Transport for NSW

# Beaches Link and Gore Hill Freeway Connection

## Chapter 8

## Construction traffic and transport

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DECEMBER 2020

# 8 Construction traffic and transport

This chapter considers the potential traffic and transport impacts from the construction of the Beaches Link and Gore Hill Freeway Connection and identifies measures which address these impacts. Potential operational traffic and transport impacts are discussed in Chapter 9 (Operational traffic and transport).

A detailed traffic and transport assessment has been carried out for the project and is included in Appendix F (Technical working paper: Traffic and transport).

The Secretary's environmental assessment requirements as they relate to construction traffic and transport, and where in the environmental impact statement these have been addressed, are detailed in Table 8-1.

Avoiding or minimising impacts has been a key consideration throughout the design and development process for the Beaches Link and Gore Hill Freeway Connection project. A conservative approach has generally been used in the assessments, with potential impacts presented before implementation of environmental management measures. The environmental management measures proposed to minimise the potential impacts in relation to construction traffic and transport are included in Section 8.5.

**Table 8-1 Secretary's environmental assessment requirements – construction traffic and transport**

| Secretary's environmental assessment requirements | Where addressed |
|---|---|
| **Traffic and Transport** | |
| 1. The Proponent must assess construction transport and traffic (vehicle, marine, pedestrian and cyclists) impacts, including, but not necessarily limited to:<br>a. a considered approach to route identification and scheduling of marine and land transport movements, particularly outside standard construction hours; | Construction traffic routes are assessed in **Section 8.4**. Construction traffic movements are shown in **Chapter 6** (Construction work). |
| b. the number, frequency and size of construction related vehicles (passenger, marine, commercial and heavy vehicles, including spoil management movements); | Information on construction traffic movements is presented in **Chapter 6** (Construction work). **Section 6.8** outlines number, frequency and size of construction vehicles. |
| c. construction worker parking; | Construction worker parking is assessed in **Section 8.4**. Temporary construction support site layouts, including provision of construction worker parking, are presented in **Chapter 6** (Construction work). |
| d. the nature of existing traffic (types and number of movements) on construction access routes (including consideration of peak traffic times and sensitive road users and parking arrangements; | The nature of existing traffic is detailed in **Section 8.3**. The assessment of potential traffic impacts during construction are detailed in **Section 8.4**. |

| Secretary's environmental assessment requirements | Where addressed |
|---|---|
| e. access constraints and impacts on public transport, pedestrians and cyclists; | Access constraints and impacts on public transport, pedestrians and cyclists is described in **Section 8.4**. |
| f. how construction of the project affects the capacity of, and the need to close, divert or otherwise reconfigure elements of, the road, cycle and pedestrian network; | Impacts during construction on the road, cycle and pedestrian networks are detailed in **Section 8.4**. |
| g. details of how construction and scheduling of works are to be coordinated in regard to public events and cumulative traffic impacts resulting from concurrent work on the project and other major projects, under or preparing for or commencing construction in the vicinity of the proposal; | Coordination regarding public events and recreational activities is discussed in **Section 8.4.8** and **Section 8.5**. Cumulative construction impacts are discussed in **Section 8.4.6**. |
| h. alternatives to road transport of construction spoil including marine and rail options as well as potential re-use in existing land reclamation areas or in association with Resource Recovery Exceptions (if obtained from the EPA) to minimise traffic impacts on the road network; | Impacts from transportation of dredged material are discussed in **Section 8.4.3**.<br>Potential reuse of spoil is addressed in **Chapter 24** (Resource use and waste management).<br>Alternatives to road transport of construction spoil including marine and rail options are discussed in **Chapter 4** (Project development and alternatives). |
| i. the likely risks of the project to public safety, paying particular attention to pedestrian safety and users of Middle Harbour; and | The assessment of potential traffic impacts during construction for pedestrians and users of Middle Harbour are detailed in **Section 8.4**.<br>**Chapter 23** (Hazard and risk) (**Section 23.2** and **Section 23.3**) assess the interactions between maritime traffic and tunnel infrastructure. |
| j. impacts to water based traffic on Middle Harbour. | Impacts to water based traffic and shipping channels during construction are discussed in **Section 8.4.3**. |

## 8.1 Strategic transport planning context

Details regarding the project's compatibility with key Australian Government and State strategic planning and transport policies are provided in Chapter 3 (Strategic context and project need). Specific transport strategies relevant to operation of the project are discussed in Chapter 9 (Operational traffic and transport).

## 8.2 Assessment methodology

### 8.2.1 Overview

The assessment methodology for construction traffic and transport impacts considered five core components:

- Road traffic
- Local roads and parking
- Public transport
- Pedestrian and cyclists (active transport)
- Maritime traffic.

The method and outputs of assessment for each of these components are summarised in Table 8-2. The construction traffic and transport assessment conservatively focused on the impacts during peak construction activities to reflect the greatest potential impact of the project. For example, the quantitative assessment of road network performance is for the highest potential construction site traffic generation per hour. These peak construction activities are likely to be short in duration and would only occur for a small proportion of the overall construction program. Typical site traffic generated per hour would therefore generally be lower than the peak site traffic numbers assessed.

