria with windows open. Peripheral areas of Sydney Park and the majority of Simpson Park would be exposed to road traffic noise levels which also exceed the applicable noise criteria.

Overall, 144 receivers and the two buildings within St Peters Public School have been identified as eligible for further consideration of feasible and reasonable noise mitigation measures based on the current design of the project and this road traffic noise assessment. Further discussion of mitigation treatments is provided in **Section 12.5**.

Parallel routes and redistributed traffic

Based on the operational traffic assessment carried out for the project (refer to **Chapter 9** (Traffic and transport), parts of the existing road network around the project have been identified as experiencing increases in traffic volumes as a result of traffic redistribution. These parts of the existing road network include:

- Along King Georges Road, from near the interchange with the M5 East Motorway, along Stoney Creek Road, Forest Road and the Princes Highway to around the M5 East Motorway near Marsh Street

- Along Stoney Creek Road, Bay Street, West Botany Street, Bestic Street and General Holmes Drive
- Vanessa Street or Morgan Street, Kingsgrove Avenue, Slade Road and Darley Road
- Along Bexley Road from the interchange with the M5 East Motorway, along Forest Road and Stoney Creek Road
- Along Moorefields Road, William Street, Homer Street / Bayview Avenue, and Unwins Bridge Road.

Section 5.1.12 of the Technical working paper: Noise and vibration (**Appendix J**) provides a summary of the traffic figures and associated change in noise levels for a number of key routes that would be affected by this project.

The noise model shows that generally noise levels would increase by one1 dB(A) or less, which, is generally considered to be indiscernible. To be considered a traffic generating development noise levels would need to increase by greater than two dB(A). As such further consideration of the impacts on parallel routes does not require further consideration.

Operational road traffic noise – sleep disturbance

An assessment of maximum traffic noise levels has been carried out to analyse the potential for sleep disturbance from road traffic noise. Two indicative locations have been assessed:

- 97 Tallawalla Street, Beverly Hills, near the western surface works area
- 108 Campbell Street, St Peters, near the St Peters interchange and local road upgrades surface works area.

Noise monitoring data gathered for the project (refer to **Section 12.1.2**) has been analysed for these locations to determine the number of maximum noise events experienced during the night, the range of maximum noise levels and the average of maximum noise levels. A summary of this analysis is presented in **Table 12-48**.

Table 12-48 Analysis of current maximum noise events

Location	Distance from road (m)	Typical number of maximum noise events per night	Range of measured maximum noise events (dB(A))	Average maximum noise level (dB(A))
97 Tallawalla Street, Beverly Hills	89	8	65-88 dB(A)	75 dB(A)
108 Campbell Street, St Peters	6	126	65-112 dB(A)	97 dB(A)

It is not possible to conclusively determine the likely future number of maximum road traffic noise events. However, broadly:

- Around the western surface works area, there is likely to be an increase in engine braking, particularly as trucks descend into the eastbound main alignment tunnel. The severity of engine braking events would be mitigated by the inclusion of a mild gradient in the decent and this increase is likely to be offset to some degree by shielding provided by the cutting in this area and lower topography of the descent into the western portal relative to the elevations of surrounding receivers
- There is likely to be an increase in maximum road traffic noise events around the St Peters interchange and local road upgrades, broadly commensurate with the anticipated increase in traffic in this area. The presence of intersections around the local road upgrades (as distinct from free flowing motorway conditions) is likely to increase the probability of maximum road traffic noise events through vehicle braking at theses intersections.

The anticipated increase in maximum road traffic noise events, particularly around the local road upgrades, would contribute to the need to prioritise road traffic noise mitigation and management measures in this area. Further discussion of these measures is provided in **Section 12.5**.

Cumulative operational noise

Potential cumulative noise impacts during the operation of the project have been taken into account as part of the assessments presented in earlier sections of this chapter. In particular:

- The fixed facility operational noise assessment takes into account existing noise levels, with contributions from existing developments. The application of the amenity noise criteria specified in the NSW Industrial Noise Policy (and which are the more stringent criteria for most NCAs) ensures that potential 'noise creep' is appropriately taken into account. No significant new future noise sources have been identified in proximity to project operational sites
- The operational road traffic noise assessment takes into account forecast traffic growth (and increases in road traffic noise) as part of the analysis of future road traffic noise scenarios (in 2021 and 2031). Scenarios including the full WestConnex program of works have been taken into account in these scenarios.

12.5 Environmental management measures

This section considers the broad approach to mitigation and management of noise during construction and operation, and concludes with a summary of proposed mitigation and management measures.

12.5.1 Mitigation and management of construction noise

Construction site noise

Section 12.4.1 outlines anticipated construction noise impacts associated with the project. In most cases, construction activities are expected to generate noise impacts above noise management levels developed in accordance with the requirements of the *Interim Construction Noise Guideline*.

It is important to recognise that many of the predicted construction noise impacts would be relevant to only part of the anticipated complete construction program, and in most cases receivers would not be exposed to elevated construction noise levels for the entire construction period.

The construction program for the project has been developed with the aim of balancing reasonable protection of local amenity, while achieving project timeframes.

Construction works have only been proposed outside of standard construction hours where the works would not generate a significant noise impact, or where required for safety or road network operational reasons. To carry out these activities during standard construction hours would either not be feasible from a road safety or traffic management perspective, or would not be unreasonable given only minor noise impacts are anticipated.

A construction noise and vibration management plan(s) would be developed and implemented. Subject to detailed design and project requirements, these plans may be development construction compounds and sites, or groups of construction activities. The construction noise and vibration management plan(s) would identify specific mitigation measures, taking into account the number and sensitivity of potentially affected receivers, the nature and duration of relevant construction activities, and the availability of feasible and reasonable mitigation measures.

To mitigate and manage construction noise measures, the approach to be used would be similar to that recently applied to the NorthConnex, the Hills M2 Motorway Upgrade and the Sydney Metro Northwest projects, including:

- A review of the predicted construction noise impacts, including any refinements to the assessment presented in this EIS as a result of detailed design
- Identification of receiver specific mitigation and management measures depending on the level of predicted construction noise impact relative to rating background levels (RBLs).

An indication of the types of mitigation and management measures that would be developed and applied for affected receivers is presented in **Table 12-49**.

Potential mitigation and management measures would include:

- Letterbox drop – notification of construction activities as part of periodic community updates distributed across areas surrounding construction activities
- Noise verification – receiver or catchment specific noise verification used to confirm the construction noise performance of the project and to proactively inform, where relevant, review and update noise mitigation and management measures, and site construction practices
- Individual briefing – offers of individual briefings about relevant construction activities and potential impacts with potentially affected receivers
- Receiver specific notifications – individual correspondence to potentially affected receivers providing information on construction activities and potential impacts specific to the situation
- Receiver specific contact – individual phone calls, emails of visits to potentially affected receivers providing information on construction activities and potential impacts specific to the situation
- Respite periods – programming of feasible and reasonable respite periods for potentially affected receivers
- Alternative accommodation – offers of reasonable alternative accommodation for receivers potentially affected by construction activities conducted at night (from 10 pm to 7 am). Alternative accommodation would be subject to consultation with the affected receiver and would take into account the duration and intensity of the potential impact.

Construction compound sites

The noise associated with the operation of compound sites would primarily result from the operation of fixed and mobile plant and truck movements. Consideration would be given to the layout of the site in order to maximise distance and shielding to nearby receivers.

Sheds would be erected at the construction compounds that are proposed to support 24 hour tunnelling activities. Acoustic sheds would be utilised at Kingsgrove North (C1), Bexley Road North (C4) and Bexley Road South (C5) construction compounds. The indicative insertion loss of the acoustic sheds would be around 25 dB(A), however this would be confirmed during the detailed design phase. During night time tunnelling activities, all works would be located within the sheds and doors would be kept closed. Non-acoustic sheds would be erected at Commercial Road (C3) and Arncliffe (C7) construction compounds. The indicative insertion loss of the non-acoustic sheds would be around 10 dB(A), however this would be confirmed during the detailed design phase. The proposed shed locations can be found in Technical working paper: Noise and vibration (**Appendix J**).

Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant would be selected for each task to minimise the noise contributions.

Alternative works methods such as use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function (such as rubber wheeler plant) would be considered in place of steel tracked plant.

Equipment would be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable.

Noise barriers

Where practicable, permanent noise barriers would be scheduled for completion as early as possible so they can assist in mitigating construction noise. However, in a number of areas, the existing noise walls or parts of the existing noise walls would have to be demolished before the new wall can be constructed due to accessibility and safety. In these circumstances, an assessment of feasible and reasonable noise mitigation measures would be undertaken.

Where reasonable and feasible, the use of temporary noise walls or hoarding would be investigated where works or compounds are in proximity to residential receivers. The proposed noise barrier locations can be found in Technical working paper: Noise and vibration (**Appendix J**).

Noise monitoring

Noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during the construction program as the works progress.

Table 12-49 Indicative construction noise management measures

Predicted construction noise impact	Receiver specific mitigation and management measures
Airborne noise during standard construction hours	
For receivers affected by construction noise more than 0 dB(A) but less than 10 dB(A) above the applicable rating background level.	No additional receiver specific mitigation and management measures
For receivers affected by construction noise more than 10 dB(A) but less than 20 dB(A) above the applicable rating background level.	Letterbox drop
For receivers affected by construction noise more than 20 dB(A) but less than 30 dB(A) above the applicable rating background level.	Letterbox drop Verification of noise levels
For receivers affected by construction noise more than 30 dB(A) above the applicable rating background level.	Letterbox drop Verification of noise levels
Acutely affected receivers (equal to or more than 75 dB(A))	Letterbox drop Verification of noise levels Respite periods
Airborne noise outside of standard construction hours	
For receivers affected by construction noise more than 0 dB(A) but less than 5 dB(A) above the applicable rating background level.	No additional receiver specific mitigation and management measures
For receivers affected by construction noise more than 5 dB(A) but less than 10 dB(A) above the applicable rating background level.	Letterbox drop
For receivers affected by construction noise more than 10 dB(A) but less than 20 dB(A) above the applicable rating background level.	Letterbox drop
For receivers affected by construction noise more than 20 dB(A) but less than 30 dB(A) above the applicable rating background level.	Letterbox drop Verification of noise levels
For receivers affected by construction noise more than 30 dB(A) above the applicable rating background level.	Letterbox drop Verification of noise levels Individual briefing Receiver specific notifications Receiver specific contact Respite periods Alternative accommodation
Highly noise affected receivers (equal to or more than 75 dB(A))	Letterbox drop Verification of noise levels Individual briefing Receiver specific notifications Receiver specific contact Respite periods Alternative accommodation

Predicted construction noise impact	Receiver specific mitigation and management measures
Ground-borne noise	
For receivers affected by ground-borne noise more than 0 dB(A) but less than 5 dB(A) above the evening ground-borne noise criterion.	No additional receiver specific mitigation and management measures
For receivers affected by ground-borne noise more than 5 dB(A) but less than 10 dB(A) above the evening ground-borne noise criterion.	Letterbox drop
For receivers affected by ground-borne noise more than 0 dB(A) but less than 5 dB(A) above the night time ground-borne noise criterion.	Letterbox drop Verification of noise levels Receiver specific notifications
For receivers affected by ground-borne noise more than 5 dB(A) but less than 10 dB(A) above the night time ground-borne noise criterion.	Letterbox drop Verification of noise levels Receiver specific notifications Receiver specific contact Alternative accommodation
Sleep disturbance impacts	
For receivers affected by sleep disturbance impacts more than 0 dB(A) but less than 10 dB(A) above the applicable sleep disturbance criterion.	Letterbox drop Receiver specific notifications Receiver specific contact Respite periods
For receivers affected by sleep disturbance impacts more than 10 dB(A) but less than 20 dB(A) above the applicable sleep disturbance criterion.	Letterbox drop Verification of noise levels Individual briefing Receiver specific notifications Receiver specific contact Alternative accommodation
For receivers affected by sleep disturbance impacts above the awakening reaction criterion.	Letterbox drop Verification of noise levels Individual briefing Receiver specific notifications Receiver specific contact Alternative accommodation

Construction traffic noise

Potential options for mitigating and managing construction traffic noise include:

- Managing construction traffic to minimise construction traffic noise impacts, particularly through scheduling of haulage times
- Reductions in noise at the source, either through changes to the traffic fleet or the road pavement
- Installation of noise barriers.

Opportunities to schedule construction traffic to minimise potential construction traffic noise impacts would be considered during detailed design of the project, including construction program.

The construction noise and vibration management plan(s) for the project will detail measures to manage construction haulage routes, timeframes and schedules.

Changes to road pavement type to reduce noise generation along construction haulage routes are not considered reasonable or feasible.

Further, given the extent of potentially affected receivers and the limited duration of construction activities, the installation of additional noise barriers or consideration of at-property acoustic treatments are also not considered to be reasonable or feasible.

12.5.2 Mitigation and management of operational noise

Fixed facility noise

The noise emissions from permanent operational fixed facilities and from the jet fans within the tunnels have been modelled for three different weather conditions for both normal and emergency conditions. The predicted noise levels demonstrate that the operational noise criteria would not be exceeded in any of these situations. No further mitigation is required.

Operational road traffic noise

A full list of residential receivers for which further consideration of feasible and reasonable noise mitigation measures is required is provided in Section 5.1 of the Technical working paper: Noise and vibration (**Appendix J**). In addition to these residential receivers, two buildings within the St Peters Public School would require consideration of feasible and reasonable noise mitigation measures (during the day time period).

The list of receivers which require further consideration of feasible and reasonable noise mitigation is preliminary and based on the current design of the project. These receiver locations would be confirmed during detailed design of the project, which may result in minor amendments to the number and locations of relevant receivers.

Options to mitigate road traffic noise include the following (in order of priority):

- At-source mitigation, including choice of road pavement
- Noise attenuation using noise barriers
- At-receiver noise mitigation, including at-property acoustic treatments.

When considering road traffic noise mitigation and management measures, it is important to appreciate the key sources of noise to provide a focus for consider feasible and reasonable measures.

<u>At-source mitigation</u>

The project has been designed to include the following pavement types:

- Dense graded asphalt at the St Peters interchange and local road upgrades
- Open graded asphalt for the main alignment tunnels, on and off ramps and M5 East Motorway integration works.

Dense graded asphalt is commonly used for arterial and other major roads, and provides a durable, relatively long wearing road surface. Dense graded asphalt is appropriate for application to medium to high speed roads.

Open graded asphalt has been selected for the motorway components of the project, principally based on its performance as a high speed road surface. It is typically more costly than dense graded asphalt, but provides better skid reduction properties, particularly in wet weather conditions. Open graded asphalt also generates lower road pavement noise than dense graded asphalt, by around two dB(A) to three dB(A).

It would be possible to apply open graded asphalt to the St Peters interchange and local road upgrades, with resulting reductions in road traffic noise of up to several decibels. However, this reduction in road traffic noise would not be sufficient to justify the additional capital and maintenance cost of applying open graded asphalt in these areas. On this basis, use of open graded asphalt at the St Peters interchange and local road upgrades would not be a reasonable road traffic noise mitigation approach.

Noise attenuation using noise barriers

Existing noise barriers along the western surface works area would be retained or relocated outside the project's construction and operational footprints, at an equivalent height with the exception of the noise berm south at Beverly Grove Park (refer to **Section 12.4.1**). The noise barriers would be relocated as early as practicable during the construction phase of the project to provide ongoing noise attenuation during construction and operation. The presence of noise barriers has been included in the operational traffic modelling and assessment conducted for the western surface works area.

Despite the presence of noise barriers, one existing residential receiver near the western surface works area has been identified as requiring further consideration of feasible and reasonable noise mitigation measures. Because a single receiver is being considered for operational road traffic noise mitigation around the western surface works, a new noise barrier, or increased height of an existing noise barrier, is not considered to be reasonable. A reasonable, more cost effective and efficient noise mitigation outcome is likely to be achievable for this residence through potential at-property acoustic treatment.

The potential application of noise barriers around the St Peters interchange and local road upgrades area has been considered, taking into account that the principal source of road traffic noise to be mitigated in this area relates to local road upgrades (rather than the St Peters interchange). Although noise barriers would be feasible within the St Peters interchange site, they are unlikely to make a significant difference to predicted road traffic noise levels at residential receiver locations or at the St Peters Public School. The use of noise barriers to mitigate noise from the St Peters interchange would therefore not be reasonable.

Installation of noise barriers along the local road upgrade works may be feasible, but is considered not to be reasonable for the following reasons:

- The noise barriers would need to be installed along street frontages, which would either completely block direct street access to and from adjacent properties, or would be ineffective due to the presence of gaps in the noise barriers to allowed continued street access
- The proximity of noise barriers to residential receivers would likely generate an unacceptable urban design, visual amenity and overshadowing impact
- The location and extent of noise barriers that would be required would likely contribute to unacceptable land use outcomes, through severance and isolation of both residential and public open space areas
- The noise barriers would require additional land take, including acquisition of residential land to install the barriers.

The use of noise barriers to mitigate road traffic noise around the local road upgrades would not provide a reasonable or appropriate noise mitigation outcome.

At-property acoustic treatments

At-property acoustic treatment would be considered at each of the properties which require further consideration of feasible and reasonable noise mitigation (refer to Section 5.1 of the Technical working paper: Noise and vibration (**Appendix J**) for a list of these properties) and at the St Peters Public School. The number of receiver locations which require further consideration of feasible and reasonable noise mitigation would be confirmed during detailed design, including further operational road traffic noise assessment where required. Confirmation receivers eligible for consideration of at-property acoustic treatment may result in minor changes to the number and location of receivers.

Where a receiver is confirmed during detailed design as being eligible for consideration of at-property acoustic treatment, further consultation with the affected landowner would be carried out. This would include inspection of the property and discussion with the landowner about the types of acoustic treatment that could be reasonably applied to the property. Broadly, two categories of at-property treatments would be considered:

- Type 1 – for exceedances of up to 10 dB(A), at-property treatments may include fresh air ventilation, sealing of wall vents and upgrading door and window seals
- Type 2 – for exceedances of more than 10 dB(A), at property treatments may include the treatments listed for Type 1 above, plus additional upgrades to windows and doors.

12.5.3 Noise mitigation and management commitments

Where possible, the project has been designed and planned to avoid and minimise construction and operational noise and vibration impacts. This has included careful identification of construction compound sites and construction haulage routes to avoid residential and other noise-sensitive receivers where possible. In the case of operational noise, the project has been designed to include noise mitigation measures where feasible and reasonable.

Despite this, noise and vibration impacts would occur during construction of the project, and road traffic noise impacts would occur during operation. Mitigation and management measures would be implemented to avoid, minimise and/ or manage these impacts. These are summarised in **Table 12-50**.

Table 12-50 Environmental management measures – noise and vibration

Impact	No.	Environmental management measure	Timing
Construction			
General	NV01	A construction noise and vibration management plan(s) will be prepared and implemented consistent with the requirements of the *Interim Construction Noise Guideline* (DECC, 2009), and will include the following: • Identification of nearby residences and other sensitive land uses • Description of approved hours of work • Description and identification of construction activities, including work areas, equipment and duration • Description of what work practices (generic and specific) will be applied to minimise noise and vibration • A complaints handling process • Noise and vibration monitoring procedures • Overview of community consultation required for identified high impact works.	Pre-construction

Impact	No.	Environmental management measure	Timing
Construction noise	NV02	Induction and training will be provided to relevant staff and subcontractors outlining their responsibilities with regard to noise.	Construction
	NV03	Noisy activities that cannot be undertaken during standard construction hours will be scheduled as early as possible during the evening and/or night time periods.	Construction
	NV04	Permanent noise barriers will be scheduled for completion as early as possible in order to minimise construction noise.	Construction
	NV05	Property treatments identified for the operational phase of the project will be considered for installation before or early in the construction period, where they would improve noise levels.	Construction
	NV06	Acoustic sheds will be erected at the Kingsgrove North (C1), Bexley Road North (C4) and Bexley Road South (C5) construction compounds, to mitigate noise generated by tunnelling support activities. The noise attenuation requirements for these acoustic sheds will be reviewed and confirmed during detailed design.	Pre-construction
	NV07	Temporary acoustic hoardings will be installed at the Kingsgrove North (C1), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5), Bexley Road East (C6), Arncliffe (C7), Canal Road (C8) and Campbell Road (C9) construction compounds. The design and location of acoustic hoardings will be confirmed during detailed design.	Pre-construction
	NV08	When working adjacent to schools, particularly noisy activities will be scheduled outside normal school hours, where practicable.	Construction
	NV09	Where feasible and reasonable, equipment with directional noise emissions will be oriented away from sensitive receivers.	Construction
	NV10	Verification checks on the noise emissions of plant and machinery will be conducted.	Construction
	NV11	Ongoing noise monitoring will be undertaken during construction at sensitive receivers during critical periods to identify and assist in managing high risk noise events.	Construction
	NV12	Reversing of equipment will be minimised to prevent nuisance caused by reversing alarms. Use of non-tonal reversing alarms ('quackers') will be implemented to further reduce the nuisance caused by reversing alarms.	Construction

Impact	No.	Environmental management measure	Timing
	NV13	Loading and unloading will be carried out away from sensitive receivers, where practicable.	Construction
	NV14	Deliveries will be carried out during standard construction hours where feasible and reasonable.	Construction
	NV15	Additional noise mitigation measures during out of hours works will be determined on a case-by-case basis using individual receiver predictions, and may consist of offers of alternative accommodation, monitoring, individual briefings, letter box drops, project specific respite offers, phone calls and specific notifications.	Construction
	NV16	Respite periods (eg one hour respite for every three hours of continuous construction activity) will be scheduled for high noise impact works where appropriate.	Construction
Construction traffic noise	NV17	Truck drivers will be advised of designated vehicle routes, parking and queuing locations, acceptable delivery hours and other relevant practices (ie minimising the use of engine brakes, and no extended periods of engine idling).	Construction
	NV18	Deliveries and spoil removal will be planned to avoid queuing of trucks around construction compounds.	Construction
Construction vibration	NV19	Before the start of tunnelling or other vibration intensive works at each site, condition surveys will be undertaken on properties and structures within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface works.	Construction
	NV20	The safe working distances will be complied with where feasible and reasonable. This will include the consideration of smaller equipment when working close to existing structures.	Construction
	NV21	If vibration intensive works are required within the safe working distances, vibration monitoring or attended vibration trials will be undertaken at the outset of these works to ensure that levels are within relevant criteria.	Construction
	NV22	Building condition surveys of potentially affected structures will be completed both before and after the works to identify existing damage and any damage due to the works.	Pre-construction and post construction

Impact	No.	Environmental management measure	Timing
Ground-borne noise	NV23	Vibration intensive construction works will be confined to the less sensitive daytime period (9.00 am to 12.00 pm and 2.00 pm to 5.00 pm) as far as reasonably practicable.	Construction
	NV24	A detailed ground-borne noise assessment will be undertaken following further geotechnical investigations. This will include developing the vibration site law for the project.	Construction
Blasting	NV25	Noise and vibration mitigation methods specific to blasting will be incorporated into the construction noise and vibration management plans where required.	Construction
	NV26	Blasting with the potential to generate an impact at the surface will be restricted to standard daytime hours (except where approved by the relevant authority). Blasting would occur between 9:00am and 5:00pm, up to five days per week (Monday to Friday) and on Saturdays (9:00 am to 1:00pm). Blasts would be limited to one single detonation in any one day per receiver group, unless otherwise agreed by the NSW EPA through consultation on the Construction Noise and Vibration Management Plan.	Construction
	NV27	Site investigations will be conducted prior to production blasting to define suitable blast sizes to comply with project blasting noise and vibration criteria.	Construction
	NV28	Dilapidation studies of nearby receiver buildings will be undertaken where the potential for exceedances of the blasting criteria is identified.	Pre-construction
	NV29	Where the predicted levels exceed the noise or vibration criteria for blasting, alternative construction methods, such as penetrating cone fracture, will be utilised.	Construction
Consultation with impacted receivers	NV30	Community consultation protocols for sensitive receivers likely to be impacted by construction activities such as blasting, vibration and noise will be prepared and implemented.	Pre-construction and construction
Operation			
Road traffic noise	OpNV01	At locations where residual impacts remain after all feasible and reasonable approaches have been exhausted, noise mitigation in the form of acoustic treatment of existing individual dwellings will be considered.	Operation

Impact	No.	Environmental management measure	Timing
	OpNV02	Operational traffic noise will be monitored at sensitive receivers between six months and one year after opening. If the traffic noise levels are above the predicted levels, consideration of additional feasible and reasonable mitigation measures will be undertaken.	Operation
Operational fixed facilities	OpNV03	Operational fixed facilities will be designed to meet project specific noise criteria derived in accordance with the NSW Industrial Noise Policy.	Pre-construction

(blank page)

13 Land use and property

This chapter assesses land use and property impacts associated with the project. The assessment includes:

- Identification of the local land uses, existing access arrangements and potential property acquisition for both public and private land affected by the project
- Assessment of the potential impacts of the project on property, land use and access arrangements during construction and operation of the project
- Identification of appropriate management and safeguard measures to minimise these impacts.

Table 13-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to land use and property, and where in the environmental impact statement (EIS) these have been addressed.

Table 13-1 SEARs – land use and property

Secretary's Environmental Assessment Requirement	Where addressed
Land use changes as a result of the proposal and the acquisition of privately owned, Council and Crown lands, and impacts to Council and Crown lands,	Land use changes as a result of the proposal and the acquisition of privately owned, council and Crown lands, and impacts to council and Crown lands are detailed in **Section 13.3**.
An analysis of the proposal including an assessment, with a particular focus on the requirements of the listed key issues, in accordance with clause 7(1)(d) of Schedule 2 of the Regulation (where relevant), including an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing mitigation measures (to avoid, manage, offset and monitor impacts and where relevant, improve the existing environment)...	An assessment of the project's potential impacts on land use and property is included in **Section 13.3** and mitigation measures are presented in **Section 13.4**. A full description of the project is provided in **Chapter 5** (Project description). **Chapter 6** (Construction work) identifies the land to be used for the project. A list of approvals for the project is provided in **Chapter 2** (Assessment process). Indirect impacts are considered to be mainly social and economic related and therefore covered in **Chapter 15** (Social and economic). **Chapter 27** (Cumulative) provides the cumulative impact assessment. **Chapter 30** provides a summary of the environmental management and mitigation measures for the project.
The EIS must also address the following specific matters: • impacts on directly affected properties and land uses, including impacts related to access, land use, settlement and subsidence associated with tunnel excavation, property acquisition (including relocations and expenses for those properties acquired) and amenity related changes;	Potential impacts of the project on property access, land use, settlement and subsidence associated with tunnel excavation, property acquisition are discussed in **Section 13.3**. Amenity related changes are addressed in **Chapter 14** (Visual impacts and urban design).

Secretary's Environmental Assessment Requirement	Where addressed
• opportunities for local centre and street revitalisation near the St Peters interchange;	Opportunities for local centre and street revitalisation are provided in the Urban Design Report (**Appendix L**).
• an assessment of the impact of the proposal on community facilities, including open space and recreational facilities. The assessment must include the use of existing facilities impacted by the proposal, and options and opportunities for the relocation and/or reconfiguration of the community facilities, both temporary and permanent;	Impacts of the proposal on community facilities is describes in **Section 13.3** and **Chapter 15** (Social and economic)
• where there are potential impacts to the OEH estate reserved under the National Parks and Wildlife Act 1974 or where the proposal is located upstream of OEH estate, an assessment of the matters to be considered outlined in the *Guidelines for developments adjoining land and water managed by Department of Environment, Climate Change and Water* (DECCW 2010);	The project would not directly impact any OEH estate reserved under the *National Parks and Wildlife Act 1974*. Impacts of the project on land use and property during construction and operation are described in **Section 13.3.1** and **Section 13.3.2**.
• potential impacts on utilities (including communications, electricity, gas, and water and sewerage) and the relocation of these utilities	Potential impacts of the project on utilities are described in **Section 13.3**.

13.1 Assessment methodology

The assessment of impacts from the project on property and land use included:

- Providing an overview of the existing character, land use and zoning in the vicinity of the project components
- Reviewing the zoning and minimum lot size provisions of the relevant local environment plans
- Identifying the properties and land uses that would be impacted by the project
- Assessing the potential for land used for construction of the project, but not proposed to include permanent operational infrastructure (surplus or residual land) to be redeveloped following construction
- Identifying potential impacts of the project on future development within the project area
- Compiling mitigation measures that would assist in reducing impacts on land use and property.

13.2 Existing environment

The existing environment for land use and property has been described in terms of the broader, regional environment of the project corridor within Sydney, as well as the local environment relevant to each of the specific elements of the project.

13.2.1 Regional context

The project corridor spans the Hurstville, Canterbury, Rockdale, Marrickville, Botany Bay and City of Sydney local government areas (LGAs). Land use and existing development within and around the project corridor is urban (eastern end of the project corridor) and suburban (western end of the project corridor) in nature, containing a mix of residential, commercial, industrial and open space uses. There are several major transport corridors and other infrastructure located in or adjacent to the project corridor, including the M5 East Motorway, the Princes Highway, the Sydney Trains suburban railway network and the Sydney Airport.

Land uses within the project corridor include a mix of:

- Residential land: Predominately low density residential, with medium and high density residential land uses in areas close to public transport, along arterial roads and at the eastern extent of the project corridor. Land use changes are occurring within the project corridor as older industrial areas are redeveloped for residential purposes. This includes the significant mixed use redevelopment at Wolli Creek within the Rockdale LGA
- Open space: Nature reserves, active recreational uses (such as golf courses and sports grounds) and passive recreational uses are located throughout the project corridor. This includes the Canterbury Golf Course, Beverly Grove Park, Wolli Creek Regional Park, Cahill Park, Barton Park, the Kogarah Golf Course, Tempe Recreation Reserve and Sydney Park. Continuous open space corridors, consisting of a series of smaller open spaces, are located along Bardwell Creek, Wolli Creek and the Cooks River
- Industrial and commercial land: Concentrated in the suburbs of Kingsgrove, Turrella, Wolli Creek, Arncliffe, Tempe, St Peters, Mascot and Alexandria. Commercial uses are typically concentrated along arterial roads (such as the Princes Highway) and at railway stations and, alongside medium and high density residential uses. Community facilities, churches, schools, medical and veterinary centres are located along the length of the project corridor.

Land use zonings within the project corridor are set by the following environmental planning instruments:

- *Sydney Regional Environmental Plan No. 33* – Cooks Cove (Cooks Cove SREP)
- *Hurstville Local Environmental Plan 2012* (Hurstville LEP)
- *Canterbury Local Environmental Plan 2012* (Canterbury LEP)
- *Rockdale Local Environmental Plan 2011* (Rockdale LEP)
- *Botany Bay Local Environmental Plan 2013* (Botany Bay LEP)
- *Marrickville Local Environmental Plan 2011* (Marrickville LEP)
- *Sydney Local Environmental Plan 2012* (Sydney LEP).

The regional land use zoning context of the project is shown **Figure 13-1**. The land use zoning generally aligns with existing development types within the project corridor and includes:

- General and light industrial
- Business (commercial) zones, including centres, enterprise corridors along major road and business parks
- Residential zones, ranging from low to high density
- Mixed use zones (commercial and residential)
- Special infrastructure zones, which align with major transport infrastructure and corridors, as well as drainage, electricity infrastructure and educational establishments
- Recreational zones (private and public)
- Conservation and waterways zones, including national parks and nature reserves.

Transitional areas where the land use zonings and current development types are not fully aligned include industrial areas in Wolli Creek, Sydenham, St Peters and Alexandria undergoing redevelopment and conversion to residential areas.

A number of strategic planning initiatives are also underway within and around the project corridor. These include:

- The *Princes Highway Corridor Strategy* (Rockdale City Council)
- The Cooks Cove Growth Centre, on land subject to *Sydney Regional Environmental Plan No. 33 – Cooks Cove* (Cooks Cover SREP)
- The Mascot Station Town Centre Precinct (City of Botany Bay Council)
- Sydenham Green (Marrickville Council)
- The Sydney Gateway, a future part of the WestConnex program of works (Transport for NSW)
- Southern and northern extensions to the WestConnex program of works (Transport for NSW)
- The Sydney Metro projects (Transport for NSW)
- Zoned employment lands.

The *Princes Highway Corridor Strategy*, an initiative of Rockdale City Council, was adopted by the Council in late 2013. The strategy focuses on revitalising the corridor within the Rockdale local government area for employment uses and growing the Arncliffe town centre. This strategy targets changes to the distribution of residential, mixed use and business zones, as well as increased development densities.

The Cooks Cove Growth Centre is a 100 hectare precinct, which is bounded by the Cooks River and Muddy Creek, Marsh Street, West Botany Street and Bestic Street, and is subject to the Cooks Cover SREP. Historical master planning for the site identified an area for potential employment uses near Marsh Street with the remainder of the site to be set aside for conservation, open space and recreational purposes. Planning for the site is currently being managed by the Urban Growth Development Corporation.

The Mascot Station Town Centre Precinct, an initiative of the City of Botany Bay Council, is centred on the Mascot railway station and is partially located within the project corridor. The area has been rezoned as part of the *Botany Bay Local Environmental Plan 2013*, allowing for the intensification of residential and commercial land uses.

Sydenham Green is a local park in Sydenham, which is partially located within the project corridor. Sydenham Green is bounded by Unwins Bridge Road, George Street, Henry Street, Railway Road, Stewart Lane, Park Road, Rowe Lane, and Reilly Lane. Sydenham Green was created through the demolition of houses in the mid-1990s as a result of a Commonwealth Government property acquisition program associated with the building of the third runway at Sydney Airport, and management of aircraft noise. More recently, Marrickville Council has developed the *Sydenham Green Master Plan* (ASPECT Studios, 2013) and the *Sydenham Green Draft Plan of Management* (Marrickville Council, 2013) to provide the basis for a future upgrade of the park to improve its amenity.

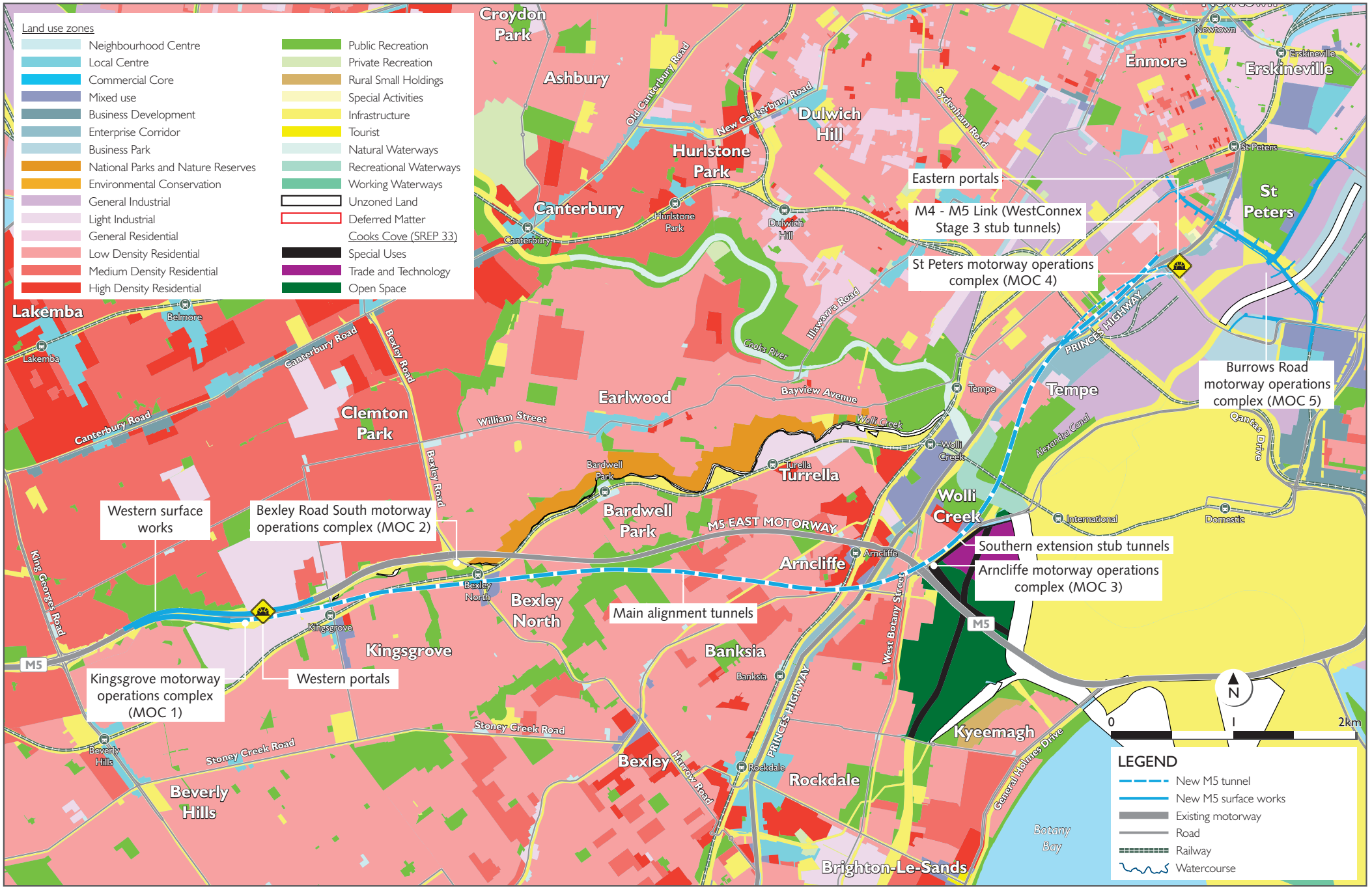


Figure 13-1 Regional zoning context of the project

(blank page)

Sydney Gateway, a future part of the WestConnex program of works, would link the WestConnex motorway projects to the Sydney Airport and Port Botany. The future Sydney Gateway would comprise a mix of existing roads, upgraded roads and new infrastructure. Consultation with Sydney Airport and other strategic landholders is underway to develop a detailed proposal for the connection of the WestConnex motorways from the St Peters interchange to the airport and port precinct.

The NSW Government is currently considering potential Northern and Southern connections to the WestConnex program of works. The extensions, one north from the WestConnex M4 East project and the other south from the WestConnex New M5 project (the southern extension), would create broader connections between the WestConnex motorways and the Sydney metropolitan road network. This may include a connection to Sydney's North Shore via a third harbour crossing, and a connection towards the F6 corridor in the south. Both potential extensions have been identified in the NSW Government's 2012 *Long Term Transport Master Plan* as vital to Sydney's infrastructure and would provide an uninterrupted motorway corridor from Sydney's south to the Anzac Bridge, the CBD at Darling Harbour and North Sydney.

The Sydney Metro projects would connect and extend a separate railway line from the North West Rail Link under Sydney Harbour, through the CBD, through Sydenham and west to Bankstown, with capacity to run up to 30 trains per hour in each direction on the new line (Transport for NSW, 2014). Investigations are currently underway to develop the design and alignment for a series of projects to complete the Sydney Metro connection.

Zoned employment lands within the project corridor include light industrial lands at Kingsgrove, mixed use and enterprise corridor land along the Princes Highway at Arncliffe and general industrial areas in St Peters and Alexandria.

13.2.2 Local context

The project would comprise an underground road tunnel and would therefore avoid direct impacts to the majority of land uses and properties within the project corridor. Impacts to land use and property would mainly occur at locations where surface works are proposed. Consequently, the local context is described below in terms of the land use surrounding each of the following surface sites:

- The western surface works, including:
  - The M5 East Motorway integration works during construction and operation
  - The Kingsgrove North construction compound (C1), the Kingsgrove South construction compound (C2) and the Commercial Road construction compound (C3) during construction
  - The Kingsgrove motorway operations complex (MOC1) during operation.
- The Kingsgrove Road surface works including installation of toll infrastructure on the M5 East Motorway.
- The Bexley Road surface works, including:
  - The Bexley Road North construction compound (C4), the Bexley Road South construction compound (C5) and the Bexley Road East construction compound (C6) during construction
  - The Bexley Road South motorway operations complex (MOC2) during operation.
- The Arncliffe surface works, including:
  - The Arncliffe construction compound (C7) during construction
  - The Arncliffe motorway operations complex (MOC3) during operation.
- The St Peters interchange and local road upgrade surface works, including:
  - The St Peters interchange works during construction and operation

- The Canal Road construction compound (C8), the Campbell Road construction compound (C9), the Landfill closure construction compound (C10), the Burrows Road construction compound (C11) and the Campbell Road bridge construction compound (C12), Gardeners Road bridge construction compound (C13) and Sydney Park construction compound (C14)
- The St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5) during operation
- Local road upgrade works during construction and operation.

A full list of community facilities that were identified in proximity to the project are provided in the Technical working paper: Social and Economic (**Appendix M**)

Western surface works

The western surface works would be located in a corridor along the M5 East Motorway, between King Georges Road and Kingsgrove Road. Land use zonings and development controls in this area are regulated under:

- The Canterbury LEP to the north of the M5 East Motorway
- The Hurstville LEP to the south of the M5 East Motorway.

The land use zonings within and around each the sites forming part of the western surface works are summarised in **Table 13-2** and shown in **Figure 13-2**.

Existing land uses in the immediate vicinity of the western surface works include the M5 East Motorway corridor, the local and regional road network, residential lands and industrial lands. The East Hills, Airport and Inner West railway line passes in an east-west direction, about 300 metres to the south of the M5 East Motorway.

Public recreation areas and infrastructure located around the western surface works include:

- A shared pedestrian and bicycle path within Beverley Grove Park, part of the M5 Linear Park, located on the northern and southern side of the M5 East Motorway corridor. This shared path would be directly affected by the Kingsgrove North construction compound (C1) and Kingsgrove South construction compound (C2) and would be relocated around the northern perimeter of that site at the start of construction, so that a path remains accessible during construction
- Canterbury Municipal Golf Course, located adjacent and to the north of the M5 East Motorway. Part of the golf course would be directly affected by the Kingsgrove North construction compound (C1)
- Smith Park, located about 300 metres to the south east of the western surface works, across the East Hills, Airport and Inner West railway lines. The park includes netball courts and the Kingsgrove early childhood health centre
- Beverly Hills Park, located about 350 metres to the south east of the western surface works. The park contains a narrow strip of native vegetation (Sydney Turpentine-Ironbark Forest) and further to the south east, open space and tennis courts
- Several other smaller parks within around one kilometre of the western surface works.

Sensitive and other special land uses (zoned as SP1 Special Uses) around the western surface works include:

- McCallums Hill Public School, located about 700 metres to the north of the western surface works
- Brethren Church and an adjacent cemetery, located about 550 metres to the north of the western surface works
- Kingsgrove High School, located about 850 metres to the north east of the western surface works

- Regina Coeli Catholic Church and School, Beverly Hills Uniting Church and a Baptist Church, located between 1.3 kilometres and 1.5 kilometres to the south west of the western surface works
- Beverly Hills Girls High School and Beverly Hills North Public School, located on the western side of King Georges Road, around one to 1.5 kilometres to the west of the western surface works.

A small neighbourhood centre is located about 550 metres to the north of the western surface works, near Moorefields Road.

An important local business centre is located along Kingsgrove Road, to the south of the M5 East Motorway and straddling the boundary between the Hurstville and Rockdale LGAs. This local centre is around 300 metres to the east of the Commercial Road construction compound (C3), to the south of the East Hills, Airport and Inner West railway line. The local centre includes:

- Kingsgrove railway station
- Our Lady of Fatima Church and school
- St Ursula's College
- Kingsgrove Police Station
- Kingsgrove Post Office
- The South-West Chinese Christian Church.

Further details of sensitive receivers and community infrastructure located around the Western surface works are provided in the Technical working paper: Social and economic (**Appendix M**).

Table 13-2 Western surface works land use zonings and development

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Surface road works (M5 East Motorway integration works and western portals)				
M5 East Motorway integration works and western portals.	The site is zoned SP2 Infrastructure (Road) under the Canterbury and Hurstville LEPs.	Surface road construction works and continued operation of the M5 East Motorway.	Operational road infrastructure (the New M5 and the M5 East Motorway).	The site is located within the existing motorway corridor. For most of the length of the M5 East Motorway integration works, surrounding land is zoned and used for public recreation (RE1 Public Recreation under the Canterbury and Hurstville LEPs). In addition, at the western end of the integration works the site is flanked by: • Medium density residential areas (R3 under the Canterbury LEP) to the north • Low density residential areas (R2 Low Density Residential under the Hurstville LEP) to the south. Around the western portals, adjacent land is zoned and used for industrial development (IN2 Light Industrial under the Canterbury and Hurstville LEPs).
Construction ancillary facilities				
Kingsgrove North construction compound (C1).	Part of the site (within the existing motorway corridor) is zoned SP2 Infrastructure (Road) under the Canterbury LEP. Outside of the existing motorway corridor, the site is zoned RE1 Public Recreation. The eastern end of the site is zoned IN2 Light Industrial.	The site would be used as a construction compound for civil infrastructure works and tunnelling support activities.	The site would be rehabilitated and returned to use as public open space, or in areas currently zoned as N2 Light Industrial, the land may be made available for redevelopment.	The site is bounded to the north by land zoned and used for medium density residential (R3 Medium Density Residential under the Canterbury LEP) and to the south by land currently occupied by the M5 East Motorway (SP2 Infrastructure (Road)). The site interfaces with land zoned as RE1 Public Recreation (Canterbury Golf Course) in the west and IN2 Light Industrial in the east.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Kingsgrove South construction compound (C2).	The site is zoned IN2 Light Industrial under the Hurstville LEP.	The site would be used as a construction compound for civil infrastructure works.	Part of the site would be occupied by the Kingsgrove motorway operations complex (MOC1) (refer below). The remainder of the site would be rehabilitated and returned to use as public open space.	The site is bounded to the south by land zoned and used for light industry (IN2 Light Industrial under the Hurstville LEP) and to the north by land currently occupied by the M5 East Motorway (SP2 Infrastructure (Road)). A relatively thin strip of land associated with the Wolli Creek channel (RE1 Public Recreation under the Hurstville LEP) lies adjacent to the south west boundary of the site.
Commercial Road construction compound (C3).	The site is zoned SP2 Infrastructure (Road) under the Hurstville LEP.	The site would be used as a construction compound for tunnelling support activities.	The site would be rehabilitated and returned to use as public open space.	The majority of the site is surrounded by land zoned and used for light industry (IN2 Light Industrial under the Hurstville LEP). The exceptions are to the north, where the site is bounded by the M5 East Motorway (SP2 Infrastructure (Road)) and thin strip of land zoned RE1 Public Recreation along the motorway corridor. A small area of land zoned RE1 Public Recreation is also located to the south east of the site, adjacent to the site access point.
Operation ancillary facilities				
Kingsgrove motorway operations complex (MOC1).	The site is zoned IN2 Light Industrial under the Hurstville LEP.	The site would be occupied by the Kingsgrove South construction compound (C2).	Operational ancillary infrastructure associated with the Kingsgrove motorway operations complex (MOC1), including the western ventilation facility.	The site is bounded to the south by land zoned and used for light industry (IN2 Light Industrial under the Hurstville LEP) and to the north by land currently occupied by the M5 East Motorway (SP2 Infrastructure (Road)). A relatively thin strip of land associated with the Wolli Creek channel (RE1 Public Recreation under the Hurstville LEP) lies adjacent to the south west boundary of the site.

(blank page)

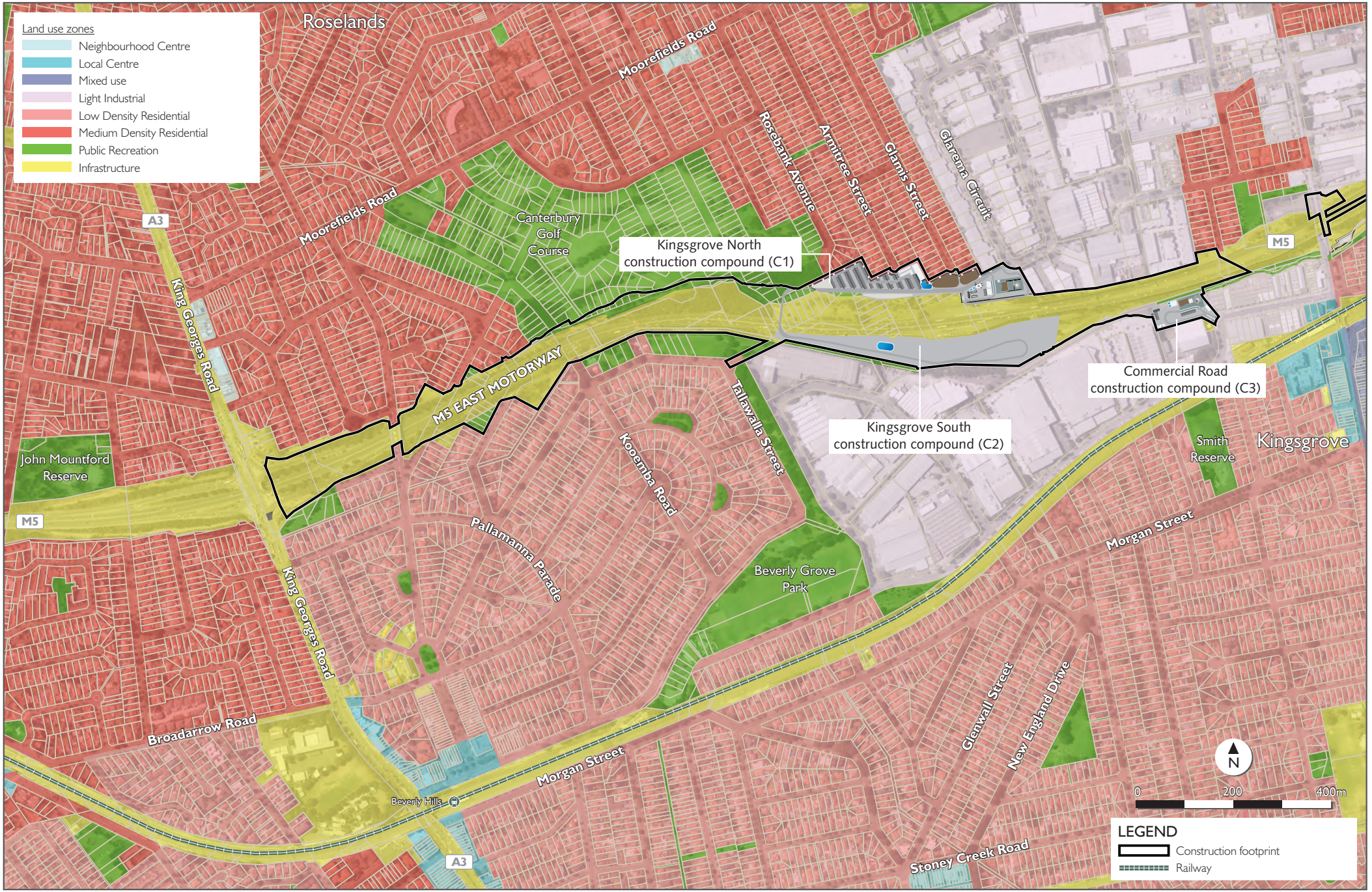


Figure 13-2 Western surface works land use zonings

(blank page)

Kingsgrove Road surface works

The Kingsgrove Road surface works are immediately east of the western surface works and would be located in a corridor along the M5 East Motorway, east of Kingsgrove Road. All land used for the Kingsgrove Road surface works is owned by Roads and Maritime Services. Land use zonings and development controls in this area are regulated under:

- The Canterbury LEP to the north of the M5 East Motorway
- The Hurstville LEP to the south of the M5 East Motorway
- The Rockdale LEP to the south of the M5 East Motorway.