**Table 8-2 Overview of approach to the construction traffic and transport assessment**

| Project impacts | Method of assessment | Assessment output |
|---|---|---|
| Road traffic | Analysis of road network performance during construction based on strategic traffic forecasting and modelling of the worst case construction traffic scenario. | Quantitative assessment of road network performance with and without the project. |
| Local roads and parking | Analysis of changes to local road access arrangements, loss of parking spaces and availability of comparable alternative parking in nearby locations.<br>The analysis considers both temporary impacts (ie during construction) and permanent impacts. | Qualitative assessment of local road changes.<br>Estimate of number of lost parking spaces.<br>Qualitative assessment of the impact of parking overflow to parking in nearby locations. |
| Public transport | Analysis of changes to public transport routes and stops, and service timeliness and efficiency during construction. | Qualitative assessment of impacts on public transport performance (increase or decrease in travel times). |
| Pedestrians and cyclists (active transport) | Analysis of temporary changes to shared user paths, cycle ways, footpaths and pedestrian crossings. | Qualitative assessment of impacts on pedestrian and cycling networks and accessibility. |

| Project impacts | Method of assessment | Assessment output |
|---|---|---|
| Maritime traffic | Analysis of proposed use of the waterway including the number, type, frequency and duration of marine construction traffic.<br>Simulation of marine vessels and transport of immersed tube tunnel elements. | Qualitative assessment of impacts on existing waterway navigation and commercial and recreational usage.<br>Simulation report showing the paths of marine vessels and the area required for the transport of immersed tube tunnel elements in Middle Harbour. |

The assessment methodology for road traffic is described in more detail below.

### 8.2.2 Road traffic assessment methodology

The potential construction impacts of the project on road network performance were assessed through strategic traffic demand forecasting and traffic modelling. The assessment included modelling, which enabled existing and future traffic and transport conditions and road network performance to be characterised during construction of the project. An overview of the transport modelling methodology used in the assessment of the project is provided in Figure 8-1.

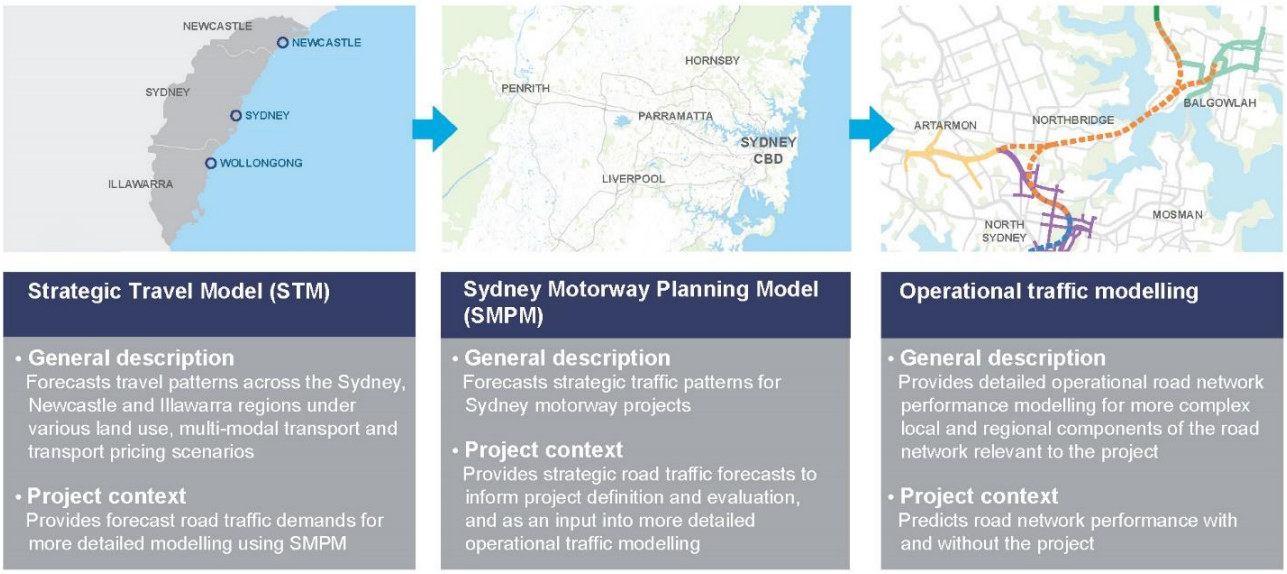



**Figure 8-1 Overview of transport modelling approach**

#### Construction traffic modelling scenarios

Construction modelling was based on construction traffic routes to and from the various temporary construction support sites. Based on the planned construction activities, the worst case construction traffic scenario was assumed to occur during the peak period of spoil removal from tunnel construction and associated surface works during 2024.

Models were developed for the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) to assess the future performance of the road network during construction. Forecast traffic growth was taken from the Sydney Motorway Planning Model (SMPM) to derive background traffic demand. The SMPM, developed and operated by Transport for NSW, provides a platform to understand changes in future traffic patterns under different land use, transport infrastructure and pricing scenarios.

Construction traffic was then added to the background traffic. This was based on the proposed construction methodology as described in Chapter 6 (Construction work) including vehicle types,

volumes and construction traffic routes. The performance of the roads and intersections in the vicinity of the temporary construction support sites was then calculated.

The scenarios modelled to assess the impacts of construction on the road network are listed in Table 8-3. In addition, key intersections were modelled based on 2016 travel demands to characterise existing intersection performance. The SMPM model forecasts travel demands in five year increments (ie 2016, 2021, etc). The 2016 baseline year represents transport network conditions available at the time of assessment. Ongoing and continuous traffic surveys carried out by Transport for NSW indicate that the 2016 baseline year is appropriate for modelling purposes as there is little material difference between 2016 and existing (2020) traffic conditions in the project area.

Specific intersections were assessed if they would form part of a construction traffic route and the increase in construction vehicles due to the project would be greater than 50 vehicles per hour (ie the vehicle contribution was significant enough to warrant modelling).