The land use zonings within and around each the sites forming part of the Kingsgrove Road surface works are summarised in **Table 13-3**.

Existing land uses in the immediate vicinity of the Kingsgrove Road surface works include the M5 East Motorway corridor, the local and regional road network, residential lands and industrial lands. The East Hills, Airport and Inner West railway line passes in an east-west direction, about 300 metres to the south of the M5 East Motorway.

Public recreation areas and infrastructure located around the Kingsgrove Road surface works include:

- A shared pedestrian and bicycle path within a linear park located on the northern and southern side of the M5 East Motorway corridor. Construction of the tolling infrastructure may result in a temporary short term disruption, however there would be no impact on the path once construction has finished
- Forrester Reserve and Kingsbury Reserve, located adjacent and to the north of the M5 East Motorway
- Several other smaller parks within around one kilometre of the Kingsgrove Road surface works.

Sensitive and other special land uses (zoned as SP1 Special Uses) around the Kingsbury Road surface works include:

- Our Lady of Fatima Church, located about 230 metres to the south of the Kingsgrove Road surface works
- St Ursula's College, located about 350 metres to the south of the Kingsgrove Road surface works
- Kingsgrove High School, located about 450 metres to the north of the Kingsgrove Road surface works.

Table 13-3 Kingsgrove Road surface works land use zonings and development

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Construction and operation of tolling infrastructure				
Toll point on the M5 East Motorway at Kingsgrove Road	The site is zoned SP2 Infrastructure (Road) under the Canterbury LEP.	Construction and operation of toll gantries over the M5 East Motorway.	The site would continue to be used as a motorway.	The site is located within land zoned as SP2 Infrastructure (under both the Canterbury LEP and Rockdale LEP) and IN2 Light Industrial (under both the Canterbury LEP and Hurstville LEP). Areas of land zoned as RE1 Public Recreation (under Canterbury LEP and Rockdale LEP) are located adjacent to the M5 East Motorway.

Bexley Road surface works

The Bexley Road surface works would be located around the Bexley Road / M5 East Motorway interchange. Land use zonings and development controls in this area are regulated under the Canterbury LEP. Land to the south of the Bexley Road surface works is subject to the Rockdale LEP.

The land use zonings within and around each of the sites forming part of the Bexley Road surface works are summarised in **Table 13-4** and shown in **Figure 13-3**.

Existing land uses in the immediate vicinity of the Bexley Road surface works include the M5 East Motorway corridor and the M5 East Motorway western tunnel portals, the local and regional road network, residential lands, public recreation lands and land zoned for environmental conservation. The East Hills, Airport and Inner West railway line passes in an east-west direction to the south of the Bexley Road surface works, with the Bexley North railway station located on the railway line to the south east of the Bexley Road South construction compound (C5).

Public recreation areas and infrastructure located around the Bexley Road surface works include:

- Illoura Park / Wolli Creek corridor (which connects to the Wolli Creek Regional Park further east), located immediately to the east of the Bexley Road East construction compound (C6)
- Beaumont Reserve, across Poole Street to the north of the Bexley Road North construction compound (C4)
- Kingsgrove Avenue Reserve, immediately to the south of the Bexley Road South construction compound (C5)
- Kingsbury Reserve (within M5 Linear Park) located about 700 metres to the west of the Bexley Road surface works, on the northern side of the M5 East Motorway
- Junee Crescent Reserve located about 650 metres to the north west of the Bexley Road North construction compound (C4)
- SJ Harrison Reserve located about 800 metres to the north east of the Bexley Road East construction compound (C6)
- Stotts Reserve, about 600 metres south east of the Bexley Road East construction compound (C6)
- Bexley North Park and Gilchrist Reserve, which are located about 350 metres south of the Bexley Road South construction compound (C5). These public recreation areas contain the Kingsgrove Bexley North Community Centre in the north, and Bexley Bowls Club in the south
- Several other, smaller, parks within one kilometre of the Bexley Road surface works.

Sensitive and other special land uses (zoned as SP1 Special Uses) around the Bexley Road surface works include:

- Uniting Church on Miller Street, located about 850 metres north west of the Bexley Road North construction compound (C4)
- Clemton Park Public School, located about 750 metres to the north of the Bexley Road North construction compound (C4)
- Uniting Church on Barnsbury Grove, about 950 metres to the east of the Bexley Road East construction compound (C6)
- Booth College School for Christian Studies Bexley North, about 600 metres to the south-east of the Bexley Road South (C5) construction compound.

The Bexley North mixed use centre is located along Bexley Road, about 300 metres to the Bexley Road South construction compound (C5). The mixed use centre is an important local focus for commerce and is associated with the Bexley North railway station.

Further details of sensitive receivers and community infrastructure located around the Bexley surface works are provided in the Technical working paper: Social and economic (**Appendix M**).

Table 13-4 Bexley Road surface works land use zonings and development

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Construction ancillary facilities				
Bexley Road North construction compound (C4).	The site is zoned SP2 Infrastructure (Road) under the Canterbury LEP.	The site would be used as a construction compound for tunnelling support activities.	The site would be rehabilitated and returned to use as public open space.	The site is bounded by Bexley Road to the east and the M5 East Motorway to the south, both of which are zoned SP2 Infrastructure (Road) under the Canterbury LEP. Immediately to the west of the site is land zoned R3 Medium Density Residential, and to the east across Bexley Road is land zoned R2 Low Density Residential. A parcel of RE1 Public Recreation land (Beaumont Park) lies to the north of the site, across Poole Street.
Bexley Road South construction compound (C5).	The site is partly zoned IN2 Light Industrial and partly zoned SP2 Infrastructure (Road) under the Canterbury LEP.	The site would be used as a construction compound for tunnelling support activities.	The site would be occupied by the Bexley Road motorway operations complex (MOC2) (refer below).	The site is bounded by Bexley Road to the east and the M5 East Motorway to the north, both of which are zoned SP2 Infrastructure (Road) under the Canterbury LEP. Land to the south and west is zoned RE1 Public Recreation under the Canterbury and Rockdale LEPs and is associated with Kingsgrove Avenue Reserve and the Wolli Creek canal.
Bexley Road East construction compound (C6).	The majority of the site is zoned SP2 Infrastructure (Road) under the Canterbury LEP. Small areas of the site encroach onto land zoned R3 Medium Density Residential along the northern boundary of the site.	The site would be used as a construction compound for ancillary works and car parking.	The site would be rehabilitated and returned to use as public open space.	The site lies between land zoned SP2 Infrastructure (Road) to the west and south (Bexley Road and the M5 East Motorway), R2 Low Density Residential to the north, and E1 National Parks and Nature Reserves to the east (Illoura Park, as western part of the Wolli Creek corridor).

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Operation ancillary facilities				
Bexley Road South motorway operations complex (MOC2).	The site is partly zoned IN2 Light Industrial and partly zoned SP2 Infrastructure (Road) under the Canterbury LEP.	The site would be occupied by the Kingsgrove South construction compound (C2).	Operational ancillary infrastructure associated with the Bexley Road South motorway operations complex (MOC2), including the Bexley Road South emergency smoke extraction facility.	The site is bounded by Bexley Road to the east and the M5 East Motorway to the north, both of which are zoned SP2 Infrastructure (Road) under the Canterbury LEP. Land to the south and west is zoned RE1 Public Recreation under the Canterbury and Rockdale LEPs and is associated with Kingsgrove Avenue Reserve and the Wolli Creek canal.

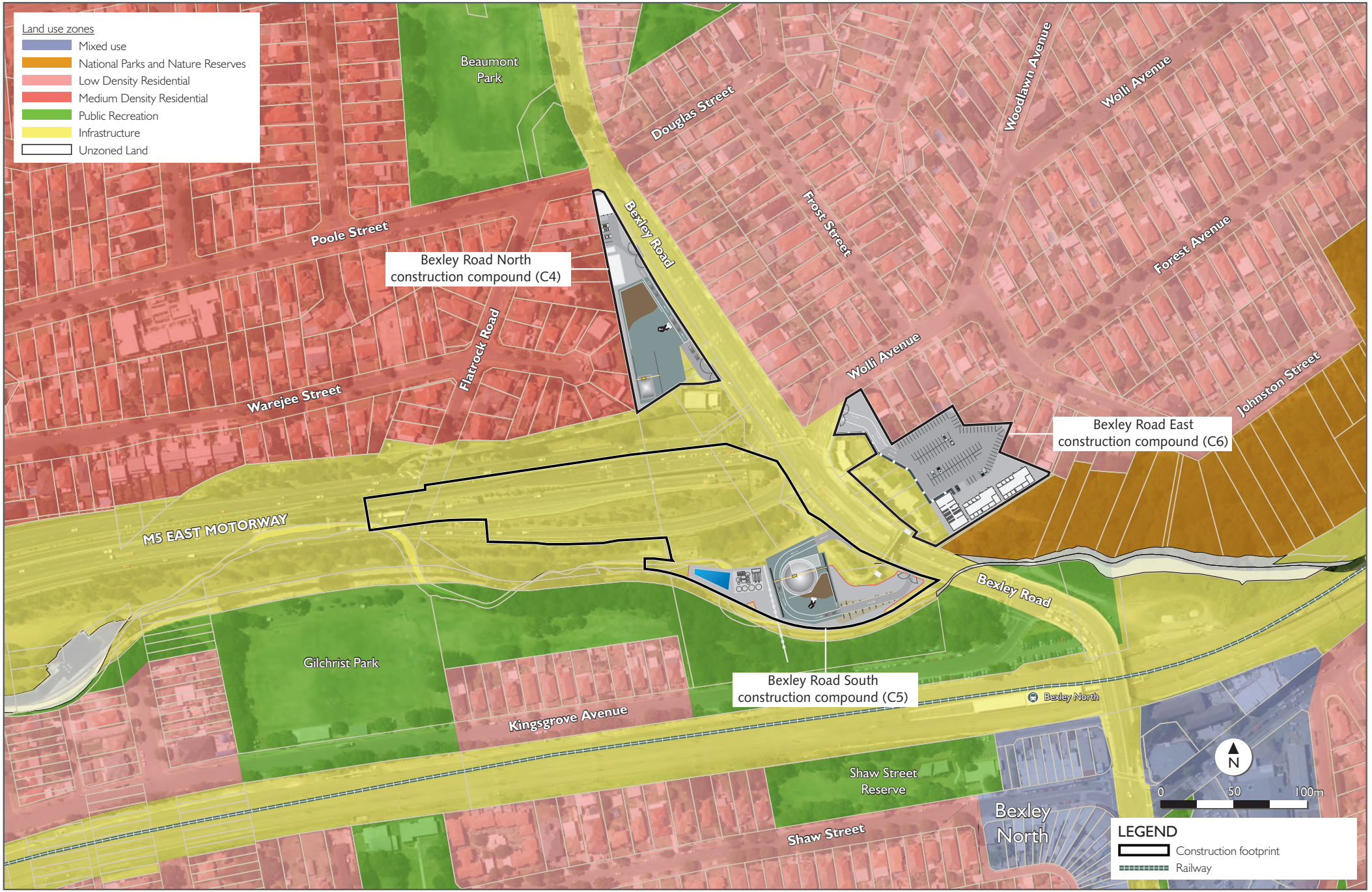


Figure 13-3 Bexley Road surface works land use zonings

(blank page)

Arncliffe surface works

The Arncliffe surface works would be located on land currently used as the Kogarah Golf Course. Land use zonings and development controls applicable to the Kogarah Golf Course (and to land south to around Bay Street) are detailed in the Cooks Cove SREP. Land around the golf course site is subject to Rockdale LEP south of the Cooks River and Marrickville LEP north of the Cooks River.

The Arncliffe surface works would be located on land intended for land use transition in the future. The site is currently occupied by the Kogarah Golf Course, but is zoned under the Cooks Cove SREP for future infrastructure (special uses), employment (trade and technology) and open space uses. Action has not been taken at this time to give effect to these proposed future uses of the site.

The land use zonings within and around each of the sites forming part of the Arncliffe surface works are summarised in **Table 13-5** and shown in **Figure 13-4.**

Existing land uses in the immediate vicinity of the Arncliffe surface works include the M5 East Motorway corridor, the local and regional road network, residential lands, public and private recreation lands.

Sydney Airport lies east of the site, across the Cooks River. The Main Southern railway line passes in a north-south direction west of the Arncliffe surface works, with the Arncliffe railway station located around 500 metres west of the Arncliffe construction compound (C7).

Public recreation areas and infrastructure located around the Arncliffe surface works include:

- Cahill Park immediately to the north of the Arncliffe surface works, across Marsh Street
- Tempe Recreation Reserve to north of the Arncliffe surface works, across the Cooks River
- Riverine Park to the south of the Arncliffe surface works, across the M5 East Motorway corridor
- Kyeemagh, Barton Park, Banksia Field, Muddy Creek and White Oak Reserves around 500 metres to one kilometre to the south, around Muddy Creek
- Arncliffe Park on Wollongong Road, around one kilometre to the west of the Arncliffe surface works
- Several other, smaller, parks within one kilometre of the Arncliffe surface works

Sensitive and other special land uses around the Arncliffe surface works include:

- St George Rowing Club to the north of the Arncliffe surface works, within Cahill Park and adjacent to the Cooks River
- Wolli Creek Islamic Mosque, around 400 metres to the west of the Arncliffe surface works
- Arncliffe Scots Sports and Social Club, around 600 metres to the west of the Arncliffe surface works
- Arncliffe Fire Station, around 400 metres to the south west of the Arncliffe surface works
- St Francis Xavier's Catholic Primary School around 650 metres to the south west of the Arncliffe surface works
- Arncliffe Public School, around 750 metres to the south west of the Arncliffe surface works.

Significant areas of commercial land use zonings and development stretch along a corridor to the west and south west of the Arncliffe surface works, from around Arncliffe in the north to around Rockdale in the south. These commercial areas area associated with the Princes Highway and the Main Southern railway line, with more extensive development located around the Rockdale town centre.

Further details of sensitive receivers and community infrastructure located around the Arncliffe surface works are provided in the Technical working paper: Social and economic (**Appendix M**).

Table 13-5 Arncliffe surface works land use zonings and development

Project site	Land use zoning	Use during construction	Use during operation	Surrounding land use zonings and developments
Construction ancillary facilities				
Arncliffe construction compound (C7).	The north of the site zoned Trade and Technology. The south of the site is zoned Open Space under the Cooks River SREP. A corridor zoned for Special Uses (as part of the historical F6 corridor) bisects the site.	The site would be used as a construction compound for civil infrastructure works and tunnelling support activities.	Part of the site would be occupied by the Arncliffe motorway operations complex (MOC3). The remainder would be rehabilitated and returned for ongoing recreational uses or potential development as a permissible use(s) under the Cooks Cove SREP (trade and technology, or open space).	The site is bounded along the north west by Marsh Road, which is zoned SP2 Infrastructure (Road) under the Rockdale LEP. Between Marsh Street and Cahill Park (zoned RE1 Public Recreation) are residential areas zoned as R2 Low Density Residential and R4 High Density Residential. Two pockets of B4 Mixed Use land are located adjacent to the southern boundary of Cahill Park, on the eastern and western sides of the high density residential area. The Cooks River is unzoned (subject to the Cooks River SREP). Land further to the east forms the Sydney Airport site, which is zoned SP2 Infrastructure (Airport) under the Rockdale LEP. To the south of the site, across the corridor occupied by the M5 East Motorway are areas zoned for Open Space under the Cooks River SREP. An area of R2 Low Density Residential is located along West Botany Street.
Operation ancillary facilities				
Arncliffe motorway operations complex (MOC3).	The north of the site zoned Trade and Technology. The south of the site is zoned Open Space under the Cooks River SREP. Land along the southern boundary of the site is zoned Special Uses.	The site would be occupied by the Arncliffe construction compound (C7).	Operational ancillary infrastructure associated with the Arncliffe motorway operations complex (MOC3), including the Arncliffe emergency smoke extraction facility and a ventilation facility.	The site is bounded along the north west by Marsh Road, which is zoned SP2 Infrastructure (Road) under the Rockdale LEP. Between Marsh Street and Cahill Park (zoned RE1 Public Recreation) are residential areas zoned as R2 Low Density Residential and R4 High Density Residential. Two pockets of B4 Mixed Use land are located adjacent to the southern boundary of Cahill Park, on the eastern and western sides of the high density residential area. Land immediately to the east of the site is zoned for Trade and Technology, and for Open Space under the Cooks Cove SREP. These zonings continue eastward until the unzoned Cooks River, and the Sydney Airport (SP2 Infrastructure (Airport)) beyond that. To the south of the site, across the corridor occupied by the M5 East Motorway are areas zoned for Open Space under the Cooks River SREP. An area of R2 Low Density Residential is located along West Botany Street.

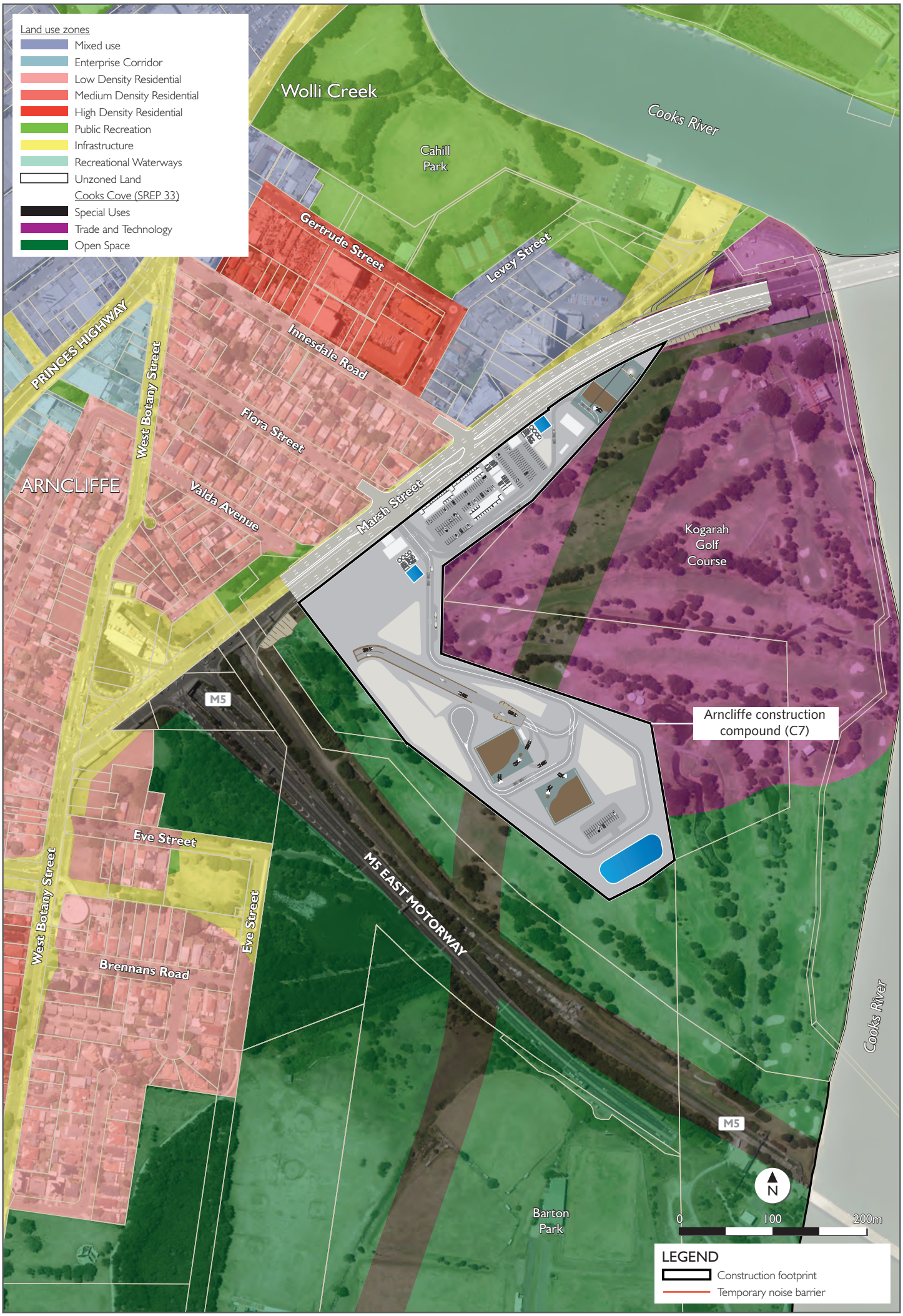


Figure 13-4 Arncliffe surface works and land use zonings

(blank page)

St Peters interchange and local road upgrade surface works

The St Peters interchange and local road upgrade surface works would be centred on the St Peters interchange (forer Alexandria Landfill site) and local roads around the south and east of Sydney Park. The St Peters interchange would span the local government boundary between Marrickville and Sydney that broadly bisects the Alexandria Landfill site in a north east to south west direction. Local road upgrade works would also cross the local government area boundary between Sydney and Botany Bay, which lies along Gardeners Road, to the east of Alexandra Canal.

Land use zonings and development controls in this area are regulated under:

- The Marrickville LEP for the western portion of the Alexandria Landfill site, and areas to the south and west.
- The Sydney LEP for the eastern portion of the Alexandria Landfill site, and areas to the north and east (and north of Gardeners Road).
- The Botany Bay LEP for areas to the south of Gardeners Road.

The land use zonings within and around each of the sites forming part of the St Peters interchange and local road upgrade surface works are summarised in **Table 13-6** and shown in **Figure 13-5**.

Existing land uses in the immediate vicinity of the St Peters interchange and local road upgrade surface works include the Alexandria Landfill (to be closed as part of the project), which currently occupies the majority of the St Peters interchange works site and industrial lands. Adjacent land uses include an enterprise corridor along the Princes Highway, general industrial lands, local and arterial roads, Sydney Park to the north and Alexandra Canal to the east. Surrounding land uses include the residential neighbourhoods of St Peters, Sydenham and Newtown, as well as general residential and industrial areas of Alexandria to the east.

Public recreation areas and infrastructure include:

- Sydney Park, in which the Sydney Park construction compound (C14) would be located, is to the north of the St Peters interchange
- Simpson Park, to the north of local road upgrade works along Campbell Street
- May Street Reserve, on the corner of May Street / Unwins Bridge Road / Campbell Street
- Camdenville Park, to the north of local upgrade works along Bedwin Road and to the west of May Street
- Roswell Playground, around 180 metres to the west of the Canal Road construction compound (C8) and the St Peters motorway operations complex (MOC4)
- Sydnenham Green, around 500 metres to the south west of the Canal Road construction compound (C8) and the St Peters motorway operations complex (MOC4).

Sensitive and other special land uses include:

- St Peters Public School, around 150 metres to the west of the St Peters interchange (former Alexandria Landfill) site
- The St Peters Church of England, around 150 metres to the west of the St Peters interchange (former Alexandria Landfill) site
- Camdenville Public School, around 250 metres to the north of local road upgrades at Bedwin Road.
- The Building Blocks Early Childhood, to the north of local road upgrade works along Bourke Road/ Bourke Street
- Hotel Ibis Budget, on the Princes Highway, immediately adjacent to the St Peters interchange (Alexandria Landfill) site.

An important commercial enterprise corridor is established along the Princes Highway, immediately to the west of the St Peters interchange and local road upgrade surface works. Other significant areas of commercial activity include those around the Bourke Road/ Bourke Street/ Gardeners Road intersection, and associated with the Sydney Airport.

Further details of sensitive receivers and community infrastructure located around the Arncliffe surface works are provided in the Technical working paper: Social and economic (**Appendix M**).

Table 13-6 St Peters interchange and local road upgrade surface works land use zonings and development

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Surface road works (St Peters interchange local road upgrades)				
St Peters interchange	Within the Marrickville LGA, the majority of the site is zoned IN1 General Industrial, with pockets of IN2 Light Industrial land in the north west and south west corners and a strip of B6 Enterprise Corridor along the Princes Highway frontage. Within the Sydney LGA, the site is a mix of SP2 Infrastructure (Road) and IN1 General Industrial land.	Surface road construction works.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped. Subject to future detailed design and the requirements of the future M4-M5 Link, parts of the site not required for road infrastructure may be contemplated for separate future redevelopment.	Most land to the north east, east and south of the site is zoned IN1 General Industrial, with some pockets of B7 Business Park located along Alexandra Canal to the north east and around Canal Road to the south east. The site is bounded to the east by an unzoned section of Alexandra Canal. A strip of B6 Enterprise Corridor land lies along the Princes Highway to the west of the site, beyond which land is mostly zoned R2 Low Density Residential with some areas of IN1 General Industrial and IN2 Light Industrial along the Main Southern Railway line. To the north of the site, the principal land use is Sydney Park (RE1 Public Recreation), with a triangle of R1 General Residential and B4 Mixed use land near the intersection of the Princes Highway and Campbell Street.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Upgrade and widening of Euston Road.	The site is zoned SP2 Infrastructure (Road) under the Sydney LEP for a short distance north of Campbell Road and north from the Sydney Park Road/ Huntley Street intersection. Between these areas, generally along Sydney Park, the site is zone IN1 General Industrial.	Surface road construction works and continued operation of local surface roads.	rastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Land along the eastern side of Euston Road is zoned IN1 General Industrial. Along the western side, zonings include RE1 Public Recreation (Sydney Park) south of Sydney Park Road and a combination of B4 Mixed Use and IN2 Light Industrial to the north of Sydney Park Road.
Upgrade, widening and extension of Bedwin Road / Campbell Street / Campbell Road.	Within the Marrickville LGA (from Bedwin Road east to the western boundary of Sydney Park), the site includes a mix of IN1 General Industrial, R1 Low Density Residential, RE1 Public Recreation, B4 Mixed Use and IN2 Light Industrial land use zonings. In these areas the existing road corridor has been zoned consistent with adjacent land use zonings. Within the Sydney LGA (west of the western boundary of Sydney Park), the site is zoned SP2 Infrastructure (Road). The land comprising Alexandra Canal is unzoned.	Surface road construction works and continued operation of local surface roads.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Bedwin Road is flanked by RE1 Public Recreation (Camdenville Park) to the north and IN1 General Industrial to the south. Land uses adjacent to Campbell Street are varied, with land along the south including R2 Low Density Residential west of the Princes Highway and a mix of B4 Mixed Use, IN1 General Industrial and IN2 Light Industrial to the east of the Princes Highway. Along its northern side including R1 General Residential, B4 Mixed Use, B7 Business Park and RE1 Public Recreation (Simpson Park). Campbell Road is generally surrounded by land zoned IN1 General Industrial and B7 Business Park. The key exceptions are Sydney Park (RE1 Public Recreation) to the north, and the unzoned section of Alexandra Canal.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Upgrade and widening of Bourke Road / Bourke Street.	The majority of the site is zoned IN1 General Industrial under the Sydney LEP, consistent with the zoning of adjacent land. The part of the site from the new intersection between the Campbell Road extension and Bourke Road/ Bourke Street south to Gardeners Road is zoned SP2 Infrastructure (Road).	Surface road construction works and continued operation of local surface roads.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Bourke Road is mainly adjacent to IN1 Industrial land, with some small areas of B7 Business Park and SP2 Infrastructure (Road) (at the site of the new intersection between the Campbell Road extension and Bourke Road). Bourke Street to the south of Gardeners Road is flanked by land zoned B4 Mixed Use.
Minor upgrade works on Unwins Bridge Road and May Street.	The site is partly zoned R2 Low Density Residential (Unwins Bridge Road) and partly zoned IN2 Light Industrial (May Street) under the Marrickville LEP, consistent with the zoning of adjacent land.	Surface road construction works and continued operation of local surface roads.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Unwins Bridge Road is adjacent to R2 Low Density Residential land to the east and a mix of IN1 General Industrial and IN2 Light Industrial land to the west. May Street is adjacent to Camdenville Park (RE1 Public Recreation), R2 Low Density Residential and B5 Business Development land use zonings to the west. To the east, it is adjacent to a mix of R1 General Residential, R2 Low Density Residential, B5 Business Development and B7 Business Park land use zonings.
Minor upgrade works on Albert Street.	The site is zoned a mix of B6 Enterprise Corridor, IN2 Light Industrial and IN1 General Industrial under the Marrickville LEP.	Surface road construction works and continued operation of local surface roads.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Albert Street is surrounded on both sides by a mix of B6 Enterprise Corridor, IN2 Light Industrial and IN1 General Industrial land.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Permanent road and intersection closures at: Harber Street Campbell Lane Woodley Street Holland Street The Campbell Road / Woodley Street intersection.	The site is zoned SP2 Infrastructure (Road) under the Sydney LEP.	Surface road closure works.	Disturbed areas would be rehabilitated and returned for permissible uses consistent with land use zonings or open space.	Road and intersection closures are surrounded by land zoned SP2 Infrastructure (Road).
Widening and extension of Gardeners Road.	The site is zoned SP2 Infrastructure (Road) under the Sydney LEP and Botany Bay LEP.	Surface road construction works and continued operation of local surface roads.	Operational road infrastructure. Disturbed areas adjacent to operational road infrastructure would be rehabilitated and landscaped consistent with the existing road corridor.	Gardeners Road is adjacent to IN1 Industrial land to the north, and B4 Mixed Use land to the south.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Construction ancillary facilities				
Canal Road construction compound (C8).	The site is zoned IN1 General Industrial and IN2 Light Industrial under the Marrickville LEP.	The site would be used as a construction compound for civil infrastructure works and tunnelling support activities.	Part of the site would be occupied by the St Peters motorway operations complex (MOC4) (refer below) and road infrastructure associated with the St Peters interchange. Disturbed areas adjacent to the motorway operations complex and operational road infrastructure would be rehabilitated and landscaped. Subject to future detailed design and the requirements of the future M4-M5 Link, parts of the site not required for the motorway operations complex and road infrastructure may be contemplated for separate future redevelopment.	Most land around the site is zoned IN1 General Industrial. A strip of B6 Enterprise Corridor land lies along the Princes Highway to the west of the site, beyond which land is mostly zoned R2 Low Density Residential with some areas of IN1 General Industrial and IN2 Light Industrial along the Main Southern Railway line.
Campbell Road construction compound (C9).	The site is zoned SP2 Infrastructure (Road) under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works.	The site would be rehabilitated and landscaped. Subject to future detailed design and the requirements of the future M4-M5 Link, parts of the site may be contemplated for separate future redevelopment.	The site fronts Campbell Road (zoned SP2 Infrastructure (Road)) to the north, beyond which is Sydney Park (RE1 Public Recreation). Other land around the site includes SP2 Infrastructure (Road) to the south east and IN1 General Industrial to the south west.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Landfill closure construction compound (C10).	The site is zoned IN1 General Industrial under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works, administration and Alexandria landfill closure works.	The site would be landscaped. Parts of the site not required for road infrastructure may be contemplated for separate future redevelopment.	The site is surrounded by IN1 General Industrial, and IN2 Light Industrial and B6 Enterprise to the north.
Burrows Road construction compound (C11).	The site is zoned SP2 Infrastructure (Road) and IN1 General Industrial under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works, administration and car parking.	The site would be used as the Burrows Road motorway operations complex (MOC5)	Most of the land around the site is zoned IN1 General Industrial, with the exception of land immediately to the north, which is zoned SP2 Infrastructure (Road).
Campbell Road bridge construction compound (C12).	The site is zoned IN1 General Industrial under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works.	The site would be rehabilitated and returned to use as public open space or other permissible uses.	Most of the land around the site is zoned IN1 General Industrial, with the exception of land immediately to the east, which is an unzoned portion of Alexandra Canal.
Gardeners Road Bridge construction compound (C13)	The site is zoned IN1 General Industrial under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works.	The site would be rehabilitated and returned to use as public open space.	Most of the land around the site is zoned IN1 General Industrial, with the exception of land immediately to the east, which is an unzoned portion of Alexandra Canal.
Sydney Park construction compound (C14)	The site is zoned RE1 Public Recreation under the Sydney LEP.	The site would be used as a construction compound for civil infrastructure works, administration and car parking.	The site would be rehabilitated returned to use as public open space or other permissible uses.	Land to the north is zoned as RE1 Public Recreation (Sydney Park) and SP2 Infrastructure (Road) to the south. Most of the remaining land is zoned as IN1 General industrial. Pockets of R1 (General residential) occur to the east and west.

Project site	Land use zoning of the project site	Use of the project site during construction	Use of the project site during operation	Surrounding land use zonings and developments
Operation ancillary facilities				
St Peters motorway operations complex (MOC4).	The site is zoned IN1 General Industrial and IN2 Light Industrial under the Marrickville LEP.	The site would be occupied by the Canal Road construction compound (C8).	Operational ancillary infrastructure associated with the St Peters motorway operations complex (MOC1), including the eastern ventilation facility.	Most land around the site is zoned IN1 General Industrial. A strip of B6 Enterprise Corridor land lies along the Princes Highway to the west of the site, beyond which land is mostly zoned R2 Low Density Residential with some areas of IN1 General Industrial and IN2 Light Industrial along the Main Southern Railway line.
Burrows Road motorway operations complex (MOC5)	The site is zoned SP2 Infrastructure (Road) and IN1 General Industrial under the Sydney LEP.	The site would be occupied by the Burrows Road construction compound (C11).	Operational ancillary infrastructure associated with the Burrows Road motorway operations complex (MOC5)	Most of the land around the site is zoned IN1 General Industrial, with the exception of land immediately to the north, which is zoned SP2 Infrastructure (Road).

(blank page)

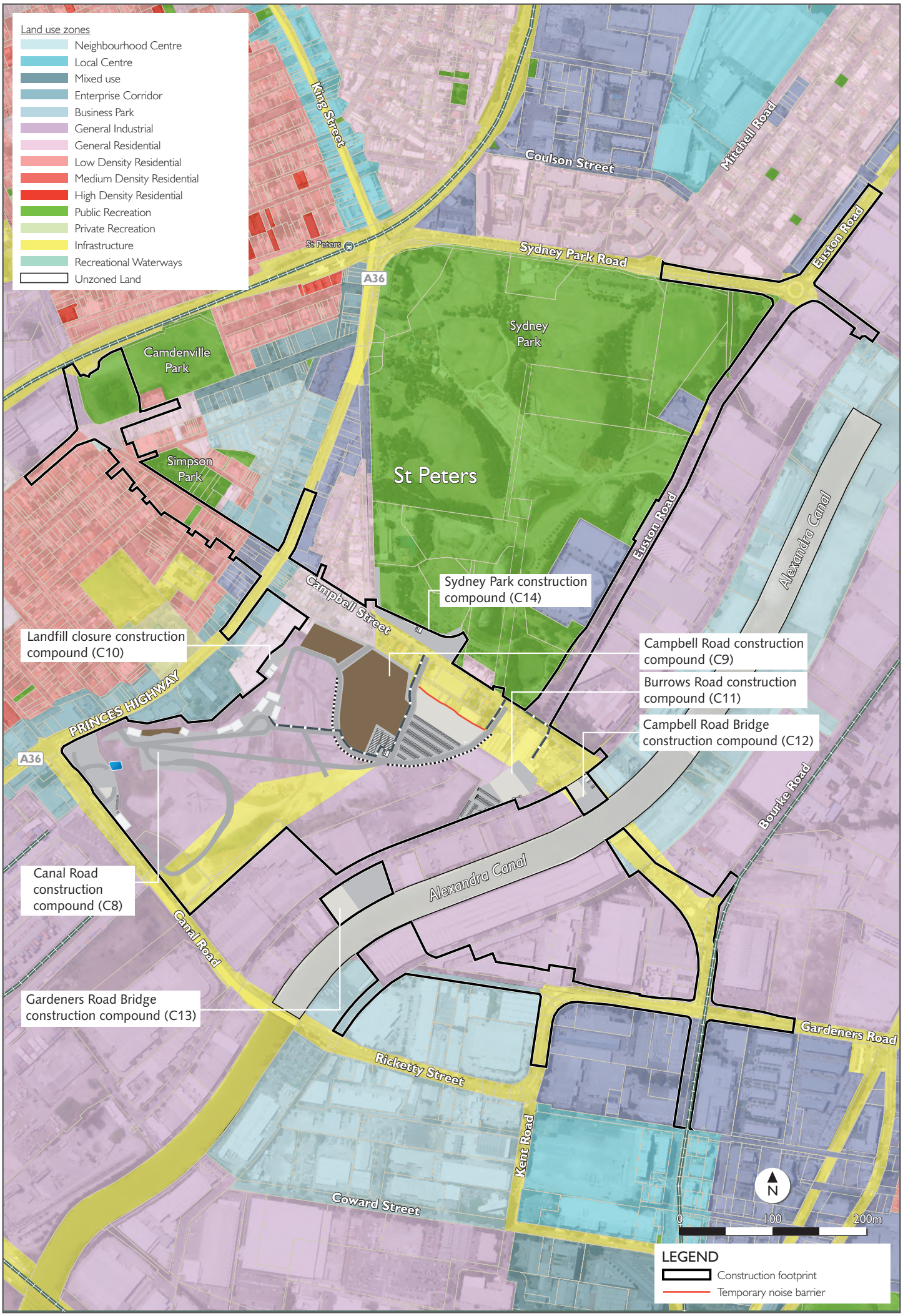


Figure 13-5 St Peters interchange and local road upgrade surface works land use zonings

(blank page)

13.3 Assessment of potential impacts

The preferred design for the project has been developed such that it minimises the need for surface property acquisition and other impacts to residential properties and public open space and reserves where reasonable and feasible to do so. This has been balanced with maximising opportunities for beneficial re-use of the properties required for construction that would be surplus to operational needs. Notwithstanding this design intent, construction and operation of the project would result in temporary and permanent impacts on land use and property.

Properties requiring acquisition to allow for the construction and operation of the project are referred to as directly affected land, and include:

- Properties requiring partial acquisition, where only a portion of the property is required
- Properties requiring full acquisition, where the majority of the property would be directly impacted by the project.

In the event that land is required that is not currently owned by the NSW Government, discussions would be held with the affected property owner concerning the purchase or lease of the land required during construction. All compulsory acquisition required for the project would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW). Relocation and some other categories of expenses would be claimable under this Act.

13.3.1 Construction

Potential land use and property impacts associated with construction of the project would include:

- Changes to land use and property resulting from acquisition of properties in order to construct the project
- Temporary alteration and / or temporary disruption to property accesses resulting from traffic diversions for road construction
- Temporary occupation of land, to allow for construction of the project, which would temporarily restrict the development potential of that land
- Settlement of the surface as a result of tunnelling activities.
- OEH estate reserved under the *National Parks and Wildlife Act 1974*

Potential indirect impacts as a result of changes to land use and property are considered to predominantly relate to social and economic values. **Chapter 15** (Social and economic) provides detail relating to these potential impacts.

OEH estate

The project would not directly impact any OEH estate reserved under the *National Parks and Wildlife Act 1974*. The project would be located upstream of the Towra Point Wetlands and therefore the following matters outlined in the *Guidelines for developments adjoining land and water managed by Department of Environment, Climate Change and Water* (DECCW 2010) were given consideration:

- Erosion and sediment control
- Stormwater runoff
- Wastewater

Erosion, sedimentation and drainage controls would be implemented during construction of the project and include construction water treatment plants, sediment fencing, check dams, temporary ground stabilisation, diversions berms or site regrading. These controls would be consistent with Managing Urban Stormwater – Soils and Construction Volumes 1 and 2, 4th Edition (the Blue Book) (Landcom, 2004).

Stormwater runoff and construction water would be diverted to water treatment plants that would treat construction water, surface water runoff and groundwater inflows. Based on the design of the project, it is anticipated that the discharged water quality would be higher than the current water quality of the receiving environments. Water quality of the treated construction wastewater and outflow velocities

would be in accordance with the requirements of the relevant agencies and local councils, including Sydney Water and the EPA. Water quality criteria and targets are provided in **Chapter 16** (Soil and water quality).

Residual impacts to downstream OEH estates are therefore considered to be unlikely and not significant. Further information relating to erosion and sediment control, stormwater runoff and construction wastewater quality criteria / targets can be found in **Chapter 16** (Soil and water quality) and **Chapter 18** (Flooding and drainage).

Temporary occupation

Temporary occupation of land would be required to allow for construction of the project. Occupation of land would restrict the development potential of that land for the duration of construction.

Table 13-7 summarises the potential implication of construction compounds and construction activities on existing land use zonings and development potential. Further assessment of residual lots during construction and operation is provided in **Section 13.2.1** and **Section 13.2.2.**

In most cases, land that is occupied for construction compounds and construction activities would be rehabilitated at the end of the construction period and returned for potential development for permissible uses under land use zoning provisions. The key exception would be where land used for construction purposes is required permanently such as for one of the five motorway operations complexes.

Where land affected by construction is not required for the ongoing operation of the New M5, it would be rehabilitated and made available for potential sale and/ or redevelopment for a permissible use. In some cases, including the Landfill closure construction compound site and the surplus land around the St Peters interchange, there may be an opportunity to review the current land use zoning of the affected land. The relevant local council would be consulted in these areas to determine whether current land use zonings and permissible land use types remain appropriate following construction of the New M5.

Temporary construction compounds located outside of the road reserve would occupy land temporarily, resulting in a temporary change in land use during construction works. Existing land uses, site accessibility and potential opportunities to co-locate construction compounds near or within the footprint of permanent operational facilities have been considered when determining the size and location of construction facilities.

The 30 properties (115 parcels of land) that would be directly impacted by construction are detailed in **Appendix D**. Some of these properties would also be directly impacted by operational infrastructure (refer to **Section 13.3.2**). Of these 30 properties:

- Five properties (51 parcels of land) are already owned by Roads and Maritime
- Four properties (6 parcels of land) are owned by other NSW Government agencies
- Six properties (7 parcels of land) are privately owned.
- Fifteen properties (51 parcels of land) are owned by Local Government.

Figure 13-6 to **Figure 13-9** show the land parcels currently anticipated to be directly impacted during construction of the project, including partial and full acquisitions. The extent of property acquisition would be reviewed and confirmed during detailed design of the project.

All acquisitions would be carried out consistently with the principles in the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the *Land Acquisition Information Guide* (Roads and Maritime, 2012c).

Existing uses and development of sites that would be directly impacted by construction and returned / modified to a non-project related land use include:

- Four properties that are currently not occupied by significant development and used for open space adjacent to the M5 East Motorway corridor (ie properties within M5 Linear Park)
- Three properties currently occupied by industrial developments
- Three properties currently used for the Kogarah Golf Course.

Temporary access impacts

Construction works and the location of temporary construction compounds may result in temporary impacts to access to adjacent properties. Impacts to property access would be avoided where possible, and where unavoidable, property owners would be consulted in order to develop an appropriate alternative access arrangement.

(blank page)



Figure 13-6 Western surface works - land parcels to be temporarily occupied for construction

(blank page)



Figure 13-7 Bexley surface works - land parcels to be temporarily occupied for construction

(blank page)



Figure 13-8 Arncliffe surface works - land parcels to be temporarily occupied for construction

(blank page)

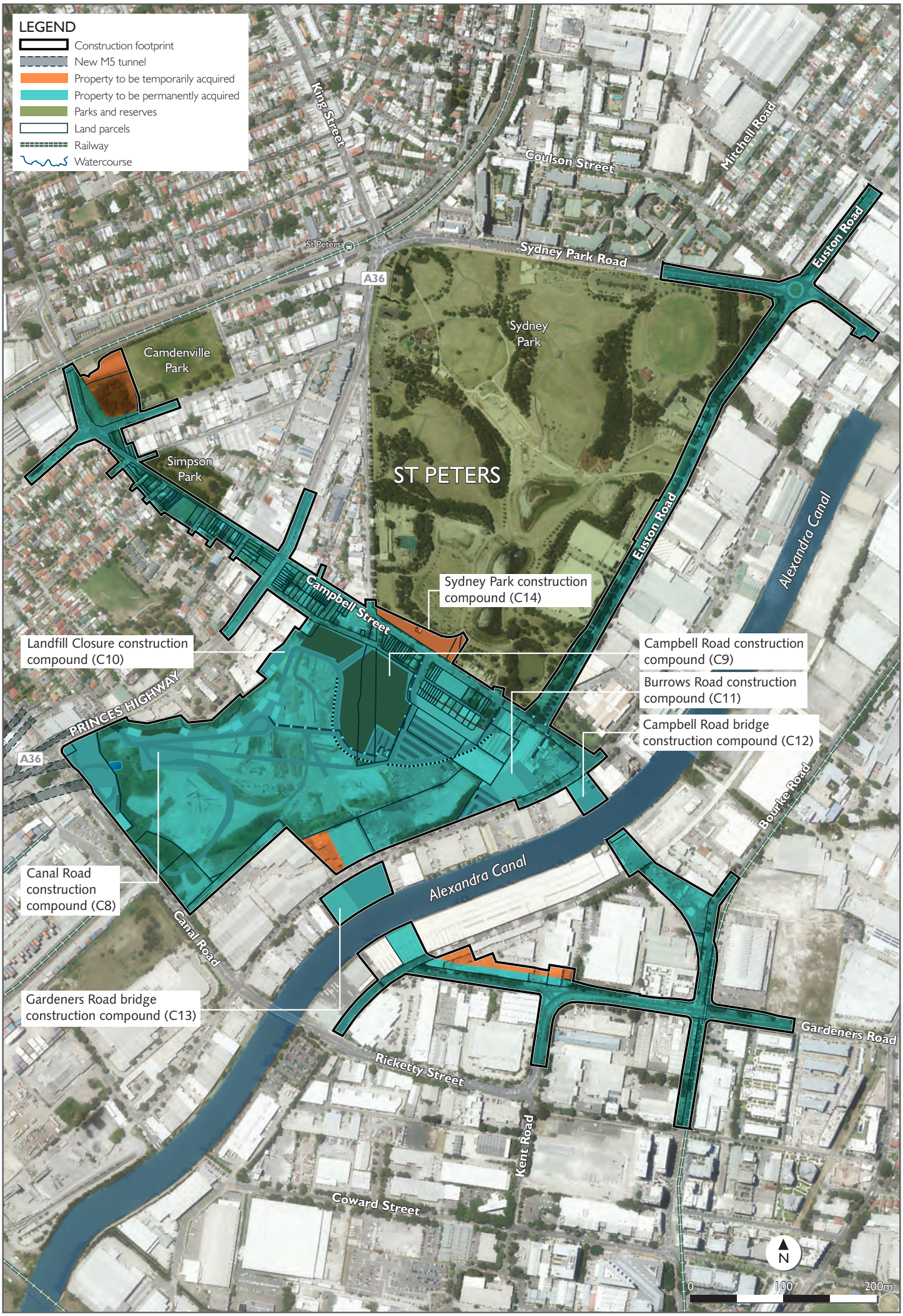


Figure 13-9 St Peters interchange and local road upgrades - land parcels to be temporarily occupied for construction

(blank page)

Table 13-7 Potential temporary impacts on land use and development potential

Project site	Potential impacts on land use and development potential
Western surface works	
M5 East Motorway integration works and western portals.	The M5 East Motorway integration works and construction of the western portals would be carried out within the existing motorway road reserve. These construction works would be consistent with the current and future use of the land as road infrastructure, and would not adversely impact on land use or development potential. The potential impact of the M5 East Motorway integration works and construction of the western portals is therefore not considered to be significant.
Kingsgrove North construction compound (C1).	The Kingsgrove North construction compound would be partly located within the existing M5 East Motorway corridor, and partly on land currently zoned and used for public recreation and light industrial development. The area of land currently used for public recreation (Beverly Grove Park) would not be available during construction of the project. Alternative pedestrian and bicycle access arrangements would be provided around the northern boundary of the construction compound during this period. The use of Beverly Grove Park would be temporarily restricted during construction, and would be rehabilitated and returned for public recreation at the end of construction. Other public recreation sites in the area, including Beverly Hills Park and Clemton Park would remain and would not be affected during construction. The potential impact to users is therefore considered to be not significant. The current zoning and use of Beverly Grove Park for public recreation limits the potential for development of the site for other permissible uses. The potential for construction of the project to significantly affect the development potential of the site would therefore be low. The eastern end of the Kingsgrove North construction compound would occupy land currently zoned and occupied by light industrial development. This light industrial development would need to be relocated, and current infrastructure on the site demolished in the initial stages of the construction program. The project would therefore restrict the use of this land for permissible uses, including as light industrial development, for the duration of the construction period. The majority of the site would be returned for use as light industrial and or other permissible development at the end of the construction period. Given the temporary duration of the construction works, impacts to this land used for light industrial development is not considered to be significant.
Kingsgrove South construction compound (C2).	The Kingsgrove South construction compound would affect land within the existing motorway road reserve (which includes M5 Linear Park). These construction works would be consistent with the current and future use of the land as road infrastructure, and would not adversely impact on land use or development potential. Impacts are therefore not considered to be significant.
Commercial Road construction compound (C3).	The Commercial Road construction compound would occupy land currently zoned and occupied by light industrial development. This light industrial development would need to be relocated, and current infrastructure on the site demolished in the initial stages of the construction program. The project would therefore restrict the use of this land for permissible uses, including as light industrial development, for the duration of the construction period. The site would be returned for use as light industrial and or other permissible development at the end of the construction period and therefore impacts are not considered to be significant.

Project site	Potential impacts on land use and development potential
Bexley Road surface works	
Bexley Road North construction compound (C4).	The Bexley Road North construction compound would affect currently undeveloped land within an existing road reserve. These construction works would be consistent with the current and future use of the land as road infrastructure, and would not adversely impact on land use or development potential. Impacts are therefore not considered to be significant.
Bexley Road South construction compound (C5).	The Bexley Road South construction compound would affect currently undeveloped land within an existing road reserve (which includes M5 Linear Park). These construction works would be consistent with the current and future use of the land as road infrastructure, and would not adversely impact on land use or development potential. Impacts are therefore not considered to be significant.
Bexley Road East construction compound (C6).	Most of the Bexley Road East construction compound would affect currently undeveloped land within an existing road reserve (which includes existing M5 East filtration plant). These construction works would be consistent with the current and future use of the land as road infrastructure, and would not adversely impact on land use or development potential. Impacts are therefore not considered to be significant. Those small areas of the compound that would encroach onto adjacent residential land would not affect existing developments on the land. There would be a temporary loss of development potential on the affected land for the duration of the construction works. As the construction works are only temporary, the impact is not considered to be significant.
Arncliffe surface works	
Arncliffe construction compound (C7).	The Arncliffe construction compound would be located on land currently used for the Kogarah Golf Course. Location of the construction compound on this site would affect the operation of the golf course and would require the golf course to operate as a 9 hole course rather than an 18 hole course for the duration of construction. The site is not currently developed for other permissible uses under the Cooks Cove SREP. The potential for such development would be restricted within the footprint of the construction compound for the duration of construction activities. Those parts of the disturbed site not required for the Arncliffe motorway operations complex (MOC3) would be rehabilitated and returned for potential future development consistent with land use zoning provisions. Therefore, impacts are not considered to be significant.
St Peters interchange and local road upgrade surface works	
St Peters interchange	The St Peters interchange would be located mostly on land currently used for the Alexandria Landfill. The potential continued operation of the landfill or other permissible industrial uses on the site would not be possible during construction. Surplus land on the site not used for road infrastructure in the future may be considered for redevelopment for a permissible use (which would not be for the purpose of continued landfilling).The change in land use is considered to be beneficial with land comprising road infrastructure, operational facilities, and open space. Part of the St Peters interchange would affect land subject to planning controls which expressly contemplate a road. The construction works on the site and the St Peters interchange itself are consistent with these controls and therefore the impact is not considered to be significant.

Project site	Potential impacts on land use and development potential
Local road upgrades	Most of the local road upgrades would be conducted on land currently zoned and used for road infrastructure. In some cases minor encroachment into attached land use zonings may be required during construction and for ancillary infrastructure (such as footpaths and bicycle paths) during operation. Local road upgrades would therefore be consistent with the current land use zoning and development of land in these areas. As the construction works are only temporary, the impact is not considered to be significant. In some cases, particularly with the Marrickville local government area, existing roads have adopted the land use zoning of adjacent residual land for example landscaping / open spaces / carks parks on Campbell Road. In these areas, the land affected by the project is currently occupied by or immediately adjacent to existing roads. Continued use of this land, in an upgraded form, would be consistent with current land use and development patterns and therefore impacts are not considered to be significant.
Canal Road construction compound (C8).	The Canal Road construction compound would be located on land currently used for the Alexandria Landfill and commercial / industrial purposes. The potential continued operation of the landfill or other permissible industrial uses on the site would not be possible during construction. Most of the construction compound site would be used for the St Peters motorway operations complex (MOC4) during operation and there would be limited potential for further development of the site in the future. The change in use is not considered to represent a significant adverse impact to the development potential of the land given the small land take of the motorway operations complex.
Campbell Road construction compound (C9).	The Campbell Road construction compound would be located on land currently used for the Alexandria Landfill, and subject to planning controls which expressly contemplate road infrastructure. The potential continued operation of the landfill would not be possible during construction. The closure of the Alexandria Landfill and use of the land for the construction of road infrastructure would be consistent with the current planning controls for the land on which the construction compound would be located. Potential impacts are therefore not considered to be significant.
Landfill closure construction compound (C10).	The Landfill closure construction compound would be located on the Alexandria Landfill and is currently zoned as General Industrial. The potential continued operation of the landfill would not be possible during construction. The existing hardstand area for the construction compound would be utilised for site office, amenities, laydown and material storage areas. Upon completion of the project the compound components would demobilise and landscaping would occur. Surplus land on the site may be considered for redevelopment for a permissible use (which would not be for the purpose of continued landfilling). The change in use following completion of the project is considered to be beneficial to the land. No significant adverse impacts are anticipated.
Burrows Road construction compound (C11).	The Burrows Road construction compound would be located on land currently used for commercial / industrial purposes. The potential continued operation of the landfill or other permissible industrial uses on the site would not be possible during construction. Surplus land on the site not subject to planning controls which expressly contemplate road infrastructure in the future may be considered for redevelopment for a permissible use (which would not be for the purpose of continued landfilling). The change in use following completion of the project is considered to be beneficial to the land. No significant adverse impacts are anticipated.
Campbell Road bridge construction compound (C12).	The Campbell Road bridge construction compound would be located on land currently zoned and occupied by industrial development. Use of the land for the construction compound would require relocation of the existing industrial operations and demolition of existing development on the site. Continued use of the site for these uses would not be possible during the construction period. The site would be rehabilitated and returned for potential future development of permissible uses under the land use zoning. As the construction works are only temporary, the impact on industrial operations is not considered to be significant.

Project site	Potential impacts on land use and development potential
Gardeners Road bridge construction compound (C13)	The Gardeners Road bridge construction compound would be located on land currently zoned and occupied by industrial development. Use of the land for the construction compound would require relocation of the existing industrial operations and demolition of existing development on the site. Continued use of the site for these uses would not be possible during the construction period. The site would be rehabilitated and returned for potential future development of permissible uses under the land use zoning. As the construction works are only temporary, the impact on land use and the development potential on the land is not considered to be significant.
Sydney Park construction compound (C14)	The Sydney Park construction compound would be located on land currently used for public recreation. Continued use of the site for permissible uses would not be possible during the construction period. The site would be rehabilitated and returned for potential future development of permissible uses under the current land use zoning (ie open space within Sydney Park). At the end of the construction period, the site would be rehabilitated. As the construction works are only temporary, the impact on recreational users is not considered to be significant.

Settlement and subsidence

Settlement along the tunnel route may occur in some areas as a result of volume loss during tunnel excavation, groundwater drawdown and subsequent ground consolidation. Areas most likely to be affected by settlement are usually where tunnelling is closest to the ground surface, around the main alignment tunnel portals and on and off ramps.

Settlement of the surface can create tensile strains in buildings above and around the settlement. The extent of settlement, and the resultant strains affecting buildings, has been calculated for the project. Affected buildings have been assigned an indicative damage category, from 'negligible' to 'very severe', based on the risk of damage to the buildings as a result of settlement. Damage categories of 'negligible' to 'slight' are acceptable as they represent potential aesthetic damage only (for example, minor cracking of plaster). Damage categories of 'moderate' to 'very severe' are related to serviceability and stability damage and therefore present significant risk of damage, potentially requiring major remedial works or demolition of the structure.

Further details of the settlement assessment and anticipated damage categories for reference buildings are provided in **Chapter 17** (Groundwater), in **Section 19.4.6**.

It is expected that settlement would stabilise within about two months of tunnel excavation occurring under a structure. A building condition survey would be undertaken within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface works.

Building condition surveys of potentially affected structures would be completed both before and after the works to identify existing damage and any damage due to the works. Where project induced settlement is deemed the cause of cracking, cracks would be filled, new external masonry cracks would be repointed for weather tightness, and depressions created by depressions would be rectified. A monitoring program would also be undertaken to ensure that settlement has stabilised before monitoring is completed.

Relocation of Utilities

It is likely that utilities and services located within or close to the project, including electricity, telecommunications (including optic fibre cables), sewer and water mains, would need to be relocated or realigned as part of construction of the project. This is particularly the case around areas of surface or shallow soil disturbance.

The nature and extent of utility changes would be confirmed during the detailed design of the project, with appropriate relocation or replacement alternatives identified in consultation with the relevant utility provider. A summary of utilities that have been identified that would be protected or require adjustment / relocation is provided in **Table 13-8**.

Changes to utilities outside of the project footprint would be subject to separate environmental assessment and approval processes. Details on the provision of utilities to supply the project can be found in **Chapter 5** (Project description).

Table 13-8 Changes to access for the local road upgrades

Zone	Service Authority	Summary of utilities potentially affected	Potential action
Western surface works	Ausgrid	Low-voltage supply for lighting on shared pathway	The asset would be relocated where affected by the works.
	Telstra	Optic fibre and copper cables	Combination of protect in place where feasible to do so and relocation.
	Sydney Water	Sewers	Combination of protect in place, where feasible to do so, and relocation.
Arncliffe surface works	Ausgrid	Low-voltage cables	The asset would be relocated where affected by the works.
	Jemena Gas	Steel secondary gas main	The asset would be protected in place.
	Sydney Water	Desalination pipeline	The asset would be protected in place.
	Telstra	Optic fibre and copper cable	The asset would be protected in place.
Main alignment tunnels	Gorodok	Ethane and ethylene gas pipeline	The project has been designed to avoid impacts to these assets.
	Jemena Gas	Gas main	The project has been designed to avoid impacts to these assets.
	Optus	Optic fibre cables	The project has been generally designed to avoid impacts to these assets. However, where avoidance is not possible, they would be protected in place.
	Shell	High pressure multi-product pipeline	The project has been designed to avoid impacts to these assets.
	Viva Energy	High pressure oil pipeline	The project has been designed to avoid impacts to these assets.
	Sydney Water	The South western suburbs ocean outfall sewer (SWSOOS) and five other sewers	The project has been designed to avoid impacts to the SWSOOS. Other sewers would be protected in place.
	Transgrid	330kV feeder cables	The project has been designed to avoid impacts to these assets.
St Peters interchange	Ausgrid	33kV and 132kV high voltage transmission cable	The asset would be protected in place
	Disconnections	Various gas, water, sewer, power and communications assets	Utility connections would be disconnected prior to demolition works.
	Jemena Gas	Gas main	The asset would be protected in place.
	Optus	Optic fibre cable	The asset would be protected in place.
	Sydney Water	Desalinisation pipeline, two sewers, and three water mains	The asset would be protected in place.
	Telstra	Optic fibre and copper cables	The asset would be protected in place.
	Transgrid	330kV high voltage cable	The asset would be protected in place.
Canal Road	AARNet	Optic fibre cable	The asset would be protected in place.
	Ausgrid	33kV and 132kV high voltage cables and a low voltage cable	The asset would be protected in place.
	Optus	Optic fibre cable	The asset would be protected in place.

Zone	Service Authority	Summary of utilities potentially affected	Potential action
	Sydney Water	Desalinisation pipeline and water mains	The asset would be protected in place.
	Telstra	Optic fibre and copper cable	The asset would be protected in place.
	Transgrid	330kV feeder cable	The project has been designed to avoid impacts to these assets. However, activities would be monitored and the assets would be protected in place where required.
Gardeners Road extension	AARNet	Optic fibre cable	The asset would be relocated where affected by the works.
	Ausgrid	132kV high voltage and low voltage cables	The 132kV transmission cable would be monitored and protected in place. Low voltage cables would be relocated.
	Jemena Gas	Secondary gas main and two nylon gas mains	An integrity test would be undertaken for the secondary gas main and permanent protection provided where necessary. The nylon gas mains would be relocated where required.
	Luminet	Optic fibre cable	The cable would be monitored and temporary protection provided during construction where necessary.
	NBN	Optic fibre cable	The assets would be monitored and either relocated where affected or protected in place during construction.
	Nextgen	Optic fibre cable	The assets would be monitored and either relocated where affected or protected in place during construction.
	Optus	Southern cross international optic fibre cable including cable station, and an ordinary optic fibre cable	Temporary or permanent protection would be provided as necessary for the Southern cross international optic fibre cable. The ordinary optic fibre cable would be relocated where affected by works, and monitored and protected in place for other locations.
	Pipe Networks	Optic fibre cable	The asset would be monitored and protected in place.
	Primus	Optic fibre cable	The asset would be monitored and protected in place.
	Sydney Water	Sewers and water mains	The assets would be monitored and either relocated/ re-laid where affected or protected in place during construction.
	Telstra	Optic fibre and copper cables	The assets would be monitored and either relocated where affected or protected in place during construction.
	Uecomm	Optic fibre cable	The assets would be monitored and either relocated where affected or protected in place during construction.
	Verizon	Optic fibre cable	The assets would be monitored and either relocated where affected or protected in place during construction.
	Vocus	Optic fibre cable	The assets would be monitored and either relocated where affected or protected in place during construction.

13.3.2 Operation

Potential impacts on land use associated with operation of the project would include:

- Permanent acquisition of properties
- Changes to site accessibility
- Formation of residual lots, with potential implications for the development potential of those lots.
- Changes to development patterns on the project's operational sites
- Implications for development patterns beyond the boundaries of the project's operational sites.

Properties required for the project

A number of properties would be required to accommodate the following operational components for the project:

- Around the western portals, where the existing motorway road corridor needs to be widened
- The five motorway operations complexes for the project, at Kingsgrove (MOC1), Bexley Road (MOC2), Arncliffe (MOC3), St Peters (MOC4) and at Burrows Road (MOC5)
- The St Peters interchange works
- In some areas along local road upgrade works, where road widening or realignment works extend beyond the existing road reserve and/ or road infrastructure footprint.

There are 143 properties (364 parcels of land) that would be directly impacted by operational infrastructure. These are detailed in **Appendix D** and consist of:

- Thirty nine properties (218 parcels of land) already owned by Roads and Maritime
- Six properties (10 parcels of land) to be acquired from other NSW Government agencies
- Seventy six properties (102 parcels of land) to be acquired from private owners
- Five properties are owned by utility providers (6 parcels of land)
- Seventeen properties (28 parcels of land) are owned by councils.

Figure 13-10 to **Figure 13-13** show the properties currently anticipated to be directly impacted during operation of the project. Where a property is not owned by Roads and Maritime, full or partial acquisition of the property would be required. The extent of property acquisition would be reviewed and confirmed during detailed design of the project.

All acquisitions would be undertaken consistently with the principles in the *Land Acquisition (Just Terms Compensation) Act 1991* and the *Land Acquisition Information Guide* (Roads and Maritime, 2012c).

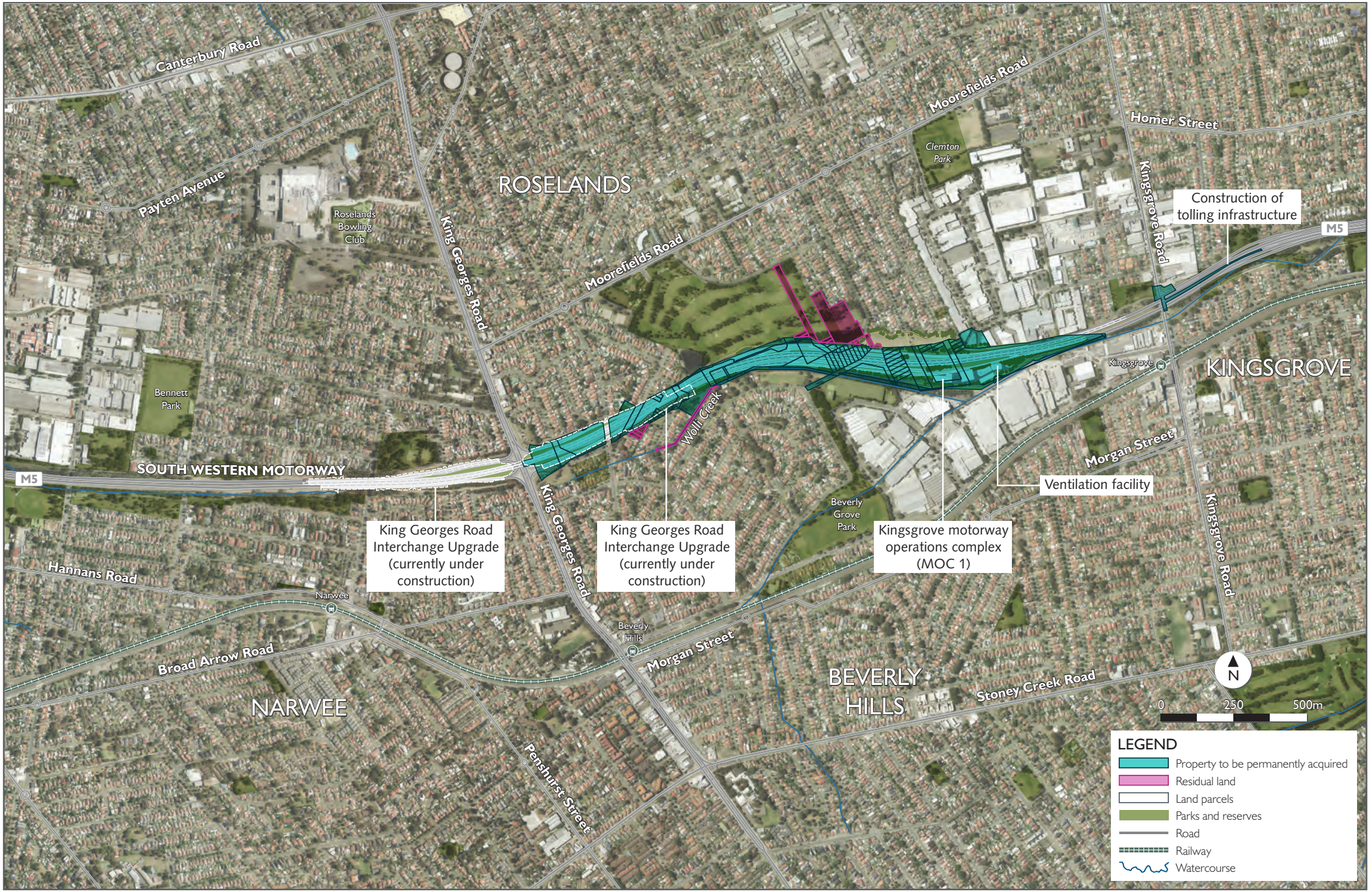


Figure 13-10 Land parcels to be permanently acquired for operation around the Western surface works

(blank page)



Figure 13-11 Land parcels to be permanently acquired for operation around the Bexley surface works

(blank page)



Figure 13-12 Land parcels to be permanently acquired for operation around the Arncliffe surface works

(blank page)



Figure 13-13 Land parcels to be permanently acquired for operation around the St Peters interchange

(blank page)

Subsurface acquisition

In addition to the properties affected by surface activities, land (or interests in land such as easements) below the surface of the ground would be acquired. This is called subsurface acquisition and is illustrated in **Figure 13-14**.

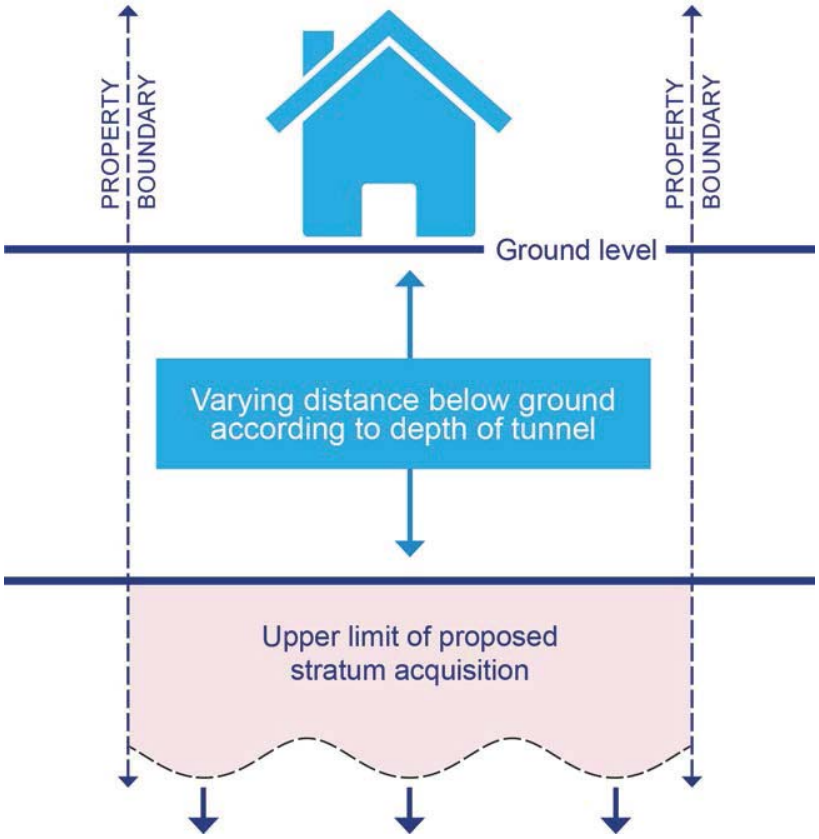


Figure 13-14 Example of sub-surface stratum acquisition

The *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) provides that compensation is not payable for the majority of subsurface acquisition of land or easements, unless specific circumstances as detailed in that Act apply. Appendix C of the Roads and Maritime *Land Acquisition Information Guide* (Roads and Maritime 2014d) sets out in detail the compensation provisions of the Act relating to subsurface acquisition.

In most cases, subsurface acquisition would not affect the future use of property at the surface. Subject to council regulations and approvals, property owners would generally be able to:

- Carry out improvements such as installing a swimming pool
- Dig deeper foundations for a new building or second storey additions
- Undertake property development.

All property acquisition requirements would be confirmed during detailed design.

Changes to accessibility

The operation of the project has the potential to restrict local access and connectivity between the various land uses around the surface components of the project. Restrictions are most likely to occur at the western surface works, St Peters interchange and local roads upgrades.

The western surface works would be located within a linear infrastructure corridor, which already contains the M5 East Motorway. Therefore, the main impacts of the project on connectivity of land would be along the corridor during construction within the M5 Linear Park. Following completion of construction, access to the linear pedestrian and cycle paths would be reinstated and therefore the project is unlikely to generate connectivity impacts at the western surface works during operation.

The project has the potential to restrict access and connectivity around the St Peters interchange and local roads upgrades. The project has been designed to enhance pedestrian and cyclist access around the St Peters interchange and would connect with existing cycle paths to Sydney Park via a Campbell Road pedestrian and cyclist bridge.

The property adjustments required for the local road upgrades consist typically of driveway adjustments / extensions to suit the realignment of Euston Road, Campbell Street / Campbell Road and Gardeners Road. Where the works have an impact on a structure such as a residential or commercial building, it is generally assumed that the entire property has been acquired. The exception is along Euston Road and Gardeners Road at St Peters where the partial demolition of buildings would be required on some properties.

The details of property adjustments required for the local road upgrades are provided in **Table 13-9**.

Table 13-9 Changes to access for the local road upgrades

Location	Changes to access arrangements
225 Euston Road	Modification of existing driveway to suit Euston Road widening
215 Euston Road	Modification of existing driveway to suit Euston Road widening
201 Euston Road	Modification of existing driveway to suit Euston Road widening
Camdenville Park (corner of Bedwin Road and May Street)	Upgrade of existing access to suit modification to basin
67 Campbell Street	Extension of concrete driveway to suit new kerb line
65 Campbell Street	Extension of concrete driveway to suit new kerb line
63 Campbell Street	Extension of concrete driveway to suit new kerb line
61 Campbell Street	Extension of concrete driveway to suit new kerb line
59 Campbell Street	Extension of concrete driveway to suit new kerb line
129 Pacific Highway	Extension of concrete driveway to suit new kerb line
36 Burrows Road	Provision of new concrete driveway to suit new kerb line resulting from the modifications to the Campbell Road / Burrows Road intersection
200 Bourke Road	Minor adjustments likely to suit new road alignment
697 Gardeners Road	Site split by new connection between Gardeners Road and St Peters interchange Access for southern portion of site via Venice Street to Ricketty Street Access for northern portion of site via new intersection on Campbell Road extension
691 Gardeners Road	Access from Gardeners Road would be left-in-left-out only. Traffic would exit site via Venice Street to Ricketty Street Modification of concrete driveway to suit new local roads arrangements
566 Gardeners Road	Existing western property access to be closed Modification of concrete driveway at eastern end of site required to suit new kerb line

Location	Changes to access arrangements
562 Gardeners Road	Modification of concrete driveway at eastern end of site required to suit new kerb line
538 Gardeners Road	Modification of concrete driveway at eastern end of site required to suit new kerb line
530 Gardeners Road	Modification of concrete driveway at eastern end of site required to suit new kerb line
520 Gardeners Road (Bunnings Mascot)	Modification to two existing accesses to suit widening of Bourke Road and Gardeners Road Modification of existing car park following partial acquisition
655 Gardeners Road	There is currently no access off Bourke Street for this property. However, the widening works would result in the loss of existing parking areas on the property, and would potentially narrow the driveway along the eastern side of the property. This may restrict access to the rear of the property and may require access off Bourke Street to be provided.
Sydney Park	Provision of a new pedestrian and cyclist access across Campbell Road into Sydney Park (Campbell Road pedestrian and cyclist bridge)
1 Ricketty Street	Modification of existing access arrangements following the construction of Venice Street including a new access off Venice Street

Formation of residual lots

Residual lots are the fragments of a property left over when part of the property is acquired or occupied by development. There are two types of residual lots that would be generated:

- Surplus lots that are the left over parcels of land that were acquired or occupied during construction, but are not required for operational infrastructure. Surplus lots provide an opportunity for future development, either for a similar use of the site prior to construction of the project, or a different use depending on the land use zoning of the land
- Residual lots that are the left over parcels of land when only part of a property is acquired for construction or operation of the project. Many local environmental plans place restrictions on the minimum size of lots that can be developed for specified uses, so the number and size of residual lots are an important consideration.

Surplus lots that remain following construction of the project would, in most cases, be rehabilitated and sold or otherwise made available for development consistent with permissible land uses. In some cases, for example the surplus land around the St Peters interchange (ie Sydney Park construction compound (C14)), there may be an opportunity to review the current land use zoning of the affected land. The relevant local council would be consulted in these areas to determine whether current land use zonings and permissible land use types remain appropriate following construction of the New M5.

For the purposes of assessing any potential change in the permissible use of residual land, **Table 13-10** sets out the minimum subdivision sizes in the LGAs where there would be residual land. Larger minimum lot sizes exist in other areas within the relevant LGAs. However, for those areas impacted by the project these are the identified minimum lot sizes. Minimum subdivision sizes have not been adopted in the LEPs of Marrickville, Botany Bay and Sydney.

Table 13-10 Relevant minimum lot sizes

LGA	Relevant minimum lot size (square metres)
Canterbury	460
Hurstville	450
Marrickville	Not available
Rockdale	450
Botany Bay	Not available
Sydney	Not available

Where residual lots remain that are smaller than the minimum lot requirements set by the relevant LEP, the following options would be considered:

- Where lots are adjacent to each other, the lots may be able to be combined to create a lot area suitable for development
- Where lots are not adjacent to each other, the lots may be incorporated into the road reserve landscaping
- Opportunities to sell smaller lots to adjacent land owners may also be investigated.

Table 13-11 lists the residual lots which would be left over when a property is partially acquired outside the road reserve, the relevant zoning, the residual lot size and whether this complies with the minimum lot size restrictions under the provisions of the applicable environmental planning instrument.

Table 13-11 Residual lots

Lot number	Land use zoning	Minimum lot size (square metres)	Approx. residual land size (square metres)	Complies with minimum lot size?
Western surface works				
1/DP1079064	RE1 Public Recreation	460 (Canterbury LEP)	175	No
1/DP224270	RE1 Public Recreation	460 (Canterbury LEP)	15,305	Yes
1/DP456521	RE1 Public Recreation	460 (Canterbury LEP)	5,562	Yes
1044/DP13705	SP2 Infrastructure	460 (Canterbury LEP)	384	No
1045/DP13705	SP2 Infrastructure	460 (Canterbury LEP)	482	Yes
34/DP15737	RE1 Public Recreation	460 (Canterbury LEP)	502	Yes
41/DP1076996	SP2 Infrastructure	460 (Canterbury LEP)	485	Yes
N/A	RE1 Public Recreation	450 (Hurstville LEP)	280	No
43/DP15737	RE1 Public Recreation	460 (Canterbury LEP)	195	No
44/DP15737	RE1 Public Recreation	460 (Canterbury LEP)	404	No
5/DP1038625	RE1 Public Recreation	450 (Hurstville LEP)	235	No
6/DP1038625	RE1 Public Recreation	450 (Hurstville LEP)	128	No
7/DP1038625	RE1 Public Recreation	450 (Hurstville LEP)	26	No
711/DP13496	RE1 Public Recreation	450 (Hurstville LEP)	665	Yes
N/A	R2 Low Density Residential	460 (Canterbury LEP)	47	No
29/DP1076996	R2 Low Density Residential	460 (Canterbury LEP)	1,883	Yes
Arncliffe surface works				
1/DP108492	Non-Standard	450 (Rockdale LEP)	121,130	Yes
1/DP329283	Non-Standard	450 (Rockdale LEP)	17,024	Yes
14/DP213314	Non-Standard	450 (Rockdale LEP)	28,893	Yes
St Peters interchange and local road upgrades				
1/DP1040114	RE1 Public Recreation	Not adopted (Sydney LEP)	1288	N/A
1/DP543708	B4 Mixed Use	Not adopted (Sydney LEP)	1380	N/A
16/DP270785	SP2 Infrastructure	Not adopted (Sydney LEP)	1090	N/A
17/DP270785	B7 Business Park	Not adopted (Sydney LEP)	4577	N/A
2/DP543708	B4 Mixed Use	Not adopted (Sydney LEP)	1322	N/A
3/DP543708	B4 Mixed Use	Not adopted (Sydney LEP)	1530	N/A
52/DP605290	RE1 Public Recreation	Not adopted (Sydney LEP)	13,415	N/A
6/DP810522	RE1 Public Recreation	Not adopted (Sydney LEP)	12,559	N/A
80/DP1033767	RE1 Public Recreation	Not adopted (Sydney LEP)	5,636	N/A
9/DP879483	RE1 Public Recreation	Not adopted (Marrickville LEP)	31,969	N/A
SP62691	IN1 General Industrial	Not adopted (Sydney LEP)	4,611	N/A

Lot number	Land use zoning	Minimum lot size (square metres)	Approx. residual land size (square metres)	Complies with minimum lot size?
1/DP1056652	SP2 Infrastructure	Not adopted (Marrickville LEP)	41,894	N/A
81/DP1033767	RE1 Public Recreation	Not adopted (Sydney LEP)	564	N/A
2/DP1105933	RE1 Public Recreation	Not adopted (Sydney LEP)	69	N/A
2/DP775391	RE1 Public Recreation	Not adopted (Sydney LEP)	419	N/A
1/DP864698	RE1 Public Recreation	Not adopted (Sydney LEP)	6,973	N/A
SP36878	IN1 General Industrial	Not adopted (Sydney LEP)	13,614	N/A
SP45388	IN1 General Industrial	Not adopted (Sydney LEP)	6,568	N/A
2/DP547069	IN1 General Industrial	Not adopted (Sydney LEP)	24,926	N/A
B1/DP430291	IN1 General Industrial	Not adopted (Sydney LEP)	4,152	N/A
1/DP397364	B4 Mixed Use	Not adopted (Botany Bay LEP)	3,250	N/A
1/DP405527	IN1 General Industrial	Not adopted (Sydney LEP)	1,193	N/A
100/DP864502	IN1 General Industrial	Not adopted (Sydney LEP)	18,601	N/A
A/DP430291	IN1 General Industrial	Not adopted (Sydney LEP)	7,962	N/A
101/DP864502	IN1 General Industrial	Not adopted (Sydney LEP)	4,250	N/A
12/DP606737	IN1 General Industrial	Not adopted (Sydney LEP)	3141	N/A
1/DP91123	IN1 General Industrial	Not adopted (Sydney LEP)	37,664	N/A

Changes to development patterns – project operational sites

Within its operational surface footprint, the project would result in a change in some land use to be consistent with road infrastructure. The operational surface footprint has been generally located along existing roads, and within existing infrastructure corridors, so that the new infrastructure would generally be consistent with the surrounding land use.

Closure of the Alexandra Landfill, as part of the project, would result in a positive land use change by re-using the site as the St Peters interchange. The redevelopment of this site would also enhance pedestrian and cycle path connectivity between Sydney's south and Sydney Park as well as providing an opportunity to create additional public open space. The Campbell Road cycle and pedestrian bridge and local road upgrades have been designed to avoid impacts to the development of City of Sydney's City Farm.

The project would occupy a portion of the Kogarah Golf Course during construction and operation. The construction footprint has been minimised so that nine holes would remain open during construction and reduce impacts on the recreation value of the land. The footprint of the permanent facilities has been restricted and appropriately sited to minimise impacts to the future use or development potential of the golf course site.

Additional offset habitat for the Green and Golden Bell Frog would be required. The ongoing use of this land as habitat would need to be considered in the future land use planning for this area. However, the use of the land as habitat is consistent with the surrounding land use, which is for public recreation. **Chapter 21** (Biodiversity) provides further detail on the offset habitat requirements.

Changes to development patterns – around project operational sites

The project has the potential to affect or influence development in three key ways:

- For development at ground level, through changes in existing amenity around surface components of the project
- For receivers above ground level (for example, residential receivers on higher floors of residential buildings) in proximity to the project's ventilation outlets
- For operation of the nearby Sydney Airport.

Ground level development

Potential changes in amenity for ground level receivers have been assessed in the relevant parts of this EIS, including **Chapter 9** (Traffic and transport), **Chapter 10** (Air quality, in particular **Section 10.4**), **Chapter 12** (Noise and vibration), **Chapter 14** (Visual impacts and urban design) and **Chapter 18** (Flooding and drainage). In each case, the impacts of the project on local amenity have been demonstrated as manageable within acceptable limits subject to the application of appropriate mitigation and management measures. These mitigation and management measures are outlined in each chapter, and summarised in a consolidated form in **Chapter 28** (Summary of environmental management measures).

The project would result in an increase in flood levels for the Probable Maximum Flood (PMF) event in the vicinity of Canterbury Golf Course (refer to Chapter 18) (Flooding and drainage)). The increase in flood levels during the PMF would constrain development in at least one residential property, in Elouera Street, Beverley Hills. This property would be constrained from being developed as a vulnerable land use such as a child or aged care facility as these land uses are restricted in land affected by the PMF.

The ventilation facilities for the project would be located as far from existing residential dwellings as possible. The operation of the ventilation facilities would not prevent continued use of surrounding land for residential and related purposes. The potential air quality impacts and human health impacts associated with the ventilation facilities are discussed in **Section 10.8** of **Chapter 10** (Air quality) and **Chapter 11** (Human health).

Notwithstanding, it is recognised that decisions will be made by individual landowners about existing and future developments based on their own assessment of the impacts presented in this EIS. Such individual assessments may affect decisions around land development beyond the outcomes of the statutory environmental impact assessment of the project.

The provision of a new motorway standard connection between St Peters and Kingsgrove, and the possible future connection to the rest of the WestConnex program of works, is likely to increase the desirability of residential, commercial and industrial developments particularly around motorway access points. This improved connectivity and reduced traffic congestion may make some areas more desirable for living and working than is currently the case. Changes in desirability are likely to gradually affect the nature and scale of development around key project connection points over time.

Elevated receiver locations

The project has the potential to influence development patterns for existing and future elevated receiver locations (for example, those receivers within multi-storey residential buildings) as a consequence of operation of the project's ventilation outlets. Elevated receivers have the potential to experience higher air quality impacts because emissions from the ventilation outlets have less time to disperse compared with potential impacts at ground level. **Section 10.8** of **Chapter 10** (Air quality) includes an assessment of potential air quality impacts for ground level and elevated receiver locations.

The future development of land (including re-zonings) in the vicinity of the ventilation facilities that may involve multi-story buildings would need to consider the air dispersion performance of the Arncliffe ventilation facility. Roads and Maritime would assist local councils, or the Department of Planning and Environment (in relation to Cooks Cove), in determining any relevant land use considerations applicable to future development for inclusion in local environmental plans or development control plans, where required.

Potential impacts on elevated receivers are relevant around:

- The Kingsgrove ventilation facility. Development patterns and height restrictions for developments in this area are regulated under the Hurstville LEP and the Canterbury LEP. Current building height controls applying around the Kingsgrove ventilation facility are:
  - Most development is residential and limited to a height of 8.5 metres (in Canterbury LGA) or nine metres (in Hurstville LGA). This is equivalent to two storeys plus a roof structure

- Land occupied by the Canterbury Golf Course and the industrial areas around Garema Circuit in the Canterbury LGA are currently not subject to statutory building height controls
- The industrial areas around The Crescent in the Hurstville LGA have a building height limit of 10 metres
- The business and medium density residential development in Hurstville LGA, along King Georges Road between the railway line and Stoney Creek Road, is limited in height to 10 metres (residential development) and 15 metres (business development). These building heights are equivalent to around three to four storeys

- The Arncliffe ventilation facility. Development patterns and height restrictions for developments in this area are regulated under the *Rockdale Local Environmental Plan 2011* and *Sydney Regional Environmental Plan No. 33 – Cooks Cove*. Current building height controls applying around the Arncliffe ventilation facility are:
  - Land currently occupied by the Kogarah Golf Course is restricted to six storeys, except within 120 metres of the Cooks River where the building height limit is five storeys. The Cooks Cove (SREP) allows for one building within the Trade and Technology Zone to be up to 11 storeys provided it is not closer than 10 metres from the zone boundary. In addition to statutory environmental planning controls, development will need to satisfy the requirements for safe operation of the Sydney Airport including restrictions on intrusion into regulated airspace
  - Land immediately around to and the west of the ventilation facility is zoned for low or medium density residential development and is restricted to a building height of 8.5 metres (two storeys plus roof structure)
  - Business and medium to high density residential development along the Princes Highway to the west of the ventilation facility and further west towards the railway line, is limited in height to 14.5 metres, increasing to 28 metres near the intersection of the Princes Highway and Wickham Street/ Forest Road. This is around four to nine storeys in height
  - To the north, where West Botany Street meets the Princes Highway, building heights are limited to 28 to 29.5 metres for residential development with some building height limits up to 46 metres for business development. This is around nine to 15 storeys
- The St Peters ventilation facility. Development patterns and height restrictions for developments in this area are regulated under the *Marrickville Local Environmental Plan 2011* and the Sydney LEP. Current building height controls applying around the Arncliffe ventilation facility are:
  - Development around the ventilation facility and within the Sydney LGA (to the north and east) is generally industrial in nature and subject to an 18 metre building height limit. Some areas along the Alexandra Canal have building height limits up to 22 metres.
  - There are no statutory building height limits that apply to Sydney Park.
  - Most land immediately around the St Peters ventilation facility in the Marrickville LGA is not currently subject to a statutory building height limit. Residential development further to the west, between the Princes Highway and Unwins Bridge Road is limited to a building height of 9.5 metres, which is around two storeys plus a roof structure.

Refer to **Section 10.8** of **Chapter 10** (Air Quality) for further information on potential impacts to elevated receivers.

Operation of the Sydney Airport

As detailed in Section 5.8.2 the air quality within longitudinally ventilated road tunnels is most effectively and efficiently managed through a ventilation outlet located at the end of the tunnel, as close as reasonably possible to the tunnel portal. In the case of the New M5, which includes twin road tunnels, this means a ventilation outlet at each end of the project as close as possible to the tunnel portals would be the optimum approach to management of in tunnel air quality.

The St Peters ventilation facility, located near the eastern tunnel portals, would be situated on land that is regulated to ensure the ongoing safe operation of the Sydney Airport. In this area, restrictions are placed on the height of structures as well as the velocity of discharges from activities such as road tunnel ventilation facilities and industrial emissions stacks. Through detailed consultation with the Civil Aviation Safety Authority (CASA) during the development of the ventilation design for the project, WDA has identified that operation of a single ventilation outlet at St Peters near the eastern portals could not at the same time comply with both:

- The discharge velocity / air turbulence requirements to ensure safe ongoing operations at Sydney Airport without the potential for changes being required to aircraft operations.
- The ventilation requirements of the project to ensure acceptable in tunnel air quality and good dispersion of ambient emissions.

For this reason, an additional ventilation outlet is required at Arncliffe (the Arncliffe ventilation facility, in the south-western corner of the Kogarah Golf Course site). This approach would allow both in tunnel and ambient air quality requirements to be met, without compromising the safety of aircraft operations at Sydney airport.

The operation of three ventilation facilities is a necessary and unavoidable requirement, driven by a balanced approach to minimising environmental and land use impacts while avoiding adverse impacts on airspace and the viable operation of Sydney Airport. Details of the *Airports Act 1996* is provided in **Section 2.4.2**.

13.4 Environmental management measures

Development of the project would minimise the requirement for property acquisition, by optimising the use of land already owned by Roads and Maritime, or otherwise already identified for a future road. Notwithstanding, the project would impact on land use and property through the full and partial acquisition of properties, impacts to access and changes to land use planning requirements for future developments. **Table 13-12** provides the environmental management measures that would be implemented through the construction and operational phases of the project to minimise potential impacts.

Table 13-12 Environmental management measures – land use and property

Impact	No.	Environmental management measure	Timing
Construction			
Full and partial acquisition	LP01	The relevant property owners would be consulted in relation to the acquisition of properties required to facilitate construction of the project. Acquisition would be undertaken consistently with the principles in the Land Acquisition Information Guide (Roads and Maritime, 2012) and the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW).	Construction
Property access	LP02	Prior to any impact to access, alternative arrangements would be negotiated with the affected parties in order to enable continued access and to minimise disruption as much as reasonably possible.	Pre-construction and construction

Impact	No.	Environmental management measure	Timing
	LP03	Affected property owners and community facilities would be provided with advanced notification of relevant project schedules, construction works and changes to access arrangements.	Construction
	LP04	Community updates would be provided on changes to the local road network within the project area during construction.	Construction
	LP05	Appropriate signage would be provided advising of walking track closures and alternative walking routes.	Construction
Settlement	LP06	A Settlement Monitoring Plan would be prepared that would provide details on: • Location of monitoring points • Duration of monitoring • Data collection and review • Roles and responsibilities for review of data • Triggers and actions for corrective actions.	Construction
	LP07	Building condition surveys would be undertaken on properties and structures within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface.	Construction
	LP08	Services in locations where differential / angular settlement is anticipated would be identified. A monitoring plan, triggers and actions would be agreed with the utilities owner prior to potential impacts occurring	Construction
	LP09	A monitoring program, undertaken as part of the Settlement Management Plan, would be undertaken to ensure that settlement has stabilised before monitoring is completed.	Construction
Utilities	LP10	Utilities requiring adjustment or relocation would be confirmed during detailed design and would be adjusted according to utility provider requirements.	Detailed design / preconstruction
Operation			
Permanent acquisition	OpLP01	Land acquisition for the project would be undertaken consistently with the principles in the Land Acquisition Information Guide (Roads and Maritime, 2012c) and the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW).	Detailed design / preconstruction
Loss of land use and property access	OpLP02	Property accesses that are affected as a result of the project would be reinstated in consultation with the affected landowners including relocation if required.	Detailed design / construction

(blank page)

14 Visual impacts and urban design

This chapter provides an assessment of the urban design, landscape character and visual amenity implications associated with the project. The Technical working paper: Landscape character and visual impact and the Urban design report have been prepared, and are provided in **Appendix K** and **Appendix L**. This chapter provides a summary of those documents and an assessment of the potential impacts of the project.

Table 14-1 sets out the Secretary's Environmental Assessment Requirements (SEARs) as they relate to urban design, landscape character and visual amenity, and notes where these have been addressed in the environmental impact statement (EIS).

Table 14-1 SEARs – urban design, landscape character and visual amenity

SEARs	Where addressed
A consideration of the urban design and visual amenity implications of the proposal, including supporting infrastructure, during construction and operation. The assessment must identify urban design and landscaping objectives to enhance the ventilation stacks, interchanges, tunnels, 'cut and cover' arrangements, consider resulting residual land and treatments, and demonstrate how the proposed hard and soft urban design elements of the proposal would be consistent with the existing and desired future character of the area traversed affected by the proposal.	Potential impacts to visual amenity during the construction and operation phase are provided in **Sections 14.3.1** and **14.3.2**. Urban design and landscaping objectives are provided in **Section 14.1.3** and Sections 3.1 and 3.3 of **Appendix L**. Consideration of the existing and desired future character of the area is provided in **Sections 14.1.1** and **14.3.2**.
Identification of opportunities to utilise surplus or residual land, and utilise key structures (such as stacks) for multiple uses ie integration with other structures.	Refer to **Sections 14.3.1**, **14.3.2**, **13.2.1** and **13.2.2**.
Evaluation of the visual impacts and urban design aspects of the proposal (and its components) on surrounding areas, and consistency with the urban and landscape design of the M5 East Motorway and WestConnex Urban Design Corridor Framework.	Refer to **Section 14.1.3**.
A consideration of impacts on views and vistas, streetscapes, key sites and building, and direct amenity impacts (such as proximity and overshadowing).	Refer to **Sections 14.3.1** and **14.3.2**.
Details of urban design and landscape mitigation measures, having regard to the urban design and landscape objectives for the proposal.	Refer to **Section 14.4**.
Measures to manage lighting impacts both during construction and operation, in particular lighting of the St Peters interchange and impacts on the operation of Sydney Airport.	Refer to **Section 14.4**.
Artists' impressions and perspective visualisations of the proposal from a variety of locations along and adjacent to the route.	Refer to **Section 14.3.2**, and Section 5.2 to 5.6 of **Appendix L** and Section 6 of **Appendix K**.

14.1 Assessment methodology

The urban design, landscape character and visual amenity impact assessment within this chapter has been undertaken in accordance with the *Environmental Impact Assessment Practice Note: Guidelines for Landscape Character and Visual Impact Assessment* (Roads and Maritime, 2013b), the *WestConnex Urban Design Corridor Framework*, and *Beyond the Pavement: Urban Design Policy Procedures and Design Principles* (Roads and Maritime, 2014c). Further guidelines used to inform this impact assessment include:

- Bridge Aesthetics: Design guidelines to improve the appearance of bridges in NSW (Roads and Maritime, 2012)
- Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (Roads and Traffic Authority, 2011)
- Noise Wall Design Guideline: Design guidelines to improve the appearance of noise walls in NSW (Roads and Traffic Authority, 2006)
- Shotcrete Design Guidelines – Design guidelines to avoid, minimise and improve the appearance of Shotcrete (Roads and Traffic Authority, 2005b)
- *Designing to Minimise Vandalism* (Final Draft) (Roads and Traffic Authority, 2008a)
- Landscape Guideline: Landscape design and maintenance guidelines to improve the quality, safety and cost effectiveness of road corridor planting and seeding (Roads and Traffic Authority, 2008)

The assessment comprised three components: an urban design assessment, a visual assessment and a landscape character assessment.

Key steps in the urban design, landscape character and visual amenity impact assessment included:

- Analysis of the landscape and visual context, including:
  - Assessment of the existing landscape character and visual environment
  - Definition of landscape character zones
  - Identification of potential views to the project during construction and operation
- Summary of the policy and planning setting
- Identification of urban design and landscape objectives
- Assessment of potential impacts and benefits during construction and operation
- Identification of reasonable and feasible mitigation measures.

Aboriginal and non-Aboriginal heritage items were also considered as although they may not be directly affected by the project, they may be indirectly impacted through physical and visual encroachment into curtilage areas, and changes to the heritage context of the landscape. Visual impacts to Aboriginal heritage have been assessed in **Sections 23.3.1** and **23.3.2**. Visual impacts to non-Aboriginal heritage items have been assessed in Section 8.7 and Table 60 of the Technical working paper: Non-Aboriginal heritage (**Appendix R**), and are summarised in **Sections 20.3.1** to **20.3.3**.

14.1.1 Analysis of the landscape and visual context

Assessment of the existing environment

The existing landscape and visual environment along the project has been assessed through a desktop review of aerial photography, geographic information system (GIS) mapping of topography and vegetation, land use mapping and site inspections. A description of the existing landscape and visual environment is provided in **Sections 14.2.1** to **14.2.4**.

An assessment of the visibility of key project elements from surrounding areas has been facilitated through the use of a visual envelope model. The visual envelope model uses GIS mapping to plot areas which would be able to see the highest point of the major portion of each project element. The GIS map contains landform, generally without consideration of land cover such as trees or houses, which may provide screening.

Definition of landscape character zones

In order to assess potential landscape character impacts, the project corridor has been divided into separate areas, with each assigned one of five landscape character zones as follows:

- Residential
- Industrial
- Recreational
- Transport corridor
- Urban centre
- Commercial corridor.

These landscape character zones relate to the existing environment prior to constructing the project and are summarised in **Table 14-6**. The landscape character zones have been identified based on areas of landscape with similar characteristics or strongly defined spatial qualities, visually distinct from adjoining areas. As the majority of the project comprises underground infrastructure, the landscape character zones have focused on surface areas.

Operational components of the project are described in detail in **Section 14.3.2**. The potential impacts on landscape character as a result of the operation of the project are assessed in **Table 14-14**. Works undertaken as part of the construction stage have also been assessed for landscape character impacts.

Identification of potential views to the project

The assessment of visual impacts is based on viewpoints or the viewshed within which project components may be seen. Key project components which may be visible during construction and operation include:

- Construction:
  - Construction activities and construction disturbance areas
  - Construction ancillary facilities, such as temporary construction compounds
- Operation:
  - The Kingsgrove motorway operations complex (MOC1) and western surface works
  - Bexley Road South motorway operations complex (MOC2)
  - Arncliffe motorway operations complex (MOC3)
  - The St Peters interchange and local road upgrades, and the St Peters and Burrows Road motorway operations complexes (MOC4 and MOC5).

The visual impact assessment and night lighting assessment in **Sections 14.3.1** and **14.3.2** have considered potential views of these key project components during construction and operation.

14.1.2 Policy and planning setting

The policy and planning setting for the project and its potential landscape and visual impacts has been established based on the following regional planning documents and relevant Local Environment Plans (LEPs):

- Sydney Regional Environmental Plan No. 33 – Cooks Cove, a deemed State Environmental Planning Policy
- Princes Highway Corridor Strategy 2013 (Rockdale City Council, 2013)
- Hurstville Local Environment Plan 2012 (Hurstville LEP 2012)
- Canterbury Local Environment Plan (Canterbury LEP 2012)
- Rockdale Local Environment Plan (Rockdale LEP 2011)
- Sydney Local Environment Plan (Sydney LEP 2012)
- Marrickville Local Environment Plan (Marrickville LEP 2011).

The Cooks Cove Growth Centre is a 100 hectare precinct, which is bounded by the Cooks River and Muddy Creek, Marsh Street, West Botany Street and Bestic Street. It is subject to *Sydney Regional Environmental Plan No. 33 – Cooks Cove*. Preliminary strategies identified an area for employment uses near Marsh Street with the remainder of the site to be set aside for conservation, open space and recreational purposes. Planning for the site is now being handled by the Urban Growth Development Corporation. However, it is understood that the Department of Planning and Environment (DP&E) is investigating the site as a potential priority precinct, which may result in changes to the current land use zonings. Future development of land (including re-zoning) in the vicinity of the ventilation facility that involves multi-storey buildings would need to consider the air dispersion performance of the facility.

The Princes Highway Corridor Strategy, an initiative of Rockdale City Council, was adopted by the Council in late 2013. The strategy focuses on revitalising the corridor within the Rockdale local government area for employment uses and growing the Arncliffe town centre. This strategy recommends changes to the distribution of residential, mixed use and business zones, as well as increased densities.

The desired future character of the area has been informed by the strategic direction provided in these documents. Existing land use zonings and the desired character of these zonings are summarised in **Table 14-2**. Details of potential land use and property impacts are provided in **Sections 13.2.1** to **13.2.2** (Land use and property) of the EIS.

Table 14-2 Land use zonings within areas of the project

Area of project	Description of land use zoning
Western surface works	The M5 East Motorway corridor is zoned as SP2 Infrastructure under both the Hurstville LEP 2012 and the Canterbury LEP 2012. This zoning reflects the desire to maintain accessibility, supporting economic activity and efficient freight movement. The land to the north of the M5 East Motorway and western surface works area is zoned as RE1 Public Recreation, R3 Medium Density Residential, IN2 Light Industrial under the Canterbury LEP 2012. The land to the south of the M5 East Motorway and western surface works area is zoned as R2 Low Density Residential and IN2 Light Industrial, with some pockets of RE1 Public Recreation under the Hurstville LEP 2012. This zoning reflects the desire to maintain the existing low-medium density residential character and suburban setting of the area, with pockets of bushland.