**Table 8-3 Construction traffic modelling scenarios**

| Model year | Without project | With project | Modelling scenario | Description |
|---|---|---|---|---|
| 2024 | ✓ | | Base case 2024 | The existing road network with no new projects or upgrades. |
| 2024 | | ✓ | Construction 2024 | Peak tunnelling and associated surface works for the project. The current road network with construction traffic movements for the project. No new projects or upgrades are included. |
| 2024 | | ✓ | Cumulative construction 2024 | Peak construction year for the Western Harbour Tunnel and Beaches Link program of works. The current road network with construction traffic movements for the project and the Western Harbour Tunnel and Warringah Freeway Upgrade project. No new projects or upgrades are included. |

### 8.2.3 Assessment criteria

The criteria used to assess road network performance were as follows:

- At an intersection level, showing changes to traffic flow (expressed in vehicles per hour), average delay (expressed in seconds per vehicle), level of service (as defined in the *Guide to Traffic Generating Developments Version 2.2* (RTA, 2002)) and degree of saturation (expressed as the ratio of traffic volumes at an intersection to its overall capacity (V/C ratio))
- At a midblock level, showing changes on traffic volumes, volume to capacity ratio (ratio of traffic volumes at a midblock road to its overall capacity) and level of service (as defined in the *Guide to Traffic Generating Developments Version 2.2* (RTA, 2002))
- At a network level for cumulative assessments, showing changes to overall traffic demand and average speeds within the modelled areas, travel times along key routes, and changes to stopping frequencies.

### 8.2.4 Intersection and midblock level of service

Level of service (LoS) is a measure to describe the operational conditions and efficiency of a road or intersection. The definition of level of service generally outlines the operating conditions in terms of speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and road safety. It is a qualitative measure describing operational conditions within a roadway or

intersection, as perceived by motorists and passengers. Average delay is commonly used to assess the operational performance of intersections, with level of service used as an index.

The performance of roads can also be defined by the midblock level of service. The midblock level of service is based on the degree of saturation, which is the ratio between traffic volumes and the road capacity (V/C ratio). Satisfactory operations usually occur with a degree of saturation below 0.9. As degree of saturation approaches one, both queue length and delays increase rapidly. The level of service for freeways and motorways is calculated from vehicle density, which is the traffic volume divided by the average passenger car speed. Density is measured in passenger car units (PCU) per kilometre per lane. Passenger car units account for the amount of road space various vehicle types use. Heavy vehicles and buses use more road space than cars or light commercial vehicles and therefore have a passenger car unit greater than one.

A description of the level of service scale for intersection and midblock performance is shown in Table 8-4. There are six levels of service; labelled LoS A to LoS F. LoS A represents the best operating conditions and LoS F the poorest operating conditions. For the purposes of this assessment, LoS E and LoS F are considered unsatisfactory.

**Table 8-4 Level of service criteria for intersection and midblock performance**

| LoS | Intersection criteria | Mid block criteria |
|---|---|---|
| A | Good operation | A condition of free flow in which 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, and the general level of comfort and convenience provided is excellent. |
| B | Good with acceptable delays and spare capacity | In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is a little less than with LoS A. |
| C | Satisfactory | In the zone of stable flow, but 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. |
| D | Operating near capacity | 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 would generally cause operational problems. |
| E | Unsatisfactory. At capacity. At traffic lights, incidents would cause delays. Roundabouts require other control mode. | 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 would cause breakdown. |
| F | Unsatisfactory. Extra capacity required. | In the zone of forced flow, where the amount of traffic approaching a point exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result. |

Source: Roads and Traffic Authority (2002) Guide to Traffic Generating Developments and Austroads.

## 8.3 Existing environment

The existing traffic and transport environment for the project within the context of the broader road network is outlined below, along with more detailed analysis across the following local areas:

- Warringah Freeway and surrounds
- Gore Hill Freeway and Artarmon
- Northbridge to Seaforth (Middle Harbour crossing)
- Balgowlah and surrounds
- Frenchs Forest and surrounds.

### 8.3.1 Broader road network

#### Travel times and speed along key corridors

A summary of 2016 travel times and average speeds for trips for key road corridors between destinations in the Northern Beaches and lower North Shore of Sydney in the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) is provided in Figure 8-2 and Figure 8-3. These centres are connected by motorways and major arterials with posted speeds of between 50 and 80 km/h. Typical operating speeds during peak periods are shown to be in the range of 20 to 40 km/h, indicating these corridors are operating at capacity resulting in congestion and delays.

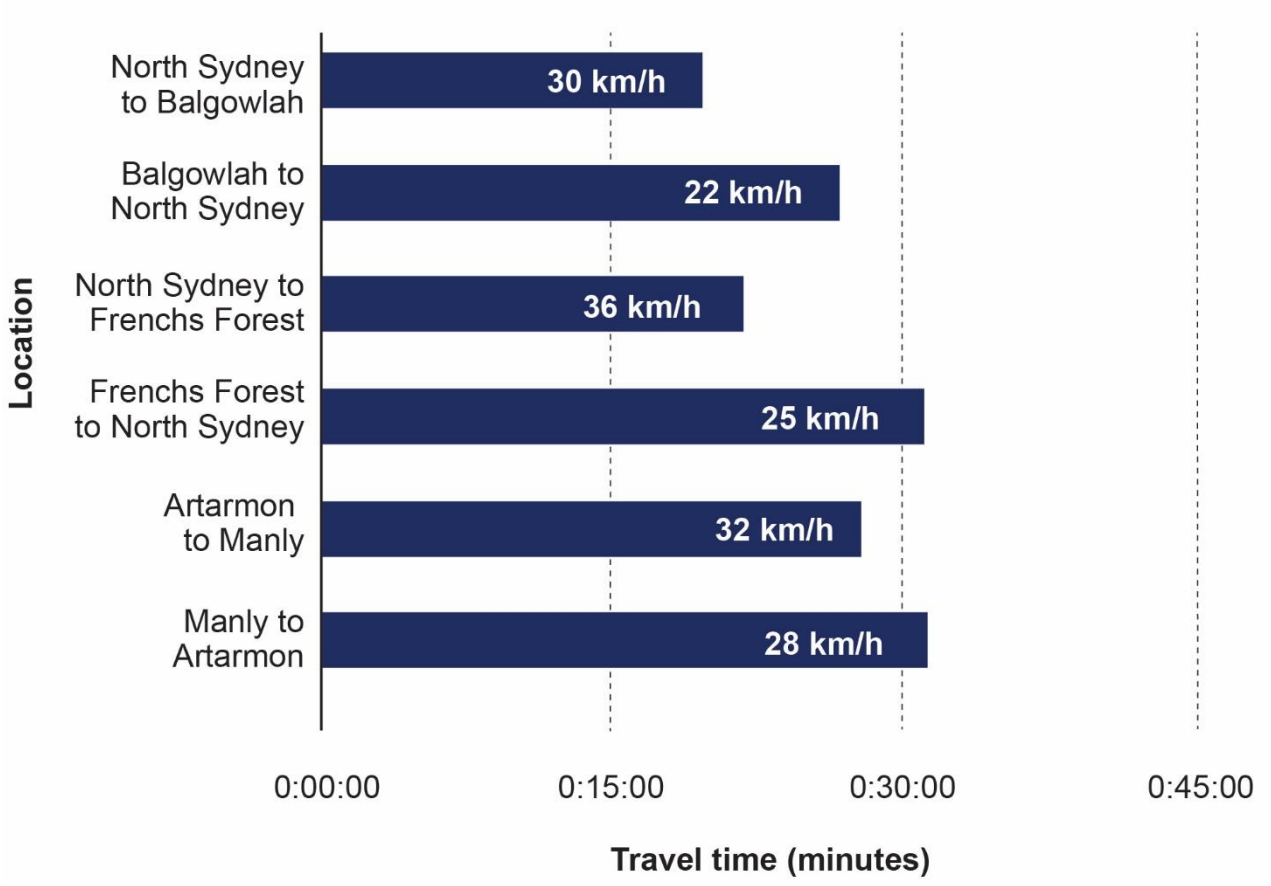



**Figure 8-2 2016 AM peak travel times and average speeds along key corridors**

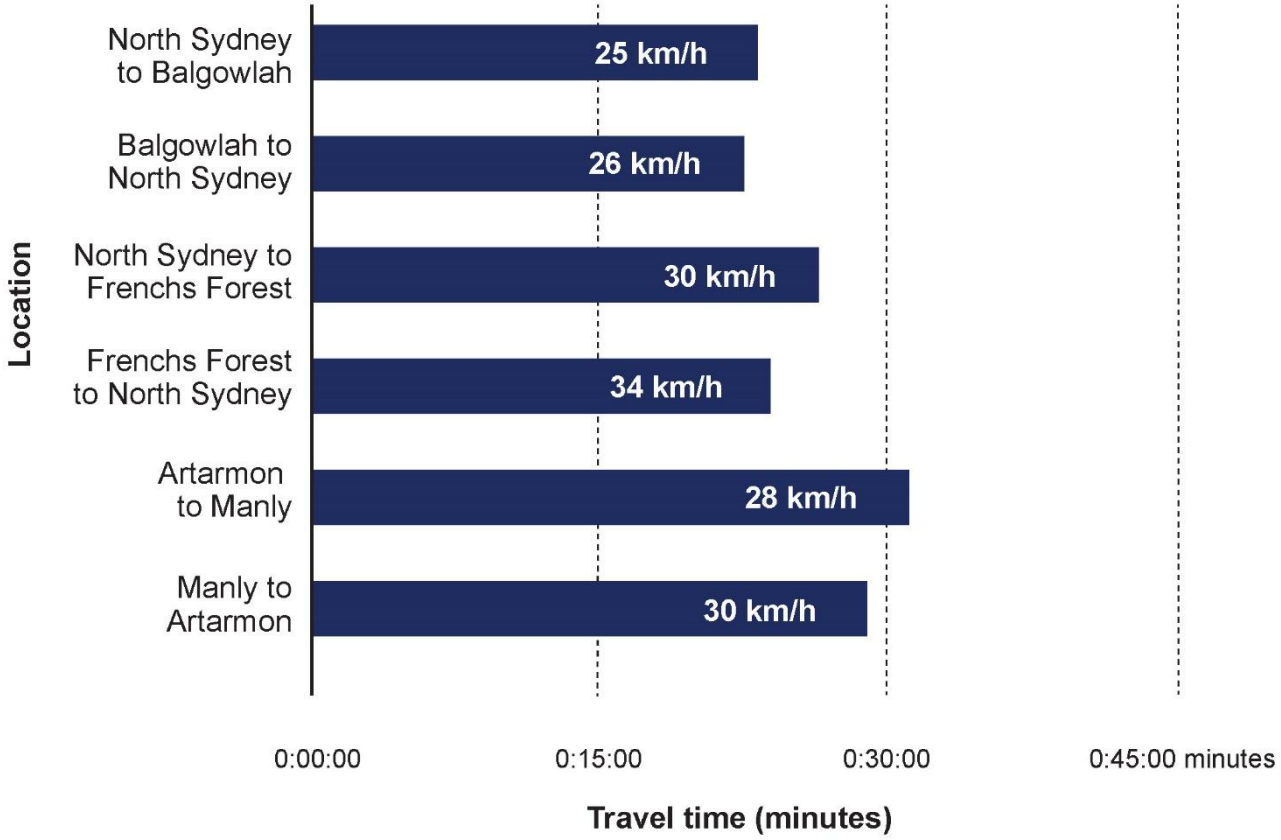



**Figure 8-3 2016 PM peak travel times and average speeds along key corridors**

### Heavy vehicles and freight

Spit Road/Military Road and Warringah Road are both arterial commuter corridors and the movement of heavy vehicles along these roads is limited by capacity constraints and congestion, particularly during peak periods. Further, Spit Road and Military Road have access restrictions for large articulated trucks (ie B-Doubles and other Higher Mass Limit vehicles are not permitted). As such, access to the Northern Beaches for B-Doubles is currently limited to Mona Vale Road and Warringah Road.