Area of project	Description of land use zoning
Bexley Road surface works	The M5 East Motorway and Bexley Road are zoned as SP2 Infrastructure under the Canterbury LEP 2012. This zoning reflects the desire to maintain accessibility, supporting economic activity and efficient freight movement. North of the M5 East Motorway and west of Bexley Road is zoned as R3 Medium Density Residential and some pockets of RE1 Public Recreation under the Canterbury LEP 2012. East of Bexley Road is zoned as R2 Low Density Residential, E1 National Parks and Nature Reserves and some pockets of RE1 Public Recreation under the Canterbury LEP 2012. This zoning reflects the desire to maintain the existing low-medium density residential character and bushland setting of the area. South of the M5 East Motorway and west of Bexley Road is zoned as R2 Low Density Residential, RE1 Public Recreation, and SP2 Infrastructure (along the East Hills railway line) under the Canterbury LEP 2012. This zoning reflects the desire to maintain the existing low density residential character and bushland setting of the area, while maintaining accessibility.
Arncliffe surface works	East of the Kogarah Golf Course is Sydney Airport which is zoned as SP2 Infrastructure under the Rockdale LEP 2011. This zoning reflects a desire to maintain accessibility, supporting economic activity, tourism and efficient freight movement.Marsh Street and West Botany Street, to the north and west of the Kogarah Golf Course, are zoned as SP2 Infrastructure under the Rockdale LEP 2011. This zoning reflects the desire to maintain access and connectivity between local centres of employment and economic activity. The north of the Kogarah Golf Course, along Marsh Street, is zoned as R2 Low Density Residential, B4 Mixed Use, R4 High Density Residential and RE1 Public Recreation under the Rockdale LEP 2011. This zoning reflects the desire to maintain the residential character of the area along with integrated business development and recreational areas, in keeping with the *Sydney Regional Environmental Plan No. 33 – Cooks Cove* and the *Princes Highway Corridor Strategy.* The west of the Kogarah Golf Course, along West Botany Street, is zoned as R2 Low Density Residential. This zoning reflects the desire to maintain the existing low density residential character of the area.
St Peters interchange and local road upgrades	The Princes Highway is zoned as SP2 Infrastructure under the Rockdale LEP 2011 and Campbell Road is zoned as SP2 Infrastructure under Sydney LEP 2012. Canal Road is also zoned as SP2 Infrastructure under the Sydney LEP 2012 and the Marrickville LEP 2011 This zoning reflects the desire to maintain access and connectivity between local centres of employment and economic activity. The Alexandria Landfill (the future site of the St Peters interchange) is zoned as SP2 Infrastructure (Sydney LEP 2012) and IN1 General Industrial (Rockdale LEP 2011). To the north of the Alexandria Landfill along the Princes Highway are areas zoned as B6 Enterprise Corridor and B4 Mixed Use, to the east along Campbell Street and Campbell Road are areas zoned as IN2 Light Industrial and R1 General Residential under the Rockdale LEP 2011, and RE1 Public Recreation under the Sydney LEP 2012. To the east and south along Burrows Road and the Alexandra Canal the land is zoned as IN1 General Industrial under the Sydney LEP 2012. To the west of the landfill and Canal Road is land zoned as IN1 General Industrial under the Marrickville LEP 2011. The zoning of the areas surrounding the St Peters interchange identify that the desired future character of the broader area is to retain the existing low to medium density development, whilst also continuing to encourage business development within the enterprise corridor and mixed use areas and industrial development contained within the existing industrial areas.

14.1.3 Urban and landscape design

The WestConnex Urban Design Framework provides specific urban design direction for the development and delivery of WestConnex in the form of design objectives. Each of the WestConnex Motorway Urban Design Framework objectives is supported by design principles that guide the urban design and provide a benchmark against which to assess outcomes. The relevant urban design objectives of the project are outlined in **Table 14-3**.

An Urban Design Review Panel has been formed to oversee development of urban and landscape design for the project. The role of the Panel is to provide advice regarding the urban design concept and its development. The Panel makes recommendations in relation to architecture, urban and landscape design and artistic aspects of the project.

A landscape and urban design plan would be prepared in consultation with the local community and the Canterbury, Hurstville, Rockdale, Marrickville, Sydney and Botany Bay local councils. It would include input from the New M5 Urban Design Review Panel to ensure the requisite design quality is achieved. Refer to **Section 14-44** for more detail.

Table 14-3 Specific urban design objectives and their application to the project

Objective	Application to project
Environmental Responsiveness: Planning, design construction and long term management shall be based upon a natural systems approach which is responsive to the environment and promotes the highest levels of sustainability.	• Protect and retain as much existing vegetation as possible to minimise the footprint, maximise vegetated screening and reduce loss of green space and green links • Use only containerised planting stock to facilitate rapid establishment of new landscape installations • Include plant species that reinforce local indigenous plant communities • Key elements such as retaining walls and noise barriers would have textured surfaces where needed to discourage vandalism and contain anti-graffiti coatings allowing easy graffiti removal • Balance the composition of built form and landscape by maximising planting opportunities including large trees as a foil for the proposed infrastructure elements and to help in cooling, masking noise and improving air quality • Use of dimmable light emitting diode strip lighting and other energy saving products for lighting.
Connectivity and Legibility: Build connectivity across the city, beyond the boundaries of the M5 East Motorway corridor and promote increased legibility of places, buildings, streets and landmarks.	The design would create a simple, legible and inviting design solution that: • Provides self-explanatory roads with geometry and design to match posted speeds and ease of way-finding • Enhances and creates active transport infrastructure to provide safe and seamless journeys for pedestrians and cyclists • Enhances and creates connections to and from public open space • Provides visual stimuli within the tunnel to create a progressive sequence of events for the motorist.
Placemaking: Create beautiful places, streets, structures and landscapes that draw their form, character and materiality from local context, the intrinsic natural and cultural qualities of each locale.	The design would add to local places, streets, structures and landscape and minimise impacts on the local community through the following design treatments: • Use of high quality, robust and functional materials and products in the public domain • Activating the edges of public spaces through design by considering pedestrians and cyclists and adjacent land uses • Offering opportunities for the future redevelopment and renewal of land along the corridor.

Objective	Application to project
Urban renewal and liveability: Enable opportunities for urban renewal and provide high levels of urban amenity and livability.	The design would consider and integrate with local movement networks, places and land uses to support existing urban renewal and enable future opportunities for urban renewal by: • Improving access to public and active transport • Enhancing local street, pedestrian and bus connectivity (through a regular street edge) • Removing surface traffic creating long term improvements in air quality and noise on surface roads and streets that support pedestrian activity • Creation of new dedicated cycle paths, shared paths, footpaths and crossings to improve active transport connections • Providing extensive tree planting of endemic species to achieve canopy cover for shade, shelter and habitat.
Memorable identity and a safe, enjoyable experience: Provide a memorable project identity and experiences for road users and adjacent stakeholders that are safe, convenient and enjoyable.	A memorable identity would be created with a high quality user experience for motorists and adjacent communities by: • Keeping a simple and consistent language of built elements and components to minimise visual clutter • Providing a secure environment including aspects such as passive surveillance, clear sight lines and lighting • Creating distinctive portal access points that reinforce the character of the local area and are respectful of the individual setting • Differentiating character zones and breaking up tunnel lengths to vary the driver experience and heighten awareness of geographical location through lighting, signage and art • Maximising opportunities to provide a well vegetated green corridor by maintaining or improving links to open space at the western surface works and providing public open space at the St Peters interchange.
A new quality benchmark: Provide design and construction quality of world class standard. WestConnex shall establish a new benchmark for integrated sustainability, engineering, art, architecture and urban design.	A world-class solution for the M5 East Motorway would be delivered that sets a benchmark in the travel experience. The design would establish an identity for the existing M5 East Motorway and future stages by: • Integrating the various existing and proposed built form elements such as portals, noise barriers and retaining walls to reinforce an integrated design that enhances visual unity and clarity • Utilising durable and high quality materials and providing good access to ensure the motorway maintains its identity for years to come.

14.1.4 Assessment of potential impacts during construction and operation

The impact assessment for the construction and operational phases of the project was undertaken as follows:

- A visual impact assessment for construction works, which evaluated the impact of the construction of the project on the surrounding landscape and receiver views from residential areas and those of passing road users. The following project components were included:
  - Construction compounds and tie-in works
  - Changes to pedestrian, cyclist and vehicular traffic movements to surrounding areas
  - Night lighting impacts
- An operational landscape character assessment evaluating the potential impacts of the project's operation on the combined quality of the built, natural and cultural aspects that make up the project area and provide its unique sense of place (see below for further detail)

- An operational visual impact assessment evaluating the impact of the project's operation on the surrounding landscape and receiver views from residential areas and those of passing road users. Project components considered included:
  - Operational facilities
  - Night lighting impacts (see below for further detail)
- Urban design assessment, which considered:
  - In-tunnel urban design
  - Integration of the project with surrounding areas
  - Benefits for local communities through provision of access and open space
  - Landscape and built form of permanent facilities.

Assessment of landscape character and visual impacts

The sensitivity of changes in landscape character and other visual impacts were compared to the magnitude of those changes. For the purposes of the visual assessment, the sensitivity of the landscape is based on the extent to which it can accept a particular type and scale of change without adverse character impacts. The magnitude of change affecting a landscape or visual receptor depends on factors such as the nature, scale and duration of the particular change. These concepts are explained further in Section 2.3.1 of Technical working paper: Landscape character and visual impact (**Appendix K**).

Potentially most affected visual receivers have been identified through a GIS mapping system taking into account topography and potential screening by vegetation and existing development. Artists' impressions of the project are included in the Technical working paper: Landscape character and visual impact. Select artists' impressions demonstrating the visual implications of 10 years post project are included in **Section 14.3.2**.

A visual envelope was defined by considering the extent to which elements of the project would be visible from surrounding areas. The visual envelope was broadly mapped to provide an indication of which parts of the project would be likely to be viewed from surrounding areas. The mapping typically shows 'worst case,' scenarios (eg some receivers may only see a small extent of a project surface facility, where as other closer receivers may view a substantial part of the infrastructure element).

With respect to ventilation facilities at Kingsgrove, Arncliffe and St Peters motorway operation complexes, a detailed review and finalisation of architectural treatment of the ventilation facilities would be undertaken during detailed design. This would be guided by the ventilation performance requirements and the following design principles, as well as outcomes of community consultation:

- Reflective of site and context
- Integration with landscape
- Sculptural urban scale objects – urban landmarks
- Forms informed by function
- Identifiable by their materiality
- Appropriate use of materials.

Further detail in these principles can be found in the Urban design report (**Appendix L**). For the purposes of this assessment, an envelope design has been considered with a preliminary architectural treatment concept.

Assessment of night lighting

The assessment of night lighting impacts considers the change from the existing situation using the visual impact grading matrix in Section 2.3.1 of Technical working paper: Landscape character and visual impact (**Appendix K**). An assessment has been carried out for each site, for both construction and operation phases. Residents and road users are the key receiver locations and are separately assessed. For both construction and operational phases of the project, the visual impact assessment assumed that light levels would be sufficient to meet work health and safety requirements, site security levels, whilst also meeting the operational requirements of Sydney Airport.

14.2 Existing environment

The project would traverse the suburbs of Narwee, Beverly Hills, Kingsgrove, Bexley North, Earlwood, Bardwell Park, Bardwell Valley, Arncliffe, Wolli Creek, Tempe, Sydenham, St Peters, Alexandria and Mascot. It comprises a series of contained surface works areas connected by two (east and west bound) tunnels. For the purposes of the Technical working paper: Landscape character and visual impact and the Urban design report (which are provided in **Appendix K** and **Appendix L**), the project has been divided into the following areas for analysis and assessment:

- Western surface works area
- Bexley Road surface works area
- Arncliffe surface works area
- St Peters interchange and local road upgrades surface works area.

A study area boundary for the visual assessment of each surface works area was defined as 500 metres from the boundary of the construction footprint associated with each surface works area (refer **Figure 14-1**). Due to the landform, tree cover, built form and street layout, the study areas provide reasonable boundary within which the project could visually influence the landscape through which the corridor runs. Further, the boundary of each surface works area has been assumed to be the boundary of the construction footprint of the project. As this would be greater in area than the operational footprint in most instances, this approach would represent the worst case scenario for disturbance.

The existing environment of the project area contains a mixed level of visual amenity. This is due to a variety of factors, most significantly the fact that road and rail transport corridors already exist through much of the project area. Furthermore, there are few iconic views available within the project area, and some sections of the project area (such as the existing Alexandria landfill) do not currently provide a high level of visual amenity.

(blank page)

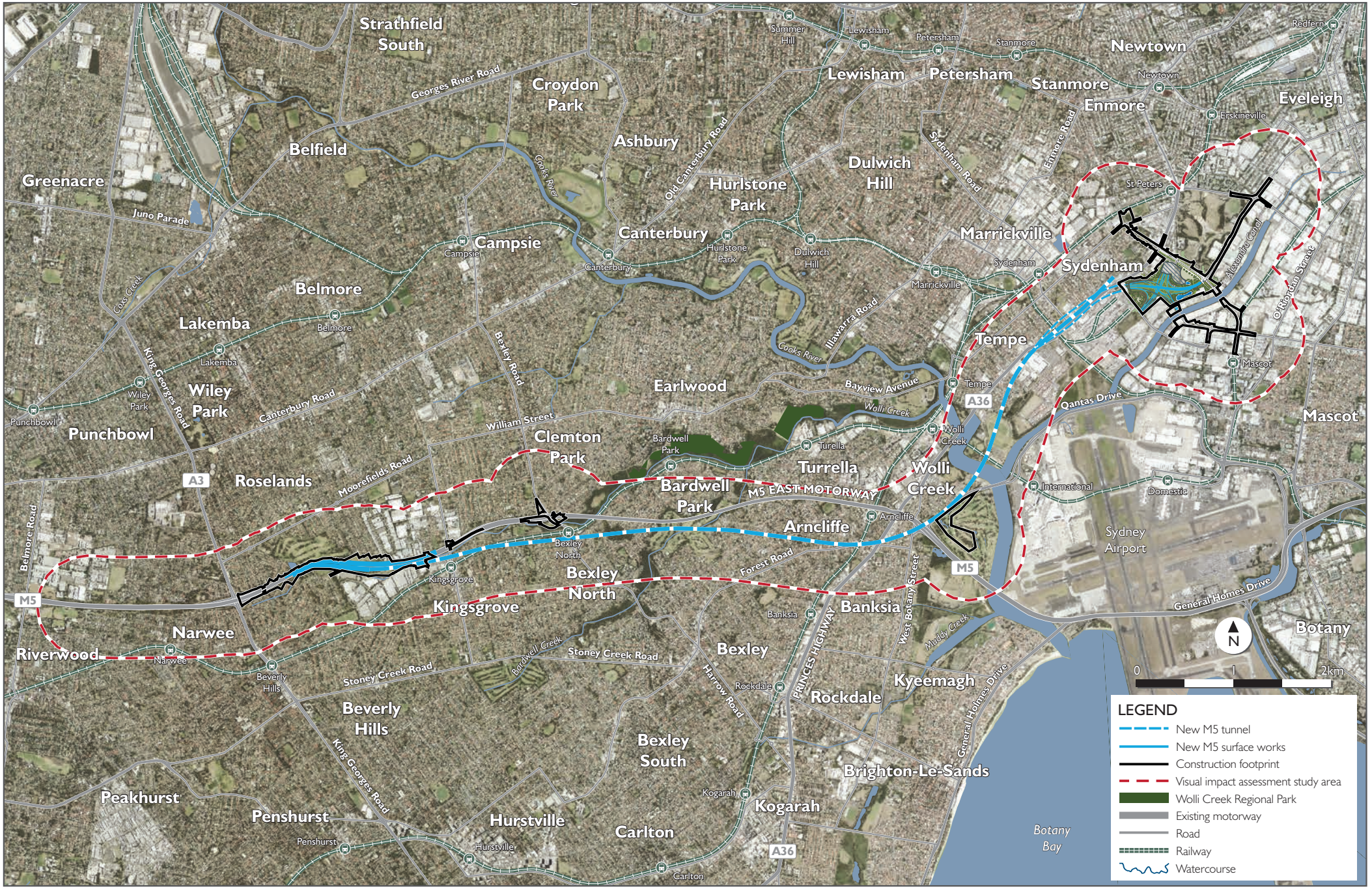


Figure 14-1 Project area and study area boundary

(blank page)

14.2.1 Western surface works area

Topography and visibility

The western surface works area gently rises in elevation from east to west. Around half of the western surface works area (west of the Kindilan underpass) lies on a valley floor. Elevated land visually buffers the M5 East Motorway from the surrounding landscape. Despite its elevation in places, views to and from the western surface works area are limited due to the prevalence of mature tree cover in the surrounding landscape, the gentle, even rise of the landform between valley and ridgeline, and industrial development in the valley floor to the south of the M5 East Motorway.

Context

The western surface works area ties in with the existing M5 East Motorway and is surrounded by a mix of residential and light industrial development. The central portion of the area is bounded by Canterbury Golf Course to the north, which is buffered from the M5 East Motorway by a patch of Cooks River / Castlereagh Ironbark Forest (ie the Beverly Grove bushland).

The M5 East Motorway is flanked on both sides by the M5 Linear Park, which provides a pedestrian and cycle path linking pockets of recreational open space of varying sizes, including a road reserve area. Wolli Creek runs roughly parallel to the M5 Linear Park, comprising a fenced concrete channel with occasional pockets of in-channel vegetation (either reed beds or weedy tree species).

Housing in the area is zoned medium density residential to the north and low density residential to the south of the M5 East Motorway corridor. Surrounding suburbs contain well established landscapes (gardens and parks) and mature street trees.

The Airport, Inner West and South railway corridor runs south of the M5 East Motorway with a local mixed use urban centre located at Kingsgrove Railway Station. Views between this area and the western surface works area are screened by vegetation and buildings.

Key non-Aboriginal heritage items and conservation areas in and around the western surface works area include:

- Welfare Avenue Urban Conservation Area, listed on the Register for the National Estate (a non-statutory register)
- Pallamana Parade Urban Conservation Area, listed on the Register for the National Estate, a non-statutory register, located in Beverly Hills
- Kingsgrove Railway Station Group (local heritage significance) located at corner of Kingsgrove Road and Commercial Road, Kingsgrove
- Kingsgrove East urban conservation area, listed on the Register of the National Estate (a non-statutory register), located in Kingsgrove
- The Kingsgrove West Urban Conservation Area, listed on the Register of the National Estate (a non-statutory register), which lies just west of the Kingsgrove East urban conservation area.

Further information on visual impacts to these and other non-Aboriginal heritage items can be found in Section 7.4 of the Technical working paper: Non-Aboriginal heritage (**Appendix R**). These impacts are summarised in **Sections 20.3.1** and **20.3.3**. None of the above listed non-Aboriginal heritage items would experience significant visual impacts as a result of the project.

Landscape character zones

The existing landscape character of the landscape zones around the western surface works area are identified in **Table 14-4** and shown in **Figure 14-2** to **Figure 14-5**.

Table 14-4 Description of landscape character zones – Western surface works

Landscape character zone	Description
Residential	This zone flanks the western surface works area along its north-western, south-western and central-northern boundaries. It consists of low and medium density residences, predominantly single and double storey houses on individual lots with mature landscaping and street trees. Residential housing is generally buffered along the M5 East Motorway by a strip of recreational land, ranging in width from a pedestrian / cycle path pavement to a wider tract of recreational land.
Industrial	There are two pockets of industrial development near the western surface works area, one to the north and one to the south of the M5 East Motorway. The northern pocket comprises an older mix of light industrial buildings, each addressing streets lined with mature street trees. This industrial zone abuts residential neighbours to the west and east, Clemton Park to the north and the M5 East Motorway to the south. The southern pocket contains a mix of older style, low rise light industrial buildings with mature street trees, in addition to more recent, larger scale industrial complexes. It lies between the M5 Linear Park and the Airport, Inner West and South railway corridor on the valley floor. It is buffered from residential development by the railway corridor to the south, Kingsgrove Road to the east, the M5 Linear Park to the north, and by the continuation of Beverly Grove Park South towards the west.
Recreational	Several pockets of recreational land lie within the western surface works area: • Recreational land within or in the vicinity of the M5 Linear Park including: – Four small pocket parks and one pocket park with a large stormwater basin to the north and south of the M5 East Motorway along the pedestrian / cyclist pathway between Cooloongatta Road and Kooemba Road – Tallawalla Reserve on Tallawalla Street – Beverly Grove Park South, south of the M5 East Motorway and north of Wolli Creek at the eastern end of the western surface works area – Beverly Grove Park North, north of the M5 East Motorway and abutting back fences of residences on Rosebank Avenue, Armitree Street and Glamis Street • Recreational land outside the M5 Linear Park such as Beverly Hills Park • Canterbury Golf Course • Beverly Grove bushland, a patch of Cooks River / Castlereagh Ironbark Forest, a critically Endangered Ecological Community.
Transport corridor	The transport corridor comprises: • The M5 East Motorway • The Airport, Inner West and South railway corridor • Major road corridors such as King Georges Road and Kingsgrove Road. While these are large scale transport corridors, the urban design and land use on either side of the roadways help to integrate these elements into the surrounding landscape.
Urban centre	An urban centre lies south-east of Kingsgrove Railway Station, along Kingsgrove Road around 200 metres from the south-eastern corner of the western surface works area. It comprises a small cluster of commercial development with a few scattered community facilities.

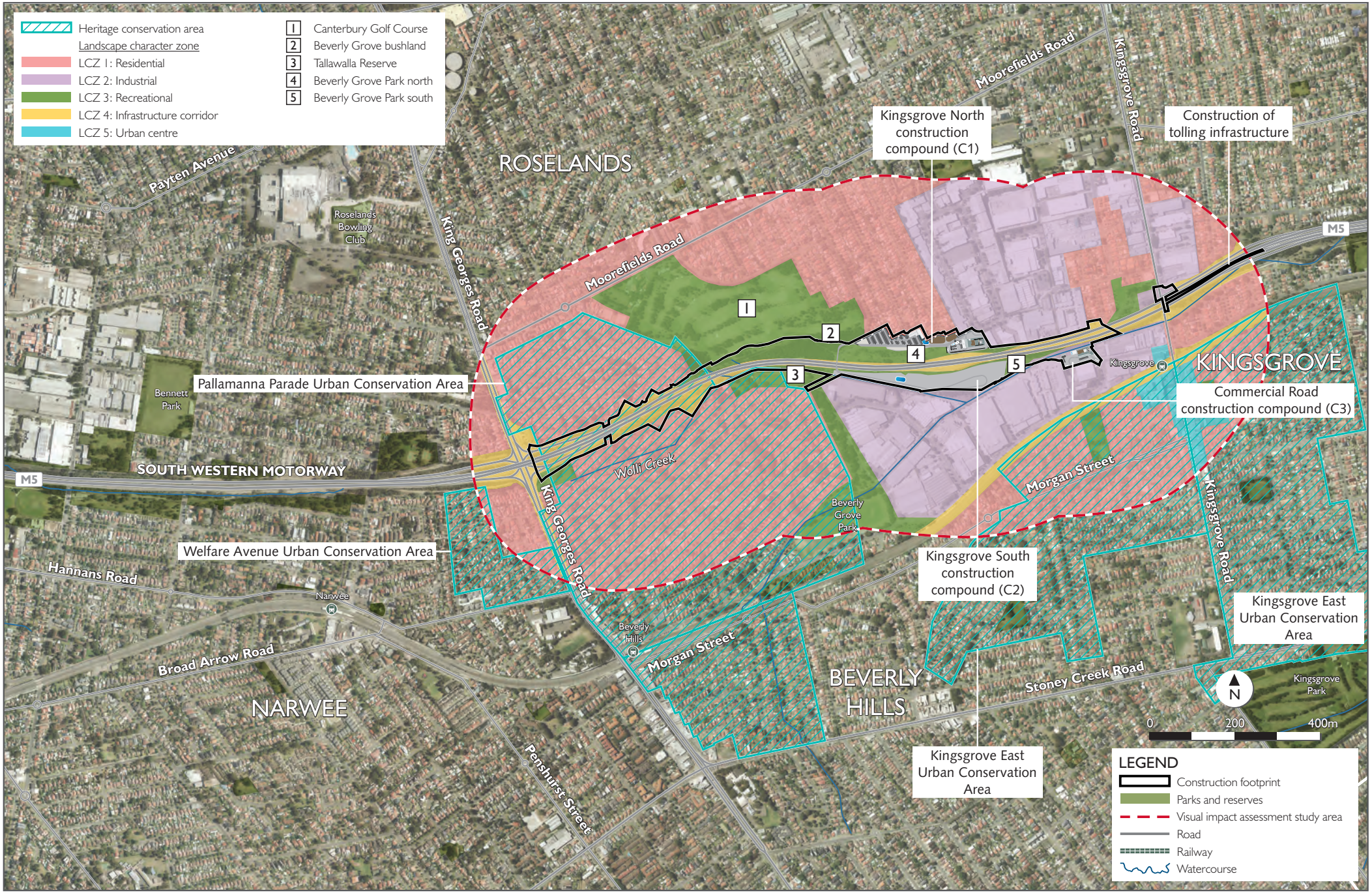


Figure 14-2 Landscape character zones - Western surface works

(blank page)

14.2.2 Bexley Road surface works area

Topography and visibility

The Bexley Road surface works area lies north of Wolli Creek, broadly on the valley floor. The landform rises to the north almost immediately from Wolli Creek to a ridgeline around 400 metres north of the northern boundary of the site. The M5 East Motorway, adjacent to Wolli Creek to the north, has been built up above the valley floor, before entering a dive structure under Bexley Road.

Local screening elements at this location include:

- Barrier structures, such as noise barriers and screening walls, particularly associated with the M5 East Motorway corridor which limit views along Bexley Road
- Mature vegetation, including street trees, park trees, and riparian vegetation along Wolli Creek which particularly limit views from areas south of Wolli Creek northwards to the site and from areas to the east, where there is further riparian vegetation associated with Wolli Creek (east of Bexley Road)
- Landform, such as noise mounds and other mounds mitigating level changes between roadways and Wolli Creek.

Context

The Bexley Road surface works area is zoned SP2 infrastructure and is transected by the M5 East Motorway and Bexley Road into the three distinct areas – the Bexley Road North construction compound, the Bexley Road East construction compound and the Bexley Road South construction compound.

The Bexley Road North construction compound and Bexley Road East construction compound remain fenced off from public access. The Bexley Road South construction compound has been landscaped and is currently utilised as a public recreational area, part of the M5 Linear Park.

Wolli Creek flanks the Bexley Road South construction compound and the Bexley Road East construction compound to the south, comprising a fenced concrete channel with occasional pockets of in-channel vegetation, and a fringe of mature riparian vegetation. The land immediately south of Wolli Creek is zoned Public Recreation (RE1), and comprises a steep, densely vegetated embankment.

The western boundary of the Bexley Road North construction compound backs onto the backyards of residential properties, which front onto Flatrock Road and Jones Avenue. These dwellings lie within medium density residential land.

Along its north-eastern boundary, the Bexley Road North construction compound site is flanked by Bexley Road and low density residential development on land zoned for low density residential.

The Bexley Road East construction compound is bounded on the east by low density housing, and to the west by Bexley Road. To the south, the site adjoins a bushland area associated with the western extent of Bardwell Valley Park, which is zoned National Parks and Nature Reserves. At the boundary, the park is well vegetated with a mix of mature indigenous tree and shrub vegetation and woody weeds such as Large Leaf Privet. This vegetation effectively screens the Bexley Road East construction compound from the south.

Key non-Aboriginal heritage items and heritage conservation areas in and around the Bexley Road surface works area include:

- Bexley North Railway Station Group, listed on the Sydney Trains Section 170 Heritage and Conservation Register located in Bexley Road, Bexley North
- Wolli Creek culvert, listed on the Roads and Maritime Section 170 Heritage and Conservation Register, located in Bexley Road, Earlwood
- Clemton Park heritage conservation area, listed on the Register of the National Estate (a non-statutory register), located within and adjacent to the Bexley Road East construction compound

- Wolli Creek Valley, listed on the Rockdale LEP 2011 as an item of local significance and located to the east of the Bexley Road surface works.

Further information on visual impacts to these and other non-Aboriginal heritage items can be found in Section 7.4 of the Technical working paper: Non-Aboriginal heritage (**Appendix R**). These impacts are summarised in **Sections 20.3.1** to **20.3.3**. None of the above listed non-Aboriginal heritage items would experience significant visual impacts as a result of the project.

Landscape character zones

The existing landscape character of the landscape zones around the Bexley Road surface works area are identified in **Table 14-5** and shown in **Figure 14-3**.

Table 14-5 Description of landscape character zones – Bexley Road surface works area

Landscape character zone	Description
Residential	Land surrounding the Bexley Road surface works area is predominantly residential, zoned medium density to the west of Bexley Road, north of the M5 East Motorway, and low density in all other areas. This zone adjoins or lies adjacent to: • The western boundary of the Bexley Road North construction compound site (C4) • The northern and north eastern boundaries of the Bexley Road East compound site (C6).
Recreational	This zone can be broadly divided into three groups: • Parks with organised sporting facilities (Beaumont Park and Kingsgrove Avenue Reserve) • Parks typically characterised by flat topography and central playing fields surrounded by mature shade and street trees • Bushland reserves / National Parks (Bardwell Valley Park and Wolli Creek corridor).
Transport corridor	This zone comprises: • The M5 East Motorway • The railway corridor • Bexley Road corridor. The urban design and land use on either side of the roadway allows integration of these elements into the surrounding landscape.
Urban centre	An urban centre is situated on the southern side of the railway line adjacent to the Bexley Railway Station, around 150 metres from the south-eastern corner of the Bexley Road surface works area boundary. It comprises a small commercial area with shops, cafes and restaurants, community facilities (eg a public library), and a number of small pocket parks with limited facilities.

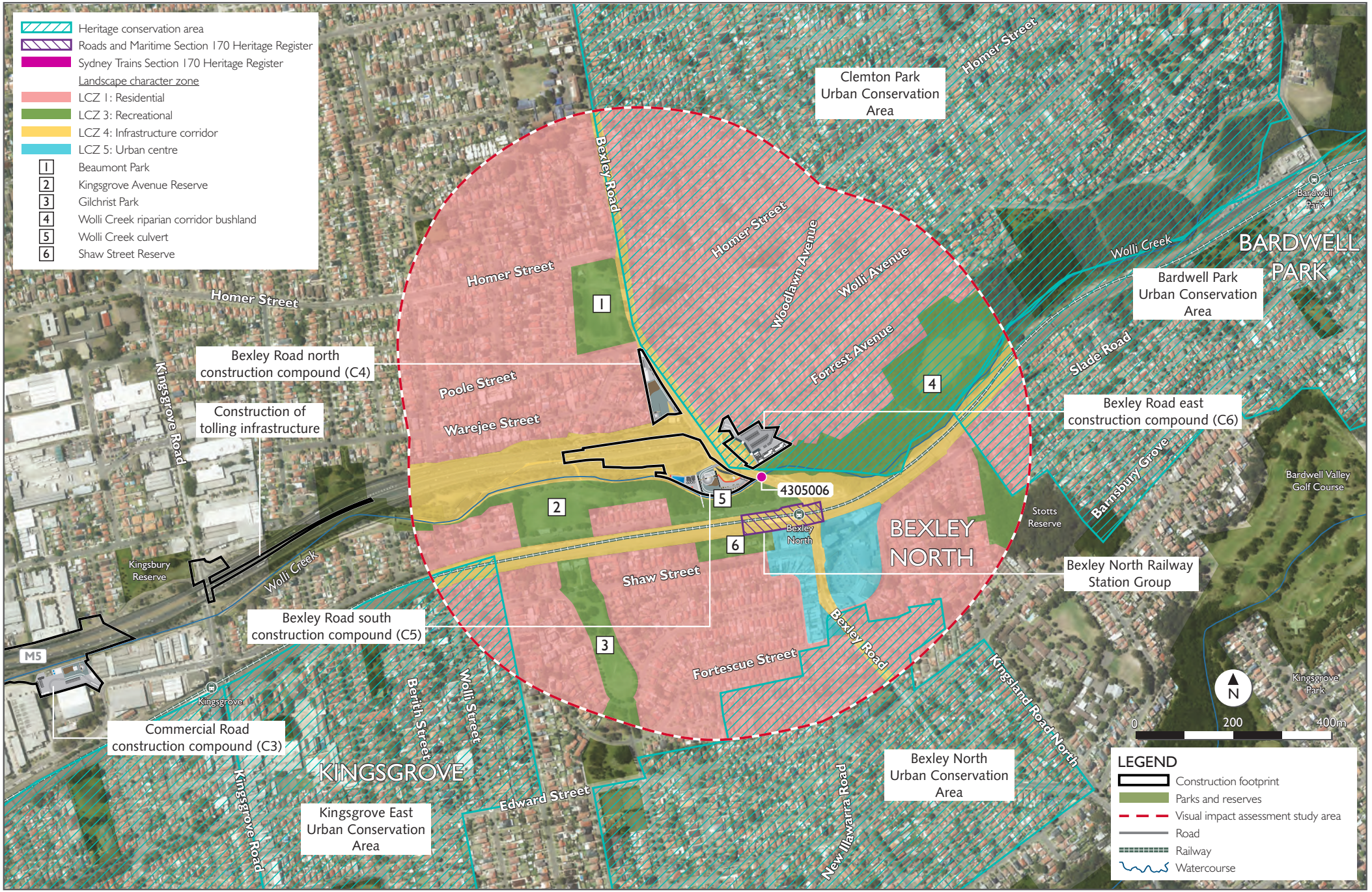


Figure 14-3 Landscape character zones - Bexley surface works

(blank page)

14.2.3 Arncliffe surface works area

Topography and visibility

The Arncliffe surface works area is generally low-lying and flat due to its proximity to Cooks River and Botany Bay. The topography begins to rise from the north-western corner westwards, but there are no significant views to or across the area from ridgelines due to the gradual rise and distance from elevated ground. A view eastwards across the Arncliffe surface works area is available from the north western corner of the site on Marsh Street where the street rises to a bridge over the M5 East Motorway.

The Cooks River catchment is highly urbanised and is dominated by low density residential development and pockets of industrial areas concentrated in Botany along the Alexandra Canal. Views to the Arncliffe surface works area from much of the low density residential development are limited by the flat landform and low (single and double storey) housing, although some views are available from taller buildings in surrounding areas, namely from the high density and mixed use zoned land to the north of the site.

Views from the M5 East Motorway (along the western boundary of the Golf Course) are screened by landform, vegetation and noise barriers associated with the road corridor. No views are available from beyond the M5 East Motorway corridor (ie from Cahill Park and Riverine Park, which lie on the western side of the M5 East Motorway).

Context

The Arncliffe surface works area is located in the eastern corner of the Kogarah Golf Course. The Golf Course is a roughly triangular site, bounded by:

- Marsh Street, which forms the northern boundary of the site and crosses the Cooks River at the north-eastern boundary
- The M5 East Motorway / Eve Street cycle path along the south western boundary
- The Cooks River along the eastern boundary.

Arncliffe Railway Station is located around 600 metres east of the site at the corner of Burrows Road and Arncliffe Street.

The land to the east of the Arncliffe surface works area (on the eastern bank of the Cooks River) is Sydney Airport, which is zoned SP2 infrastructure. The majority of the land to the west of the site is zoned low density residential, with pockets of mixed use, high density residential and public recreation, particularly to the north of Marsh Street.

The Kogarah Golf Course is well connected to other recreational open space along the Cooks River, including Cahill Park to the north and Riverine Park to the south.

The Eve Street Cycle Path is part of the greater Cook Park Trail which runs along the north western and south western boundary of the Kogarah Golf Course. It is an off-road pedestrian and cycling route that follows the western foreshore of Botany Bay and connects with the Cooks River Cycleway at Tempe to the north, which leads to Olympic Park at Homebush.

In terms of non-Aboriginal heritage items in and around the Arncliffe surface works, the Western Outfall Main Sewer - Rockdale to Homebush (State Heritage Significance) is located at the corner of Marsh Street and M5 East Motorway Tempe. Further information on visual impacts to non-Aboriginal heritage items can be found in Table 60, Section 8.7 of the Technical working paper: Non-Aboriginal heritage (**Appendix R**). These impacts are summarised in **Sections 20.3.1** to **20.3.3**. The above listed non-Aboriginal heritage item would not experience significant visual impacts as a result of the project.

Landscape character zones

The existing landscape character of the landscape zones around the Arncliffe surface works area are identified in **Table 14-6** and shown in **Figure 14-4**.

Table 14-6 Description of landscape character zones – Arncliffe surface works area

Landscape character zone	Description
Residential	Residential land is located to the north, west and south of Kogarah Golf Course. This zone can be divided into two groups: • High Density Residential: – This zone comprises a small portion to the north of the site and borders Innesdale Road and Marsh Street – A combination of residential apartments and airport transit hotels overlook the Kogarah Golf Course and beyond. This area is characterised by closely spaced high rise buildings with limited green open space at ground level – Opportunities for district and regional views from these buildings would be available • The Low Density Residential: – This zone forms a large area to the west of Marsh Street, West Botany Street and south of the M5 East Motorway – This zone comprises predominantly single and double storey houses on individual lots with mature landscaping and street trees – Characterised by generally wide, quiet streets periodically traversed by transport corridors (eg Marsh Street, West Botany Street and the M5 East Motorway).
Recreational	A large expanse of recreational land lies within and to the north, south and east of Kogarah Golf Course. This zone can be broadly divided into two groups: • Recreation – open space: – This zone is characterised by green space used for passive and active recreational pursuits – This zone is zoned as Public Recreation and is well connected to other recreational open spaces along the Cooks River to the north and south – Kogarah Golf Course is contained within this zone • Recreation – waterways: – This zone is characterised by recreational land directly adjacent to waterways – They are often narrow (sometimes limited to pedestrian / cycle access only) with occasional breakout spaces, areas of mature 'bushland' pockets, and turfed recreation spaces – These areas are predominantly used for active recreation (walking / cycling) as well as the Cooks River waterway itself, which is used for active aquatic-based recreation activities such as rowing, kayaking and fishing to the north of the Marsh Street bridge. Refer to **Sections 16.3.1** and **16.3.2** for potential impacts of the project on this waterway – This zone is located north of the Marsh Street Bridge, along the Cooks River.
Infrastructure	This zone is utilitarian in nature, characterised by the individual spatial necessities of their transport uses. This zone is divided into two groups: • Infrastructure – transport corridor, comprising the M5 East Motorway, Marsh Street, West Botany Street and Wickham Street • Infrastructure – airport, comprising the land east of the Cooks River that forms Sydney Airport.

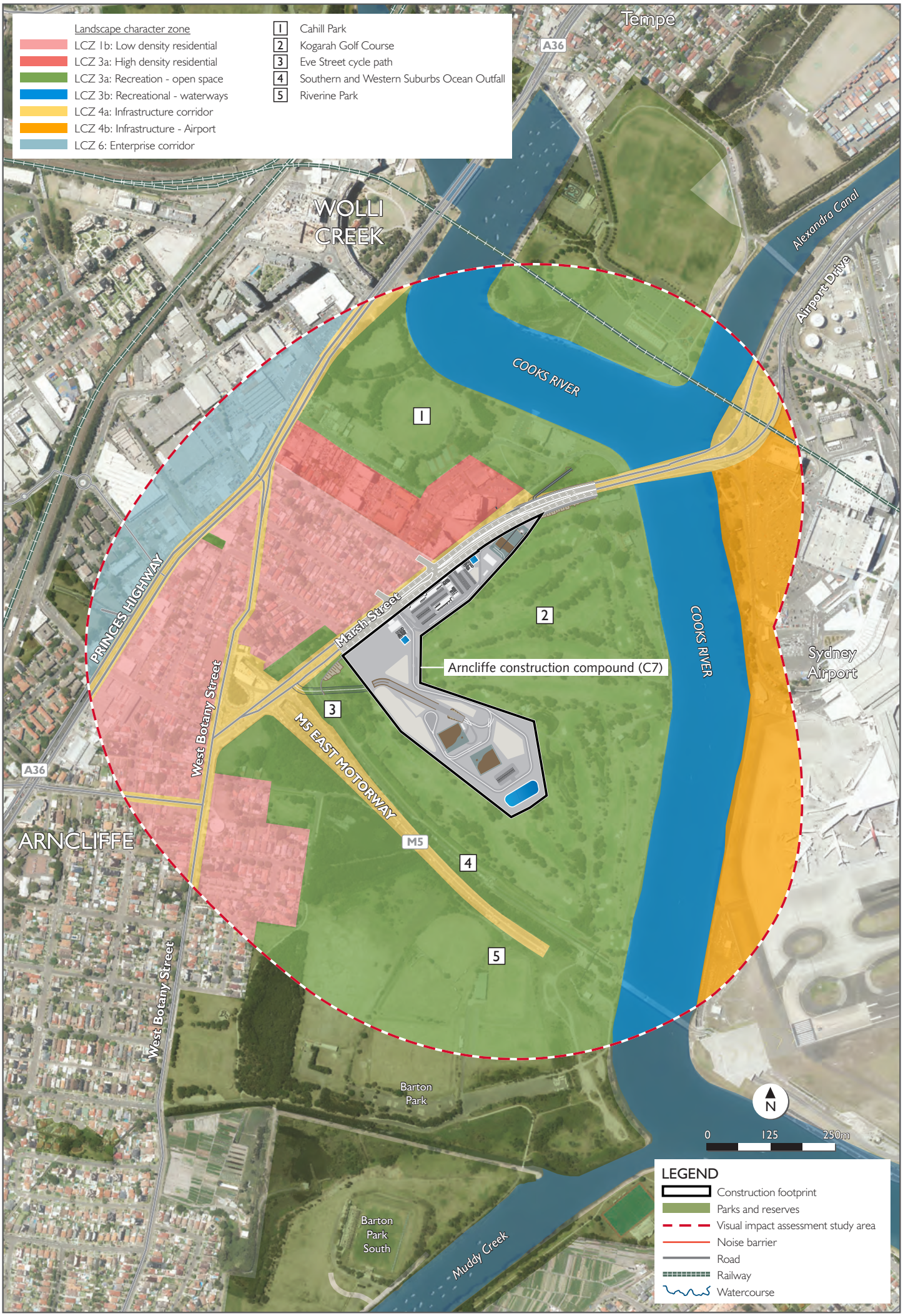


Figure 14-4 Landscape character zones - Arncliffe surface works

(blank page)

14.2.4 St Peters interchange area

Topography and visibility

The St Peters interchange lies within a flat, low lying area adjacent to the Alexandra Canal. West of the Alexandra Canal, the landform gently rises to the Princes Highway corridor, which follows a low ridgeline. Views from the Princes Highway towards the Canal are generally screened by hoarding and opaque fencing surrounding existing industrial complexes along the Princes Highway. Some localised mounding on the northern side of the highway (such as from the St Peters Anglican Church) provides glimpses over the fencing and to the Alexandria Landfill, but views to the Canal itself are not available due to viewing distance and obstruction by buildings and vegetation.

The Alexandra Canal is bounded on both banks by large industrial complexes. Therefore no views from the Canal itself would be available to the project.

Sydney Park, located to the north of the St Peters interchange, comprises a series of constructed landforms, the tallest reaching around 30 metres in height. These landforms form the highest viewing positions within the surrounds of the St Peters interchange, providing views to Sydney Airport and the Sydney central business district. However no views are obtained to the Alexandria Landfill site due to mature fringing vegetation surrounding the park, residential housing and localised landform.

Context

The St Peters interchange site lies on land zoned as:

- IN1 General Industrial (majority of the site)
- SP2 Infrastructure
- IN2 Light Industrial (the north western corner at the Princes Highway, Canal Road intersection).

To the north of the St Peters interchange, the Princes Highway is an active business corridor with commercial and industrial development on both sides. This land is zoned B6 Enterprise Corridor, SP1 Special Activities, SP2 Infrastructure, RE2 Private Recreation and B4 Mixed Use. North of the development fronting the Princes Highway, the land is predominantly low density residential housing, with pockets of recreation spaces.

North of the St Peters interchange, Campbell Street is bounded by land zoned as R2 Low Density Residential to the south-west, and a mixture of B4 Mixed Use, B6 Enterprise Corridor, RE1 Public Recreation and R1 General Residential zoned land to the north. It is a narrow, two lane street bounded by terrace housing, vacant land, Simpson Park and industrial buildings.

Sydney Park, which is zoned RE1 Public Recreation, is located to the north of the proposed St Peters interchange and is the largest park in the City of Sydney at approximately 40 hectares in size. It is a regionally significant open space and a valuable community asset that would provide an important cycle and pedestrian connection to the St Peters interchange.

Main roads surrounding the proposed St Peters interchange include:

- Canal Road, which forms the south western boundary of the site and is a key arterial route serving the Sydney CBD as well as Sydney Airport and Port Botany
- Gardeners Road, which lies south east of the Alexandra Canal forms an important transport connection including as a heavy vehicle route.

The St Peters Railway Station, which forms part of the Bankstown to City line, is located around 700 metres north of the site at the corner of King Street and Lord Street.

Key non-Aboriginal heritage items and heritage conservation areas in and around the proposed St Peters interchange include:

- Southern Cross Hotel (Local Heritage Significance) located at 340 Princes Highway, St Peters
- Service Garage (Local Heritage Significance) located at corner of Canal Street and Princes Highway, St Peters
- Terrace Group (Local Heritage Significance) located at 2-34 Campbell Road, Alexandria
- Warehouse 'Rudders Bond Store' (Local Heritage Significance) located at 53-57 Campbell Road, Alexandria
- Alexandra Canal (State Heritage Significance) located at the confluence of the Cooks River
- Town and Country Hotel (Local Heritage Significance) located at 2 Unwins Bridge Road, St Peters
- Group of Victorian Filigree and Victorian Italianate terrace houses – 'Narara' (Local Heritage Significance) located at 4-18 Unwins Bridge Road, St Peters
- Waugh and Josephson industrial buildings (Local Heritage Significance) located at 1-7 Unwins Bridge Road, St Peters
- Goodsell Estate Conservation Area (Local Heritage Significance) located between Bedwin Road, May Street, Caroline and May Lane and the railway line, St Peters
- St Peters Anglican Church (State Heritage Significance) located at 187-209 Princes Highway, St Peters
- St Peters Brickpit Geological Site (Local Heritage Significance) located between Bedwin Road, May Street, Caroline and the Princes Highway, St Peters
- Cooks River Container Terminal (Local Heritage Significance) located at 20 Canal Road, St Peters
- Houses (Local Heritage Significance) located at 28-44 Campbell Street, St Peters
- House (Local Heritage Significance) located at 82 Campbell Street, St Peters
- Former site of 'Petersleigh', demolished in 1910 (Local Heritage Significance) located at 310 Princes Highway, St Peters
- Former site of 'Nun-Cotnook', demolished, c1920s (Local Heritage Significance) located at Corner of Berne Street and Princes Highway, St Peters
- Ricketty Street bridge crossing Alexandra Canal (Local Heritage Significance) at St Peters.

Further information on visual impacts to non-Aboriginal heritage items can be found in Section 8.7 and Table 60 of the Technical working paper: Non-Aboriginal heritage (**Appendix R**). These impacts are summarised in **Sections 20.3.1** to **20.3.3**. Of the above listed non-Aboriginal heritage items, only the Alexandra Canal would experience significant visual impacts as a result of the project.

Landscape character zones

The existing landscape character of the landscape zones around the proposed St Peters interchange area are identified in **Table 14-7** and shown in **Figure 14-5**.

Table 14-7 Description of landscape character zones – St Peters surface works area

Landscape character zone	Description
Residential	This zone lies to the north and north-west of the proposed St Peters interchange, lying over a gently undulating landform. The zone comprises: • Predominantly R2 Low Density zoned land, which is characterised by a mix of single and double storey brick and rendered terrace homes on small lots, punctuated by special use buildings such as schools and churches. Some newer townhouses and detached dwellings also exist within the terrace housing • Pockets of R1 General zoned land are dotted throughout the area (mainly along more major roads) and comprise low rise apartment blocks • A number of heritage listed items are located within this zone, including two groups of double storey 'Victorian' terrace houses located in Campbell Road and Unwins Bridge Road. The Campbell Road terraces, which are zoned R1 General Residential, comprise a row of double story terrace houses with rear lane access that backs onto Sydney Park. This zone is generally characterised by suburban streets that are periodically traversed by transport corridors, such as Campbell Road.
Industrial	Three distinct groups of industrial zoned land lie within the proposed St Peters interchange, including: • The former Alexandria Landfill site: – Much of the landfill site is not visible from the existing road network, due to the existing urban form, topography and screening provided by existing vegetation and mature street tree planting. Where the site does lie directly adjacent to a road, it is bound by tall solid fencing, hoardings or visually impenetrable sheds • The active industrial corridor which backs onto the Alexandra Canal: – Characterised by large, low lying industrial buildings and sheds with open, fenced lots between them for private car parking and truck loading facilities – While the buildings themselves address the main roads on either side of the Canal (namely Burrows Road and Bourke Road), glimpses can be seen between these large, long buildings to the Alexandra Canal – The streets are lined with large, mature trees – Some blocks act as storage areas for large shipping containers, which visually tie these industrial developments to the Canal and its history as an active shipping corridor • Large blocks of industrial land with large industrial complexes on them, many of which have internal courtyard car parking areas. These complexes visually address the streets in a similar manner to those backing onto the Alexandra Canal, with blank building fronts softened by mature street trees and occasional entries to car parks and courtyards at the rear of the buildings.

Landscape character zone	Description
Recreation	Due to the density of the surrounding residential area, recreational green space is highly used and valued by the local community. It typically comprises formalised, turfed parks with mature fringing vegetation (street trees). Recreational parks within the area fall within two categories: • Large scale parks: – Sydney Park is a regionally significant park located north of Campbell Road – The park topographically comprises a series of manmade landforms and wetlands – The park is characterised by large, open turfed areas and mounds, fringed with mature trees and screening vegetation, as well as pockets of dense vegetation – Facilities within the park include walking paths, BBQs, picnic facilities, seating, public toilets, a playground, and educational elements such as the water sensitive urban design initiatives (eg the bio retention systems) • Smaller sized pocket parks – Simpson Park: a small, flat, rectangular, local park located north of Campbell Street, fenced on all sides and consisting of a playground, cricket nets, and mature fig trees that line Campbell Street – Camdenville Park: a small park located on the corner of Unwins Bridge Road and Bedwin Road, comprising a playing field and detention basin.
Transport corridor	This zone comprises a number of major roads: • Princes Highway: – Strong linear transport corridor broadly following a low ridgeline and characterised by active retail, light industrial, and commercial development – Views are visually confined within the road corridor, predominantly due to built forms on either side of the road. Glimpses can be seen to the landscape beyond the fringing development along perpendicular roads and through gaps between buildings and commercial complexes – Utilitarian character with limited scenic amenity • Canal Road: – Visually characterised by industrial development on either side of the road – The road crosses over the Alexandra Canal, which provides views along the Canal to adjacent industrial development – The road corridor is intermittently flanked by substantial tree cover – The landform slopes away from the Princes Highway to the west.
Commercial corridor	This zone is an active business and commercial corridor which runs north - south adjacent to the Princes Highway. Although this zone broadly follows the ridgeline along the Princes Highway, views to the landscape beyond are limited by built form. The heritage listed St Peters Anglican Church sits on a natural high point and is the only area that contains substantial tree cover along the corridor within the area. The character of the zone is primarily influenced by the utilitarian nature of the road setting, with business and commercial development prominent on either side of the Princes Highway.