The largest proportion of truck movements into and out of the Northern Beaches peninsula in 2016 occurred via Mona Vale Road, likely due to lower congestion and its proximity to the M1 Sydney Newcastle Motorway and industrial areas in Mona Vale, Warriewood, Belrose and Terrey Hills.

While Mona Vale Road carries much higher volumes of heavy vehicles compared to Spit Road/ Military Road and Warringah Road, the poor standard of the road, particularly through Terrey Hills and Mona Vale, likely contributed to two fatal crashes over the past 10 years. It is noted that the NSW Government is upgrading Mona Vale Road from two to four lanes between Terrey Hills and Mona Vale. The upgrade is being carried out in two stages to provide customers with a better travelling experience and to improve safety and traffic flow. Works have commenced and are anticipated to be completed in 2022.

### 8.3.2 Warringah Freeway and surrounds

#### Description

##### *Transport network*

The existing transport network within the Warringah Freeway and surrounds area is shown in Figure 8-4 and includes the suburbs of Cammeray, Neutral Bay, North Sydney, Naremburn and Waverton.

##### *Traffic volumes and patterns*

A summary of existing peak hour traffic volumes for Warringah Freeway and surrounds in the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) is provided in Table 8-5.

**Table 8-5 Existing (2016) peak hour traffic volumes – Warringah Freeway and surrounds**

| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| **Warringah Freeway and surrounds** | | | | | |
| Pacific Highway south of Walker Street | Northbound | 2100 | 4% | 1410 | 11% |
| | Southbound | 380 | 13% | 580 | 6% |
| Pacific Highway south of Bay Road | Northbound | 690 | 8% | 800 | 7% |
| | Southbound | 1100 | 7% | 950 | 3% |
| Bay Road west of Pacific Highway | Eastbound | 230 | 2% | 260 | 1% |
| | Westbound | 380 | 4% | 280 | 2% |
| Berry Street east of Walker Street | Eastbound | 1650 | 7% | 2390 | 4% |
| | Westbound | - | - | - | - |
| Falcon Street east of Miller Street | Eastbound | 1250 | 2% | 1350 | 6% |
| | Westbound | 1170 | 6% | 1110 | 5% |
| Ridge Street east of Miller Street | Eastbound | 330 | 5% | 130 | 2% |
| | Westbound | 160 | 9% | 260 | 4% |
| Miller Street north of Ernest Street | Northbound | 470 | 6% | 730 | 8% |
| | Southbound | 1050 | 4% | 1060 | 3% |
| Ernest Street east of Miller Street | Eastbound | 1070 | 4% | 1380 | 4% |
| | Westbound | 1050 | 1% | 870 | 2% |
| Ernest Street west of Merlin Street | Eastbound | 650 | 3% | 2000 | 1% |
| | Westbound | 2070 | 1% | 990 | 1% |
| Blue Street south of Pacific Highway | Northbound | 330 | 3% | 500 | 1% |
| | Southbound | 290 | 3% | 220 | 1% |

| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| Arthur Street north of Pacific Highway | Northbound | 800 | 2% | 610 | 1% |
| | Southbound | - | - | - | - |
| Alfred Street north of Mount Street | Northbound | 40 | 9% | 30 | 0% |
| | Southbound | 1420 | 1% | 730 | 3% |
| Falcon Street west of Merlin Street | Eastbound | 2330 | 7% | 2910 | 5% |
| | Westbound | 3140 | 6% | 2110 | 8% |
| Walker Street north of Pacific Highway | Northbound | 830 | 3% | 650 | 2% |
| | Southbound | 290 | 2% | 360 | 3% |
| Brook Street south of Merrenburn Avenue | Northbound | 720 | 9% | 1660 | 2% |
| | Southbound | 2070 | 2% | 1020 | 6% |

### *Public transport network*

The Warringah Freeway and surrounds area is readily accessible via public transport.

Heavy rail services are provided at Milsons Point, North Sydney, Waverton and Wollstonecraft railway stations, which are located on the T1 North Shore and Western Line and T9 Northern Line. A new station as part of Sydney Metro City & Southwest is under construction in North Sydney (Victoria Cross station) and is expected to be operational in 2024.

The Warringah Freeway and surrounds area is a major thoroughfare for buses including services operating along the Warringah Freeway, Military Road, Miller Street and the Pacific Highway.

The area is also serviced by ferry, with ferry wharves located at McMahons Point, Milsons Point, Kirribilli, North Sydney, Neutral Bay and Kurraba Point.


**Figure 8-4 Transport network within the Warringah Freeway and surrounds area**

### *Active transport network*

The pedestrian network in the Warringah Freeway and surrounds area is well developed, with footpaths along most roads and controlled crossings at signalised intersections. Pedestrians are prohibited from walking along the Warringah Freeway. Significant pedestrian activity associated with retail and commercial activities occurs within the North Sydney CBD, including in the vicinity of several schools located west of the Pacific Highway and along Miller Street. Balls Head Reserve and other parks and reserves in the area are also associated with high levels of pedestrian activity.

The cycle network in the Warringah Freeway and surrounds area consists mostly of on-road cycle routes on local, collector and sub-arterial roads.

The Warringah Freeway presents a significant barrier to east–west movements for pedestrians and cyclists, with crossings available at select locations. Based on pedestrian and cyclist surveys carried out for the project, Mount Street was identified as the most used crossing for pedestrians due to its proximity to North Sydney CBD, while West Street was the most used crossing for cyclists. The Falcon Street underpass was identified as being under-utilised by pedestrians and cyclists during the week and on weekends.

## Existing road performance

### *Road network performance*

The Warringah Freeway is the busiest section of motorway in NSW. Congestion and delays are highest during the AM peak period, particularly for southbound traffic with queues extending as far north as the Miller Street interchange. During the PM peak, queuing and congestion is frequently observed on the northbound off ramp to Falcon Street eastbound.