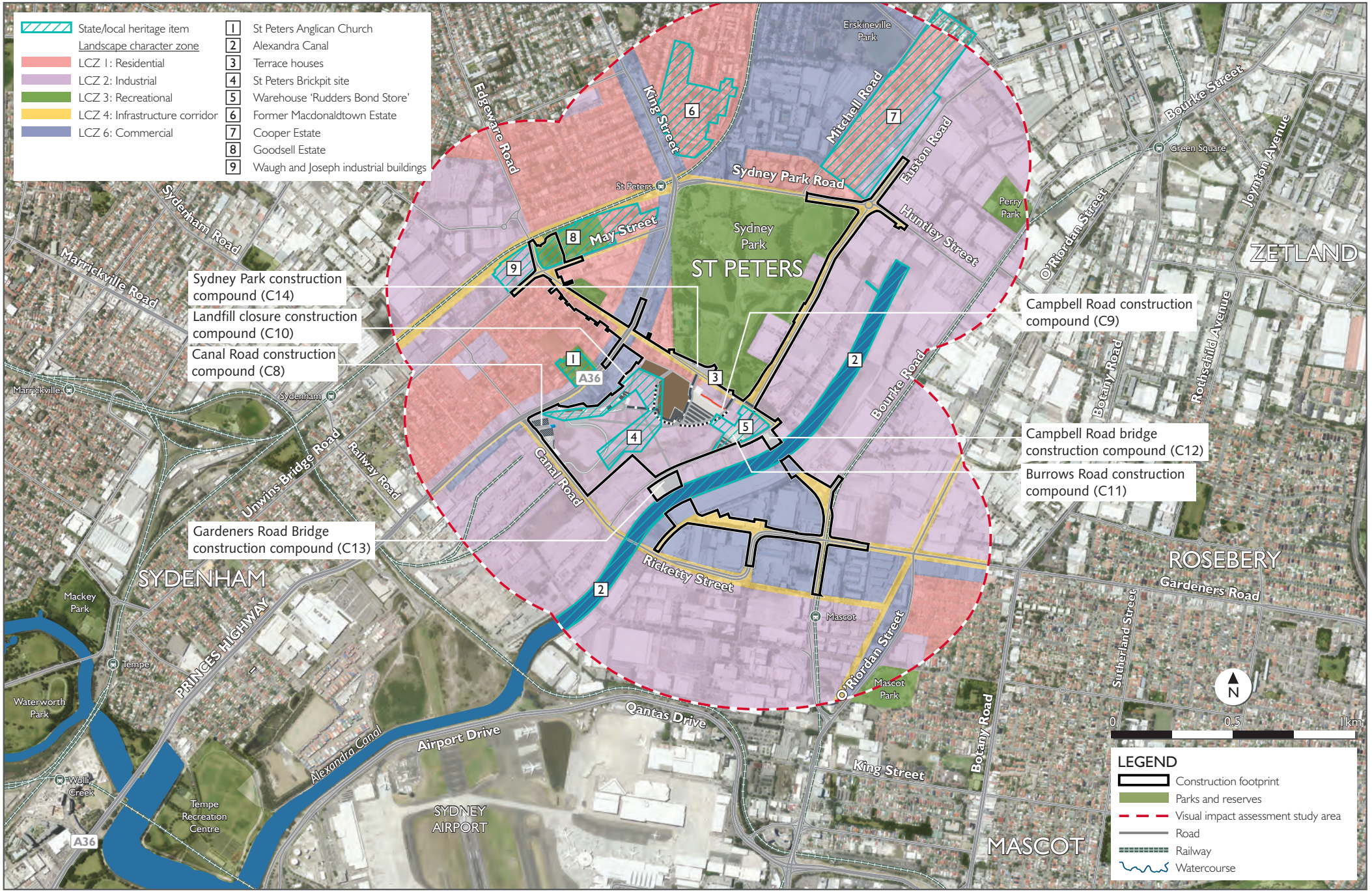


Figure 14-5 Landscape character zones - St Peters interchange and local road upgrades

(blank page)

14.3 Assessment of potential impacts

14.3.1 Construction

The following sections provide an assessment of the potential construction visual impacts and the construction night lighting impacts of the project. Potential visual and lighting impacts associated with construction would be temporary for the duration of the works at each site and works would be undertaken to revegetate and rehabilitate each site on completion of construction.

Construction visual impacts

Visual impacts during the construction of the project would result from the introduction of construction activities and construction ancillary facilities into the existing urban landscape. For the purpose of assessing these impacts, temporary construction compounds and construction disturbance areas have been grouped depending on landscape and receiver contexts:

- Western surface works within the existing motorway corridor
- Pedestrian and Cyclist Routes – Beverly Hills, Kingsgrove, Bexley
- Kingsgrove North construction compound (C1)
- Kingsgrove South construction compound (C2)
- Commercial Road construction compound (C3)
- Bexley Road North construction compound (C4)
- Bexley Road South construction compound (C5)
- Bexley Road East construction compound (C6)
- Arncliffe construction compound (C7)
- Canal Road construction compound (C8)
- Campbell Road construction compound (C9)
- Landfill closure construction compound (C10)
- Burrows Road construction compound (C11)
- Alexandra Canal bridge construction compound (C12)
- Gardeners Road bridge construction compound (C13)
- Sydney Park construction compound (C14)
- Pedestrian and cyclist routes through the M5 Linear Park at Beverly Hills, Kingsgrove and Bexley and along the M5 East Motorway.

The location of each of the construction compounds is shown in **Figure 6-7** in **Section 6.6.4** (Construction work). **Section 14.3.1** provides a description of the duration and scope of works to be carried out at each site. The locations of representative receivers are identified in **Table 14-11**, and in Sections 6.1.1 to 6.1.14 of the Technical working paper: Landscape character and visual impact (**Appendix K**).

The potential visual impacts at each of these sites are assessed further in this section.

M5 East Motorway in-road construction activity

To ensure the capacity on the existing M5 East Motorway is maintained whilst construction work is in progress, the western surface works would be constructed over the traffic stages outlined below:

- Stage 1: road alignment maintains two 3.5 metre wide lanes in both directions
- Stage 2: alignment switches eastbound traffic onto the new eastbound carriageway constructed in previous stage and retains westbound traffic on the existing westbound carriageway

- Stage 3: this is the permanent alignment that has east and westbound traffic using the final carriageways.

Road users would be subject to road construction works over a period of up to around three years. During this time, the following structures, equipment and construction activities are likely to be visible for road users travelling along the M5 East Motorway:

- Earthworks including cuttings, fill embankments and construction of cut and cover dive structures / portals
- Temporary noise barriers and concrete barriers along the M5 East Motorway
- Fencing around the site
- Vehicle access and egress directly to and from the M5 East Motorway.

The receivers would be road users, and the potential impacts to these receivers are outlined in **Table 14-8**, and in more detail in Section 6.1.15 of the Technical working paper: Landscape character and visual impact (**Appendix K**).

Table 14-8 Western surface works – construction activity within the motorway

Receiver location	Construction stage	Visual impact
M5 East Motorway - Adjacent to Coolongatta Road	1	Low sensitivity with high magnitude for stages 1 and 2, and moderate magnitude for stage 3, with a moderate overall impact rating for stages 1 and 2, and a moderate to low overall impact for stage 3.
	2	
	3	
East of Kindilan Underpass	1	Low sensitivity with high magnitude for stages 1 and 2, and moderate magnitude for stage 3, with a moderate overall impact rating for stages 1 and 2, and a moderate to low overall impact for stage 3.
	2	
	3	

Pedestrian and Cyclist Routes – Beverly Hills, Kingsgrove, Bexley

The landscape character changes to and visual impacts of changes to pedestrian and cyclist routes during construction and operation are outlined in **Table 14-9**.

Table 14-9 Proposed landscape character changes to and visual implications of pedestrian and cyclist routes

Pedestrian and cyclists route	Proposed changes
M5 East Motorway cycleway: • Eastbound – King Georges Road to Bexley Road • Westbound – Bexley Road to King Georges Road.	As part of King Georges Road interchange upgrade, cyclists are now unable to use M5 East Motorway and have been detoured to an alternative route.
Shared path on southern side of M5 East Motorway between Karingal Street and Kindilan Underpass	Existing path closed and cyclists detoured to northern side cycleway via Karingal Street and Kindilan Underpass.
Shared path on northern side of M5 East Motorway between Garema Circuit and Kindilan Underpass	Existing path closed and cyclists detoured to a new alignment that runs along the rear of the site.
Kindilan Underpass	Pedestrian and cyclist access maintained. Width of underpass reduced to allow construction vehicle access between Kingsgrove North construction compound and Kingsgrove South construction compound.
Shared path on southern side of M5 East Motorway, western side of Bexley Road	Path realigned to allow for site establishment and works associated construction compound C5.

Alternative pedestrian and cycle way routes outlined above are to be provided where existing routes cannot be maintained during construction. These routes would be clearly defined and sign posted to safely manage pedestrian and cyclist activity. Pedestrian and cycleway routes would be protected by hoarding and / or other barriers, be constructed of an all-weather surface and well maintained.

Each of the receiver locations assessed in **Table 14-10** have been assessed as part of the changes seen due to the nearest construction compound. Below, these locations have been reassessed as points within the greater journey of the user. No ratings have changed at these locations due to this assessment.

Overall, the journey along the existing pathway through the M5 Linear Park would be visually disrupted in a number of places due to construction activity. The changes to views near the Kindilan Underpass, Kingsgrove North construction compound (C1), Kingsgrove South construction compound (C2) and Bexley Road North and South construction compounds (C4 and C5) constitute high visual impacts, although these must be viewed within the context of being points within the greater journey that the pedestrian / cyclist would pass, and that the changes are temporary.

Table 14-10 Pedestrian and cyclist routes – Beverly Hills, Kingsgrove, Bexley construction visual impact assessment

Location	Receiver position	Visual impact assessment
M5 Linear Park: North of the M5 East Motorway	Beverly Grove Park North, adjacent to Glamis Street	The sensitivity of pedestrians and cyclists is high due to the importance of the quality of the view to recreational users, the slow speed at which they would move through the site, and the proximity with which they would view certain construction activities. The magnitude of changes to views during construction at these locations is high, as the character of the view would change significantly from the existing parkland to constricted views between noise barriers and fences adjoining the construction compound, and pedestrians and cyclists would also be diverted.
	Beverly Grove Park, adjacent to Kindilan Underpass	
	Bexley Road, entry to park	
M5 East Motorway		While recreational cyclists may use the M5 East Motorway most cyclists using the M5 East Motorway are assessed as commuters. The sensitivity of cyclists using the M5 East Motorway is therefore low. The magnitude of these changes for cyclists is unable to be assessed, as cyclists would be diverted via another route during construction.

Kingsgrove North construction compound (C1)

Kingsgrove North construction compound would be located north of the M5 East Motorway and accessed via Garema Circuit. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Hoarding (around four metres high)
- Temporary noise barriers (around 2.5 metres high along of northern boundary of the compound, and around 4.5 metres along the eastern boundary of the compound)
- Car parking for up to around 170 personnel
- Tunnel shaft within an acoustic spoil shed and associated haulage
- Site offices and crib area
- Storage laydown areas
- Access between the northern and southern side for light construction vehicles via the existing Kindilan Underpass
- Sedimentation pond.

Kingsgrove North construction compound would be highly visible to adjoining residential development due to the acoustic shed area and associated infrastructure. The site works would be visually screened with hoarding, fencing, and would also incorporate a temporary noise barrier adjoining residential development. As such, much of the compound infrastructure would be visible only above the perimeter hoarding, fencing and noise barriers.

The existing shared pedestrian and bicycle path that currently passes through the site would be permanently realigned to generally follow the temporary noise barrier along the boundary of the compound before connecting back to the existing shared path on the northern side of the Kindilan underpass.

Five receiver locations have been identified, including views from a mixture of residential and industrial premises, recreation areas (golf course), roadways and pedestrian / cycleways as identified in **Table 14-11**.

Kingsgrove South construction compound (C2) and Commercial Road construction compound (C3)

The Kingsgrove South construction compound would be located south of the M5 East Motorway and accessed via the Kindilan Underpass (connecting this compound to the Kingsgrove North construction compound). The site currently comprises a road reserve known as Beverly Grove Park. The following project structures, equipment and construction activities are likely to be visible from surrounding receiver locations:

- Civil site compound
- Stockpiling of fill and pavement materials as well as materials generated from excavation activities prior to off-site removal
- Laydown and storage of materials to be incorporated into permanent works
- Access between the northern and southern side for construction traffic via the existing Kindilan Underpass
- Construction of the Kingsgrove motorway operations complex (MOC1)
- A chain link fence surrounding the site
- Removal of noise mounds / barriers.

The Commercial Road construction (C3) compound would be located on the southern side of the existing M5 East Motorway, within a private property between Tallawalla Street and Commercial Road, Kingsgrove. The Commercial Road construction compound would be mainly used as a tunnelling support site. The site currently comprises of an industrial property. The following structures, equipment and construction activities are likely to be visible from surrounding receiver locations

- Hoarding (around four metres high) and chain link fence surrounding the site
- An acoustic shed and associated haulage
- Two site offices and crib area
- Substation.

Both compounds would be highly visible to the adjoining industrial development due to the proximity of the construction site and activities such as the civil works, acoustic shed area and associated infrastructure. Site works would be visually screened with hoarding and fencing adjoining the industrial development. As such, much of the compound infrastructure that would be visible would be restricted to activities or infrastructure that extends above the perimeter hoarding and fencing.

It is anticipated that once the tunnelling activities have been completed at the Commercial Road construction compound, the construction facilities would be removed and the tunnel shaft backfilled. The land would be returned for future industrial uses consistent with the land use zoning for the site.

Once supporting works for the western surface works are complete at the Kingsgrove South construction compound, activities would commence for the construction of the permanent Kingsgrove motorway operations complex (MOC1). Three representative receiver locations have been identified for views from industrial neighbours and roadways as detailed in **Table 14-11**.

Bexley Road North construction compound (C4)

The Bexley Road North construction compound would be located on the western side of Bexley Road and north of the existing M5 East Motorway. It would be located within an area of vacant land bounded by the intersection of Bexley Road and Poole Street in the north, Bexley Road in the east, the M5 East motorway in the south and residential properties along Flatrock Road and Jones Avenue in the west. The Bexley Road North construction compound would be mainly used as a tunnelling support site.

The following project structures, equipment and construction activities are likely to be visible from surrounding receiver locations:

- Noise barrier (around 4.5 metres high) surrounding the site
- Tunnel shaft
- Acoustic shed
- Self bunded fuel storage
- Electrical substation and electricity supply point
- Spoil stockpile and associated haulage.

The Bexley Road North construction compound would be highly visible to adjoining residential development due to the tunnelling shaft, acoustic shed area and associated infrastructure. The construction compound would provide complete excavation for the westbound tunnel. Site works would be visually screened and would include a temporary noise barrier around 4.5 metres high along the boundaries of the construction compound. As such, much of the compound infrastructure that would be visible would be restricted to activities or infrastructure that extends above the perimeter hoarding and fencing, or could be viewed from elevated locations.

Once tunnelling activities have been completed, the temporary infrastructure would be removed and the tunnel shaft would be backfilled in order to prepare the land for other use consistent with the land use zoning. An air quality monitoring station for the project has been constructed at the site.

Six representative receiver locations have been identified for views from motorways, residential areas and pedestrian / cycleways as detailed in **Table 14-11**.

Bexley Road South construction compound (C5)

The Bexley Road South construction compound would be located on the western side of Bexley Road to the south of the existing M5 East Motorway tunnel portals. The site would be used for tunnelling support during construction, and for the Bexley Road South motorway operations complex (MOC2), including emergency smoke extraction facility, during operation.

The construction compound is surrounded by Bexley Road to the east, M5 East Motorway to the north and Wolli Creek to the south and west. The following structures, equipment and construction activities are likely to be visible from surrounding Receiver Locations:

- Hoarding (around four metres high) and noise barrier (around 4.5 metres high) around the site
- Tunnel shaft
- Acoustic shed
- Electrical substation on mezzanine within acoustic shed
- Water treatment plant
- Sedimentation pond
- Spoil stockpile.

The Bexley Road South construction compound would include a noise barrier around 4.5 metres high erected around the site and spoil activities to occur within an acoustic shed. Heavy vehicles would enter the site via Bexley Road and once would exit back onto Bexley Road heading west via the M5 East Motorway.

Once construction works are completed, the tunnelling shaft would become part of the permanent Bexley Road South motorway operations complex (MOC2).

Four representative receiver locations have been identified for views from motorways, residential areas and pedestrian / cycleways as detailed in **Table 14-11**.

Bexley Road East construction compound (C6)

The Bexley Road East construction compound would be located on the eastern side of Bexley Road, south of the intersection with Wolli Avenue. This site would be used mainly for car parking and administrative support activities for the Bexley Road North construction compound (C4) and the Bexley Road South compound (C5).

The construction compound is located on the eastern side of Bexley Road, with site access from Wolli Avenue. The following structures, equipment and construction activities are likely to be visible from surrounding Receiver Locations:

- Hoarding (around four metres high) or noise barrier (around 4.5 metres high) surrounding the compound
- Two site offices and crib areas
- Ablutions block
- Parking for around 105 light vehicles.

Three representative receiver locations have been identified for views from motorways, residential areas and pedestrian / cycleways.

Arncliffe construction compound (C7)

The Arncliffe construction compound would be located on the southern side of Marsh Street, encompassing part of the Kogarah Golf Course. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Hoarding (around four metres high) and temporary noise barrier (around three metres high) surrounding the site
- Car parking for around 193 light vehicles
- Tunnel shaft (around 12 metre diameter)
- Acoustic spoil shed and associated haulage
- Electrical substations and electricity supply points
- Water treatment plants
- Three site offices, crib rooms
- Two ablutions blocks
- Storage laydown areas
- Concrete testing station
- Sedimentation ponds.

The Arncliffe construction compound would be highly visible to adjoining residential development due to the construction and excavation of two tunnel shafts (one temporary tunnel access and one for the Arncliffe ventilation facility) within one of two acoustic spoil sheds adjoining Marsh Street. Further, the entry / exit point to the site on Marsh Street would be in operation 24 hours a day, seven days a week, therefore night lighting adequate to support safe construction activity is assumed.

The site works would be visually screened with hoarding and also incorporate a temporary noise barrier adjoining residential development. As such, much of the compound infrastructure would be visible only above the perimeter hoarding, fencing and noise barriers.

Four representative receiver locations have been identified for views from motorways, roadways, recreational areas and pedestrian / cycleways as detailed in **Table 14-11**.

Canal Road construction compound (C8)

The Canal Road construction compound would be located on the north-eastern side of Canal Road and the southern side of the Princes Highway, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Chain-link fence and temporary noise barrier (around 2.5 metres high) surrounding the site
- Site carpark
- Spoil stockpile
- Electrical substations and electricity supply point
- Water treatment plant
- Site offices (including one double stacked office), workshop area and ablutions block
- Storage laydown areas
- Sedimentation pond.

The entry / exit point to the site on Canal Road would be in operation 24 hours a day, seven days a week, therefore night lighting adequate to support safe construction activity is assumed.

Four receiver locations have been identified, including views from a mixture of road users, industrial and commercial premises as detailed in **Table 14-11**.

Campbell Road construction compound (C9)

The Campbell Road construction compound would be located on the southern side of Campbell Road between Woodley Street and Harber Street, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Chain-link fence and temporary noise barrier (around 2.5 metres high) to the north eastern boundary of the compound
- Stockpile of materials generated from the St Peters interchange and local road upgrades
- Site offices
- Site carpark
- Storage laydown areas
- Sedimentation pond.

One receiver location has been identified, which included views from a mixture of residential recreation areas and roadways as detailed in **Table 14-11**.

Landfill closure construction compound (C10)

The landfill closure construction compound would be located on the southern side of Campbell Road, west of the Campbell Road Compound, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Hardstand areas for site offices, amenities, laydown and material storage
- Site fencing, barriers and demolition of existing buildings
- Land closure works consisting of earthworks, foundation treatment and capping.

One receiver location has been identified, which included views from industrial premises as detailed in **Table 14-11**.

Burrows Road construction compound (C11)

The Burrows Road construction compound would be located on the northern side of Burrows Road, west of the intersection with Campbell Road, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Demolition of existing buildings
- Hardstand areas for overflow car parking
- Laydown and storage areas for materials.

One receiver location has been identified, which included views from and industrial premises and road users as detailed in **Table 14-11**.

Alexandra Canal bridge construction compound (C12)

The Alexandra Canal bridge construction compound would be located on the southern side of Burrows Road, opposite the intersection with Campbell Road, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Crib room and ablutions block
- Car parking
- Minor stockpiles of materials
- Laydown and storage of permanent materials for bridge works.

One receiver location has been identified, which included views from a mixture of industrial premises and road users as detailed in **Table 14-11**.

Gardeners Road bridge construction compound (C13)

The Gardeners Road bridge construction compound would be located on the southern side of Burrows Road in St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Minor stockpiles of materials
- Laydown and storage of permanent materials for bridge works.

One receiver location has been identified, which included views from a mixture of industrial premises and road users as detailed in **Table 14-11**.

Sydney Park construction compound (C14)

The Sydney Park construction compound would be located on the northern side of Campbell Road in Sydney Park, St Peters. The following project structures, equipment and construction activities would be visible from surrounding receiver locations:

- Establishment works associated with construction of shared path, bridge and ramps
- Laydown and storage of permanent materials for bridge works
- Construction of bridge across Campbell Road
- Construction of shared path in Sydney Park.

Three receiver locations have been identified, including views from a mixture of residential and recreation areas, and road users as detailed in **Table 14-11**.

Summary of construction visual impacts

A summary of assessed visual impacts based on evaluation of landscape / view sensitivity and magnitude of change (refer to **Table 14-4**) is provided for residential receivers and road users surrounding construction sites in **Table 14-11**.

Table 14-11 Construction visual impacts summary

Receiver identity	Receiver type / construction area	Sensitivity of receivers	Magnitude of change	Overall rating
Western surface works - construction activity within the motorway				
M5 East Motorway adjacent to Coolongatta Road	Stage 1 – road users	Low	High	Moderate
	Stage 2 – road users	Low	High	Moderate to low
	Stage 3 – road users	Low	Moderate	Moderate to low
East of Kindilan Underpass	Stage 1 – road users	Low	High	Moderate
	Stage 2 – road users	Low	High	Moderate
	Stage 3 – road users	Low	Moderate	Moderate to low
Pedestrian and cyclist routes along and around the M5 Linear Park at Beverly Hills, Kingsgrove, Bexley				
Beverly Grove Park North, adjacent to Glamis Street	Pedestrians and cyclists	High	High	High
Beverly Grove Park, adjacent to Kindilan Underpass	Pedestrians and cyclists	High	High	High
Bexley Road, entry to park	Pedestrians and cyclists	High	High	High
Cyclists along the M5 East Motorway	Cyclists	Low	Unable to be assessed, as cyclists would not use the M5 East Motorway during these construction works	NA
Kingsgrove North construction compound (C1)				
1 - Garema Circuit	Industrial neighbours	Low	Low	Low
2 - Glamis Street	Residents and Pedestrians / cyclists	High	High	High
3 - 101 Armitree Street	Residents	Moderate	Moderate	Moderate
4- Kindilan underpass	Pedestrians and cyclists - M5 Linear Park	High	High	High
5- Canterbury Golf Course	Golf players	Moderate	Low	Moderate to low
6 - M5 East Motorway	Road users	Low	Low	Low
Kingsgrove South (C2) and Commercial Road (C3) construction compounds				
6 - M5 East Motorway	Road users	Low	Low	Low
7 - Commercial Road C3 entry	Industrial neighbours	Low	Low	Low

Receiver identity	Receiver type / construction area	Sensitivity of receivers	Magnitude of change	Overall rating
8 - Vanessa Street industrial compounds	Industrial neighbours	Low	High	Moderate
Bexley Road North construction compound (C4)				
6 - M5 East Motorway	Road users	Low	Low	Low
9 – Bexley Road, north of Poole Street	Residents and road users	Moderate to low	High to moderate	High to moderate for residences, moderate to low for road users
10 - M5 Linear Park, Bexley, north of M5 entry	Pedestrians / cyclists	High	High	High
11 - Intersection of Bexley Road and Wolli Avenue	Residences and road users	Moderate to low	Moderate	Moderate for residences, moderate to low for road users
12 - Flatrock Road / Jones Avenue	Residences	High	High	High
Bexley Road South construction compound (C5)				
6s - M5 East Motorway	Road user	Low	Low	Low
11 - Intersection of Bexley Road and Wolli Avenue	Residences and road users	Moderate to low	Moderate to low	Moderate for residences, moderate to low for road users
13 - M5 Linear Park, Bexley, south of M5 entry	Pedestrians / cyclists	High	High	High
15 - Bexley Road, south of the pedestrian underpass	Road users	Low	Moderate	Moderate to low
Bexley Road East construction compound (C6)				
11 - Intersection of Bexley Road and Wolli Avenue	Residences and road users	Moderate to low	Low	Moderate to low for residents, low for road users
13 - M5 Linear Park, Bexley, south of M5 entry	Pedestrians/cyclists	High	Low	Moderate
14 - Reserve adjacent to 9 Johnston Street, Bexley	Residences	High	Moderate	High to moderate

Receiver identity	Receiver type / construction area	Sensitivity of receivers	Magnitude of change	Overall rating
Arncliffe construction compound (C7)				
6 - M5 East Motorway	Road users	Low	Negligible	Negligible
15 - Intersection of Flora and Marsh Street	Residences	Moderate	High	High to moderate
	Residential neighbours (high density housing)	High	High	High
	Road users	Low	High	Moderate
	Pedestrians / cyclists	Moderate to High	High	High to moderate
16– Eve Street cycle path	Pedestrians / cyclists	High	Moderate	High - moderate
17 – Kogarah Golf Course	Active recreation	High	High	High
Canal Road construction compound (C8)				
18 – intersection of Princes Highway and Canal Road	Commercial neighbours	Low	Low	Low
	Road users	Low	Low	Low
19 – complexes backing onto the St Peters interchange	Commercial neighbours	Low	Low	Low
20 – on the Princes Highway	Industrial neighbours	Low	Low	Low
	Road users	Low	Low	Low
21 – St Peters Anglican Church	Commercial neighbours	Moderate	Negligible	Negligible
Campbell Road construction compound (C9)				
22	Residential neighbours	High	High	High
22	Road users	Moderate	High	High to moderate
22	Recreational users within Sydney Park	Moderate	Moderate	Moderate
Landfill closure construction compound (C10)				
20 – on the Princes Highway	Industrial neighbours	Low	Low	Low
Burrows Road construction compound (C11)				
23 – Burrows Road	Industrial neighbours	Low	Low	Low
	Road users	Low	Low	Low
Alexandra Canal bridge construction compound (C12)				
23 – Burrows Road	Industrial neighbours	Low	Low	Low
	Road users	Low	Low	Low
Gardeners Road bridge construction compound (C13)				
24 – Burrows Road	Industrial neighbours	Low	Low	Low
	Road users	Low	Low	Low
Sydney Park construction compound (C14)				
22 – Campbell Road	Residential neighbours	High	Moderate	High to moderate

Receiver identity	Receiver type / construction area	Sensitivity of receivers	Magnitude of change	Overall rating
	Road users	Moderate	High	High to moderate
25 - Sydney Park	Active and passive recreation	Moderate	High	High - moderate
26 – Barwon Park Road	Residential neighbours	High	High	High

Construction night lighting impacts

The potential night lighting impacts and receivers at each construction site are summarised in **Table 14-12**.

Table 14-12 Construction night lighting impacts assessment summary

Construction area	Receiver	Sensitivity to change	Magnitude of change	Overall rating
Western surface works - construction activity within the roadway	Receivers located near the M5 East Motorway, adjacent to Coolongatta Road	Low	Moderate	Moderate to low
	Receivers located near the east of Kindilan Underpass works	Low	Moderate	Moderate to low
Kingsgrove North compound (C1)	Industrial neighbours	Low	Moderate	Moderate to low
	Residents	High to moderate	High to low	High to moderate
	Pedestrians / cyclists	High	Low	Moderate
	Golf course users	High	Negligible	Negligible
	Road users	Low	Negligible	Negligible
Kingsgrove South and Commercial Road compounds (C2 and C3)	Road users	Low	Negligible	Negligible
	Industrial neighbours	Low	Moderate	Moderate to low
Bexley Road North compound (C4)	Road users	Low	Negligible	Negligible
	Residents	High to Moderate	Moderate	High to Moderate
	Pedestrians / cyclists	High	Low	Moderate
Bexley Road South compound (C5)	Road users	Low	Negligible	Negligible
	Residents	Moderate	Low	Moderate to low
	Pedestrians / cyclists	High	Low	Moderate
Bexley Road East compound (C6)	Residents	High to moderate	Moderate to low	High to moderate
	Road users	Low	Negligible	Negligible
	Pedestrians / cyclists	High	Low	Moderate
Arncliffe construction compound (C7)	Road users	Low	Negligible	Negligible
	Residential (low density)	Moderate	Moderate	Moderate
	Residential (high density)	High	High	High
	Road users	Low	Low	Low
	Pedestrians / cyclists	Moderate	Moderate	Moderate
	Pedestrians / cyclists	High	N/A	N/A
	Active recreation	High	N/A	N/A
Canal Road construction compound (C8)	Commercial neighbours	Low	Low	Low
	Road users	Low	Negligible	Negligible
	Commercial neighbours	Low	Low	Low
	Industrial neighbours	Low	Low	Low

Construction area	Receiver	Sensitivity to change	Magnitude of change	Overall rating
	Road users	Low	Negligible	Negligible
	Commercial neighbours	Moderate	N/A	N/A
Campbell Road construction compound (C9)	Residential neighbours	High	Moderate	High to moderate
	Road users	Moderate	N/A	Negligible
	Recreational users	High	N/A	N/A
Landfill closure construction compound (C10)	Industrial neighbours	Low	Low	Low
Burrows Road construction compound (C11)	Industrial neighbours – Burrows Road	Low	Low	Low
	Road users	Low	Negligible	Negligible
Alexandra Canal bridge construction compound (C12)	Industrial neighbours – Burrows Road	Low	Low	Low
	Road users	Low	Negligible	Negligible
Gardeners Road bridge construction compound (C13)	Industrial neighbours – Burrows Road	Low	Low	Low
	Road users	Low	Negligible	Negligible
Sydney Park construction compound (C14)	Residential neighbours – Campbell Road	High	Low	Moderate
	Road users – Campbell Road	Moderate	N/A	Negligible
	Active and passive recreational users – Sydney Park	High	N/A	N/A
	Residential neighbours – Barwon Park Road	High	High	High

14.3.2 Operation

This section provides an assessment of the potential operational urban design and landscape implications of the project including:

- Western surface works, including the Kingsgrove motorway operations complex (MOC1)
- Bexley Road surface works, including the Bexley Road South motorway operations complex (MOC2)
- Arncliffe surface works, including the Arncliffe motorway operations complex (MOC3)
- The St Peters interchange and local road upgrades, including the St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5).

A series of artists' impressions of key project elements has also been produced, and are available in full within Section 6 of the Technical working paper: Landscape character and visual impact (**Appendix K**). Artist's impressions presented in this chapter provide a typical view of project elements at a variety of locations along and adjacent to the route at a period of around 12 to 18 months after opening, and at around 10 years post-project (refer **Figure 14-6** to **Figure 14-10** below).

Artists' impressions have been based on the current project design and the appearance of project components and features may differ slightly as a result of design development, finalisation of materials and colours and the surrounding landscape, as well as local weather conditions on any particular day and any additional future developments in the area.

The project would be designed and operated in accordance with the WestConnex Urban Design Framework, as outlined in **Table 14-3**. An assessment of the project against these design principles is provided in Section 8 of the Urban design report (**Appendix L**) and outlined in **Table 14-13**. The project design would integrate high quality architecture with engineering solutions to sensitively integrate the project with its surrounds.

Table 14-13 Assessment against WestConnex urban design framework

Kingsgrove motorway operations complex (MOC1)	Bexley Road South motorway operations complex (MOC2)	Arncliffe motorway operations complex (MOC3)	St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5)	Tunnel design
Objective: Leading edge environmental responsiveness				
• Landscaping would be used to soften views and create habitat within and along the M5 East Motorway corridor. • Upgrade of shaded path within the M5 Linear Park would increase access to active recreation opportunities. • Location of Kingsgrove motorway operations complex (MOC1) would allow for the preservation of Wolli Creek bushland.	• Landscaping would create a green gateway to the M5 Linear Park. • Addition of tree canopies would improve streetscape amenity	• Landscaping would be used to ensure facilities recess into the existing Golf Course landscaping, as well as improving biodiversity (eg Green and Golden Bell Frog habitat).	• Landscaping would create an 'urban forest.' • New open spaces would be created for community enjoyment. • New pedestrian and cycling links would increase active transport connectivity.	• Potential use of light emitting diode lighting to reduce energy consumption.

Kingsgrove motorway operations complex (MOC1)	Bexley Road South motorway operations complex (MOC2)	Arncliffe motorway operations complex (MOC3)	St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5)	Tunnel design
Objective: Connectivity and legibility				
• Portal treatment (analogous to Stage 1B) would begin and end the overall WestConnex identity at the southern extent. • Transparent noise barriers would allow views to surrounds orientating motorists. • Shared path upgrades would provide active transport connectivity for local communities. • Built form would utilise the project-wide material palette, commencing the overall WestConnex identity in the southern extent of the M5 East Motorway corridor.	• Completion of the M5 Linear Park (western side) with a green gateway would reinforce landscape setting for the M5 East Motorway and the shared path of the M5 Linear Park.	• Location of facilities would maintain pedestrian and cyclist accessibility.	• St Peters interchange site would form the main connector between stages and within the southern reaches of the CBD – denoted by its green appearance and unique portal design marking it as a major decision point within the M5 East Motorway journey. • Local street upgrades would improve pedestrian and cyclist connectivity and access to open space.	• The M5 East Motorway would increase connectivity regionally within Sydney. • Locational identifier markers and other tunnel linings (break-down bays and emergency access points) would be the same as Stage 1B, providing visual stimuli, and a recognisable identity within the journey.

Kingsgrove motorway operations complex (MOC1)	Bexley Road South motorway operations complex (MOC2)	Arncliffe motorway operations complex (MOC3)	St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5)	Tunnel design
Objective: Place making				
• Kindilan underpass would provide opportunities to engage with the community to increase street art concepts. • Upgrades to the M5 Linear Park and shared paths would create opportunities to reinforce the green corridor, and provide an improved landscape setting. • Location of built form would recess into the existing landscape, and would also be designed to limit the overshadowing of public open space.	• Built form would recess into its surrounds with a residential style appearance complemented by landscaping at the perimeter.	• Landscape setting would be retained and enhanced allowing facilities to recede.	• Creation of open space would provide essential active and passive recreational facilities for the community. • Transformation to an urban forest would create a new chapter in the history of the St Peters interchange. • Definition of local streets through planting and paths would support active transport for local communities.	• NA.

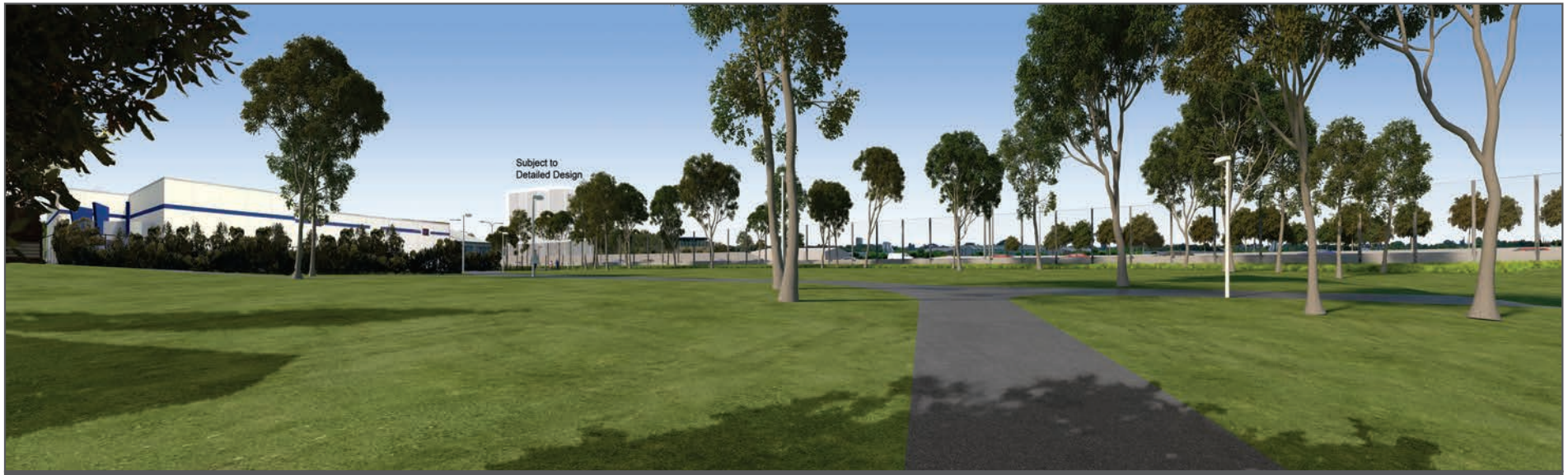
Kingsgrove motorway operations complex (MOC1)	Bexley Road South motorway operations complex (MOC2)	Arncliffe motorway operations complex (MOC3)	St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5)	Tunnel design
Objective: Urban renewal and liveability				
• Upgraded shared path with lighting would improve amenity for existing and future residents along the M5 Linear Park.	• Location of facilities on isolated site would reduce impacts to surrounding residential lands.	• Location of facilities within Golf Course site reduces impacts on surrounding residential lands.	• Utilisation of land fill site for the St Peters interchange repurposes a site unsuitable for many other uses. • Creation of open space and active transport connections would support existing urban renewal occurring in Mascot and Erskineville and provide opportunities for further renewal in the future.	• NA.
Objective: Memorable identity and a safe enjoyable experience				
• Portal design would match that of the M4 East portals-creating identity. • Landscaping would significantly green the corridor in this location. • Inclusion of public art concept would have the potential to reinforce the street art that characterises underpasses.	• Landscaping would support the green corridor concept location within this location.	• Landscaping would ensure facilities recess into the existing Golf Course landscaping.	• Distinct portal design would create an identity for the St Peters interchange. • Heavily treed landscape would reinforce the urban forest identify of the St Peters interchange. • Open space proposal for mounds would create a memorable landscape and continue the 'language' of Sydney Park. • Public art inclusion would have the ability to activate parklands and provide a distinct talking point along the M5 East Motorway journey.	• Tunnel lining design would match the proposed M4 East tunnel, reinforcing the overall WestConnex identity.

Kingsgrove motorway operations complex (MOC1)	Bexley Road South motorway operations complex (MOC2)	Arncliffe motorway operations complex (MOC3)	St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5)	Tunnel design
Objective: A new quality benchmark				
• Material selection would be durable and easy to maintain. Composition of materials would be restrained to ensure facilities wit within their surrounds.	• Material selection would be durable and easy to maintain. Composition of materials would be restrained to ensure facilities wit within their surrounds.	• Material selection would be durable and easy to maintain. Composition of materials would be restrained to ensure facilities wit within their surrounds.	• Material selection would be durable and easy to maintain. Composition of materials would be restrained to ensure facilities wit within their surrounds.	• Outcomes would be reviewed throughout design development by the Urban Design Review Panel. • Material selection would be durable and easy to maintain. • Composition of materials would be restrained to ensure facilities wit within their surrounds.

(blank page)



View to south - across Beverly Grove Park to New M5 motorway - project completion



View to south - across Beverly Grove Park to New M5 motorway - 10 years post project

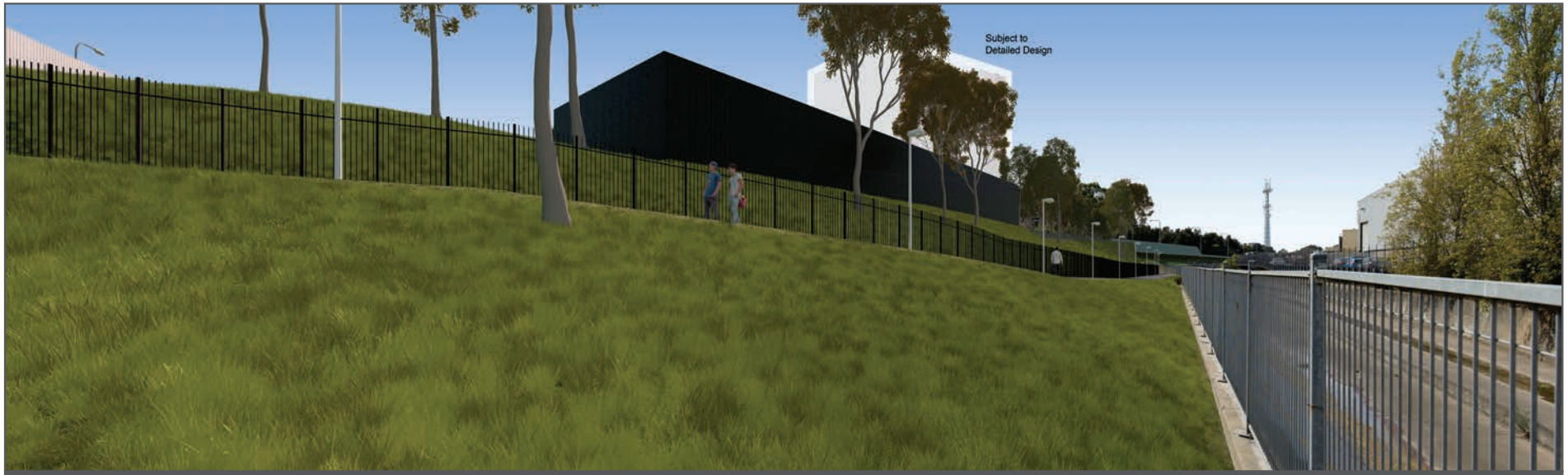
The architectural treatment of the ventilation facilities would be confirmed during detailed design as discussed in Section 5.11

Figure 14-6 Beverly Grove Park - artists impression

(blank page)



View to east - from north of Wolli Creek towards the Kingsgrove motorway operations complex (MOC 1) - project completion



View to east - from north of Wolli Creek towards the Kingsgrove motorway operations complex (MOC 1) - 10 years post project

The architectural treatment of the ventilation facilities would be confirmed during detailed design as discussed in Section 5.11

Figure 14-7 Kingsgrove motorway operations complex (MOC 1)

(blank page)



View to southeast - from entry to M5 Linear Park towards Bexley Road South motorway operations complex (MOC 2)



View to southeast - from entry to M5 Linear Park towards Bexley Road South motorway operations complex (MOC 2) - 10 years post project

Figure 14-8 Bexley Road South motorway operations complex (MOC 2) - artists impression

(blank page)



View to south - from Flora Street towards Arncliffe motorway operations complex (MOC 3)



View to south - from Flora Street towards Arncliffe motorway operations complex (MOC 3) - 10 years post project

The architectural treatment of the ventilation facilities would be confirmed during detailed design as discussed in Section 5.11

Figure 14-9 Arncliffe motorway operations complex (MOC 3) - artists impression

(blank page)



View to west - from Burrows Road and Campbell Road intersection



View to west - From Burrows Road and Campbell Road intersection - 10 years post project

Figure 14-10 St Peters interchange - artists impression

(blank page)

Western surface works

At operation, the built structures and infrastructure on site would comprise the following:

- The Kingsgrove motorway operations complex (MOC1) to support maintenance of the project during operation, accommodating around 10 workers. It would be located to the south of the western project portals and the existing M5 South West Motorway, on land previously occupied by the Kingsgrove South construction compound, and would include the following:
  - Bulky equipment storage area
  - Local maintenance facility, workshop and offices (including kitchen facilities and amenities)
  - Car parking area for up to 15 vehicles
  - Substation (including disaster recovery system)
  - Deluge tanks
  - The Kingsgrove ventilation facility
  - Access road to the facility and hardstand area
  - Reinstated shared path for pedestrians and cyclists running adjacent to the southern boundary of the park along to Wolli Creek
  - A noise barrier around five metres high adjacent to the M5 East Motorway between Kooemba Road and Beverly Grove Park, of which the top three metres would be transparent
- Beverly Grove North:
  - A transparent noise barrier around four metres high and adjacent to the M5 East Motorway between Garema Circuit and the eastern corner of Canterbury Golf Course
  - Reinstated shared path for pedestrians and cyclists, which would generally run along the northern boundary of Beverly Grove Park North
- The M5 Motorway corridor, which would include the realigned M5 East Motorway and the project:
  - Western tunnel portals
  - Two new through lanes from the M5 South West Motorway to the M5 East Motorway
  - Two new through lanes from the M5 South West and M5 East Motorway to the project
  - One new lane connecting King Georges Road interchange to the M5 East Motorway, which bypasses the project
  - Tolling gantries.

The tallest of the structures at the western surface works would be the Kingsgrove ventilation facility located at the Kingsgrove motorway operations complex (MOC1), which would be around 30 metres high. For further details on these proposed operational built structures, including artists' impressions and proposed site plans, refer to Section 5.2 of **Appendix L**.

Five landscape character zones have been identified for the western surface works site area. For an indication of landscape character zones within this area, refer **Table 14-6** and **Figure 14-2**.

The permanent changes due to the project would mainly contained within the M5 East Motorway corridor (transport corridor landscape character zone), with some encroachment into the neighbouring recreational landscape character zone at Beverly Grove Park South (due to the maintenance operations centre) and Beverly Grove Park North (with loss of the vegetated noise mound and Cooks River / Castlereagh Ironbark Forest at Beverly Grove bushland due to the M5 East Motorway tie-in works). The visibility of the infrastructure at these locations within the recreational landscape character zone would create a high to moderate visual impact for this landscape character zone.

Visual envelope mapping was undertaken from the top of the ventilation facility at the Kingsgrove motorway operations complex (MOC1) at a height of around 33 metres above existing ground level. The mapping is provided in Figure 6-51 in **Appendix K**, and illustrates the potential visibility of the project from the surrounding areas.

Views from the north-west are effectively screened by trees located along the Canterbury Golf Course perimeter. Additional vegetation planting and noise walls at Beverley Grove Park, existing and proposed as part of the project, would provide screening for residential properties bordering the park. These receivers are unlikely to experience significant visual impacts as a result of the project as only the top of the ventilation facility would be visible.

From the north-east, industrial complexes adjoining the M5 East Motorway may have views to the top of the ventilation facility. These views are likely to be generally restricted to areas within the Garema Circuit road corridor.

Similarly, views from the south and south-west are generally buffered by the large industrial complexes fronting The Crescent and Vanessa Street. The ventilation facility would be likely to be visible from a distance from the south-east, east and north-east. This is largely due to the smaller built form of industrial complexes along Commercial Road. A gentle rise in topography towards Kingsgrove Road provides an elevated position with likely views of the top of the ventilation facility from these locations.

Bexley Road surface works

The Bexley Road South motorway operations complex (MOC2) would be located to the south of the M5 East Motorway western portals, adjacent to Bexley Road, on land previously occupied by the Bexley Road South construction compound.

As with the Western surface works area, the greatest affected landscape character zone would be the road reserve which would experience a high to moderate impact. In addition, the M5 Linear Park at this location comprises a gateway to the rest of the M5 Linear Park, which places emphasis on the landscape value of this area within the greater landscape character zone.

Built structures at the Bexley Road South motorway operations complex (MOC2) would include:

- Fresh air intake and emergency smoke extraction facility
- Distribution substation.

These would be no more than five meters in height. For further details on these proposed operational built structures, including artists' impressions and proposed site plans, refer to Section 5.3 of the Urban design report in **Appendix L**.

Visual envelope mapping was untaken from the top of the MOC2 at a height of around four metres above existing ground level and demonstrates the locations from which views of the site would potentially be obtained. Figure 6-60 in **Appendix K** illustrates the potential visibility of the project from the surrounding areas.

Views from the north are restricted to the front of residential properties along the eastern side of Bexley Road (south of Poole Street) and a small section of Wolli Avenue. Views from the east are screened by the existing infrastructure and vegetation associated with the M5 East Motorway filtration plant and motorway operations support and pedestrian overpass.

It is unlikely that receivers from the south or south-west of Kingsgrove Avenue would have significant views of the Bexley Road motorway operations complex due to the density of the existing vegetation within the M5 Linear Park.

Arncliffe surface works

At operation, the built structures and infrastructure on site would comprise the following:

- The Arncliffe motorway operations complex (MOC3), which would include:
  - Ventilation facility (35 metres tall)
  - Air intake facility (10 metres tall)
  - Distribution substation (around five metres tall)
  - Water treatment plant
  - Water treatment wetland
  - Car parking.

Vehicle access is provided from Marsh Street at the intersection with Flora Street and pedestrian access is maintained adjoining the site.

Three landscape character zones have been identified for the Arncliffe surface works area. For a description of landscape character zones within this area, refer **Table 14-6** and **Figure 14-4**.

The tallest of the structures at the Arncliffe motorway operations complex (MOC3) would be the ventilation facility, which would be around 35 metres high. For further details on these proposed operational built structures, including artists' impressions and proposed site plans, refer to Section 5.4 of **Appendix L**.

The Arncliffe motorway operation complex (MOC3) would have a limited impact on the surrounding landscape character zones due to the relatively small size of the site, the potential screening and softening effect of landscaping surrounding the built elements of the project, and the limited visual integration of adjacent landscape character zones due to road corridors and boundary conditions.

Visual envelope mapping taken from the top of the ventilation facility (MOC3) at a height of around 35 metres above existing ground level demonstrates the key locations from which views of the site would be obtained. Figure 6-66 of **Appendix K** illustrates the potential visibility of the project from the surrounding areas.

The most affected receivers are likely to include motorists travelling along Marsh Street and nearby residences north-west of the site in Valda Avenue, Flora Street and Innesdale Road. In conjunction with the residential buildings and substantial mature street and garden cover, residential areas greater than 200 metres from the site are unlikely to have substantial visibility of the project elements except for the top of the ventilation facility.

Views to the motorway operations complex from the north would be available from residences in high-rise apartment buildings that line Gertrude Street, Innesdale Road and Marsh Street. Views from the south would be effectively blocked by the combination of existing screening vegetation and noise barriers along the M5 East Motorway.

Views of the MOC3 from the east within Kogarah Golf Course would be prominent, but only when users are playing on the fairways that are adjacent to the project. Areas greater than 300 metres from the site are unlikely to have substantial visibility of the project elements due to the existing mature vegetation within the golf course, except for the top of the ventilation facility.

St Peters interchange and local road upgrades

At operation, the St Peters interchange would include the following built structures and infrastructure:

- The St Peters motorway operations complex (MOC4), located on the corner of Princes Highway and Canal Road, consisting of:
  - Ventilation facility including exhaust fan room and exhaust stacks (20.5 metres tall)
  - Supply air intake building
  - Distribution substation building

  - Plenum building
  - Fire pump room (below ground)
  - Car parking and vehicle access via Canal Road
  - Deluge tanks
- The Burrows Road motorway operations complex (MOC5), located on the corner of Campbell Road and Burrows Road, consisting of:
  - The motorway control centre building (8.5 metres tall)
  - Distribution substation
  - Car parking at ground level below motorway control centre
  - Incident response parking and vehicle access via Burrows Road
- Car parking
- Leachate treatment plant
- Seven interchange bridges
- Pedestrian and cycleway bridge over Campbell Road
- Pedestrian and cycleway bridge over northern ramps
- Campbell Road bridge over Alexandra Canal
- Gardeners Road bridge over Alexandra Canal
- Two bioretention basins
- One park area, pedestrian and cycle paths, with the remaining park to be delivered as part of the M4-M5 Link.

The 'Dynamo' heritage building would be retained at the corner of the Princes Highway and Canal Road.