Queuing and congestion are also frequently observed on connecting roads within the North Sydney CBD area, to the west of the Warringah Freeway.

### *Intersection performance*

Modelled intersection performance under 2016 travel demands is provided in Table 8-6. The assessment indicates that the following intersections perform at an unsatisfactory level of service (LoS E or F) during the AM peak:

- Mount Street and Arthur Street
- High Street and Clark Road
- High Street and Alfred Street North.

The assessment also indicates that the Miller Street and Falcon Street intersection performs at an unsatisfactory level of service during the PM peak.

The intersection of Mount Street and Arthur Street is the primary western access to the Warringah Freeway, where traffic heading to the Sydney Harbour Bridge (Bradfield Highway) and Cahill Expressway lanes converges from Berry Street and Pacific Highway during the AM peak.

The intersection of Clark Road and High Street is the primary eastern access to the Sydney Harbour Bridge Cahill Expressway lane where traffic from Kirribilli and Neutral Bay converge. Queues from the intersection of High Street and Alfred Street North occasionally extend back through this intersection.

**Table 8-6 Modelled intersection performance in the Warringah Freeway and surrounds area (AM and PM peaks in 2016)**

| Intersection | AM peak (8am 9am) LoS (average delay in seconds) | PM peak (5pm 6pm) LoS (average delay in seconds) |
|---|---|---|
| Willoughby Road/Gore Hill Freeway interchange | A (11) | B (20) |
| Brook Street/Warringah Freeway on ramp | C (31) | B (16) |
| Brook Street/Warringah Freeway off ramp | C (30) | B (22) |
| Brook Street/Merrenburn Avenue | C (31) | A (12) |
| Amherst Street/West Street | A (6) | A (10) |
| Amherst Street/Miller Street | B (19) | B (15) |
| Miller Street/Warringah Freeway on ramp | A (<5) | A (6) |
| Miller Street/Warringah Freeway off ramp | A (13) | A (13) |
| Miller Street/Ernest Street | C (34) | C (31) |
| Miller Street/Falcon Street | C (35) | **E (69)** |
| Ernest Street/Warringah Freeway on ramp | A (<5) | B (15) |
| Ernest Street/Warringah Freeway off ramp (off ramp in PM, on ramp in AM) | A (<5) | B (18) |
| Falcon Street/Warringah Freeway ramps (off ramp in PM, on ramp in AM) | C (38) | D (46) |
| Watson Street/Military Road | B (16) | C (29) |
| Military Road/Ben Boyd Road | A (13) | B (20) |
| Falcon Street/Merlin Street | B (17) | C (38) |
| Berry Street/Walker Street | C (32) | D (50) |
| Berry Street/Miller Street | C (30) | B (27) |
| Mount Street/Arthur Street | **F (84)** | C (32) |
| Mount Street/Walker Street | D (43) | C (31) |
| Pacific Highway/High Street/Arthur Street | D (53) | B (19) |
| Pacific Highway/Walker Street/Blue Street | D (53) | D (48) |
| Pacific Highway/Miller Street/Mount Street | D (52) | C (41) |
| Pacific Highway/Berry Street | A (9) | A (11) |
| Pacific Highway/Bay Road | B (21) | B (14) |

| Intersection | AM peak (8am 9am) LoS (average delay in seconds) | PM peak (5pm 6pm) LoS (average delay in seconds) |
|---|---|---|
| Miller Street/McLaren Street | B (24) | B (17) |
| Miller Street/Ridge Street | C (39) | B (26) |
| Miller Street/Carlow Street | B (14) | C (29) |
| High Street/Clark Road | **F (>100)** | C (36) |
| High Street/Alfred Street North | **E (60)** | B (18) |
| Mount Street/Alfred Street North | B (24) | A (11) |
| Ernest Street/Ben Boyd Road | A (11) | B (16) |
| Pedestrian crossing at Military Road | A (<5) | B (20) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

### 8.3.3 Gore Hill Freeway and Artarmon

#### Description

##### *Transport network*

The existing transport network within the Gore Hill Freeway and Artarmon area is shown in Figure 8-5 and includes the suburbs of Artarmon, Crows Nest, St Leonards, Cammeray, Lane Cove, Naremburn and Willoughby.

##### *Traffic volumes and patterns*

A summary of existing peak hour traffic volumes for the Gore Hill Freeway and Artarmon area in the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) is provided in Table 8-7.

**Table 8-7 Existing (2016) peak hour traffic volumes – Gore Hill Freeway and Artarmon**

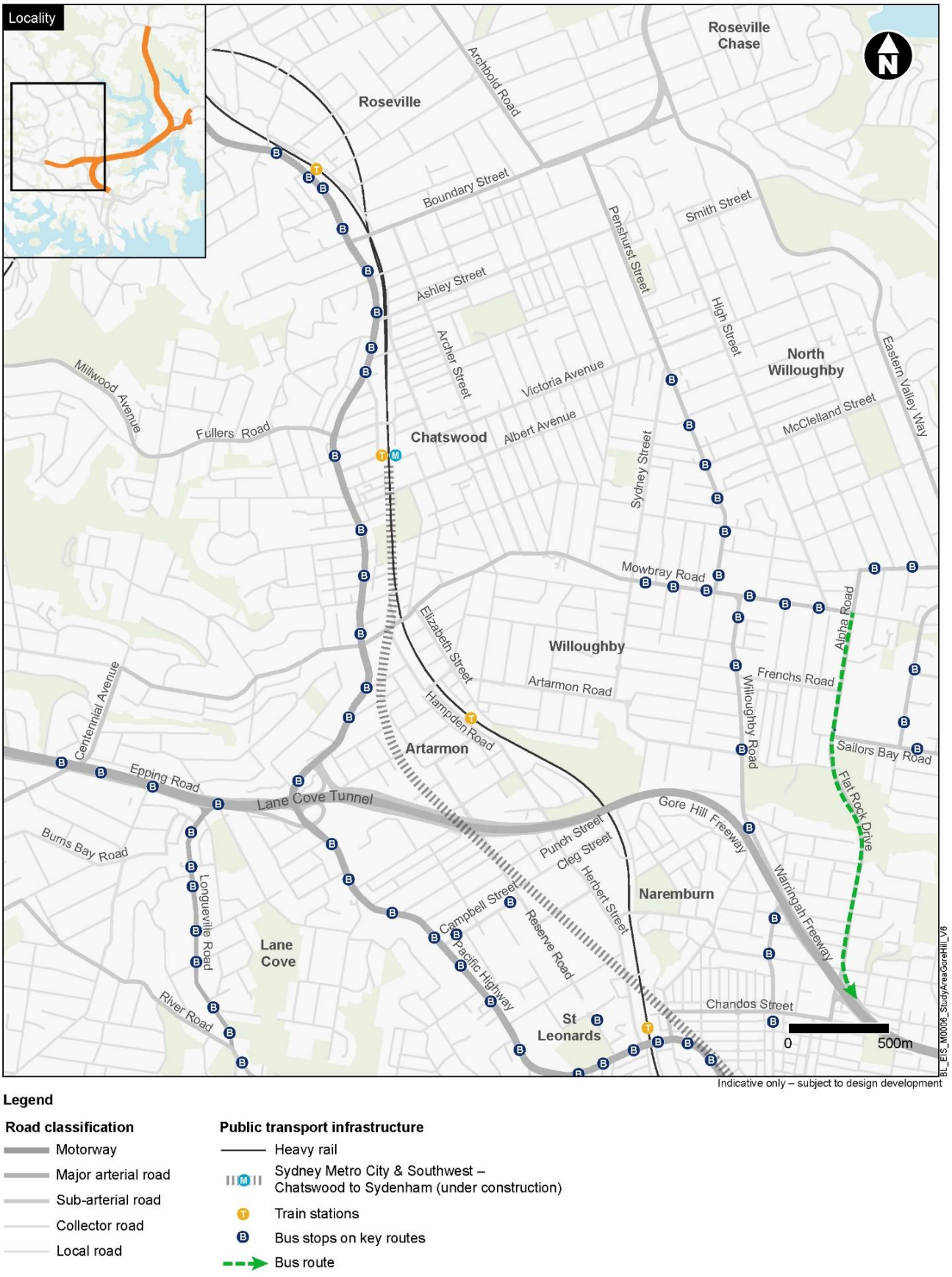
| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| **Gore Hill Freeway and Artarmon** | | | | | |
| Reserve Road north of Dickson Avenue | Northbound | 520 | 8% | 1140 | 1% |
| | Southbound | 1210 | 3% | 610 | 2% |
| Reserve Road north of Frederick Street | Northbound | 320 | 10% | 670 | 3% |
| | Southbound | 690 | 3% | 490 | 1% |
| Frederick Street east of Reserve Road | Eastbound | 440 | 5% | 560 | 1% |
| | Westbound | 360 | 8% | 420 | 5% |
| Herbert Street north of Frederick Street | Northbound | 250 | 3% | 440 | 1% |
| | Southbound | 530 | 3% | 500 | 2% |
| Cleg Street east of Herbert Street | Eastbound | 110 | 1% | 190 | 1% |
| | Westbound | 120 | 2% | 180 | 2% |

| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| Dickson Avenue east of Reserve Road | Eastbound | 250 | 3% | 150 | 0% |
| | Westbound | 130 | 5% | 30 | 2% |
| Reserve Road south of Barton Road | Northbound | 350 | 3% | 640 | 1% |
| | Southbound | 470 | 2% | 410 | 1% |

### *Public transport network*

The Gore Hill Freeway and Artarmon area is highly accessible by public transport. Heavy rail services are provided at Artarmon and St Leonards railway stations, which are located on the T1 North Shore and T9 Northern Lines. A new station as part of Sydney Metro City & Southwest is under construction in Crows Nest and is expected to be operational in 2024 (refer to Figure 8-4).

The Gore Hill Freeway and Artarmon area is also a major thoroughfare for buses, including services operating along the Warringah Freeway, Gore Hill Freeway/Lane Cove Tunnel and the Pacific Highway.




**Legend**

**Road classification**
- Motorway
- Major arterial road
- Sub-arterial road
- Collector road
- Local road

**Public transport infrastructure**
- Heavy rail
- Sydney Metro City & Southwest – Chatswood to Sydenham (under construction)
- Train stations
- Bus stops on key routes
- Bus route

**Figure 8-5 Transport network within the Gore Hill Freeway and Artarmon area**

### *Active transport network*

The pedestrian network in the Gore Hill Freeway and Artarmon area is well developed, with footpaths alongside most roads and controlled crossings at most signalised intersections. Pedestrians are prohibited from walking along the Gore Hill Freeway and through the Lane Cove Tunnel. However, a shared user path is provided adjacent to the southern side of the Gore Hill Freeway. High pedestrian activity occurs along Hampden Road within the vicinity of Artarmon railway station, around the commercial area of Artarmon, and around the health, educational and commercial land uses in St Leonards.

The cycle network in the Gore Hill Freeway and Artarmon area consists of a mix of off-road shared user paths and on-road cycle routes on local and collector roads.

Based on pedestrian and cyclist surveys carried out for the project, the shared user path adjacent to the southern side of the Gore Hill Freeway near Hampden Road in Artarmon was identified as being used by a high number of cyclists during the week, with lower volumes recorded on weekends. This can be attributed to the path forming part of a regional cycle route connecting Naremburn, Lane Cove and Macquarie Park, with the majority of cyclists likely to be commuting to and from work. Pedestrian volumes were low both during the week and at weekends.