Five landscape character zones have been identified for the St Peters interchange and local road upgrades area. For a description of landscape character zones within this area, refer **Table 14-6** and **Figure 14-10**. For further details on these proposed operational built structures, including artists' impressions and proposed site plans, refer to Sections 5.6.4 and 5.6.5 of **Appendix L**.

The St Peters interchange lies within the industrial landscape character zone. The proposed changes would comprise a significant change to the character of the site, and therefore a high change to the landscape character zone. Areas of parkland, as well as new built forms and associated landscaping would be new elements with positive implications for the existing industrial landscape.

These changes to the site would impact the surrounding landscape character zones to varying degrees. Although the impact rating for the surrounding zones lies between moderate to moderate - low, these ratings have a lot to do with the sensitivity of the individual landscape character zones. The greatest magnitude of change would be experienced by the industrial landscape character zone, and the transport corridor landscape character zone, both of which lie partly within or adjacent to the St Peters interchange.

In terms of visual envelope mapping, Figure 6-75 of **Appendix K** illustrates the potential visibility of the project from the surrounding areas at St Peters. Visual envelope mapping taken from the top of the ventilation facility (MOC4) at a height of around 20.5 metres and the top of the motorway operations complex (MOC5) at a height of around 8.5 metres above existing ground level demonstrates the locations from which views of the site would potentially be obtained.

Views to the St Peters interchange from the west would be seen across a busy intersection, with the most prominent elements of the Dynamo building and the street trees to be retained. However, a number of new elements would be seen within the view, including the ventilation facility, new motorway operations buildings and landscaping to the Canal Road edge.

Views from the north-west would be limited by the adjacent commercial buildings that front the Princes Highway. The most visible elements would be the canopy of trees within the St Peters interchange parkland as the vegetation matures.

Views from the north-east would be a significant change in terms of the character and scale of the development, particularly with regard to the widening of Campbell Road. Elements that would be seen from the road include the pedestrian bridge joining Sydney Park, the St Peters interchange and open parklands.

Views from the south at the corner of Canal Road and Burrows Road would be limited by the adjacent industrial development and Gardeners Road bridge crossing. Views from the road to the MOC5 would be of short duration and limited by landscaping and street tree plantings.

Operational landscape character impacts

A summary of the potential operational landscape character impacts of the project is presented in **Table 14-14**. The assessment has been based on the landscape character zones identified in **Table 14-6** and **Figure 14-2** to **Figure 14-5**.

Table 14-14 Landscape character impact assessment summary

Landscape character zone	Sensitivity of landscape	Magnitude of change	Overall rating
Western surface works, including the Kingsgrove motorway operations complex (MOC1)			
Residential	Moderate	Low	Moderate to low
Industrial	Low	Low	Low
Recreational	Moderate	High	High to moderate
Transport corridor	Low	Moderate	Moderate to low
Urban centre	High	Negligible	Negligible
Bexley Road surface works, including the Bexley Road South motorway operations complex (MOC2)			
Residential	Moderate	Low	Moderate to low
Recreational	Moderate	High	High to moderate
Transport corridor	Low	Low	Low
Urban centre	High	Negligible	Negligible
Arncliffe surface works, including the Arncliffe motorway operations complex (MOC3)			
High density residential	Low	Low	Low
Low density residential	Moderate	Moderate	Moderate
Recreational – open spaces	High	Moderate	High to moderate
Recreational – waterways	Moderate	Negligible	Negligible
Infrastructure - corridor	Low	Low	Low
Infrastructure - Airport	Low	Negligible	Negligible
St Peters interchange and local road upgrades, including the St Peters motorway operations complex (MOC4) and Burrows Road motorway operations complex (MOC5)			
Residential	High	Low	Moderate
Industrial	Low	High	Moderate
Recreation	High	Low	Moderate
Transport corridor	Low	Moderate	Moderate to low
Commercial corridor	Moderate	Low	Moderate to low

Desired future character assessment

The hard and soft urban design elements of the project would assist in ensuring the project is consistent with the existing and desired future character of the project area. Hard elements refer to built infrastructure, while soft elements refer to proposed landscaping features. This desired future character assessment considers both the hard and soft urban design elements of the project.

A material palette has been developed for utilisation in built-form structures throughout the project. Materials were selected for appearance, durability and maintainability, with the main focus on materials and finishes that would visually unify buildings across the project. Examples of these materials proposed to be incorporated throughout the project are included in Section 5.1 of the Urban design report (**Appendix L**).

Maintenance facilities and motorway control centres would be designed to be used and inhabited by people on a daily basis. These structures would provide spaces and volumes appropriate to human scale, contain materials with a tactile quality, and create environments that are both comfortable and sustainable for their occupying personnel and surrounding environments.

Buildings and facilities supporting the operation of the tunnels and portals would be refined and elegant sculptural objects designed to integrate into their adjacent environments.

Western surface works

The majority of the area within which permanent changes due to the western surface works area lies is zoned SP2 Infrastructure under both the Hurstville LEP 2012 and the Canterbury LEP 2012, which reflects the desire to maintain accessibility, supporting economic activity and efficient freight movement. However, some changes would spill over into land zoned RE1 Public Recreation and a strip of unzoned land.

The road reserve to the south of the M5 East Motorway comprises Beverly Grove Park South, which is a road reserve within the M5 Linear Park. The land surrounding the western surface works area is zoned as R3 Medium Density Residential, IN2 Light Industrial, R2 Low Density Residential, with some pockets of RE1 Public Recreation under the Hurstville LEP 2012 and the Canterbury LEP 2012. This zoning reflects the desire to maintain the existing low-medium density residential character and suburban setting of the area, with pockets of bushland.

The changes within the western surface works area would visually comprise a general widening of the M5 East Motorway and associated new noise barriers, as well as the western tunnel portals, a collection of built elements associated with the Kingsgrove ventilation facility, ancillary infrastructure and operational facilities for electronic tolling, and a widened Kindilan Underpass.

The widening of the M5 East Motorway and the associated ancillary elements (noise barriers, tolling gantry, signage and landscaping) would be visually consistent with the existing and future desired character of the area within the SP2 Infrastructure zoned land. The western surface works area is predominantly flanked by RE1 Public Recreation zoned land, which visually buffers the residential (and to some extent the industrial) land beyond. As such, the project would have a minimal visual impact on these areas, and therefore the overall character of ‘a suburban setting with pockets of bushland’ would not be significantly affected.

Kingsgrove motorway operations complex (MOC1)

The Kingsgrove motorway operations complex (MOC1) would be located on land zoned as SP2 Classified Road as per the Hurstville LEP 2012. Land uses permitted with consent in this zone include development for the purposes of roads, including any development ordinarily incidental or ancillary to road development. This would include the construction and operation of the Kingsgrove motorway operations complex (MOC1), as ancillary to the operation of the project.

The change within Beverly Grove Park South (from a road reserve to the maintenance facility and the Kingsgrove ventilation facility) would constitute a character change from the existing condition. Using other areas within the M5 Linear Park as a bench mark, the narrowed pedestrian and cycle access around the edge of the widened portion of M5 East Motorway would not be out of character for this park.

The Kingsgrove motorway operations complex (MOC1) would comprise a workshop with staff offices to the east, and a large covered store to the west. The overall design intent is to blend these structures with surrounding warehouse buildings so as to appear as another industrial building. A combined access road and shared path from Tallawalla Street would be located to the south-west of the Kingsgrove motorway operations complex (MOC1), with access to the secure maintenance area between the two built structures, and staff and visitor parking to the east of the workshop and office building. The Kingsgrove ventilation facility, deluge tanks and distribution substations would also form part of the Kingsgrove motorway operations complex (MOC1).

The Kingsgrove ventilation facility, deluge tanks and distribution substation would be located to the north of the maintenance facility. At around 30 metres tall, it would be impractical to screen. The form of the three vents would be articulated to add variety to the massing and robust material palette that has been chosen. The location of the Kingsgrove ventilation facility above the west bound exit tramp would provide the most practical location to serve this function. A fire pump and water deluge tank would be located adjacent to the M5 East Motorway, with the distribution substation behind. Those buildings would be largely screened from view due to the noise barrier planned to the north and landscaping proposed to the south.

The Kingsgrove motorway operations complex (MOC1) would be constructed of precast concrete panelling to the dado with zincalume profiled cladding above, wrapping over the roof to denote the building's industrial nature. On the eastern face of the workshop, staff offices would be denoted through full length curtain wall glazing between horizontal concrete bands. Those bands as well as the northern and southern facades would be further embellished with perforated corten cladding. The distinction in materials together with a reduction in roof height for the staff offices would denote their use for human-scaled activities as opposed to the more industrial nature of the workshop.

Sitting slightly lower than the westbound bypass lane, the covered store to the west of the workshop facility would feature a zincalume clad roof and concrete blockwork walls. This roof would be visible to passing motorists in keeping with the large span metal roofs surrounding warehouses. The concrete blockwork would be largely hidden from view.

The horizontal portion of the substation building would be clad in dark face brick. Openings providing service access to the plan rooms would be grouped in common recesses to expose the structure, which would be a smooth-faced concrete block. Access doors within the blockwork would be painted light grey to match.

Patterned precast concrete panels form the eastern and western facades of the Kingsgrove ventilation facility. The vertical and horizontal joints would be integrated into the cast-in pattern. Horizontal louvres would be incorporated on the northern and southern facades that are cut with varying depths to provide opportunities for interpretive patterns to be applied. The corten of the north and south facades would evoke the ochre colours of surrounding residences, whilst the patterned pre-cast concrete would be representative of surrounding industrial buildings.

The composition of materials chosen would also indicate, through design, the commencement of the new M5 East Motorway, which would be continued east along the corridor to St Peters.

Western portals

The western portals would provide eastbound ingress to and westbound egress from the M5 East Motorway. The portals would be located within an expansive transport corridor spanning 10 lanes of traffic. To ameliorate the expanse of road space, a series of 'green canopies' would assist in blending the proposed infrastructure elements within the local built and natural fabric. Urban design outcomes at these locations would be guided by a number of existing motorway infrastructure elements including the original M5 East Motorway, the original M4 Motorway and the recent M4 Motorway widening works, and the soon to be constructed King Georges Road interchange upgrade. These combine to create a varied and cluttered driver experience.

The overall design intent for tunnel portals would be to create a refined design aesthetic that avoids clutter. Portals would be designed as architectural elements which are both attractive and welcoming. The portals would be designed to fit within the existing M5 East Motorway corridor, connect with the King Georges Road interchange upgrade and present a new, sleek and refined element.

Tunnel portals would be designed using robust, durable materials with the integration of lighting and signage. Tunnel portals would feature the following:

- Portal walls with select paint finish and anti-graffiti coating
- Portal facades with black composite metal cladding on structural steel frames
- Tunnel entry portals would feature black variable message signage above tunnel entry ramps, blending with the black composite metal cladding portal facades
- Tunnel dive approach structures which feature wall cladding with a composite metal cladding coloured silver grey with feature lighting rebates staggered at regular centres with light emitting diode strip lighting.

Bexley Road South motorway operations complex (MOC2)

The Bexley Road South motorway operations complex (MOC2) would be located within land zoned SP2 Classified Road under the Canterbury LEP 2012, which reflects the desire to maintain accessibility, supporting economic activity and efficient freight movement. Land uses permitted with consent in this zone include development ordinarily incidental to or ancillary to road development. This would include the construction and operation of the Bexley Road South motorway operations complex (MOC2), as ancillary to the operation of the project.

The Bexley Road South motorway operations complex (MOC2) would be bound by the M5 East Motorway to the north and Bexley Road to the east, both of which are zoned SP2 Infrastructure. These two road corridors to the north and east of the site visually buffer the site from the residential zoned land to the north and east. As such, the project would have a minimal visual impact on these areas, and therefore the overall character of 'low-medium density residential character and bushland setting of the area' would not be significantly affected.

The Bexley Road South motorway operations complex (MOC2) shares a boundary with the M5 Linear Park. Although this narrow parkland is used for public recreation, the land is zoned SP2 Infrastructure and is closely associated with the M5 East Motorway. The change within the Bexley Road South motorway operations complex (MOC2) site (from a road reserve to the motorway operations complex) would constitute a character change from the existing condition, but as the site is zoned SP2 Infrastructure, this change is acceptable within the desired future character of the site. In addition, the narrowed pedestrian and cycle access around the edge of the motorway operations complex would not be out of character for this linear park.

The land on the southern side of Wolli Creek to the south of the Bexley Road South motorway operations complex (MOC2) is zoned RE1 Public Recreation. The Bexley Road South motorway operations complex (MOC2) would not encroach on this land and would be visually buffered by the mature vegetation associated with the Wolli Creek corridor and recreational land adjoining it. Therefore the character of this recreational land would not be affected by the Bexley Road South motorway operations complex (MOC2).

Arncliffe motorway operations complex (MOC3)

The Arncliffe motorway operations complex (MOC3) would lie within the Kogarah Golf Course, which is unzoned. The change in land use (from private recreational open space to the Arncliffe motorway operations complex (MOC3)) does constitute a significant character change from the existing condition. The land is currently zoned as Trade and Technology, Open Space and Special Uses under the *Sydney Regional Environmental Plan No. 33 – Cooks Cove*. However no action has been taken so far to action these future uses, and the DP&E has commenced investigations of the Cooks Cove area as a potential priority precinct for rezoning.

In terms of current land use zonings, the Arncliffe motorway operations complex (MOC3) would primarily lie within the Trade and Technology zone, with minor encroachments into the Open Space and Special Uses Zones. The Arncliffe motorway operations complex (MOC3) would be compatible with these land use zones as follows:

- Within the Trade and Technology zone, roads are permitted with development consent, as are ancillary facilities supporting the functions of the zone

- Within the Open Space zone, roads are permitted with development consent, as are inland uses incidental or ancillary to the land uses lawfully carried out within the zone
- Within the Special Uses zone, land uses for the purposes of roads may be carried out with development consent, and the objectives of the zone include accommodating the M5 corridor and to provide for the development of a transport corridor by Roads and Maritime.

Given these land use zonings, it is considered that development for the purposes of the Arncliffe motorway operations complex (MOC3) would ordinarily be permissible on this land, given its proper classification as development for ancillary road infrastructure on behalf of Roads and Maritime.

It is however understood that DP&E is investigating the site as a potential priority precinct, which may result in changes to current land use zonings. MOC3 will impact future development at the site However, the magnitude of this impact will be dependent on the land use. Nevertheless a number of design responses could be implemented for any future development on the Cooks Cove site that would ensure these impacts are mitigated. Ongoing liaison with DP&E during detailed design would assist in determining the magnitude of visual impacts.

The Arncliffe motorway operations complex (MOC3) would be bounded on two sides by major road corridors: to the north by Marsh Street, which is zoned SP2 Infrastructure, and to the west by the M5 East Motorway, which also lies within unzoned land. The Arncliffe motorway operations complex (MOC3) site would be visually buffered by the M5 East Motorway, which would provide a visually impenetrable barrier between the Arncliffe motorway operations complex (MOC3) and areas to the west. The Arncliffe motorway operations complex (MOC3) would therefore have no impact on the desired character of these areas.

North of Marsh Street, the land is zoned R2 Low Density Residential, B4 Mixed Use, R4 High Density Residential and a small pocket of RE1 Public Recreation under the Rockdale LEP 2011. The Arncliffe motorway operations complex (MOC3) would be visually exposed to the R2 Low Density Residential zoned and B4 Mixed Use land, but would be buffered somewhat by Marsh Street, which is a busy four lane road. During operation, and particularly when the landscaping associated with the Arncliffe motorway operations complex (MOC3) has matured, the project would have a minimal impact on the overall character of these areas to the north, particularly considering the limited visual accessibility that these areas share. The desired 'residential character with integrated business development and recreational areas' would not be affected by the project.

The facility would include the following:

- Supply vent station
- Exhaust vent station
- Distribution substation
- Water treatment pant
- Water treatment wetland.

Landscape areas would be restored with new areas of turf and tree planting to screen this infrastructure and match the area's existing parkland character. The buildings would be of relatively low height, largely screened with vegetation, and appear as part of the overall project. The distribution substation and water treatment plant would be clad in dark face brick on structural concrete blockwork. Openings providing service access to plant rooms would be grouped similarly to the other distribution substations with common recesses exposing bands of the structure – a smooth-faced concrete block. Access doors within the blockwork would be painted light grey to match. A ventilation facility would be located adjacent to Marsh Street, including four ventilation shafts. The design of the ventilation facility and associated buildings would be reminiscent of ventilation facilities along the M5 East Motorway, albeit of a lower scale. The Arncliffe ventilation facility would be around 35 metres in height, and clad in precast concrete panels on the east and west facades and corten material cladding on the northern and southern facades.

Tunnels

A large portion of the M5 East Motorway would be in tunnel, ultimately becoming Australia's longest road tunnel. Tunnel components include lining, roof, lighting, on / off ramps and safety breakdown bays. The new M5 East Motorway tunnel would set the benchmark in improving tunnel travel experiences.

A unique identity for the M5 East Motorway tunnel would be consistent with the WestConnex M4 East Stage 1B Tunnel through the inclusion of the following:

- Portal drive structures with integrated feature lighting
- Short sections providing architectural variation with 'black' panel inserts at approximate one kilometre intervals
- Location suburb identifiers with custom image panels
- A 'mid tunnel event'
- Coloured feature lighting at selected locations and coloured lining panels within breakdown bays
- All safety and emergency exit signage requirements.

Tunnel materials, colours and finishes would be as follows:

- Left side treatments:
  - Standard 'white' compressed fibre cement epoxy coated lining panels
  - Short sections with variable width panel inserts (coloured black, white and silver grey) at approximate 500 metre intervals (mainline only) that would introduce a textural effect as a contrast to the standard white panel, providing a subtle variation in visual rhythm to reduce monotony
  - Custom image panels as location identifiers at approximate two kilometre intervals
  - Custom coloured panels as location identifiers at approximate two kilometre intervals
  - Custom coloured panels at breakdown bays
- Right side treatments:
  - Standard white compressed fibre cement epoxy coated lining panels
  - Cross passages for emergency use occur at approximate 120 metre intervals, and would be marked by the use of jade green running man symbols.

Tunnels would include elements to interest travellers and provide orientation and enjoyment. These can assist in reducing driver fatigue and increasing awareness. On the left side, location identifiers that inform motorists' orientation to above ground features would be provided (eg for Bexley North, Arncliffe, Tempe and St Peters). These identifiers would also include a section of linear feature lighting in the roof providing an additional layer of interest, occurring at approximately two kilometre intervals in both westbound and eastbound tunnels (around every one minute, thirty seconds along the journey at 80 kilometres per hour.

Lighting strategies would also be developed to reduce impacts of monotony within tunnels. The design would provide the following key lighting elements:

- Western tunnel dive structures would feature walls with composite metal cladding coloured silver grey with staggered lighting rebates. Featured light emitting diode strip lighting would create a refined glow from within the rebates and a subtle wash of light across cladding panels
- Approximate 100 metre tunnel sections with variable width white, black and silver grey panel inserts with light emitting diode strip lighting between panels. These sections would occur at approximately 500 metre intervals throughout the tunnel. Light emitting diode lighting, when combined with the variable width coloured panels, would create a contrast to the standard white panel and provide a subtle variation in visual rhythm

- Custom image panels would be used to highlight suburb locations at approximate two kilometre intervals to assist driver orientation. Approximate 100 metre sections of white translucent polycarbonate illuminated panels with variable light emitting diode lighting effects would be used, adding visual interest and variety for the motorist
- Feature custom coloured yellow lining panels at breakdown bays would be complemented with feature lighting, making the location of the breakdown bay in contrast with main tunnel lining panels
- The mid tunnel event would feature select graphic panels with light emitting diode strip lighting to panel joints, and concealed light emitting diode floodlighting to ceiling panels. It would become a memorable marker in this section of tunnel, providing drivers with an understanding of where they are in the total tunnel journey. It would feature select graphic lining panels laid parallel to the road alignment, and extending to the full height of the tunnel and partially wrapping across the tunnel ceiling over lane shoulders. Light emitting diode strip lighting would be included in the panel joints providing a range of programmable lighting effects utilising a full range of colours.

St Peters interchange

The St Peters interchange, roughly bounded by the Princes Highway, Canal Road, Burrows Road and Campbell Road, would be predominantly zoned IN1 General Industrial and SP2 Infrastructure, with pockets of IN2 Light Industrial as zoned under the Marrickville LEP. Within this context, the St Peters motorway operations complex (MOC4), Burrows Road motorway operations complex (MOC5), Eastern Portals, associated interchange roads and St Peters ventilation facility would fulfil the desired character of the site to 'maintain access and connectivity between local centres of employment and economic activity.'

Under the Marrickville LEP 2011, development for the purposes of roads is permitted on land zoned as General industrial IN1 and Light industrial IN2 with consent. Also, all other development not specified as prohibited is permissible with development consent. As such, the development of the St Peters motorway operations complex (MOC4) would ordinarily be permissible with development consent, and is therefore not inconsistent with the land use objectives of the Marrickville LEP 2011.

Under the Sydney LEP 2012, development for the purposes of roads is permitted on land zoned IN1 General Industrial with consent. Also, all other development not specified as prohibited is permissible with development consent. As such, the development of the Burrows Road motorway operations complex (MOC5) would ordinarily be permissible with development consent, and is therefore not inconsistent with the land use objectives of the Sydney LEP 2012.

The St Peters interchange would be located to the east of a band of land zoned B6 Enterprise Corridor, B4 Mixed Use and IN2 Light Industrial. The St Peters interchange would be visually detached from these areas, as they either front onto the Princes Highway, or open out onto internal courtyards and parking areas. The St Peters interchange would not impact on the existing or desired character of these areas.

To the north-east, the St Peters interchange would be bounded by Sydney Park, a regional park zoned RE1 Public Recreation. The proposed recreational spaces and landscaping within the St Peters interchange would help to integrate the project with the land use of this site, and would provide additional open space for adjoining neighbourhoods (which include land zoned R1 General Residential, R2 Low Density Residential and R3 Medium Density Residential).

Road upgrades to the land surrounding the St Peters interchange include widening of Campbell Road, Campbell Street and Euston Road, as well as new bridges spanning the Alexandra Canal and adjoining Campbell Road and Gardeners Road. The widening of Campbell Road and Campbell Street would contribute to visually significant character changes within these road corridors. Where the widened road passes through land zoned SP2 Infrastructure, B4 Mixed Use and IN2 Light industrial, the change in character would be in keeping with the desire to 'maintain access and connectivity between local centres of employment and economic activity'. Where the road widening passes through land zoned RE2 Low Density Residential and adjacent to RE1 Public Recreation (ie Campbell Street), the character of the new road is consistent with the nature of this area as a road reserve in a residential area.

The three bridges proposed to span the Alexandra Canal pass through land zoned IN1 General Industrial and SP2 Infrastructure. They would constitute a different element within the existing visual setting, but the character of these bridges and road extensions would not significantly change the character of the surrounding land uses at either location.

To achieve a lasting and cohesive urban design strategy for the overall Interchange, focus would be on unifying and shaping the different stages of the project, including the M5 East Motorway, the future Sydney Gateway, and the WestConnex M4-M5 connection. The following objectives would allow design strategy to be implemented at the St Peters interchange:

- Close the former Alexandria Landfill
- Return surplus lands to the community as public open space, and to allow separate future redevelopment and other permissible land uses
- Provide an extensive green volume of vegetation to compete with and soften the scale of the proposed multi-level interchange, creating an urban forest
- Promote the use of a tall, established tree canopy cover to not only soften the scale of the proposed infrastructure, but also provide a counterpoint and extension of the green open space from Sydney Park
- Design the St Peters motorway operations complex to enhance the existing street character whilst treated as a cohesive set of architectural buildings.

Such a design would allow for future stages of the Interchange to adopt similar approaches to materials and detailing to achieve overall project cohesion and an integrated 'whole of project outcome'. The landscape approach in this area is essentially to create green volume and remediate the former Alexandria landfill by creating urban forest capable of competing with the scale of the proposed St Peters interchange.

Large areas of new tree planting would be incorporated on both sides of the northern ramps and above the portals to present a continuous green canopy and create a sense of green immersion for motorists upon entry to or exit from the tunnel.

St Peters ventilation facility and distribution substation

The St Peters ventilation facility would be designed to enhance the existing street character whilst treated as a cohesive set of architectural buildings. It would be nestled into the sloping site to reduce its apparent height and respond to its context. The lowest section of the building, which fronts Canal Road and wraps around the southern end, houses the distribution substation. Immediately adjacent and slightly higher the exhaust ventilation equipment would be placed in a two level section, the lower level being entirely below ground.

Horizontally oriented fans would allow for a lower building and, through the use of a plenum system, only require a single ventilation stack. Horizontally oriented terracotta façade panels would emphasise the low nature of the building, with the ventilation stack rising up from the southern end. Patterned exposed precast concrete structural walls to the north and south of the stack would flank the eastern and western facades which would be clad in a lightweight patterned louvered veil. This vertical structure would be visually separated from the horizontal building. The joints between panels and their surface pattern would be considered so as to accentuate the height of the St Peters ventilation facility while reducing its apparent width. To the north, the supply vent building houses vertical fans which would also be lowered below ground to reduce height. The building would be capped in architectural louvres working to lighten the building near its top and allow fresh air to be drawn in.

The horizontal portions of the building would be clad in horizontally oriented dark and light grey terracotta façade panels, responding to the predominantly masonry construction of nearby residential houses. Openings providing service access to the plan rooms would be grouped into common recesses, exposing the structure – a smooth-faced concrete block. Access doors within the blockwork would be painted to match. The lower scale supply building would be clad in vertically oriented terracotta panels reflecting its function and shape whilst acknowledging its moderate scale. Patterned precast concrete panels would form the northern and southern facades of the St Peters ventilation facility. The vertical and horizontal joints would be integrated into the cast-in pattern. Horizontal louvres would be incorporated on the eastern and western facades that are cut with varying depths to provide opportunities for interpretation, visually reducing the overall width of the building.

Landscape treatments surrounding the St Peters ventilation facility would focus on creating a defined street edge with street tree planting, and features Fig tree plantings to offer increased green volume and help define a sense of landscape character for the interchange. These Figs would also provide valuable shade for park users.

St Peters Interchange portal

At St Peters interchange the design approach to tunnel portals differs from that adopted for the western portals at Kingsgrove, as the new infrastructure elements at the St Peters interchange need to sit within and be integrated with the parklands, rather than being imposed upon them. The design would provide a simple and elegant solution unifying a range of geological issues by wrapping the portal and approaches in a giant sculptural veil form.

The sculptural veil would be a series of coloured rectangular aluminium sections laid in a curvilinear series at varying angles to establish a seemingly continuous, but transparent, sinuous form.

Local road upgrades

The overall design intent is to create a series of tree lined local streets offering amenity for local residents, creating a high quality environment for pedestrians and cyclists, and integrate the local streetscape with adjacent open space and parkland, particularly in the vicinity of Sydney Park.

The design would incorporate a series of feature pedestrian and cycleway bridges to increase connectivity for and allow integration of the open space proposed for the St Peters interchange. Tree and landscape plantings would be designed to match City of Sydney, Botany Bay and Marrickville Council guidelines, whilst vegetation and tree plantings would be used to create a sense of visual separation for pedestrians and cyclists from the road edge.

The design of wall structures would be refined and elegant, without unnecessary fussiness or embellishment, with landscape treatments used to soften the appearance of retaining walls and other structures.

Proposed pedestrian and cycleway bridges over Campbell Road and northern ramps and Alexandra Canal would become integral elements, creating new connections for the regional cycle network.

The design of the pedestrian and cycle bridges would feature simple and elegant solutions, with a focus on creating horizontal alignments responding to the adjacent landscape environment of Sydney Park and the proposed landscape earth treatments for St Peters interchange.

Burrows Road motorway operations complex (MOC5)

The Burrows Road motorway operations complex (MOC5) would be located on the corner of Campbell and Burrows Roads, accommodating an open carpark, bike storage and waste facilities at ground level. The carpark would be softened by a large landscaped buffer between the kerb and building. Slender concrete columns would support the upper level allowing views out from beneath the building and raise it above flood event levels. The upper level would house reception, open plan offices, enclosed offices, breakout spaces, as well as a lunch room and associated staff amenities.

Secure areas including the motorway control room, incident coordination room and operations manager office would all be located to the western end of the building. An accessible toilet and staff breakout would all be accessed from the rear of the motorway control room.

The Burrows Road motorway operations complex (MOC5) would blend in with the surrounding light industrial land use while maintaining the identity of the project. It would be a two level building with an open carpark below the main functional spaces. The main address, vehicle and pedestrian access would be from Burrows Road. A substation building would be situated to the rear of the main structure. A long span roof supported from the northern and southern walls would provide near limitless flexibility for the interiors. Uninterrupted power supple and electrical equipment rooms would be located in a consolidated block to the north of the floor plate. The horizontal nature of the building would be accentuated by the expression of the floor and roof lines on the south elevation to Burrows Road. The floor and roof lines return around the eastern and western ends and fold vertically down the south elevation to meet and form a continuous 'C' shaped loop. A series of vertical louvres would punctuate the Burrows Road façade and return to the east to form a screen to the double height entry space.

Clad in composite aluminium panels, the southern elevation of the Burrows Road motorway operations complex would wrap up and over the building to form a casing into which the building would be inserted. The motorway control rooms would be clad in corten steel panels, emphasising their secure nature. The office and breakout spaces would be enclosed with clear glass to provide natural light to the working environments. The long linear nature of the building would be articulated with vertical louvres spaced at different intervals along the Burrows Road façade. The spacing would respond to the private or public nature of the spaces within, providing a shifting rhythm. Egress stairs and plant spaces at the ground level would be exposed, smooth faced concrete block, expressing their function. The substation to the rear would be clad in brick, referencing the site's history and acknowledging the building's more utilitarian purpose.

Open space quantum

The inclusion of publically accessible open space is a key benefit of the project's design. The project would be constructed largely within existing road reserves and efforts have been made to minimise the footprint with every surface intervention.

In the western reaches of the project, connectivity between existing areas of open space would be improved through upgraded shared paths of the M5 Linear Park. The shared paths would be enhanced by new landscaping which would assist in screening the motorway and associated noise barriers. The upgraded shared paths and landscaping would integrate with similar upgrades being undertaken for the King Georges Road interchange upgrade.

In eastern parts of the project, significant new areas of open space would be created around the St Peters interchange. A master plan solution has been developed, encompassing the entire interchange site and ensuring its integration with surrounding areas. The majority of the open space to be provided by the master plan would be completed as part of the project. The project would extend the parklands of Sydney Park further south, providing much needed open space for a growing population. Featuring landscape mounds, the design of the interchange parklands would continue the features of Sydney Park. This space would be accessed from shared paths in the east connecting to Sydney Park or via a dedicated entrance at the corner of Canal Road and Princes Highway. New open space would feature a mixture of open turf interspaced with garden beds and large trees. Landscape mounds would have sufficient height to enable park users to take advantage of views to the Sydney central business district, Sydney Airport and surrounding neighbourhoods. This restrained design would allow future interventions to meet the needs of the community in a similar manner to the ongoing evolution of Sydney Park.

Cycle and pedestrian connectivity

The project would provide improved and upgraded connectivity for cyclists and pedestrians. In the western reaches of the project, the existing M5 Linear Park shared path would be updated to provide a three metre wide surface for the majority of its length. This would be complemented by new landscaping along the length of the Linear Park.

In the east of the project a number of local street amendments would provide the opportunity to improve pedestrian and cyclist connectivity around the St Peters interchange. Bridges over the Alexandra Canal would also provide new connections between Mascot, Alexandria and St Peters. These connections would increase access for a growing residential population to Sydney Park and the additional parklands to be created as part of the project. Dedicated cycleway upgrades as part of the project would provide:

- A new east-west route connecting the existing Bourke Road and proposed Alexandra Canal cycleways in the east to the corner of Campbell and May Streets in the west
- Separated cycleway access to Sydney Park and its network of off-road cycleways
- Together with the potential King Street Gateway upgrade, connection to the existing cycleway network on either side of Sydney Park Road.

A number of shared paths would also be provided to ensure maximum connectivity and ease of navigation around the interchange site and Sydney Park. New shared paths would be provided:

- On the northern side of Campbell Road between Barwon Park Road and Bourke Road
- On the western side of Euston Road adjacent to Sydney Park, between Campbell Road and Sydney Park Road
- Within the interchange parklands connecting the new Campbell Road dedicated cycleway with Canal Road in the south.

For intersections that include dedicated cycleways, cycle signs would be provided to ensure cyclist safety and promote ease of access.

Pedestrian permeability to Sydney Park and the open space created by the project would also be improved. All dedicated footpaths would line streets terminating in either signalised or zebra crossings. The provision of street trees and landscaping would further improve pedestrian amenity along these new paths.

Operational visual impacts

The operational visual impacts of the project have been assessed at the following areas of ongoing built form operational infrastructure:

- Western surface works, including the Kingsgrove motorway operations complex (MOC1)
- Bexley Road surface works, including the Bexley Road South motorway operations complex (MOC2)
- Arncliffe surface works, including the Arncliffe motorway operations complex (MOC3)
- The St Peters interchange and local road upgrades, including the St Peters motorway operations complex (MOC4) and the Burrows Road motorway operations complex (MOC5).

Potential operational visual impacts have been assessed in the following sections, with a summary of the outcomes of the assessment provided in **Table 14-15** and the locations of representative receivers provided in Sections 6.1.1 to 6.1.14 of the Technical working paper: Landscape character and visual impact (**Appendix K**).

Table 14-15 Operational visual impact assessment summary

Receiver location	Receiver type	Sensitivity of receivers	Magnitude of change	Overall rating
Western surface works, including the Kingsgrove motorway operations complex (MOC1)				
Glamis Street, southern end	Residents	Moderate	Moderate	Moderate
	Pedestrians / cyclists	Moderate	Moderate	Moderate
	Passive recreational users	Moderate	Low	Moderate to low
M5 Linear Park - Kindilan underpass	Pedestrians / cyclists	Moderate	Moderate	Moderate
M5 East Motorway	Road users	Low	Low	Low
Vanessa Street Industrial Compounds	Industrial neighbours	Low	High	Moderate
Beverly Grove Park South	Pedestrians / cyclists	High	High	High
Tallawalla Street	Residential neighbours	Low	Moderate	Moderate
Bexley Road surface works, including the Bexley Road South motorway operations complex (MOC2)				
M5 East Motorway	Road users	Low	Negligible	Negligible
Intersection of Bexley Road and Wolli Avenue	Residents	Low	Moderate	Moderate to low
	Road users	Low	Moderate	Moderate to low
M5 Linear Park, Bexley, south of M5 entry	Pedestrians / cyclists	High	Moderate	High
Bexley Road, south of the pedestrian underpass	Road users	Low	Moderate	Moderate to low
Arncliffe surface works, including the Arncliffe motorway operations complex (MOC3)				
M5 East Motorway	Road users	Low	Low	Low
Intersection of Flora Street and Marsh Street	Residents (low density)	Moderate	High	High to moderate
	Residents (high density)	High	Moderate	High to moderate
	Road users	Moderate	Moderate	Moderate to low
	Pedestrians / cyclists	Moderate	Moderate	Moderate
Eve Street cycle path	Pedestrian / cyclists	Moderate	Moderate	High to moderate
Kogarah golf course	Active recreation	Moderate	Moderate	Moderate
St Peters motorway operations complex (MOC4)				
Intersection of Princes Highway and Canal Road	Commercial neighbours	Low	Moderate	Moderate to low
	Road users	Low	Moderate	Moderate to low
Commercial complexes backing onto the St Peters interchange	Commercial neighbours	Low	Low	Low
Industrial	Industrial neighbours	Low	Moderate	Moderate to low

Receiver location	Receiver type	Sensitivity of receivers	Magnitude of change	Overall rating
buildings on the Princes Highway	Road users	Low	Moderate	Moderate to low
Burrows Road motorway operations complex (MOC5)				
Burrows Road	Industrial neighbours	Low	Moderate	Moderate to low
	Road users	Low	Moderate	Moderate to low
St Peters interchange				
Burrows Road near the Gardeners Road Bridge	Industrial neighbours	Low	Moderate	Moderate to low
	Road users	Low	Moderate	Moderate to low
Industrial complex on Canal Road	Industrial neighbours	Low	Low	Low
Campbell Road	Residential neighbours	High	High	High
	Road users	Moderate	High	High to moderate
Sydney Park	Active and passive recreation	Moderate	Moderate	Moderate
Barwon Park Road	Residential neighbours	High	High	High
Local road upgrades				
Campbell Street between Unwins Bridge Road and Princes Highway	Residential neighbours with adjoining boundaries	High	Moderate	High to moderate
	Industrial neighbours	Moderate	Low	Moderate to low
	Recreational users	Moderate	High	High
	Road users	Moderate	Moderate	Moderate
	Commercial neighbours	Low	Low	Low
Campbell Street between Princes Highway and Barwon Park Road	Industrial neighbours	Low	Moderate	Moderate to low
	Road users	Low	Moderate	Moderate to low
Campbell Road between Barwon Park Road and Burrows Road	Residential neighbours with adjoining boundaries	High	High	High
	Recreational users	Moderate	Moderate	Moderate
	Road users	Moderate	Moderate	Moderate
Euston Road between Campbell Road and Sydney Park Road	Recreational users	High	High	High
	Industrial neighbours	High	High	High
	Road users	Moderate	Moderate	Moderate
Bourke Street / Bourke Road	Industrial neighbours	Low	Low	Low
	Road users	Low	Moderate	Moderate to low
Gardeners Road	Industrial neighbours	Low	Low	Low
	Road users	Low	Moderate	Moderate to low

Western surface works, including the Kingsgrove motorway operations complex (MOC1)

Few receiver groups would see the changes to Beverly Grove Park South, as the site is visually contained to the north by the M5 East Motorway and is bounded to the south by industrial development. Users of the M5 Linear Park would be the most affected, as they pass in close proximity to the proposed maintenance operations centre. The visual impacts of the changes are rated as high for this receiver group at this location.

The workers in the industrial compound to the south of the Kingsgrove motorway operations complex (MOC1) would see the changes to the site, but they are anticipated to have a lower sensitivity to changes within the landscape than recreational users of public open space.

Bexley Road South motorway operations complex (MOC2)

This site is reasonably isolated from surrounding development. It has no industrial, commercial or residential neighbours adjoining the boundaries. The most affected receivers are users of the M5 Linear Park, which would receive a high to moderate rate of visitation from people using the path for active recreation (pedestrians and cyclists), and a low rate of visitation for people choosing to use the site for passive recreation. At operation, the site would no longer be available for passive recreation, but there would be a high level of change to the view for receivers viewing the site from the path. These receivers would also be the most affected by changes to night lighting, although it is expected that at night the number of receivers using the path would drop to a low level.

Arncliffe motorway operations complex (MOC3)

The Arncliffe motorway operations complex (MOC3) would be a relatively contained built element within the north western corner of the Kogarah Golf Course. Although the change in the character of the view to the site would be substantial and is broadly assessed as moderate on average, these changes may be substantially mitigated from external receiver locations with adequate landscaping to the boundary of the site, once it has matured.

St Peters motorway operations complex (MOC4)

The visual impact within the vicinity of the St Peters motorway operations complex (MOC4) would be limited by the utilitarian character of the surrounding area, coupled with the busy nature of the nearby roads and the limited sensitivity of the surrounding receivers. Some of the visual changes would be positive, especially due to the proposed parkland style landscaping surround the St Peters motorway operations complex (MOC4), complete with pedestrian access to other parts of the site.

Burrows Road motorway operations complex (MOC5)

The visual impact within the vicinity of the Burrows Road motorway operations complex (MOC5) would also limited by the utilitarian character of the area, although on Burrows Road, the character is predominantly industrial, with a less busy road. The scale and materiality of the Burrows Road motorway operations complex (MOC5) would not be out of character within the area, although the parkland landscaping associated with the building would be a new, positive element within views to the site from the surrounding industrial developments and the road corridor. The new bridges over the Alexandra Canal would constitute new elements within the area, but their visual impact would be limited by the less sensitive receivers within the area due to its utilitarian character.

St Peters Interchange and local road upgrades

Changes to Campbell Road along the St Peters interchange boundary (between Burrows Road and the Princes Highway) constitute significant differences, especially in regards to residential neighbours and users of public open space. These two receiver groups are highly sensitive and would have clear views to changes, which would include road widening, the development of the St Peters interchange site, pedestrian pathways and bridges, and landscaping.

Campbell Street between Unwins Bridge Road and Princes Highway would change from a quiet, two lane road to a busier four lane road, with the removal of some residential properties. However these visual changes would be softened by proposed landscape features such as street trees and vegetated verges.

Campbell Street between Princes Highway and Barwon Park Road would also be widened, with higher volumes of traffic passing along it and the removal of some residential properties. However the road would be flanked to the south by a vegetated island between Campbell Street and Albert Street.

Campbell Road between Baron Park Road and Burrows Road would change from a wide but only two lane road with parallel parking, to a busy four lane road with a bus lane. Industrial and residential housing would be removed and replace with the St Peters interchange. However much of the St Peters interchange would be visible as a green, vegetated space. The pedestrian bridge over the road would also be visible as a new built element at this location.

At Euston Road between Campbell Road and Sydney Park Road, the length of the park edge wold change as the road is widened and industrial parkland is demolished and replaced with more parkland. Bourke Street and Gardeners Road would also be widened to cater for increased traffic flows.

Mitigation measures to reduce the impact of the development on residents living on Campbell Road are detailed in Sections 6.4.5.1 and 7.2 of the Technical working paper: Landscape character and visual impact (**Appendix K**) and summarised in **Table 14-17**.

Operational night lighting impacts

The potential operational night lighting impacts of the project are summarised in **Table 14-16**.

Table 14-16 Operational night lighting impacts summary

Receiver location	Receiver	Sensitivity to change	Magnitude of change	Overall rating
Western surface works	Residents - Glamis Street, southern end	Moderate	Moderate	Moderate
	Pedestrians / cyclists - Glamis Street, southern end	Moderate	Negligible	Negligible
	Passive recreational users - Glamis Street, southern end	Moderate	Negligible	Negligible
	Pedestrians / cyclists - M5 Linear Park - Kindilan underpass	Moderate	Moderate	Moderate
	Road users - M5 East Motorway	Low	Low	Low
	Industrial neighbours - Vanessa Street	Low	Moderate	Moderate to low
	Pedestrians / cyclists - Beverly Grove Park South	High	Moderate	High to moderate
	Residents - Tallawalla Street	Low	Negligible	Negligible
Bexley Road South motorway operations complex (MOC2)	Road users - M5 East Motorway	Low	Negligible	Negligible
	Residents - Intersection of Bexley Road and Wolli Avenue	Low	Low	Low
	Road users - Intersection of Bexley Road and Wolli Avenue	Low	Low	Low
	Pedestrians / cyclists - M5 Linear Park, Bexley, south of M5 entry	High	Moderate	High to moderate
	Road users - Bexley Road, south of the pedestrian underpass	Low	Low	Low
Arncliffe motorway operations complex (MOC3)	Road users – M5 East Motorway	Low	Negligible	Negligible
	Residents (low density) – intersection of Flora Street and Marsh Street	Moderate	Low	Moderate to low
	Residents (high density) – intersection of Flora Street and Marsh Street	High	Low	Moderate
	Road users – intersection of Flora Street and Marsh Street	Low	Low	Low
	Pedestrians / cyclists – intersection of Flora Street and Marsh Street	Moderate	Low	Moderate to low
	Pedestrians / cyclists - Eve Street cycle path	High	N/A	N/A
	Active recreation – Kogarah Golf Course	High	N/A	N/A

Receiver location	Receiver	Sensitivity to change	Magnitude of change	Overall rating
St Peters motorway operations complex (MOC4)	Commercial neighbours - Intersection of Princes Highway and Canal Road	Low	Low	Low
	Road users - Intersection of Princes Highway and Canal Road	Low	Negligible	Negligible
	Commercial neighbours - Commercial complexes backing onto the St Peters interchange	Low	Low	Low
	Industrial neighbours - Industrial buildings on the Princes Highway	Low	Low	Low
	Road users - Industrial buildings on the Princes Highway	Low	Negligible	Negligible
Burrows Road motorway operations complex (MOC5)	Industrial neighbours - Burrows Road	Low	Low	Low
	Road users - Burrows Road	Low	Negligible	Negligible
St Peters interchange	Industrial neighbours – Burrows Road near the Gardeners Road Bridge	Low	Moderate	Moderate to low
	Road users – Burrows Road near the Gardeners Road Bridge	Low	Negligible	Negligible
	Industrial neighbours – Industrial complex on Canal Road	Low	Negligible	Negligible
	Residential neighbours - Campbell Road	High	High	High
	Road users - Campbell Road	Moderate	Low	Moderate to low
	Active and passive recreation - Sydney Park	High	N/A	N/A
	Residents – Barwon Park Road	High	Moderate	High to moderate

Operational overshadowing impacts

Overshadowing impacts of the operational project are provided in more detail in Section 6.4 of Technical working paper: Landscape character and visual impact (**Appendix K**). These impacts are summarised as follows:

- During the summer months at the Kingsgrove motorway operations complex (MOC1), no overshadowing would occur to properties outside the MOC1 site due to the built structures. During winter, some midday to late afternoon shadowing would be experienced at the industrial complexes on Vanessa Street from the ventilation tacks of the MOC1. However this would be limited to a narrow band due to the tall, narrow form of the ventilation stacks. Furthermore, these shadows would fall on industrial properties with no public open space associated with them
- At the Bexley Road South motorway operations complex (MOC2), no residential, commercial or industrial neighbours would be affected by overshadowing. Some limited shadowing would fall onto the Wolli Creek corridor during the winter months, but this land is not used for recreation purposes
- At the Arncliffe motorway operations complex (MOC3), no residential, commercial or industrial neighbours would be overshadowed. A small portion of the Eve Street cycleway would be in shadow during winter mornings for a short period of time
- Buildings at the St Peters motorway operations complex (MOC4) would not significantly overshadow surrounding areas external to the St Peters interchange. However there would be some overshadowing at 9:00am on the winter solstice, generated by the ventilation facility onto one industrial neighbour on Canal Road

- Some overshadowing from the Burrows Road motorway operations complex (MOC5) would be experienced by a residential receiver at Campbell Road (refer Figure 6-89 of **Appendix K**). The western-most terraces at this location would be overshadowed by the pedestrian bridge spanning Campbell Road between the St Peters interchange and Sydney Park. However this shadowing would only occur from about 3:00pm until sunset during the winter months.

Operational tolling gantries

A series of tolling gantries would operate within the M5 East Motorway. The final locations of tolling gantries would be confirmed during detailed design. However, indicative locations are as follows:

- King Georges Road (entry and exit)
- M5 East Motorway (east and westbound)
- Kingsgrove Road (entry and exit)
- Bexley Road (entry and exit).

Tolling gantries would be located in areas where they are unlikely to be visually prominent from adjacent sensitive receivers, given:

- The extent of proposed revegetation and screening to the corridor edges
- The relative height of noise barriers and the lower M5 East Motorway
- The fact that road users would view the toll gantries as single structures which are visually typical within the context of the M5 East Motorway.

Residual and surplus land

Construction of the project would result in some land being affected by construction activities, which would not be required during the operation of the project (ie both surplus and residual lots – refer **Section 13.2.2**). Residual lands (mostly as a result of construction) would be returned as open space for most sites where there are no ongoing operational requirements. As detailed in this section, open space areas would be created as the preferred method for dealing with surplus lands. A number of existing urban renewal areas already surround the corridor. It is considered that provision of open space as part of the New M5 project would support such current and future urban renewal opportunities. Where reasonable and practicable to do so, some land may be rehabilitated and made available for potential sale and / or redevelopment for a permissible use

In the case of some surplus and residual land, such as land surrounding the St Peters interchange, Euston Road and the Alexandria Landfill, current land use zonings may be able to be reviewed by the relevant local council (refer **Sections 13.2.1** and **13.2.2**)

Specific opportunities which would be considered in the reuse of surplus and residual land include:

- Rehabilitation and subsequent sale and / or redevelopment of surplus lots following construction of the project
- Possible combination of adjacent lots to create a combined area suitable for redevelopment
- Incorporation of non-adjacent lots into the road reserve or project landscaping (refer **Section 13.2.2**).

Where buildings such as ventilation and workshop facilities are located at the Kingsgrove, Bexley and Arncliffe motorway operations complexes (MOC1, MOC2, and MOC3), landscaping on residual land would be used to screen as much of the built form as possible (refer Section 6.3 of **Appendix L**).

Residual land at the St Peters interchange would be landscaped and incorporated into the operation of the project under a master plan, including the following operational elements (refer Section 5.6.1 of **Appendix L**):

- Bench seating
- Terraced retaining wall
- Footpath
- Shared pathways and bridges
- Interpretive signage
- Viewing platform
- Ampitheatre
- Detention basin.

For local streets, tree and landscaped plantings would make use of residual land in the vicinity of feature pedestrian and cycleway bridges, and would assist in integrating these project elements (refer Section 5.6.2 of **Appendix L**).

14.4 Environmental management measures

The project has aimed to limits its visual impact by situating project elements within or adjacent to major transport corridors. Project elements have been designed with consideration of the surrounding areas and landscape treatments have been proposed in order to reduce the visual impacts of new infrastructure. Despite this, visual impacts would occur, particularly during the construction phase due to the introduction of construction sites and large structures such as acoustic sheds.

Environmental management measures relating to urban design, landscape character and visual amenity have been identified and are provided in **Table 14-17**.

Table 14-17 Environmental management measures – urban design, landscape character and visual amenity

Impact	No.	Environmental management measure	Timing
Construction			
Landscaping	V01	Existing vegetation around the perimeter of the construction compounds would be retained where feasible and reasonable, particularly: • Vegetation surrounding the Bexley Road East construction compound, particularly along the boundary between residential properties and the compound along the northern and eastern boundaries • Mature trees along the north-west (Marsh Street) and south-west boundaries of the Arncliffe construction compound site • Mature trees and vegetation along the boundary of Sydney Park along Campbell Road and Barwon Park Road.	Pre-construction
	V02	Landscape planting would use fast growing species where reasonable and feasible. This would soften views of construction sites, particularly for compounds located within public recreational spaces.	Construction
	V03	Revegetation and landscaping would be undertaken progressively.	Construction
Visual amenity	V04	Temporary noise barriers would be erected early within the site establishment phase where required to minimise noise impacts and provide visual screening.	Pre-construction / construction

Impact	No.	Environmental management measure	Timing
	V05	Temporary noise barriers would be designed to include painted surface and project information / logo to deter graffiti and reduce the scale of noise barriers, particularly adjacent to residential areas or public open space.	Detailed design
	V06	Site hoardings and fencing would be regularly maintained, including the prompt removal of graffiti.	Construction
	V07	Acoustic sheds would be designed to minimise noise impacts and provide visual screening to be visually recessive, such as the use of mid toned colours and materials to minimise the intrusiveness and potential glare of the sheds.	Detailed design
Sydney Airport lighting	V08	During detailed design, the Roads and Maritime would liaise with the Civil Aviation Safety Authority to assess the potential for impacts of night lighting from the construction of the project on Sydney Airport operations. Mitigation measures would then be developed as required.	Detailed design
Lighting	V09	Cut-off or and directed lighting would be used within and outside of construction compounds with lighting location and direction considered to ensure glare and light spill are minimised.	Detailed design
Lighting	V10	The lighting design for shared paths located within the M5 Linear Park impacted by the project or located adjacent to compounds would be designed to minimise light spill to adjoining residential properties while maintaining a safe night time environment for path users (eg lighting position below the height of the fence line).	Detailed design
Signage	V11	A signage strategy would be developed during detailed design for temporary wayfinding and safety. Potentially affected receivers would be consulted on the final signage in relation to the location and associated impacts.	Detailed design
Visual amenity	V12	Elements within construction sites would be located to minimise visual impacts as far as feasible and reasonable, for example, locating equipment back from site boundaries.	Detailed design / construction
Visual amenity	V13	Opportunities would be investigated to maximise the separation distances as far as reasonable and feasible: • Between the Kingsgrove North construction compound to the adjoining residential areas to reduce shading and visual impacts • Between the Bexley Road North and Bexley Road East construction compounds and adjoining residential areas to reduce sharing and visual impacts.	Detailed design
Visual amenity	V14	Opportunities would be investigated to provide an alternative southern cycle route for the length of the existing shared path impacted by the western surface works.	Detailed design

Impact	No.	Environmental management measure	Timing
Operation			
Visual amenity	OpV01	Vegetated batters would be limited to 1:3 and 1:4 where possible in order to maximise the impact of vegetation on these batters and minimise maintenance.	Detailed design
Visual amenity	OpV02	Chain link fencing for sites would only be used where these would not be viewed by sensitive receivers, such as residents and users of recreational space. At these locations, high quality fencing suitable for parks and public spaces would be considered.	Detailed design
Visual amenity	OpV03	Where large areas of hardstand are or structures are designed, such as carparks, consideration of shade trees within these spaces would be considered where reasonable and feasible to soften views and provide shade and visual amenity.	Detailed design / post construction
Visual amenity	OpV04	Pedestrian and shared paths would be aligned away from residential property boundaries where public open space adjoins residential boundaries.	Detailed design
Landscaping	OpV05	Planting areas would be maximised, where feasible, between public open space and infrastructure, and would include taller screening vegetation (at the Bexley Road South motorway operations complex (MOC2) between the built form and the M5 Linear Park shared path for example).	Detailed design
Landscape and urban design (general)	OpV06	A final urban design and landscape plan would be prepared in consultation with the New M5 Urban Design Review Panel, local councils within the project corridor and the local community. The Plan shall include (but not limited to): • The architectural treatment of the ventilation facilities, which would be informed by the functional requirements and the design principles detailed in the New M5 Urban Design Report. • Landscape plans and final plant species for the western surface works, Bexley Road motorway operations complex, Arncliffe motorway operations complex, the St Peters interchange and local road upgrades • The artwork strategy for the Kindilan underpass • Consideration of the outcomes of the Safety in Design review of the project.	Detailed design
Landscape and urban design at Kingsgrove	OpV07	The design of the noise attenuation at the western surface works would be confirmed during detailed design and in consultation with the local community. This may consist of noise mounds and barriers (or a combination of both) and with consideration to the provision of accessible open space at Beverly Grove Park and a landscaped outlook.	Detailed design
Landscape and urban design at Bexley	OpV08	Landscaping at the Bexley Road motorway operations complex would consider opportunities to complement the existing topography of the built site as well as the adjacent Wolli Creek bushland.	Detailed design
Landscape and urban design at Arncliffe	OpV09	Reasonable and feasible measures to use landscaping to screen or filter views of the Arncliffe motorway operations complex from residential areas to the west would be implemented.	Detailed design
Landscape and urban design at St Peters	OpV10	Opportunities to maximise the green canopy throughout the local road upgrades at Peters with tree planting in medians where safety barriers and / or speed limits permit would be explored during detailed design, and implemented where reasonable and feasible.	Detailed design

Impact	No.	Environmental management measure	Timing
Sydney Airport lighting	OpV11	During detailed design, the Roads and Maritime would liaise with the Civil Aviation Safety Authority to assess the potential for impacts of night lighting from the operation of the project on Sydney Airport operations. Mitigation measures would then be developed as required.	Detailed design
Lighting	OpV12	Lighting design within motorway operations complexes, roadways, and on elevated pedestrian bridges would minimise the impacts of lighting to surrounding areas (particularly residential areas), for example through the use of cut-off, directed lighting and landscaping to minimise light spill and glare. This includes consideration of residences along Campbell Road.	Detailed design

(blank page)

15 Social and economic

This chapter outlines the potential social and economic impacts associated with the project. A detailed social and economic impact assessment has been undertaken for the project and is included in **Appendix M**.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued a set of environmental assessment requirements for the project; these are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 15-1** sets out these requirements as they relate to social and economic matters, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 15-1 SEARs – social and economic

SEAR	Where addressed
A description of the existing socio-economic environment.	**Section 15.2**
Social and economic impacts to businesses and the community within the vicinity of the proposal, with associated property acquisition, traffic, access, property, public domain and open space, and amenity and health related changes (including the broader regional impacts associated with the closure of the Alexandria landfill site should this be part of the proposal).	**Section 15.3**
An assessment of the impact of the proposal on community facilities, including open space and recreational facilities. The assessment must include the use of existing facilities impacted by the proposal, and options and opportunities for the relocation and / or reconfiguration of the community facilities, both temporary and permanent.	**Section 15.3**
Impacts on directly affected properties and land uses, including impacts related to access, land use, settlement and subsidence associated with tunnel excavation, property acquisition (including relocations and expenses for those properties acquired) and amenity related changes.	**Section 15.3** **Chapter 13** (Land use and property) **Chapter 19** (Groundwater)
Where there are potential impacts to the OEH estate reserved under the National Parks and Wildlife Act 1974 or where the proposal is located upstream of OEH estate, an assessment of the matters to be considered outlined in the *Guidelines for developments adjoining land and water managed by DECCW* (DECCW, 2010a).	**Chapter 13** (Land use and property)
Opportunities for local centre and street revitalisation near the St Peters interchange.	**Appendix L** (Urban design report)
Potential impacts on utilities (including communications, electricity, gas, and water and sewerage) and the relocation of these utilities.	**Chapter 13** (Land use and property)
A draft Community Consultation Framework identifying relevant stakeholders, procedures for distributing information and receiving/responding to feedback and procedures for resolving stakeholder and community complaints during construction and operation. Key issues that must be addressed in the draft Strategy include: • traffic management (including property access, pedestrian access), • landscaping/urban design matters, • construction activities including out of hours work; and • noise and vibration mitigation and management.	**Appendix E** (Draft community consultation framework)

15.1 Assessment methodology

The social and economic impact assessment considers the direct, indirect, and cumulative social and economic impacts of the project on the following groups / communities:

- Residents (directly affected, local and regional)
- Businesses
- Users of education, health and other community services and facilities
- Users of open space and recreational facilities
- Commercial road users including freight transport operators
- Private road users.

The methods for assessing the social and economic impacts (positive and negative) of the project were developed with consideration of the *Environmental Impact Assessment Practice Note − Socio-economic Assessment* (Roads and Maritime, 2013a).

The methodology for the social and economic impact assessment included:

- Defining the relevant study area for the social and economic impact assessment, taking into account the extent or scale of the potential impacts of the project, including both direct and indirect impacts, and the context of the area surrounding the project
- Developing a profile of the study area and surrounds, including relevant statistics to provide a better understanding of the social and economic circumstances of the study area that could be potentially affected by the project
- Describing groups or particular communities that may be affected by the project, including directly impacted property owners, the general community, local businesses and road users (including freight and commercial vehicles), as well as those indirectly affected through traffic impacts, including public transport and cycling changes
- An assessment of the project's potential impacts with regard to property, business, community facilities, open space, public domain, community values, as well as access and connectivity. The focus was mainly on directly affected properties but also considered those in the vicinity of the project, as well as impacts on through traffic and transport movements in the study area
- A cumulative assessment of the social and economic impacts of all phases of the WestConnex program of works, combined with the impacts of other relevant planned and anticipated projects
- Identification of measures to mitigate or manage the potential social and economic impacts of the project.

Economic impacts were considered at a local and regional level, where appropriate. Further details of the social and economic impact assessment methodology are provided in the technical working paper: Social and economic (**Appendix M**).

15.1.1 Study area

The study area for the assessment included the local government geographical statistical areas (as defined by the Australian Bureau of Statistics (ABS)) that encompass the project, as well as the wider catchment as it relates to the use of the project.

The following local government areas (LGAs) were identified as the areas most likely to experience social or economic impacts due to the project:

- Canterbury LGA
- Hurstville LGA
- Rockdale LGA
- Botany Bay LGA
- Marrickville LGA
- Sydney LGA.

The study area adopted for this assessment is presented in **Figure 15-1**.

As the majority of the project would be in tunnels, physical and direct impacts would be limited to areas close to the western (ie at Kingsgrove and Beverly Hills) and eastern (ie at St Peters) extents of the project and at other locations where temporary (construction) and permanent (operational) surface infrastructure facilities are proposed for the project.

While social impacts generally occur on a community level, business impacts such as changes to turnover or employment generally occur at the location of the business activity. This is due to the fact that businesses can also rely on the attractiveness and accessibility of their location to induce business activity. As such, businesses that are located far beyond the boundaries of the project are unlikely to be impacted by the project, unless they rely on the M5 East Motorway corridor for freight or delivery purposes.

The study area is used as a thoroughfare for freight and commercial activity linking south-western Sydney to Port Botany and Sydney Airport. Therefore, the project would deliver some benefits related to freight and commercial movement beyond the scope of the study, across broader Sydney and at a state-wide or national level.

15.1.2 Economic multipliers

Economic multipliers are used to quantify economic impacts or changes in economic activity resulting from a stimulus, such as construction of the project. These multipliers have been calculated from the most recent ABS input-output tables (ABS Australian National Accounts: Input-Output Tables 2012/13, 5209.0.55.001, 25 June 2015). The tables describe inter-industry transactions among 114 industries, showing the levels of inputs required to produce a given output at the national level.

State-level input-output tables can be derived by adjusting the national table to reflect each state's inter-industry transactions and final demand flows, based on information and data at the state level within the Australian national accounting system and on the latest Census data.

(blank page)



Figure 15-1 Social and economic statistical areas

(blank page)

15.2 Existing environment

A baseline profile of the existing environment for the social and economic study area has been informed by the most recent release of the *Australian Census of Housing and Population* (Australian Bureau of Statistics, 2012c), unless otherwise stated. The census was carried out in 2011 and provides the best available dataset for establishing baseline social and economic profiles.

The baseline profile for the social and economic study area has been compared with data for the Greater Sydney Greater Capital City Statistical Area (GCCSA), as defined by the ABS. This comparison has been carried out to provide context to the social and economic characteristics of the study area.

The Greater Sydney GCCSA represents the socio-economic extent of Sydney. It includes people who regularly socialise, shop or work within Sydney but may also live in the surrounding small towns and rural areas.

The baseline profile for the social and economic study area has been developed taking into account available information in the following areas:

- Population and demography
- Families and housing
- Socio-Economic Index for Advantage (SEIFA)
- Labour force and household income
- Travel behaviour
- Recreational and community infrastructure
- Workforce characteristics
- Business and industry
- Freight transport.

The identification of community values was also undertaken using local councils' community strategic planning documents. These values were identified to aid the assessment of potential social and economic impacts, provide insight into how the community may perceive these impacts, and assist in the assessment of indirect impacts on community identity, cohesion and sense of place.

15.2.1 Social environment

Population and demography

Key population and demographic characteristics of the study area are as follows:

- The latest ABS Population statistics estimated resident population in 2013 was 660,000 people (Australian Bureau of Statistics, 2014). Over the period between 2008 and 2013, all LGAs in the study area showed an increase in population. Between 2008 and 2013 Canterbury LGA experienced the smallest growth in the study area at 6.3 per cent. Botany Bay LGA experienced the greatest growth in the study area during this time at 12.1 per cent
- DP&E (Department of Planning and Environment, 2014) estimated that the population of the study area will reach approximately 850,000 residents in 2031. Between 2011 and 2031, it is estimated that Canterbury LGA will experience the smallest growth, with the population growing by 25 per cent over this period. Over the same period, Sydney LGA is projected to experience the greatest growth, with the population growing by 49 per cent
- Sydney LGA had the lowest median age in the social and economic study area at 32 years. Hurstville and Botany Bay had the highest median ages in the social and economic study area at 37 years. By comparison the median age in the Greater Sydney GCCSA was 36 years in 2011
- In 2011, one per cent of residents in the study area identified as indigenous

- Overall, the social and economic study area had a larger proportion of residents born overseas than the Greater Sydney GCCSA average of 33.9 per cent. Canterbury LGA had the largest proportion of overseas born residents at 48.1 per cent of the population and Marrickville LGA had the lowest proportion of overseas born residents at 34.1 per cent
- 45.2 per cent of residents in the social and economic study area speak a language other than English (LOTE) at home. Canterbury LGA had the highest proportion of LOTE residents at 63.9 per cent of the population. Sydney LGA had the lowest proportion of LOTE residents at 29.9 per cent
- The percentage of persons requiring assistance for core activities ranged from 2.5 to 5.3 per cent with Canterbury and Rockdale LGAs having the highest percentage of persons requiring assistance.

Families and housing

Key family and housing characteristics of the study area are as follows:

- Residents in Marrickville and Sydney LGAs are highly mobile in comparison to the other LGAs in the study area and the Greater Sydney GCCSA. In 2011, 43.9 per cent and 55.7 per cent of residents in Marrickville and Sydney LGAs lived at a different address in 2006
- In 2011, the study area had a total of 225,151 private occupied dwellings. These comprised of a higher proportion of flats/units/apartments and lower proportion of separate houses than the Greater Sydney GCCSA averages
- The average household sizes in Canterbury LGA (2.8 people per household), Hurstville LGA (2.8 people per household) and Rockdale LGA (2.7 people per household) were equal to or higher than the Greater Sydney GCCSA average of 2.7 people per LGA
- Family households (62.9 per cent) are the most common household composition in the social and economic study area. Canterbury and Hurstville LGAs have a larger proportion of family households than the Greater Sydney GCCSA average of 73.1 per cent. The remaining LGAs in the study area all had lower proportions of family households than the Greater Sydney GCCSA average
- Of those households that identified as family households in the study area, the majority of these families were couple families with children (41.7 per cent). The study area had a lower proportion of couple families with children than the Greater Sydney GCCSA (48.9 per cent) but a higher proportion of couple families with no children (40.1 per cent) than the Greater Sydney GCCSA (33.5 per cent)
- Renting was the most popular housing tenure in Marrickville (43.0 per cent), Botany Bay (37.6 per cent), Canterbury (36.5 per cent) and Sydney (59.8 per cent) LGAs, By comparison, on average owning with a mortgage was the most common tenure across the Greater Sydney GCCSA (34.8 per cent), followed by renting (31.6 per cent) and then owning outright (30.4 per cent).

Socio-Economic Index for Areas

An estimate of the socio-economic status of the study area has been based on SEIFA data published by the ABS. The index of relative socio-economic advantage and disadvantage (IRSAD) has been used for this assessment.

IRSAD summarises information about the social and economic conditions of people and households within an area. A low score on the index indicates a relatively greater disadvantage. A high score indicates a relative lack of disadvantage.

Overall, SEIFA suggests that socio-economic conditions differ widely across the study area. Sydney, Marrickville, Rockdale and Hurstville LGAs represent relatively advantaged areas, while Canterbury and Botany Bay LGAs are relatively disadvantaged compared to other areas with higher index scores.

Labour force and household income

Key labour force and household income characteristics of the social and economic study area are as follows:

- The median household incomes for the LGAs in the study area ranged between $1,029 per week (Canterbury LGA) and $1,639 per week (Sydney LGA). By comparison, the median household income for the Greater Sydney GCCSA was $1,447 per week
- Overall, the social and economic study area had a larger proportion of households (12.9 per cent) earning less than $399 per week than the Greater Sydney GCCSA (10.7 per cent) and a larger proportion of households (20.6 per cent) earning less than $599 per week than the Greater Sydney GCCSA average (18.2 per cent)
- In 2011, the total labour force of the study area was 510,205 residents. Full time employment represented 62.5 per cent of the labour force and part time employment represented 25 per cent of the labour force
- The social and economic study area had a higher unemployment rate (6.2 per cent) than the Greater Sydney GCCSA average (5.7 per cent)
- Residents in the study area were most commonly employed in professional occupations, followed by clerical/administrative occupations
- The most common industries of employment for the labour forces of Canterbury, Hurstville, Rockdale and Botany Bay LGAs were retail trade (10.9 per cent, 9.9 per cent, 10.0 per cent and 10.1 per cent, respectively) and health care/ social assistance (10.3 per cent, 10.4 per cent, 10.5 per cent and 11.2 per cent)
- Professional/Scientific/Technical Services was the most common industry of employment for workers living in Marrickville and Sydney LGAs (12.2 per cent and 16.8 per cent, respectively).

Recreational and community infrastructure

The social and economic study area comprises well-established urban and suburban areas and, consequently, features a wide variety of community facilities and services catering to the educational, cultural, health and social needs of residents. **Figures 15-2 to 15-5** show the location of these recreational and community infrastructure in proximity to the project, including:

- Educational facilities
- Health, emergency and aged care facilities
- Sport, recreational and cultural facilities
- Shopping facilities.

Further details are provided in the following sections.

Educational facilities

Educational facilities in the social and economic study area include child care centres, primary schools, secondary school and tertiary education facilities. Educational facilities located within the immediate vicinity of project works are detailed in **Table 15-2** and their locations are mapped on **Figure 15-2** to **Figure 15-5**.

Child care centres and primary schools within the study area would mainly draw students from the local area, accommodating residents within a local catchment around each facility. High schools and tertiary education facilities are more likely to draw from a wider catchment, particularly where they are situated close to public transport services or provide specialist education services, such as Newtown High School of the Performing Arts or Sydney TAFE Design Centre Enmore.

A more detailed list of educational facilities identified within the social and economic study area is provided in Appendix B of the Technical working paper: Social and economic in **Appendix M**.

Table 15-2 Educational facilities within the immediate vicinity of the project

Project area	Child care facilities	Primary schools	High schools	Tertiary education facilities
Western surface works	• Active Kids Beverly Hills • Active Kids Narwee • Barfa Bear Child Care Centre • Footsteps Early Learning Centre • Footsteps Early Learning Centre Oosh School Care • Kingsgrove World of Learning • Kids Oasis Childcare Centre	• Regina Coeli Catholic Primary School • Beverly Hills North Public School • McCallums Hill Public School	• Beverly Hills Girls High School • Kingsgrove North High School • St Ursula's College Catholic Girls High School	None in proximity to the works
Bexley surface works	None in proximity to the works	• Clemton Park Public School	None in proximity to the works	• Booth College, School for Christian Studies, Bexley North (Salvation Army)
Arncliffe surface works	• Busy Bee Long Day Child Care Centre • Do Re Mi Long Day Care Centre	• Arncliffe Public School • St Francis Xavier's Catholic Primary School	None in proximity to the works	None in proximity to the works
St Peters interchange	• Active Kids Mascot • Building Blocks Early Learning & Child Care Centre Alexandria • Sydney Park Child Care Centre • Lady Gowrie Child Centre Newtown • Camdenville Public School Preschool	• Camdenville Public School • St Peters Public School • Newtown Public School • Alexandria Park Community School (kindergarten to year 12)	• Alexandria Park Community School (kindergarten to year 12) • Tempe High School • Newtown High School of the Performing Arts	• Sydney TAFE Design Centre Enmore

Health, emergency and aged care

Facilities in the social and economic study area related to health and emergency include hospitals, medical centres, aged care facilities and state emergency services. These include:

- Arncliffe Fire Station
- Beverly Hills State Emergency Service (SES)
- Marrickville SES
- Kingsgrove Police Station
- Kingsgrove Health Professional Centre
- Kingsgrove Day Hospital
- Kings Medical Clinic
- Royal Freemans' Benevolent Institution (RFBI) Moorefields Masonic Village
- Bexley Gardens Retirement Village
- Tom Foster Community Care
- Newtown Police Station
- Newtown Fire Station
- Macquarie Lodge Retirement Village.

Kingsgrove Day Hospital, located on Kingsgrove Road is the closest hospital to project works. Arncliffe Fire Station is located near the Kogarah Golf Course. No other hospitals or emergency services are located in the immediate vicinity of proposed surface works. Aged care facilities located near the western surface works and Bexley Road surface works include:

- RFBI Moorefields Masonic Village, Roselands
- Bexley Gardens Retirement Village, Bexley North.

In the vicinity of the St Peters interchange, the Tom Foster Community Care provides services to older people, people with a disability and carers who live in their homes in Marrickville LGA. No other aged care facilities are located in the immediate vicinity of the project.

Sport, recreational and cultural facilities

The study area has a considerable amount of passive and active open space and a number of sporting facilities, places of worship, community halls and recreational facilities.

Areas for passive and active recreation are important in the study area, with waterways such as Wolli Creek and the Cooks River providing opportunity for parks and open space, encouraging active living for the community. Open space in the vicinity of the project is identified in **Figure 15-2** to **Figure 15-5**.

Walking and cycling paths are present in the study area including areas along the Cooks River, Wolli Creek and the M5 East Motorway (known as the M5 Linear Park) and Sydney Park.

The M5 Linear Park incorporates local open spaces such as Beverly Grove Park, Forrester Reserve, Kingsbury Reserve and Kingsgrove Avenue Reserve, and comprimises an off-road shared path that runs parallel to the M5 Motorway corridor between Belmore Road, Riverwood and Bexley Road, Kingsgrove. As such, the M5 Linear Park does not have a set boundary. Instead it comprises a cycling and pedestrian path that traverses through existing park lands and reserves or along road corridors or pathways adjacent to the M5 East Motorway where no open space is available. West of King Georges Road, the shared path is only on the southern side of the motorway, while east of King Georges Road, there is a shared path north and south of the motorway until Bexley Road. A number of north-south crossings are available along the length of the path at roadways (eg King Georges Road and Cooloongatta Road) and at underpasses beneath the motorway (eg the Kindilan underpass through Beverly Grove Park).

Kingsgrove Avenue Reserve and the Wolli Creek channel is immediately to the south of the Bexley Road South construction compound (C5).

Canterbury Golf Course is located in Beverly Hills and is a public 9-hole course. Kogarah Golf Course is an 18-hole golf course located adjacent to the Cooks River in Arncliffe. Kogarah Golf Course has been in existence for over 80 years and also provides function and conferencing facilities.

The Barton Park public driving range is south of the Kogarah Golf Course and bordered by Riverine Park and Banksia Field. Riverine Park contains play equipment and a baseball field, as well as playing fields that are used for local sporting competitions.

Bestic Street and Eve Street cycle ways are located within Riverine Park and Banskia Field. This cycleway provides connections between areas south of Banksia and Kyeemagh and to the north via Marsh Street and the Princes Highway. Eve Street wetland (closed to the public) is also located adjacent to the M5 East Motorway.

Sydney Park provides both passive and active open space. The park has several walking and cycling paths, playing fields and playgrounds. A number of local sporting and community clubs use Sydney Park, such as the South Sydney District Cricket Club, the Newtown Swans Junior AFL team and St Peters Parkrun. The Sydney Park Cycling Centre, a series of signalised cycling paths for families to learn about cycling and road safety, is also located within the park. Sydney Park is also home to walking and cycling paths used by residents and community groups.

Smaller parks are present in St Peters, including Simpson Park, Camdenville Park and May St Park. May Street Park is a small park that provides rest area function. Both other parks contain play equipment and service the immediate residential community and workforce in St Peters and Marrickville. Camdenville Park, the larger park of the two, also includes playing fields. Marrickville Council is proposing to upgrade the park to provide additional recreational uses, including BMX tracks.

Cycle paths at the eastern end of the project include a dedicated cycle path along Bourke Road, with cycle routes nominated along roads where dedicated facilities are not provided. Current planning and Longer term strategies by the NSW Government, City of Sydney Council and Botany Bay Council in this area have identified the opportunities to enhance cycle paths including:

- The Airport Cycleway along the Alexandra Canal to Coward Street, which along with the Bourke Road cycleway, would form a major north-south cycling corridor (Sydney's Cycling Future (Transport for NSW, 2013b))
- City of Sydney Council is developing a cycleway along the eastern side of Alexandra Canal as rezoning and development occurs. This would complement the Bourke Road cycleway and would link with the Airport Cycleway further to the south along Alexandra Canal
- Cycleway connections along Bourke Street between Coward and Gardeners Road to connect to Coward Street element of the Airport Cycleway and the City of Sydney's Bourke Road cycleway (Botany Bay City Council). This is being constructed by Botany Bay City Council to Church Street.

Cultural facilities located in proximity to the project include:

- Brethren Church, located around 550 metres to the north of the western surface works
- Regina Catholic Church, a Baptist Church and a community centre, located between 1.3 kilometres to 1.5 kilometres to the south west of the western surface works
- Our Lady of Fatima Church, located 300 metres east of the Commercial Road construction compound
- The South-West Chinese Christian Church located around 300 metres east of the Commercial Road construction compound
- Uniting Church around 850 metres north west of the Bexley Road North construction compound
- Uniting Church located around 950 metres to the east of Bexley Road East construction compound

- Community centre and scout hall around 250 metres to the south-west of the Bexley South construction compound
- Wolli Creek Islamic Mosque located around 400 metres to the west of the Arncliffe surface works
- Arncliffe Scots Sports and Social Club around 600 metres to the west of the Arncliffe surface works
- St Peters Church of England around 150 metres to the west of St Peters interchange.

A list of sport, recreational and cultural facilities identified in proximity to the project are provided in Appendix B of the Technical working paper: Social and economic in **Appendix M** and shown in **Figure 15-2** to **Figure 15-5**.

Shopping

Shops and shopping centres are spread throughout the study area and form an important focal point for communities. Major shopping centres in the social and economic study area include Roselands, Westfield Hurstville, Marrickville Metro Shopping Centre, and Alexandria Homemaker Centre.

Neighbourhood and local centres located in the social and economic study area are found around railway stations and main roads. In particular areas around Kingsgrove railway station, King Georges Road and Princess Highway have neighbourhood zoning areas.

King Street in Newtown is known for its unique selection of independent retailers. The southern portion of King Street is in the vicinity of the St Peters interchange and eastern end of the project. In addition, the corner of King Street and Enmore Road in Newtown is the location of the Newtown Community Market, which is open every Saturday.

(blank page)

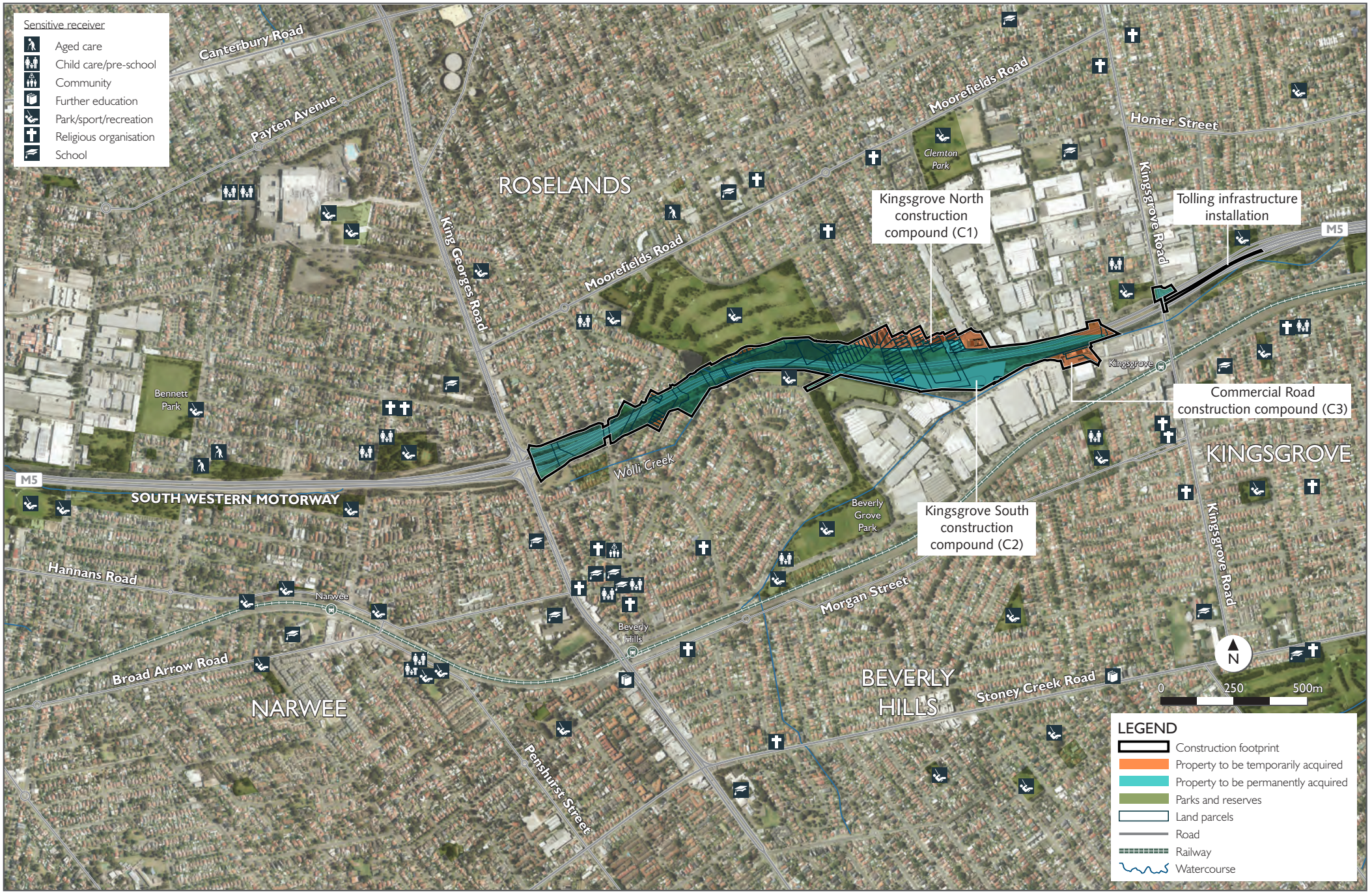


Figure 15-2 Sensitive receivers and community infrastructure in proximity to the Western and Kingsgrove Road surface works

(blank page)



Figure 15-3 Sensitive receivers and community infrastructure in proximity to the Bexley Road surface works

(blank page)



Figure 15-4 Sensitive receivers and community infrastructure in proximity to the Arncliffe surface works

(blank page)

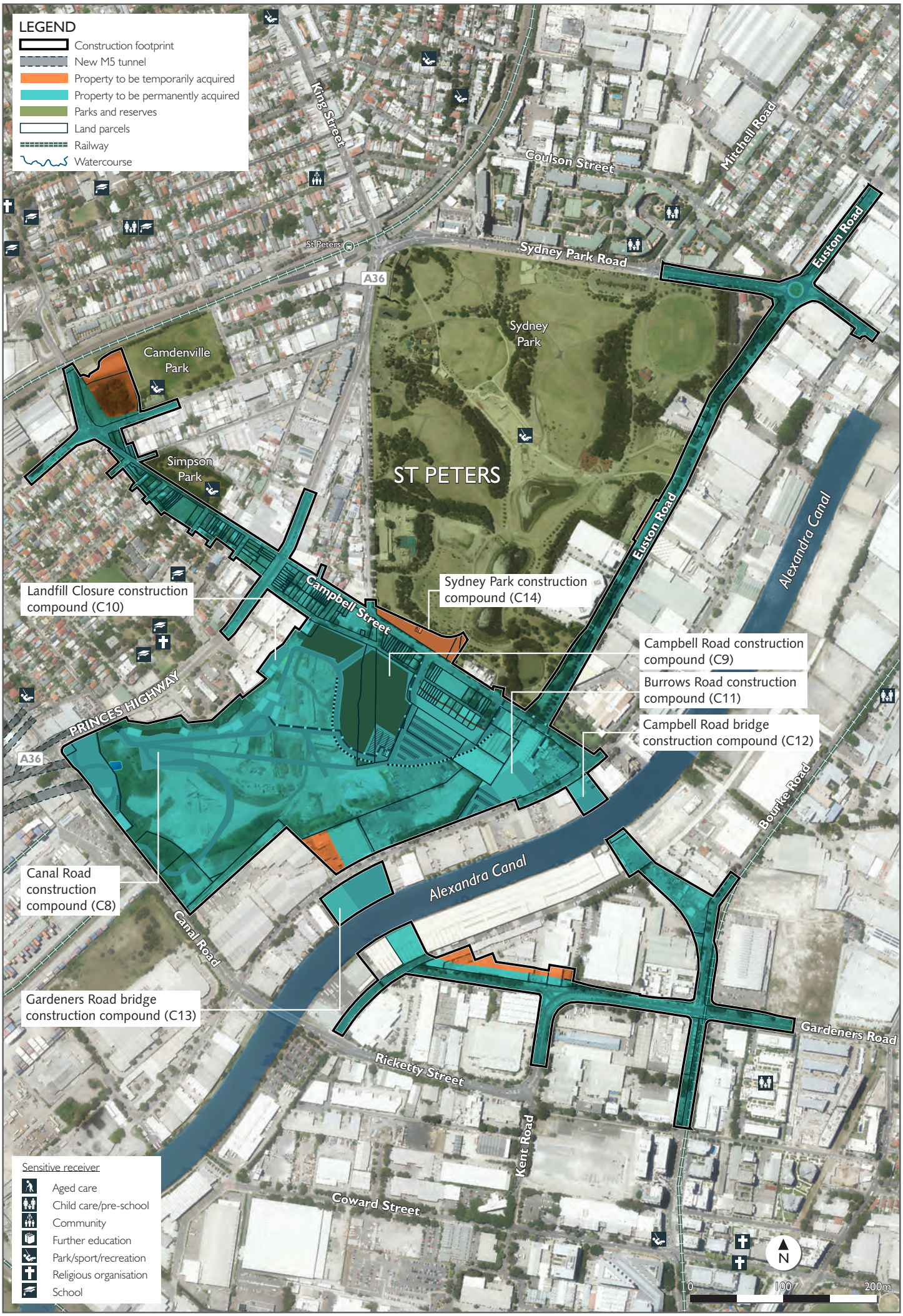


Figure 15-5 Sensitive receivers and community infrastructure in proximity to the St Peters interchange

(blank page)

Consultation and community values

A review of community strategic planning documents relevant to each LGA was undertaken to identify values and aspirations specific to each community. A summary of the community identity, values and future aspirations for each LGA within the study area is provided in **Table 15-3**.

Table 15-3 Community identity, values and aspirations (sourced from respective community strategic planning documents for each LGA)

LGA	Community identity	Community values/ aspirations
Sydney (City of Sydney 2014)	• A city characterised by diverse communities who live, work and visit Sydney • Encompasses major civic functions, government offices, cultural and entertainment assets and transport infrastructure.	• Promote an environment of equality for all people • A sustainable city with minimal environmental impact and improved green space and healthy ecosystems • Efficient buildings and transport systems • Global economic orientation • Improved physical connection through walking, cycling, high quality public transport • Improved sense of belonging, contribution and social wellbeing.
Marrickville (Marrickville Council 2013)	• A diverse, vibrant and innovative community • Diverse age profile, lifestyles and cultural backgrounds • Inner-city living • Strong sense of social justice • Creative community with high participation in arts and cultural activities • Revitalised industrial areas with a focus on high technology, creative and eco business enterprises.	• Maintain cultural diversity • Housing affordability • Availability of recreational facilities and open space • Innovative urban planning that protects the character and heritage of the area • Provision of adequate aged care facilities • Adequate health, transport and educational services • Increased availability of quality child care services • Support for disadvantaged community members • Sustainable redevelopment of the Cooks River • Improved community wellbeing and safety.

LGA	Community identity	Community values/ aspirations
Botany Bay (Botany Bay City Council, 2015)	• A diverse community that embraces multiculturalism • Inner-city living • Strong sense of local history and culture • Characterised by periods of urban decay and renewal, with historical industrial precincts replaced with new developments over time • Diverse business profile ranging from small home businesses to major multi-national corporations.	• Development of a strong sense of community, where everyone feels they belong, are listened to and respected • Clean and inviting streets, which foster improved pedestrian access • Availability and access to transport and community infrastructure • Availability of housing to suit a diverse community • Ongoing economic vitality, with good local jobs based on a diverse economy • Improved amenity of residents, with a move towards safe, clean local industries • Preservation of local history • Improved accessibility to areas of open space, parklands and recreation, including walking and cycling tracks, exercise and sporting facilities to support an active lifestyle • Creation of areas of open space promoting environmental and heritage significance of the area, such as the proposed Botany Wetlands.
Rockdale (Rockdale City Council, 2013)	• Cultural diversity • Inner-city living • Connected and engaged community • Highly urbanised with a number of transport connections (rail, road and air) • A mix of residential, industrial and commercial precincts and areas of open space.	• Welcoming and creative city with active, healthy and safe communities • High quality natural and built environment and valued heritage in liveable neighbourhoods • A city that is easy to get around with good links and connections to other parts of Sydney and beyond • Thriving economy that provides jobs for local people and opportunities for life-long learning.
Hurstville (Hurstville City Council, 2011)	• An evolving city which promotes a sustainable and safe community that connects people and places and celebrates diversity • Acts as a major transport interchange for the St George region with access to road and rail and proximity to Sydney Airport • Hurstville City Centre provides the major concentration of commercial and retail space for the region • Connection to natural environment with proximity to the Botany Bay and Georges River foreshores, as well as one of the largest native bush reserves in the St George region, Oatley Park.	• A diverse, harmonious and inclusive city that provides a range of social, cultural, educational and leisure opportunities • Protect and improve the city's natural and built environments and cultural assets for the health, wellbeing and benefit of current and future residents • Increase Hurstville's level of income and capital, and distribute this wealth to the community through local expenditure, services and employment • Improved age care facilities and services • Improved access to public transport • An informed community, with ongoing consultation, particularly around matters of human health and wellbeing.

LGA	Community identity	Community values/ aspirations
Canterbury (Canterbury City Council, 2014)	• City of cultural diversity • A built environment that is characterised by a high quantity of older residential areas, with some industrial areas on the city's fringe • Canterbury Road has been identified as a Potential Enterprise Corridor, which will act as an important centre for local employment.	• Increased opportunities and community space for appreciation of local heritage, arts, music and culture • Improved appearance of the city, with cleaner streetscapes, more green space and improved community infrastructure to create a "village feel" • Improved pedestrian and cycling access and adequate parking around shops and public transport • Promotion of healthy lifestyles supported by parks, outdoor recreational facilities and sporting facilities • Improved community safety and wellbeing, with increased access to adequate health services and educational facilities • A prosperous local economy with improved town centres and industrial precincts • Improved awareness and support of protection of the natural environment.

The outcomes of consultation with government agencies, local councils and the community have been considered during the preparation of the environmental impact statement. **Table 15-4** presents the feedback provided by government agencies, local councils, businesses, industry groups, residents and the community with regard to social and economic issues.

More detail on consultation undertaken to date and planned consultation activities can be found in **Chapter 7** (Consultation).

Consultation with residents, businesses and the community would continue throughout the planning, construction and operation of the project.

Table 15-4 Feedback provided by stakeholders

Issue	Detail
Construction	
Property	Concern about impacts on property values
	Concern about damage to properties from vibration during tunnelling and other construction activities
	Concern about residential property acquisition
	Concern about finding tenants to rent property
	Concern about negotiating a property sale following the announcement of the project
Accessibility and parking	Concerns about local traffic impacts, particularly congestion and heavy vehicles using local streets during construction
	Concern about traffic management during and after construction
	Concerns about delays in travelling to the airport
	Concern about contractors parking on local streets during construction
	Concerns about potential changes to access to the Tallawalla Street underpass and Karingal Street underpass

Issue	Detail
	Concern about a potential loss of pedestrian and cyclist connectivity to Kingsgrove Station
	Concern that local streets will be connected directly onto the M5 East Motorway
	Concern about induced traffic demand from the New M5
	Concern about safety impacts of additional traffic as there are many pedestrians around the schools, shops and railway stations
Amenity	Concern about increased levels of dust during construction
	Concern about noise and vibration during construction, particularly during night time construction activities
	Concern about the relocation of noise walls closer to properties and the height and effectiveness of existing noise walls
	Concern about the visual impact due to the loss of noise mounds
Community facilities	Concerns about the loss of green space at the golf course
	Concerns about potential impacts on the Wolli Creek bushland
	Concerns about the loss of pedestrian and cycle paths
	Concern about temporary loss of community facilities such as the grass netball courts at Tallawalla Street Reserve.
Operation	
Property	Concern about impacts on property values
	Concern about having a tunnel under people's houses
	Concern about the future of construction sites once construction is completed
Accessibility and parking	Concern about the implementation of a toll on the New M5
Amenity	Concern for health and air quality impacts of locating ventilation outlets close to homes, schools and other community facilities
	Concerns about visual impact of the ventilation outlets near residential properties, schools and other community facilities
	Concern about the relocation of noise walls closer to properties and the removal of existing noise mounds
Community facilities	Concerns about the loss of green space
	Concerns about the loss of pedestrian and cycle paths

15.2.2 Economic environment

Workforce characteristics

The following profile of the workforce within the social and economic study area has been informed by the most recent release of the *Australian Census of Housing and Population,* Working Population Profiles (Australian Bureau of Statistics, 2012b).

Key workforce characteristics include:

- In 2011, 527,725 people worked in the social and economic study area. Of these workers, 75 per cent were employed in the Sydney LGA
- Businesses within the Botany Bay LGA employed the second largest proportion of these workers at 8.5 per cent of the study area workforce
- Workers in the Canterbury, Hurstville and Rockdale LGAs were most likely to be employed in retail trade. Workers in the Sydney LGA were most likely to be employed in financial / insurance services or professional / scientific / technical Services. Workers in the Marrickville LGA were most likely to work in manufacturing, whereas workers in the Botany Bay LGA were most likely to work in the transport/ postal/ warehouse industries.

Business and industry

Key business and industry characteristics of the study area include:

- The total social and economic study area had an estimated $125.1 billion Gross Regional Product (GRP) (AECOM, 2014a) in 2012 to 2013
- The Canterbury, Hurstville, Rockdale and Marrickville LGAs have relatively diverse economies that are not heavily reliant on one industry. The estimated GRP for these areas was $4.2 billion, $3.4 billion, $3.8 billion and $4.3 billion respectively. The largest contributing industries were manufacturing, financial/ insurance services and transport/ postal/ warehousing
- The Botany Bay and Sydney LGAs have less diverse economies. Botany Bay LGA had an estimated $7.8 billion GRP with transport/ postal/ warehousing being the prominent industry. The Sydney LGA had an estimated $101.6 billion GRP with the financial/ insurance services the prominent industry.

Businesses in the social and economic study area are generally clustered around main transport hubs, such as railway stations, major bus routes or in close proximity to roads connecting with Sydney Airport or Port Botany. These areas include the Kingsgrove Business Area, Kingsgrove Road, Bexley North railway station, Princes Highway, King Street, the Mascot / Alexandria area and the Tempe area. **Table 15-5** provides a summary of the businesses in the immediate vicinity of the project.

Table 15-5 Businesses within the immediate vicinity of the project

Location	Type
Western surface works	
Kingsgrove Business/Industrial Area (the Crescent, Vanessa Street and Commercial Road)	A cluster of commercial and industrial businesses. Business activity includes warehousing, manufacturing, storage, automotive services, bulk goods and an industrial park
Kingsgrove Road (north of the M5 East Motorway)	A cluster of commercial and wholesaling retailers
Kingsgrove Road (south of the M5 East Motorway)/ Kingsgrove Station	A cluster of retail services, cafes and restaurants, real estate agents, personal services, a supermarket and Kingsgrove Hotel. Businesses are located in a high street setting along Kingsgrove Road and within a shopping centre located near the station

Location	Type
Bexley Road surface works	
Bexley North Station	A cluster of retail services, cafes and restaurants, real estate agents, supermarket and Bexley North Hotel
St Peters interchange and local roads upgrades	
Princes Highway, St Peters and Tempe	A cluster of commercial, retail and industrial businesses, including petrol stations, automotive services, personal services, wholesaling, bulk goods (including IKEA Tempe), fast food restaurants and accommodation services (Hotel Ibis Budget)
King Street, St Peters and Newtown	A cluster of retail services, cafes and restaurants. King Street is an important regional destination for nightlife and entertainment due to its location adjacent to Enmore Theatre, and the numerous pubs, bars and restaurants located along this strip
Mascot/Alexandria (Botany Road and Gardeners Road)	A cluster of commercial, retail and industrial businesses, including manufacturing, warehousing, wholesaling and bulk goods (including Alexandria Homemaker Centre and Bunnings Mascot), cafes and food services, automotive services, Alexandria Industrial Estate and a number of business centres (including Heritage Business Centre on Gardeners Road and Sydney Corporate Park)
St Peters and Alexandria (Campbell Street and Euston Road)	A cluster of commercial and industrial businesses, including automotive services, warehousing, manufacturing and Alexandria Landfill (no longer accepting new waste) and supporting businesses.

Tourism in the region is centred on Sydney Airport, which provides access to Sydney and broader NSW for domestic and international travellers. Hotels within the region provide accommodation close to the airport.

Freight transport

Key freight transport characteristics of the study area include:

- The M5 East Motorway corridor forms part of the National Land Transport Network. The National Land Transport Network is based on national and inter-regional transport corridors
- The M5 East Motorway corridor connects businesses with the M7 Westlink, King Georges Road, M4 Motorway (via King Georges Road) and the Eastern Distributor in Sydney. The M5 East Motorway corridor provides the main connection for businesses in the south-west of Sydney to interstate and international markets via the Hume Highway to the south, as well as Port Botany and Sydney Airport
- The NSW Freight and Ports Strategy (Transport for NSW, 2013e) reported that approximately 63 per cent of the total freight task in NSW was carried by road. Significant growth in the total freight task is projected over the next 20 years
- The M5 East Motorway corridor currently experiences significant congestion along the eastern portion of the motorway for an estimated 13.3 hours per day
- The cost of congestion to the NSW economy in 2011 was estimated at $5.1 billion and is expected to rise to $8.8 billion by 2020 (SMPO, 2013a).

15.2.3 Travel patterns

Detailed descriptions of travel patterns in the study area are provided in the Technical Working Paper: Traffic and transport in **Appendix G**.

Road

The social and economic study area is characterised by a number of major motorways and arterial roads. The extensive road network means that travel by car is common. Car trips (as a driver or passenger) were the most common mode of travel to work in Canterbury (71.8 per cent), Hurstville (67.3 per cent), Rockdale (68.1 per cent), Botany Bay (68.1 per cent) and Marrickville (48.9 per cent) LGAs. Car trips (as a driver or passenger) were the second most common mode of travel in Sydney CBD, behind walking, accounting for 30.4 per cent of total trips to work.

Traffic behaviour around the study area can be summarised as:

- West of the M5 East Motorway / Princes Highway interchange, east-west traffic movement is focused on the M5 East Motorway, with Canterbury Road and Illawarra Road to the north, and Stoney Creek Road, Forest Road and the Princes Highway to the south, carrying lower volumes
- East of the M5 East Motorway / Princes Highway interchange, east-west traffic movement splits fairly equally between the Princes Highway, Marsh Street and the M5 East Motorway. A similar amount of traffic also merges from General Holmes Drive to and from the south
- North-south traffic is mainly focused on King Georges Road in the west and the Princes Highway in the east. These routes onto the M5 East Motorway provide the dominant approach to Sydney Airport and Port Botany and onwards to Southern Cross Drive for traffic from Sydney's west.

At the western end of the study area, roads such as Moorefields Road, William Street, Vanessa Street and Morgan Street provide connections between key north-south roads (eg Bexley Road) as well as provide access to local destinations adjacent to the M5 East Motorway. At the eastern end of the study area around St Peters, a number of roads serve both regional and local functions, including:

- Princes Highway – A major state highway that runs from Sydney CBD at Broadway, through Newtown (King Street) and St Peters, and beyond Kogarah. In addition to its regional function, the highway also serves local connections for communities, commercial and industrial precincts located along its length
- King Street – King Street is a major state road, part of the Princes Highway, which runs through the retail precinct of Newtown. It serves as one of the key connections between the Sydney CBD and areas in the south of Sydney
- Canal Road / Ricketty Street / Kent Road – These roads provide a link in the state road network, connecting Princes Highway to Gardeners Road, Mascot. The Ricketty Street Bridge presently provides the only crossing of the Alexandra Canal in the area
- Gardeners Road – Gardeners Road is a state road which runs east-west, connecting Kent Road in the west to Anzac Parade and Bunnerong Road in the east. It provides local access to industrial, commercial and residential uses along its length
- Burrows Road – Burrows Road is a local road that begins at Huntley Street and ends south of Canal Road. It serves the light industrial precinct that runs along its length
- Campbell Road – Campbell Road is a regional road that runs between Burrows Road and Barwon Park Road. In conjunction with Campbell Street, this road provides access to residential, industrial and open space facilities
- Campbell Street – Campbell Street is a local road that runs between Barwon Park Road and Unwins Bridge Road. It provides local access for communities and industrial areas north-east of the Princes Highway, as well as through movements originating or travelling to Marrickville and suburbs beyond
- Euston Road – Euston Road is a collector road. It connects McEvoy Street in the north and Campbell Road in the south. The section between McEvoy Street and Sydney Park Road forms a part of the regional road network to the Eastern Suburbs. From Sydney Park Road to Campbell Road, it serves a light industrial precinct

- Bourke Road / Bourke Street – Bourke Road is a local road that runs between Botany Road, Waterloo and Gardeners Road, Alexandria. North of Botany Road, it becomes Bourke Street and continues until Campbell Street, Darlinghurst. To the south of Gardeners Road, it becomes Bourke Street through Mascot Town Centre to Coward Street, Mascot, when it then returns to being Bourke Road until O'Riordan Street, Mascot.

Public transport

Rail transport was the second most common mode of travel to work in Canterbury (18.4 per cent), Hurstville (25.5 per cent), Rockdale (22.4 per cent) and Marrickville (25.7 per cent) LGAs. Rail travel only accounted for 4.5 per cent of trips to work in Botany Bay LGA, where only Mascot and Sydney Domestic Airport stations are located within the north-west of the LGA.

The study area is serviced by three heavy railway lines:

- The Bankstown Line travelling from the Sydney CBD to Liverpool or Lidcombe via Bankstown
- The Airport Line travelling from the Sydney CBD to Macarthur via the Airport or Sydenham
- The Inner West and South Line travelling from the Sydney CBD to Campbelltown via Granville.

Bus transport accounted for 11.1 per cent of Marrickville LGA trips, 16.1 per cent of Botany Bay LGA trips and 15.9 per cent of Sydney LGA trips. Bus trips represented only small proportions of trips to work in Canterbury, Hurstville and Rockdale LGAs.

The bus routes around the St Peters interchange and surrounds are operated by Sydney Buses. In addition to the train services from St Peters and Mascot stations, there are a number of bus routes travelling to the Sydney CBD, including routes 308, 422 and M20, with a service frequency of between seven minutes and 20 minutes in the morning and afternoon peaks. Additional bus routes provide access to suburbs, such as Wolli Creak, Bondi Junction, Marrickville and Burwood. These bus routes are less frequent than the bus routes travelling to the Sydney CBD.

There are no regular bus services on the M5 East Motorway or the M5 South Western Motorway. Intercity coach services, such as those operated by Murrays or Greyhound, use the M5 East Motorway and/ or the M5 South Western Motorway.

Active transport

Walking was the most common mode of travel to work in Sydney CBD, accounting for 30.5 per cent of total trips to work. Walking accounted for 6.9 per cent of trips in Marrickville LGA and 6.5 per cent of trips in Botany Bay LGA. Cycling to work was most popular in Marrickville and Sydney LGAs, accounting for 4.2 per cent and 3.6 per cent of trips, respectively.

Surveys completed by City of Sydney Council between 2010 and 2014 in the St Peters area and surrounds suggests there is an increasing demand of bicycle trips in the area, with an average growth rate of about nine per cent per annum between these years.

The remaining LGAs had low proportions of walking and cycling trips.

Walking and cycling trips increase as a proportion of total trips when taking into account all travel (including weekend trips). This is reflective of the numerous recreational walking and cycling paths in the study area, including:

- At the western end of the study area, the shared path along the M5 Linear Park provides a key off-road west-east route for the local community
- The Wolli Creek Trail commences east of Bexley Road and connects to Waterworth Park at Earlwood located near the confluence of Wolli Creek and Cooks River. It loosely follows the meander of Wolli Creek
- At Arncliffe, the Cooks Park Trail connects areas south of the study area, at Kyeemagh to Arncliffe, Wolli Creek and further east to Tempe. Within the study area, the trail is travels through Barton Park and Riverine Park prior to passing under the M5 East Motorway near Eve Street wetland to connect to Marsh Street and Cahill Park

- In the vicinity of the eastern end of the study area, there are a number of recreational facilities, such as Sydney Park, which generate recreational walking and cycling trips in the area. St Peters Station also generates pedestrian movement to and from the station.

15.3 Assessment of potential impacts

Potential social and economic impacts and benefits from construction of the project would include:

- Social:
  - Amenity and health related impacts
  - Property acquisition
  - Impacts on community facilities
  - Traffic and access related impacts
- Economic:
  - Changes to business turnover and employment
  - Business amenity impacts
  - Business acquisition
  - Changes to accessibility
- Cumulative impacts with other construction projects.

15.3.1 Construction

Amenity and health

Amenity contributes to a community's identity and its sense of place. Amenity impacts during construction would include factors that affect the ability of a resident, visitor or business owner to enjoy their home, business and/ or daily activities. These impacts may affect individuals in private homes, as well as the general public's use of educational facilities, shopping centres, cultural, sport and other recreational facilities.

Amenity impacts during construction of the project would result from the introduction of construction sites and construction activities into the area and would be generally associated with noise and vibration, air quality and visual impacts. These potential impacts are discussed in detail in **Chapter 12** (Noise and vibration), **Chapter 10** (Air quality),**Chapter 11** (Human health) and **Chapter 14** (Visual impacts and urban design), Changes in amenity may also conflict with community values, contributing to a loss of or change in a community's sense of place, and subsequently a community's perceived identity.

With reference to those assessments, potential impact to residents and the community during construction could occur as a result of:

- Increases in noise and vibration associated with construction works, including increases in road traffic from construction vehicles and the construction workforce
- Increased dust and air emissions associated with surface disturbance and / or the handling, transport and disposal of soil, as well as vehicular emissions from construction vehicles
- Changes in visual amenity due to the introduction of construction compounds or activities
- Changes in traffic volumes and air quality resulting in changes in the health of residents and road users.

The majority of construction activity would occur underground, which would limit the extent of amenity impacts along the project corridor. Impacts would mainly arise at the locations of surface works, in proximity to construction sites and compounds and along transport routes used by construction traffic.

Potential amenity impacts to residents and the community from project surface work locations are provided in Section 5.1.1 in **Appendix M**. A summary of the potential impacts is provided in **Table 15-6.**

Table 15-6 Potential impacts on amenity and health during construction

Location	Potential impact
Western surface works	Noise impacts during construction
	Dust impacts during construction
	Visual amenity impacts due to the Kingsgrove North construction compound (C1), particularly resulting from the temporary noise wall proposed along the north and west boundaries of the compound
	Overshadowing from the larger or closer elements to property boundaries
	Visual amenity impacts from the removal of existing parkland views
	Pedestrians and cyclist diversions around the edge of the construction compound, resulting in a reduced visual experience
	Visual impacts from night lighting
	Visual amenity impacts to users of the M5 East Motorway
Bexley Road surface works	Noise impacts during construction
	Dust impacts during construction
	Visual amenity, overshadowing and night lighting impacts due to the Bexley Road North construction compound (C4)
	Visual amenity and lighting impacts due to the Bexley Road South construction compound (C5)
	Visual amenity and lighting impacts due to the Bexley Road East construction compound (C6)
	Reduced visual amenity and increased noise levels for pedestrians and cyclists using the M5 East Motorway Linear Park
Arncliffe surface works	Noise impact during construction, particularly at night.
	Dust impacts during construction
	Visual amenity and night lighting impacts due to the change in view from a golf course to the Arncliffe construction compound (C7) with its associated noise barriers
	Reduced visual amenity and increased noise levels for pedestrians and cyclists using the Cooks Park Trail
	Reduced visual amenity and increased noise levels for users of the Kogarah Golf Course
St Peters interchange and local road	Increased noise levels for resident along local roads, including residents located along Campbell Street/ Campbell Road, Church Street and residents located around the northern ends of St Peters Street, Florence Street, Brown Street and Unwins Bridge Road

Location	Potential impact
upgrades	Increased noise levels at St Peters Public School, located on Church Street and St Peters Anglican Church
	Dust impacts during construction
	Visual amenity impacts for residents on Campbell Road from the Campbell Road construction compound (C9) and the Sydney Park construction compound (C14), the associated noise barriers, night lighting and the Campbell Road widening works.
	Visual amenity and night lighting impacts for residents along Barwon Park Road from the Sydney Park construction compound (C14). These residents would have their view altered from one of Sydney Park to a view of the construction compound
	Visual amenity and noise impacts for active and passive recreation users of Sydney Park due to the location of construction compounds on parkland, resulting in a change of visual character, and nearby construction works
	Visual amenity, air quality and noise impacts for pedestrians, cyclists and commuters waiting at bus stops.

Property acquisition

The project requires the acquisition of land currently used for residential, business or community/recreational purposes. The project has been designed to minimise the need for land acquisition, where practical, and to limit the severance and sterilisation of private properties.

Properties impacted by the project by partial or full acquisition would include land that is subject to strata subdivision or may contain multiple leased industrial units in one property. For the purposes of this assessment, strata titles and/or multiple industrial units have been considered as one property. All acquisitions discussed as part of this assessment relate to surface acquisitions only.

The project would impact 159 properties and would require either full or partial acquisition for project works at the surface. These properties are categorised as a mix of residential, commercial, industrial or recreational uses.

Of the 159 properties that would be fully or partially acquired for the project:

- 50 properties are owned by RMS and other State Government agencies
- 26 properties are owned by local government
- 78 properties are privately owned
- Five properties are owned by utility providers.

The complete list of properties acquired for the project is identified in Appendix D (Properties affected by acquisition) of the EIS.

Of the 159 properties impacted by the project:

- A total of 47 industrial and commercial (including Kogarah and Canterbury golf courses) properties would be impacted by the project by full or partial acquisition. Of the 47 properties, 18 are already owned by Roads and Maritime or other NSW Government agencies (for example, Alexandria Landfill). Of the 18 properties owned by NSW Government or other NSW Government agencies, some are not occupied or have recently been vacated
- A total of 69 are residential properties, of which 21 are owned by Roads and Maritime. All residential properties would be subject to full acquisition and in most instances, these properties do contain residences. The exception is the partial acquisition of three private properties that has been zoned for road purposes located between residential apartments and current alignment of Euston Road.

Four public recreational facilities:

- M5 Linear Park. The majority of the park is owned by Roads and Maritime as it comprises a shared path adjacent to the M5 East Motorway. Some areas of the park are owned by Canterbury City Council and would be acquired for the project. The majority of the park is zoned for Special Infrastructure under the relevant LEP. Around 10.7 hectares of the M5 Linear Park would be permanently impacted by the project with around 2.6 hectares of M5 Linear Park land temporarily occupied during construction. Land temporarily occupied for construction would be returned to recreational purposes following the completion of construction
- Sydney Park
  - Around 0.2 hectares of City of Sydney land adjacent to the road corridor within Sydney Park would be acquired. This represents around 0.56 per cent of the total area of Sydney Park
  - An additional 0.55 hectares would be leased or temporarily occupied for construction purposes from City of Sydney and returned to recreational uses following the completion of construction.
  - Around 146 square metres of Sydney Water land adjacent to the road reserve within Sydney Park would be acquired
- May Street Reserve. This would be partially impacted by the upgrade of Campbell Street and the intersection of Unwins Bridge Road/Campbell Street/May Street/Bedwin Road. Part of the park is owned by Roads and Maritime with around 150 square metres owned by Marrickville Council that would be acquired. Around 634 square metres of land not required for road infrastructure would be landscaped to reconfigure the May Street Reserve. Additional areas along Campbell Street, not required for road infrastructure, would also be landscaped to provide around 427 square metres of open space.
- Camdenville Park. Around 1.1 hectares of Camdenville Park would be impacted as a result of the widened road and works to upgrade the existing drainage basin. The park is owned by Marrickville Council. Land not required for road infrastructure 0.86 hectares would be leased or temporarily occupied from Marrickville Council. Following completion of construction, BMX facilities would be provided at Camdenville Park or as agreed with Marrickville Council.

- Additional properties include those that are vacant, within a road reserve, or contain existing roads, such as the M5 East Motorway and properties along the Princes Highway. These are within the ownership of Roads and Maritime or other NSW Government agencies.
- A total of four public recreational areas would be partially or fully impacted:

Land that contains industrial or commercial uses that would be in excess of operational requirements would occur in limited circumstances, being:

- Three industrial properties at the western surface works
- Land at Kogarah Golf Course, which is discussed in detail above
- Areas of St Peters interchange, which would be required for the construction of the future M4-M5 Link.

Commercial and industrial properties that would be in excess of land requirements at the western surface works and local road upgrades would be made available for future commercial/industrial land uses consistent with the applicable land use zoning.

The acquisition of the properties would be undertaken consistently with the principles in the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and under the *Roads and Maritime Land Acquisition Information Guide* (Roads and Maritime, 2014b), whereby a number of matters are considered when assessing compensation, including:

- The market value of the property
- Any special value or financial value of any advantage, in addition to market value
- Severance or the amount of any reduction in the market value of any other severed land of the person entitled to compensation
- Disturbance, including legal costs, valuation fees, relocation costs, stamp duty costs, mortgage discharge and execution fees or other financial costs reasonably incurred
- Solatium or financial compensation to a person for non-financial disadvantage resulting from the necessity of the person to relocate his/her principal place of residence as a result of acquisition
- Any increase or decrease in the value of adjoining or severed land (by reason of the road proposals).

Ongoing consultation with residents and communities that may be affected by the project assists in reducing uncertainty by providing relevant information about the project and an opportunity to become aware of, suggest improvements to, and adjust to the changes.

Where land affected by construction is not required for the ongoing operation of the New M5, it would be rehabilitated and made available for potential sale and/ or redevelopment for a permissible use. The key exception would be where land used for construction purposes is used for one of the four motorway operations complexes. In some cases, including the Landfill closure construction compound site and the surplus land around the St Peters interchange, there may be an opportunity to review the current land use zoning of the affected land. The relevant local council would be consulted in these areas to determine whether current land use zonings and permissible land use types remain appropriate following construction of the project.

Recreation and community facilities

Community recreational facilities have a role in promoting cohesion and interaction among community members and are therefore important social assets.

Recreational and community facilities that have been identified as being partially acquired or fully acquired during the construction of the project include:

- M5 Linear Park
- Canterbury Golf Course
- Kogarah Golf Course
- Sydney Park
- May Street Reserve
- Camdenville Park.

Open space and cycling/walking paths within the M5 Linear Park (which includes Beverly Grove Park and Kingsgrove Avenue Reserve), the majority of which is owned by Roads and Maritime, would also be impacted as a result of the project. The partial acquisition of areas owned by Canterbury Golf Course comprises a mix of vegetation as well as the shared path that forms part of the M5 Linear Park. This would not impact fairways and would not significantly impact the values or function of this private recreational area.

Partial acquisition of the Kogarah Golf Course would be required for temporary construction activities and permanent operational facilities. During construction, the partial acquisition of Kogarah Golf Course would result in the temporary reduction and reconfiguration of the site from an 18-hole course to a nine hole course.

Members and users of the golf course are likely to experience amenity impacts during their visit, including increased noise and vibration, decreased air quality and reduced visual amenity. The distance from construction activity relative to the club facilities would limit potential amenity impacts to the club facilities. At the completion of project construction, any land temporarily occupied for construction of the project would be rehabilitated with the intention that it be returned to its original, possibly reconfigured (within the construction footprint) use. However, this would be subject to the requirements of the landowner and future discussions with the golf club.

Temporary and permanent occupation of Sydney Park would be required for the project. Partial acquisition would mainly occur adjacent to Campbell Road to facilitate the construction of the pedestrian bridge across Campbell Road and strip acquisition would occur along Euston Road. The remainder of Sydney Park would remain open to users during the construction period for recreational and sporting activities. Construction is planned to commence in the third quarter of 2018, with completion of construction in the first quarter of 2019. The total period of works for the Sydney Park construction compound is expected to be around one year.

At the completion of construction, park land temporarily occupied during construction of the project would be rehabilitated and likely returned to its original use. Recreational users of Sydney Park are likely to experience amenity impacts when in proximity to construction activities along the periphery of the park. Construction activities would also impact on available parking along Campbell and Euston roads. However, construction activities would not significantly impact large sections of Sydney Park. Impacts to walking and cycling paths within the park are not anticipated during construction of the project.

The M5 Linear Park would also be temporarily impacted by the project's construction activities, and in some instances impacts would be permanent. The latter would include the widening of the M5 East Motorway to accommodate the project, as well as the construction of the Kingsgrove and Bexley South motorway operations complexes. The land impacted is currently used for walking and cycling paths and as passive open space. The Kingsgrove construction compounds would predominantly occupy part of Beverly Grove Park, north and south of the existing M5 East Motorway. This would not be available during construction for open space, and upon completion, the available open space would be reduced (this permanent impact is discussed further in **Section 15.3.2**).

Construction is planned to commence in the second quarter of 2016, with completion of construction in the last quarter of 2019. The total period of construction works is expected to be around three and a half years.

Traffic and access

Construction of the project has the potential to result in impacts to the local traffic network associated with the establishment of traffic management measures, the introduction of spoil haulage and other heavy vehicles and physical alterations to local roads.

This may reduce the performance of the road network. However, to minimise impacts, the project has been designed and planned in order to avoid and minimise impacts to traffic during construction by:

- Locating construction compounds which provide tunnelling support adjacent to State and National roads to minimise impacts on the local road network
- Designing construction compounds to provide off-street car parking facilities to minimise impacts on access and parking for local residents.

The following changes in access to residential properties and community facilities may occur during the construction of the project:

- Alternative or reduced access to residential properties and community facilities, including reduced or alternative car parking arrangements:
  - Construction works may necessitate physical alterations to private property access or the provision of a temporary alternative access
  - It is anticipated that due to the extensive use of Campbell Road, Canal Road and Burrows Road to facilitate the construction activities, motorists would experience an increase in delays when exiting the existing properties along these roads affected by the construction vehicle routes
  - Light vehicle parking would be provided on site (in construction compounds) for the construction workforce to minimise negative impacts caused by workers parking on local streets. On-street parking would not be discouraged, which would be regularly reinforced through project inductions and toolbox talks
  - Construction personnel would be encouraged to use public transport where possible, and consider other modes of transport such as carpooling. To accommodate the large labour force anticipated on the project a temporary bus service is proposed in the industrial area to the Kingsgrove North construction compound
  - On-street parking along Campbell Road and Euston Road would be removed during construction. As the number of residential properties located in this area is limited and significant property acquisition is expected in this area, it is anticipated that the demand of the on-street parking is likely to reduce and the impact of a reduction in on-street parking is unlikely to be significant. Works along Euston Road may displace car parking practices of commercial and industrial businesses located along this road. However, these businesses currently have on-site parking and the acquisition of industrial and commercial properties for the interchange may reduce overall demand
- Changes in public transport routes, including the location of bus stops:
  - Rail services within the project corridor and surrounding areas are not expected to be affected by the project. However, during construction, longer travel times to and from rail stations by supplementary travel modes, such as travel by car, bus or walking may be experienced due to an increase in traffic volumes, slower travel speeds and increased intersection delays
  - As the M5 East Motorway does not have regular bus services operating on it, there are likely to be minimal impacts to public transport services around the western surface works. However, increases in traffic flows on the existing road network around the western surface works, Kingsgrove Road surface works and Bexley Road surface works areas, may result in some minor delays to bus services at intersections and roads used by construction vehicles
  - Bus services near the Arncliffe construction compound, the St Peters interchange construction compounds and the local road upgrades are likely to experience increases in travel times due to slower travel speeds and increased intersection delays from increased construction traffic
  - Bus stops would be temporarily relocated as part of local road upgrades at St Peters and Mascot. Where bus stops are temporarily relocated, pedestrian access, including disabled facilities would be provided at the temporary bus stop
- Diversion or temporary loss of walking and cycling paths:
  - The project would necessitate alterations to cyclist and pedestrian facilities in certain areas throughout the construction period
  - On road cyclists would experience increased delays at intersections due to an increase in traffic volumes travelling along the corridor and increased journey times due to closed shoulders and detours.

- Increased congestion and increased travel times:
  - Additional construction-related traffic has the potential to impact on the ability for residents and the community to access their homes and community facilities in the local area. Increased congestion could also impact on the community's ability to access the M5 East Motorway and the wider road network, including access to the Sydney Airport
  - Increases in traffic volumes could result in reduced roadside safety

Further traffic and access related impacts, and the identification of feasible and reasonable mitigation measures, are described in **Chapter 9** (Traffic and transport).

Business turnover and employment

Construction of the project would be of significant benefit to the economy. Project expenditure would inject economic stimulus benefits into the local, regional and state economies. Local businesses would principally benefit from this expenditure through purchases made by construction businesses and associated workers to build and support the development of the project.

Two types of benefits would occur from construction expenditure:

- Direct benefits (including employment), consisting of:
  - 'Initial' effects - referring to the impacts arising from the direct employment or expenditure used in the construction of the project
  - 'First-round' effects - referring to the impacts on businesses supplying directly to the construction of the project
- Indirect benefits referring to 'flow-on' effects to the wider state economy, such as increased expenditure and employment within industries that supply to businesses that directly supply the project with goods or services.

Businesses that may directly benefit from construction of the project would include local construction contractors and businesses which service or supply goods to the construction industry such as food and beverage retailers, accommodation providers, and other retail outlets that would cater to the day-to-day needs of the construction workforce. The increase in turnover may subsequently lead to increased employment opportunities and incomes for those businesses (and employees) providing goods and services.

The project would result in the following indirect and direct economic benefits:

- Direct construction expenditure, in terms of output, would contribute an estimated $1.3 billion, on average, per year of construction, with indirect (flow-on) effects of $0.5 billion per year, giving an estimated total benefit of $1.8 billion on average per year of construction
- Direct household income generated by the construction of the project is estimated to be $280 million, on average per year of construction, with indirect (flow-on) effects of $120 million per year, giving an estimated total household income contribution of $400 million on average per year of construction
- Direct employment (initial and 'first-round') supported by the construction of the project is estimated to average 2,840 full-time equivalent positions per year, giving a total of 7,700 annual full-time equivalent positions for the 42 month construction period
- Indirect (flow-on) employment is estimated to average 1,550 full-time equivalent positions per year, giving a total of around 9,300 annual full-time equivalent positions for the 42 months construction period
- Total employment supported by the construction of the project is estimated to average 4,390 full-time equivalent positions per year, giving a total of 26,360 annual full-time equivalent positions for the 42 month construction period
- Direct value added attributable to the construction of the project is estimated to be around $460 million directly on average per year of construction, with indirect (flow-on) effects of around $210 million per year, giving an estimated total value added contribution of $670 million per year of construction. This is the estimated contribution to Gross State Product (GSP).

The St Peters interchange would be located mostly on land currently occupied by the Alexandria Landfill. The potential continued operation of the landfill or other permissible industrial uses on the site would not be possible during construction.

The Alexandria Landfill site was acquired by the NSW Government in December 2014. Waste facility activities consistent with the existing planning approvals are continuing on site. However, the site no longer operates as a commercial landfill or receives waste. Impacts associated with this acquisition are discussed in the section below.

Business amenity

Amenity has an impact on customer decisions on where to shop. The impact of amenity on a business could potentially result in loss of trade as customers shop elsewhere to avoid adverse conditions. Amenity impacts include any factors that affect the ability of customers, employees or business owners to enjoy their workplace and daily activities such as noise, vibration, detrimental changes to views or changes to air quality.

Amenity impacts during the construction of the project have been discussed in detail in **Chapter 12** (Noise and vibration), **Chapter 10** (Air quality) and **Chapter 14** (Landscape character and visual impact) of this EIS and are outlined in the amenity and health section of **Section 15.3.1**.

The potential impact to businesses during construction within the study area as a result of changes in amenity would occur as a result of:

- Increases in noise and vibration, including increases in road traffic noise
- Potential changes in local air quality due to increased dust emissions associated with surface disturbance and/ or the handling, transport and disposal of spoil
- Changes in visual amenity due to construction compounds or activities close to businesses

The magnitude of potential amenity impacts would be largely influenced by:

- Construction work hours
- Duration of construction
- Construction activities
- Business proximity to the project
- The nature of the business.

As the majority of businesses in close proximity to construction compounds are industrial and commercial businesses, whose business activities are not considered to be dependent on amenity, the impact of noise, vibration, air quality and visual amenity would be limited.

A number of cafes and food venders are located within these industrial parks, in close proximity to the project. As these businesses generally serve the local workforce, it is not anticipated that amenity would impact the customer's decision to shop at these businesses and it is considered likely that these businesses would receive increased trade as a result of the project workforce.

Outside of commercial and industrial zoned land, Kogarah Golf Club would experience amenity impacts during construction of the project. The Kogarah Golf Club is privately run and reliant on amenity to attract members and customers for functions/ conferences. It is anticipated that during construction the golf course would experience increased noise and vibration, decreased air quality and reduced visual amenity, resulting in a potential reduction in turnover, through the loss of memberships and customers.

Business acquisition

Where possible, the location of businesses along the corridor has been considered during the design of the project so that impacts to businesses would be minimised.

Forty-seven industrial and commercial properties would be required for partial or full surface acquisition. Given the industrial nature of some of the properties within the study area, a number of small private businesses may operate within the one property. Small business types and larger commercial and industrial businesses have been identified where possible. In one instance, an area of publicly owned land used for off street car parking by a private business would be permanently lost as a result of the project.

The businesses currently located on land required for the project include but are not limited to:

- Alexandria Landfill
- Kogarah Golf Club
- Bunnings, Mascot
- Commercial and industrial businesses associated with the provision of services, such as:
  - Fire protection services
  - Demolition, construction and civil contractor services
  - Material handling equipment hire
  - Metalworking and engineering services
  - Document management and destruction, data storage and protection services
  - Catering services
- Commercial and industrial businesses associated with the manufacture, sale and distribution of goods such as:
  - Vehicle tyres and wheels
  - Electronic goods
  - Packaging materials
  - Wholesale food suppliers
  - Apparel, shoes and homewares
  - Jewellery supplies

The impact of acquisition would have both short term impacts (during construction of the project) and medium to long term impacts (during operation of the project). The economic impacts would be associated with the potential loss of employment and turnover.

Impacted businesses may choose to close down or relocate within the region. This could result in the loss of income for employees and owners and a loss in output in the region. These businesses may cater to the specific needs of residents or industries in the local community and may result in flow-on effects within the region.

Due to the nature of current business activity in the areas surrounding the commercial properties to be acquired, it is not anticipated that the viability of adjacent or surrounding businesses would be impacted by land acquisition. Businesses in these locations do not generally provide complementary or supplementary goods or services that would be affected by the loss of other business activity in the vicinity of their operations.

The Arncliffe construction compound and motorway operations complex would be located on land currently owned by Roads and Maritime and Rockdale City Council. The partial acquisition and temporary occupation of the Kogarah Golf Course during construction is expected to result in the temporary reduction of the facility from an 18-hole course to a 9-hole course. This impact may result in a reduction in turnover though the loss of memberships and a reduction in the use of club facilities.

Golf course users may use other facilities during this time as a number of alternate golf courses remain in the general vicinity of the project. These include:

- Marrickville Golf Club, Marrickville
- Tempe Golf Driving Range, Tempe
- Bexley Golf Club, Bexley
- Moore Park Golf, Moore Park
- The Australian Golf Club, Rosebery
- The Lakes Golf Course, Eastlakes
- Eastlake Golf Club, Kingsford
- Bonnie Doon Golf Club, Pagewood
- Botany Golf Club, Botany.

Partial acquisition of the golf course during construction and any associated compensation would be undertaken in accordance with the Roads and Maritime *Land Acquisition Information Guide* (Roads and Maritime, 2014b) and under the terms of the *Land Acquisition (Just Terms Compensation) Act 1991*. Compensation provided as part of the acquisition is anticipated to assist with loss of revenue, where reasonable, and assist with the ongoing viability of the business during the construction period. At the completion of project construction, any land temporarily required for construction of the project has the potential to be rehabilitated and returned to its original land use.

The land required for the project during construction and operation at Arncliffe, and adjoining areas are subject to the *Sydney Regional Environmental Plan No. 33 – Cooks Cove* (SREP 33), a deemed State Environmental Planning Policy. The SREP zones the golf course for future infrastructure (special uses), employment (trade and technology) and open space uses. Action has not been taken at this time to give effect to these proposed future uses. More recently, the DP&E has commenced investigations of the Cooks Cove area as a potential priority precinct (rezoning). The land required for permanent facilities has been designed and located to minimise the impact on any future development potential for the site as per the SREP, and any impacts are not considered to be significant.

The St Peters interchange would be located mostly on land occupied by the Alexandria Landfill. Historically, and prior to acquisition, the site was operated by Dial-A-Dump Industries Pty Ltd as a non-putrescible solid waste landfill with additional waste storage and recycling activities. The operations of the previous landowner ceased on this site in December 2014 following the acquisition of the site by the NSW Government. Dial-A-Dump now operates a waste transfer facility at Burrows Road, Alexandria, which would not be impacted by the project. It continues to operate a landfill facility in western Sydney.

The majority of operational non-putrescible landfills are located in western and south-western Sydney, with the Alexandria Landfill previously representing a rare example of an active landfill within close proximity to the CBD. However, based on available information on annual disposal rates, the landfill appears to have predominately focused on recycling and storage.

Potential broader impacts associated with the landfill closure may have included changes in the commercial and industrial waste haulage costs and an associated change in productivity for the region. Waste transfer, recovery and recycling facilities are more broadly spread across metropolitan Sydney, and a number of facilities remain in the general vicinity of the project. These include:

- SUEZ Transfer Station, Alexandria
- SUEZ Resource Recovery Centre, Rockdale
- SUEZ Resource Recovery Park, Chullora
- SUEZ Resource Recovery Park, Auburn
- REGYP Recycling Solutions & Gypsum Sales, Bronte

- Benedict Recycling, Banksmeadow and Chipping Norton.

As such, the impacts on the regional economy associated with this industry given the loss of recycling, storage and transfer functions at the site are unlikely to be significant.

There would be beneficial environmental outcomes as a result of the landfill closure, such as a reduction in ongoing leachate generation and disposal, improvement in the management of odour related impacts and an increase in public open space (with components to enhance integration with Sydney Park).

Land that contains industrial or commercial uses that would be in excess of construction requirements would occur in limited circumstances, being:

- Three industrial properties at the western surface works which would be fully acquired for construction compounds
- Areas of St Peters interchange, which would be required for the construction of the future M4-M5 Link
- Three properties that would be impacted by the local road upgrades.

Commercial and industrial properties that would be in excess of land requirements at the western surface works and local road upgrades would be made available for future commercial/industrial land uses consistent with the applicable land use zoning.

Additional details regarding property acquisition, and the identification of mitigation measures is described in **Chapter 13** (Land use and property).

Changes to access

Changes in access arrangements and parking have the potential to impact businesses by isolating them from customers or delivery/ pick-up activities required for business operation.

The construction and operation of the St Peters interchange and the local road upgrade works would require temporary modifications to the driveways of some properties along Euston Road and Gardeners Road.

Some temporary disruption for access to St Peters Public School may be experienced as road works would be undertaken along Campbell Street and St Peters Street, however these impacts would be temporary for the duration of the works and access to the school would be maintained.

The majority of the businesses along Euston Road require both heavy and light vehicle access for delivery and/ or pick-up activities. There is the potential for business turnover and employment to be impacted where business activities are temporarily impeded due to reduced access.

Parking arrangements may influence a customer's decision where to shop. No reduction in on-street parking is proposed in the area of the western surface works. As there is currently no on-street parking along Marsh Street, Wickham Street, West Botany Street and Princes Highway in the vicinity of the Arncliffe surface works, no parking impacts are anticipated for local businesses in this area.

While the project would deliver long term benefits to the freight industry (as detailed in **Section 15.3.2**), businesses reliant on freight or commercial vehicle activities may be impacted by increased congestion and decreased travel times during the construction of the project. Businesses reliant on local and regional deliveries may therefore experience increased delivery costs due to increased travel times and the resulting labour and operating costs. Due to increases in delivery costs and times, customers may take their business elsewhere.

Increased congestion from reduced traffic lanes and/ or travel speeds due to the construction of the project would impact freight movements along the M5 East Motorway, the Princes Highway and the wider road network, especially those accessing Sydney Airport and Port Botany from the south-west of Sydney. Increased congestion would result in the temporary increase in travel times for freight movements. As a result, businesses may experience an increase in freight costs associated with the increased time shipment takes in the supply-chain.

15.3.2 Operation

Potential social and economic impacts and benefits during the operation of the project would include:

- Social:
  - Amenity and health related impacts
  - Impacts on recreational and community facilities
  - Traffic and access related impacts
- Economic:
  - Impacts to business turnover and employment
  - Impacts on passing trade
  - Business amenity impacts
  - Changes to accessibility
  - Efficiency impacts on freight and commercial vehicles.

Amenity and health

Potential changes in amenity and health during the operation of the project may occur as a result of:

- Increases in noise and vibration associated with increases in road traffic
- Decreased air quality associated with increased road traffic, the operation of ventilation facilities and emergency smoke extraction facilities
- Changes in visual amenity due to permanent operational facilities
- Changes in commuting behaviour and air quality resulting in changes in the health of residents and road users.

The operational noise assessment identified that a total of 145 residential receivers would be eligible for consideration of noise mitigation through at-property treatment due to operational traffic noise levels. In addition, two building in St Peters Public School would also be eligible for consideration.

The noise assessment further identified that:

- The permanent ventilation structures located at Kingsgrove, Bexley, Arncliffe and St Peters would comply with applicable noise criteria under all circumstances, with the exception of a minor exceedance in one noise catchment area.
- Properties around the western surface works area would experience an overall reduction in noise compared to the current situation.
- During operation, traffic volumes would increase around the St Peters interchange, including Campbell Street/ Campbell Road, Euston Road and a small portion of the Princes Highway between King Street and south of Campbell Street. The increase in traffic volumes would result in increased noise levels for residents located adjacent to these roads. Some residents would experience noise levels that exceed the maximum noise criteria. Receiver's eligible for at-property treatment would be identified during detailed design. Further details are provided in **Chapter 12** (Noise and vibration).

During the operational phase of the project a number of properties have been identified where road noise has the potential to be elevated and adversely affect health. For these properties mitigation measures are required to protect the health of local residents. These mitigation measures may include low noise pavement, noise barriers and/or noise treatments on individual properties. These mitigation and management measures are detailed in Technical Working Paper: Noise and vibration (**Appendix J**).

The project is expected to result in a decrease in total pollutant levels in the community. 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 will

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 acceptable.

The ventilation facilities for the project would be located as far from existing residential dwellings as possible. The operation of the ventilation facilities would not prevent continued use of surrounding land for residential and related purposes. The potential air quality impacts and human health impacts associated with the ventilation facilities are discussed in **Chapter 10** (Air quality) and **Chapter 11** (Human health) of the EIS.

For the New M5, future development of land (including re-zonings) in the vicinity of the ventilation facilities that may involve multi-story buildings would need to consider the air dispersion performance of the New M5 facilities. The Southern extension and M4-M5 Link ventilation facilities are subject to further design development and planning approvals. Any future EIS for these projects will assess potential air quality impacts and human health risks associated with these projects, including potential impacts on elevated receivers.

While concentrations of pollutants from vehicle emissions are higher within the tunnel (compared with outside the tunnel) the time spent exposed to these pollutants is short (minutes in duration). Where health based guidelines are available, exposures within the tunnel are expected to be below these guidelines. However for nitrogen dioxide and particulates there are no health based guidelines and exposure to pollutants derived from congested traffic (including within tunnels) may increase the risk of adverse health effects. Drivers who regularly use tunnels or drive in congested traffic in Sydney can minimise exposure to vehicle emissions by keeping windows up and air conditioning on recirculation when in tunnels or heavy traffic conditions. Keeping windows closed and switching ventilation to recirculation has been shown to reduce exposures inside the vehicle by up to 80 per cent.

A detailed assessment of air quality is provided in the Technical Working Paper: Air quality assessment report in **Appendix H** of the EIS.

Residents, road users, community facilities users, pedestrians and cyclists are likely to experience changes in visual amenity due to the introduction of new operational infrastructure. Visual amenity impacts would occur where permanent facilities are located, including:

- At Kingsgrove, where the open space at Beverly Grove North would be reduced due to the widening of the motorway corridor. This would include the removal of the noise mound, which provides a vegetated screen, and the removal of Cooks River / Ironbark Castlereagh Forest (an endangered ecological community)
- At Kingsgrove, where a new noise barrier would be installed on the northern and southern sides of the motorway corridor
- At Kingsgrove where the Kingsgrove motorway operations complex (MOC1) would be located. However, the impacts at this location would be moderate to low in most instances given the proximity of the nearby industrial area. The greatest impact would be to the recreational users of the shared path that would run adjacent to the motorway operations complex
- At Bexley Road where the Bexley Road South motorway operations complex (MOC2) would be located. However, the impacts at this location would moderate to low in most instances given the distance to residential receivers. Impacts would be the greatest for the users of the M5 Linear Park that runs adjacent to the motorway given the reduction in available open space
- At Arncliffe where the Arncliffe motorway operations complex (MOC3) would be located, given the change associated with the introduction of the ventilation facility
- At the St Peters interchange. The new infrastructure would include the interchange itself, the St Peters motorway operations complex and Burrows Road motorway operations complex, including the motorway control centre and maintenance facility
- Local road upgrades, in particular the widening of Campbell Road/Street and Euston Road which would change the character and scale of these roads.

Forecast traffic volumes indicate that King Georges Road, Stoney Creek Road and the Princes Highway would experience increases in traffic after the opening of the project due to some drivers diverting through these roads to avoid motorway tolls on the M5 East Motorway and New M5. This effect would be more pronounced during off-peak hours, as Stoney Creek Road is already heavily congested during peak hours.

The increase in traffic levels on these alternative routes due to the introduction of tolls would decrease amenity for residents, shoppers, community facilities users, schools and motorists on these roads. On these alternative routes a maximum increase of 1.9 dB(A) has been identified (an increase in noise of 2 dB(A) is generally considered barely perceptible). The impact has been considered to be minor and would not appreciably impact receivers.

Noise and vibration, air quality, visual and traffic impacts have been assessed in **Chapter 12** (Noise and vibration), **Chapter 10** (Air quality), **Chapter 14** (Visual impacts and urban design) and **Chapter 9** (Traffic and transport).

Recreation and community facilities

Upon completion of the construction phase, land that is currently used for recreational purposes and used or temporarily occupied for the project would likely be rehabilitated and returned to its original land use in consultation with the landowner.

The project would result in the permanent realignment of a shared path within the M5 Linear Park on both sides of the M5 East Motorway at the western surface works. The realignment would provide the same level of access to the park as before the project. However, the path would be realigned to account for the permanent operational infrastructure for the New M5.

The land not required for operational facilities at Arncliffe would be returned to Rockdale City Council for a permissible use (such as a golf course or equivalent).

Partial acquisition and temporary occupation of Sydney Park would be required for the project. This includes land adjacent to Campbell Road to accommodate the new pedestrian bridge across Campbell Road, and a strip of land along Euston Road.

At the completion of construction, any land temporarily occupied for construction of the project would be rehabilitated and likely returned to its original use. Recreational use of the park, including the use of walking and cycling paths within the park, are not anticipated to be affected by this partial acquisition and temporary occupation.

Land on the site of the St Peters Interchange not used for existing or future road infrastructure would likely be used as additional open space for recreation and community use.

There would be no other permanent changes to the available open space at Camdenville Park or Simpson Park in St Peters.

The local road upgrades would include provision of new and upgraded pedestrian and cycle infrastructure. This infrastructure has been designed to maintain and enhance pedestrian and cyclist accessibility and connectivity, particularly around the St Peters interchange and Sydney Park.

The most significant new infrastructure would include the construction of a pedestrian and cycle bridge across the on and off ramps at the St Peters interchange and construction of a pedestrian and cycle bridge across Campbell Road.

Other key pedestrian and cycle infrastructure to be delivered as part of the local road upgrades would include:

- An on-road cycle lane along Campbell Street between Unwins Bridge Road and Barwon Park Road
- A shared path along the western side of Euston Road between Campbell Road and Sydney Park Road
- An on-road cycle lane along Bourke Road between Campbell Road and Church Avenue
- Retention of the on-road cycle lane on Bourke Road, north of the Campbell Road extension

- Provision of footpaths along all local roads upgraded as part of the project.

The upgrades to pedestrian and cycle infrastructure would provide for a safe cyclist and pedestrian environment by minimising the interface of cyclists and pedestrians with vehicular traffic, and would also provide a regional cycle connection between Mascot and Marrickville

Traffic and access

The project would facilitate increased accessibility to key markets, employment locations and community facilities through the introduction of new road, public transport and pedestrian/ cycle infrastructure.

The local road upgrades would include new and upgraded pedestrian and bicycle infrastructure. This infrastructure would maintain and enhance pedestrian and cyclist accessibility and connectivity, particularly around the St Peters interchange and Sydney Park.The upgrades to pedestrian and bicycle infrastructure would provide for a safe cyclist and pedestrian environment by minimising the interface of cyclists and pedestrians with vehicular traffic, and would also provide a regional bicycle connection between Mascot and Marrickville.

The project would also result in the permanent realignment of a shared path within the M5 Linear Park on both sides of the M5 East Motorway at the western surface works. The realignment would provide the same level of access to the park as before the project. However, the path would be realigned to account for the permanent operational infrastructure for the New M5.

The access changes at residential properties or community facilities due to the operation of the project would include:

- Maintenance of an existing signalised intersection at Flora Street and Marsh Street, which would be constructed as part of the Marsh Street widening project (Roads and Maritime) to enable access in and out of the Arncliffe motorway operations complex. This intersection provides access to residences to the north of the site.
- Changes to one way arrangements for Barwon Park Road to minimise the potential for vehicles using this local road for ‘rat-running’
- The existing driveway located between 3 Ricketty Street, Mascot and 5 Ricketty Street, Mascot would be extended to form a new road, Venice Street, to maintain access for local businesses. Venice Street would provide access to properties between Ricketty Street and Gardeners Road and would be one lane in each direction with a turning head at the northern end.

Changes to parking as a result of local road upgrades would include:

- On-street and off-street parking would be provided along Campbell Street between Princes Highway and Unwins Bridge Road. Final numbers would be confirmed during detailed design
- Parking along Campbell Road between Barwon Park Road and Euston Road would be removed
- At project opening, parking along Euston Road would be provided during off-peak periods. However, by around 2031, the traffic performance demands along Euston Road may require all lanes to be available for traffic and off-peak parking may need to be removed. The removal of car parking would be to the discretion of Roads and Maritime
- Parking along Gardeners Road between the Kent Road and Gardeners Road intersection to the end of Gardeners Road would be removed
- As part of the local road upgrades, parking along Albert Street would be removed.

The project has the ability to connect residential communities with locations of employment, due to reduced congestion and decreased travel times. The project provides greater accessibility for residents of south and south-west Sydney to access Sydney Airport and Sydney central business district. Further information on road changes is available in **Chapter 5** (Project description). Further information on traffic is available in **Chapter 9** (Traffic and transport).

Business turnover and employment

It is estimated that direct and indirect impacts to business turn over and employment as a result of the operation of the project would include:

- Generation of up to 116 full-time equivalent jobs for the operation and maintenance of the project
- Generation of around $35 million directly, with flow-on (indirect) effects of around $9 million, giving an estimated total impact of around $44 million per year
- Around $8 million of household income, with flow-on effects of around $2 million, giving an estimated total household income contribution of around $10 million per year
- Around 86 full-time equivalent positions per year of operation. Flow-on employment is estimated to average 30 full-time equivalent positions per year of operation, giving a total of 116 full-time equivalent positions per year of operation
- Value added attributable to the operation of the project is estimated to be $14 million directly, with flow-on effects of $4 million, giving an estimated total value added contribution of $18 million. This is the estimated contribution to Gross State Product (GSP).

Passing trade

Changes in traffic volumes and changes to visibility have the potential to impact businesses on the Princes Highway between the M5 East Motorway and the St Peters interchange that are reliant on passing trade. The New M5 tunnels would enable the bypass of the Princes Highway and businesses along that road that were previously visible to passing trade.

Businesses that currently advertise on the Princes Highway between the M5 East Motorway and the St Peters interchange may experience decreased visibility from the reduction in traffic volumes. Visibility is important for businesses that rely on passing trade. Customers of these types of businesses are generally impulse or convenience purchasers. The likely change in through traffic may necessitate potential changes to advertising operations to continue to draw customers to some businesses.

A total of nine businesses were identified as potentially being impacted by a reduction in passing trade. These include service stations, fast food restaurants and accommodation services located in east bound and west bound directions on Princes Highway between the M5 East Motorway and the St Peters interchange.

The linkages with other businesses supplying goods and services to those businesses impacted through a reduction of passing trade were not quantified. These would be indirect or flow-on impacts on employment and turnover resulting from the diversion of through traffic and are likely to be minor.

To assess the potential impact the project would have on passing trade, changes in traffic volumes were reviewed. Further information regarding the potential changes on key major roads is provided in **Chapter 9** (Traffic and transport). These results have been used in conjunction with industry data to estimate the impact of the project on passing trade. A reduction in passing trade would negatively impact both employment and business output. The resulting estimated potential losses are summarised in **Table 15-7**.

Table 15-7 Potential impacts of business acquisition

Type of business	Number of businesses	Annual potential loss of output ($)	Annual potential loss of employment (FTE positions)
Accommodation Services	2	102,000	1
Fast Food Restaurants	4	311,000	1
Petrol/Service Stations	3	10,000	0
Total	**9**	**423,000**	**2**

This is a worst case scenario analysis of the impact of the reduction of passing trade based on industry averages and the results presented in **Table 15-7** should be regarded as indicative only.

The assessment of the impacts associated with loss of passing trade should also be considered in the context of, and balanced against, a range of benefits such as travel time improvements, efficiencies for the freight industry and the employment opportunities generated by the project.

Business amenity impacts

Potential changes in amenity that may impact businesses during the operation of the project may occur as a result of:

- Increases in noise and vibration associated with increases in road traffic
- Decreased air quality associated with increased road traffic, the operation of ventilation outlets and emergency smoke extraction facilities
- Changes in visual amenity due to permanent operation facilities.

As the majority of businesses in close proximity to the project are industrial and commercial businesses, the impact of noise, vibration, air quality and visual amenity are limited. These businesses are not considered sensitive receivers as their business activities are not dependent on amenity.

There would be an increase in traffic using alternative routes as a result of the introduction of tolls on the M5 East Motorway. This would increase road traffic noise on these routes. However, it would be within accepted criteria.

Businesses located along the Princes Highway between the M5 East Motorway and the St Peters interchange, where traffic levels are anticipated to decrease due to the project may experience improved amenity due to reduced traffic levels. Improved amenity and accessibility due to the project may facilitate urban renewal of this area, attracting businesses that would benefit from improved amenity.

King Street and Enmore Road business precinct contains numerous businesses, including retail, services, restaurants and cafes. The project does not propose to modify King Street, including speed limits or on-street parking arrangements along King Street. In future years, traffic modelling indicates that King Street is expected in most cases to experience reduced peak hour volumes under the 2021 'with project' scenario and 2031 cumulative scenario when compared to the without project scenario (refer to Technical Working Paper: Traffic and transport (**Appendix G**). The exception to this would occur in the 2031 cumulative case, where AM peak hour volumes southbound would increase by around 35 per cent when compared to the 'without project' scenario. However, this is in the opposing direction to the dominant AM peak hour and is within the design carrying capacity of the road. As there would not be any significant changes to traffic volumes or no modifications to King Street are proposed as part of this project, the project would not have a significant impact on businesses or amenity along King Street.

Changes to accessibility

Changes in accessibility have the potential to impact the viability of a business, depending on the type of business and the ability of that business to respond to any changes. Reduced accessibility would occur if access arrangements for individual businesses or retail centres change as a direct result of the project.

Access to one business would be permanently modified due to the project. Bunnings Mascot would have its access permanently modified to be off Bourke Road to accommodate the proposed widening of Bourke Road and Gardeners Road. It is not anticipated that this change in impact would have any effect on the viability or operation of the business. The provision of a secondary access point for an additional property on Gardeners Road, near the Bourke Street/Road intersection, may also be required due to strip acquisition. This would be confirmed during detailed design and in consultation with the property owner.

A distribution facility at Gardeners Road would also have altered access due to the construction of the Gardeners Road and Campbell Road bridges. Access to the portion of the property would be via

Venice Street to Rickety Street while access to the northern portion of the property would be by a new intersection on Campbell Road extension. The Campbell Road access would restrict right hand turn movements out from the northern portion of property and access to Gardeners Road would not be available. This would result in a reduction in access currently afforded to the businesses contained within the facility. However, existing roads, including Campbell Road / Street, Princes Highway and Canal Road would provide opportunities for vehicles wishing to travel east.

Due to the decrease in congestion along the Princes Highway between the M5 East Motorway and the St Peters interchange, businesses located in this area are likely to experience increased accessibility to their businesses. Increased accessibility and increase amenity along this section of the Princes Highway may encourage new and diverse businesses into the region and provide the opportunity for urban renewal.

Changes to parking are not anticipated to have a significant impact on business activity, as most businesses within the area can accommodate off-street parking. Additional on-street and off-street parking provided on Campbell Street, Venice Street and Albert Street, as part of the project would help to alleviate impacts associated with removal of parking in other nearby areas. Existing on-street parking would still remain on other local roads.

Efficiency of freight and commercial vehicles

Businesses that rely on commercial and freight vehicle movements have the potential to significantly benefit from the operation of the project. The following potential impacts on these businesses, during project operation, would include:

- Increased productivity from decreased congestion and the reduction in travel times for commercial and freight movements
- Increased economic activity from increased efficiency of freight and resulting increased economic output
- Reduced costs of commercial and freight movements.

The traffic assessment conducted for the project determined that the project would result in reduced travel times and decreased congestion along the M5 East Motorway corridor. Once fully operational, it is anticipated that travel times along the M5 East Motorway between King Georges Road and Foreshore Road will decrease by six to eight minutes during the AM and PM peaks due to the project.

Without the project, congestion along the M5 East Motorway would increase further, impacting on travel speeds. Reduced travel speeds (and the resulting increase in travel time) would impact on road freight and commuter vehicle productivity and commuter vehicle occupants, representing an economic cost to the state.

The reduced travel times for freight and commercial vehicles would reduce operational costs associated with fuel and wages and improve safety by reducing stop-start traffic conditions caused by congestion. In 2013, travel time for freight movement has been valued by Transport for NSW at $57.84 per vehicle hour, demonstrating significant benefits associated with reduced travel times.

Reduced travel times would also improve the efficiency of freight and commercial vehicle movements, given the improvements in capacity on the M5 East Motorway and the introduction of the New M5. The project would indirectly benefit access to Sydney Airport and Port Botany which would improve business access to interstate and international markets. This would lead to improvements in the efficiency and reliability of Sydney's freight network, facilitating more efficient movement of goods through the supply chain and ultimately enhancing productivity. The project would not only benefit Sydney's freight network, but would also benefit regional and interstate movements through the improvement of connectivity and efficient movements across Sydney.

The reduced travel times would also reduce operational costs associated with fuel and wages and improve safety by reducing stop-start traffic conditions caused by congestion. As the cost of freight movement decreases, the cost of the goods moving through the supply-chain decreases accordingly. As such, there is the potential for cost savings to be passed on to consumers of transported goods.

Commercial vehicle movements are generally more focused around commercial centres as workers travel between major centres for business, such as professionals, tradesmen and salesmen. The M5 East Motorway acts as a main thoroughfare for commercial vehicles as they make deliveries and support services to or from major centres in western and south-western Sydney, Port Botany, Sydney Airport and the Sydney central business district. In addition, the M5 East Motorway plays an important role in the National Land Transport Network, enabling commercial vehicle movements across Sydney and to regional and interstate markets. Improvements in efficiency and reliability of the road network leads to the more efficient commercial vehicle movements and therefore has the potential to reduce costs and enhance the productivity of this workforce.

In summary, the project would improve network efficiency, delivering travel time savings and provide more efficient movement of freight and commercial vehicles, thereby reducing operational costs. The project would also provide increased road capacity along the M5 East Motorway corridor, which is a key corridor for the movement of freight between Sydney Airport/ Port Botany and the western and south-western suburbs of Sydney and commercial vehicle movements between major centres.

15.4 Environmental management measures

Mitigation and management measures would be implemented to avoid, minimise or manage social and economic impacts. As described above, a number of potential social and economic impacts are associated with changes to amenity (such as noise, air quality and visual) and changes in traffic and access during the construction and operation period.

Mitigation measures identified in each of those respective sections are relevant to managing potential social and economic impacts. Consultation with the community during the construction phase of the project is outline in the Draft Community Communications Framework (**Appendix E**).

Additional mitigation and management measures specific to social or economic impacts are listed in **Table 15-8**.

Table 15-8 Environmental management measures – social and economic

Impact	No.	Environmental management measure	Timing
Construction			
Accessibility	SEO1	A community involvement plan would be implemented to provide timely, regular and transparent information about changes to access and traffic conditions, details of future work programs and general construction progress throughout the construction phase of the project. Information would be provided in a variety of ways including letter box drops, media releases, internet site, signage and a hotline.	Construction
Property acquisition	SEO2	Acquisition would be undertaken consistently with the principles in the Land Acquisition Information Guide (Roads and Maritime, 2014b) and the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW).	Pre-construction and construction
Business impacts	SEO3	A toll free number and website would be maintained to enable business owners and/or operators to receive prompt responses to their concerns, access information and view assistance measures in place during construction related work.	Construction

Impact	No.	Environmental management measure	Timing
	SEO4	A business impact risk register would be maintained to identify and manage the specific impacts associated with construction related works for individual businesses.	Construction
	SEO5	The business stakeholder forum would be continued during detailed design and throughout construction to address business concerns. Further information about consultation can be found in **Chapter 7** (Consultation)	Construction

(blank page)