## Existing road performance

### *Road network performance*

The Gore Hill Freeway connects the M2 Motorway corridor with the M1 Motorway corridor through Artarmon and Willoughby. Traffic volumes are highest heading southbound in the AM peak and northbound in the PM peak, as a result of trips heading into and out of the Sydney CBD as well as local traffic from Lane Cove and Ryde.

Most traffic on Reserve Road travels to and from the Gore Hill Freeway, limiting capacity for the off ramps that often operate at or close to capacity during the AM peak.

The intersection of Longueville Road and Epping Road is the primary surface road constraint in the corridor due to the high volumes of traffic travelling to and from Lane Cove and Riverview.

Bus priority is provided on Epping Road west of Longueville Road in the form of signal priority for westbound traffic at Longueville Road and continuous bus lanes on Epping Road. Signal priority for buses is also provided for eastbound buses on Longueville Road at Pacific Highway, while eastbound buses on the Gore Hill Freeway use the 24-hour T2 transit lane that extends to Willoughby Road.

### *Intersection performance*

Modelled intersection performance under 2016 travel demands is provided in Table 8-8. The assessment indicates that the intersection of Epping Road, Longueville Road and Parklands Avenue is currently performing at an unsatisfactory level of service (LoS E) in the PM peak. This intersection has limited capacity due to the high volume of westbound traffic that conflicts with right turn traffic from Longueville Road south. Delays on the eastern approach of this intersection are also exacerbated by buses stopping at the Lane Cove interchange, which block traffic turning left into Longueville Road.

**Table 8-8 Modelled intersection performance in the Gore Hill Freeway and Artarmon area (AM and PM peaks in 2016)**

| Intersection | AM peak (8am 9am) LoS (average delay in seconds) | PM peak (5pm 6pm) LoS (average delay in seconds) |
|---|---|---|
| Epping Road/Longueville Road/Parklands Avenue | D (48) | E (63) |
| Longueville Road/Pacific Highway | C (42) | C (36) |
| Pacific Highway/Howarth Road/Norton Lane | A (7) | A (7) |
| Pacific Highway/Gore Hill Freeway interchange | B (23) | B (23) |
| Reserve Road/Gore Hill Freeway interchange | D (47) | C (29) |
| Reserve Road/Dickson Road | A (14) | B (19) |
| Reserve Road/Barton Road | A (11) | A (6) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

### 8.3.4 Northbridge to Seaforth (Middle Harbour crossing)

The project includes the crossing of Middle Harbour, extending from Northbridge in the south to Seaforth Bluff in the north. Construction of the project would also involve navigation through the outer part of Sydney Harbour (referred to as the Outer Harbour). These areas are described as follows:

- Outer Harbour is a wide waterway between Sydney Heads, the Opera House at Bennelong Point and Admiralty House at Kirribilli Point
- Middle Harbour borders the western side of the Outer Harbour, extending west of Middle Head and Grotto Head.

The Outer Harbour is relatively deep and wide, with water depths generally exceeding 20 metres below chart datum (the zero-reference point from which tidal heights and chart soundings are calculated) between South Head and North Head, decreasing to eight metres chart datum between Grotto Point and Middle Head.

The water depths in Middle Harbour are highly variable, ranging from three metres chart datum at the sand bar at the entrance to Middle Harbour, up to 26 metres chart datum on the eastern side of the Spit Bridge. Upstream of the Spit Bridge, the water depths are more than 20 metres chart datum with depths decreasing towards the heads of each of the bays off the main Middle Harbour channel. The depth of the channel at the proposed crossing location is particularly deep, up to 32 metres chart datum at its deepest point.

The entrance to Middle Harbour is about 750 metres wide, decreasing to a waterway width of about 165 metres at the Spit Bridge. Upstream of the Spit Bridge, the width of the waterway is generally about 400 metres, decreasing towards the heads of each of the bays of the main Middle Harbour channel. At the location of the proposed harbour crossing, the navigation width between the headland at Northbridge and the existing moorings and jetties near Seaforth Bluff is about 350 metres.

Spit Bridge (refer to Figure 8-6), spans 227 metres across Middle Harbour, connecting Mosman and Seaforth. When closed, the bridge presents a barrier to boats with heights greater than five or six metres above the water level (depending on tides). Clearance height under the bridge when closed is as follows:

- 4.7 metres at highest astronomical tide under the opening span
- 5.7 metres at highest astronomical tide under the first fixed span at the northern end.

Spit Bridge has scheduled daily openings to allow boats that are above the clearance height to pass through. When the bridge is open, the navigational channel between the piers of the lifting span is 24.3 metres wide. Current scheduled bridge opening times are listed in Table 8-9.

**Table 8-9 Current Spit Bridge scheduled opening times**

| Weekday | Weekends and public holidays |
|---|---|
| 10.15 am<br>11.15 am<br>1.15 pm<br>2:15 pm<br>8.15 pm<br>9.15 pm (during daylight saving only) | 8.30 am<br>10.00 am<br>11.30 am<br>2.30 pm<br>4.30 pm<br>6.30 pm<br>8.30 pm<br>9.30 pm |

Source: Transport for NSW (2019)

Users of Middle Harbour can be divided into three main groups: recreational users, community groups and clubs; commercial operators; and government organisations. Middle Harbour and the Outer Harbour are also used for recreational purposes, as well as some private uses. These are discussed in detail below and shown in Figure 8-6.

### Recreational users, community groups and clubs

Middle Harbour supports a wide range of water based recreational activities. Key community groups and clubs using Middle Harbour include:

- Paddle craft users and clubs
- Recreational fishers
- Sailing and yacht clubs
- Scout and guide clubs
- Marine Rescue NSW.

Mosman Rowing Club, Northbridge Sailing Club, and two sea scout groups regularly use the waterway upstream of Spit Bridge, regularly traversing the location of the proposed Middle Harbour crossing. Marine Rescue NSW has its base for Middle Harbour located at The Spit.

Several boat storage and boat launching facilities are located in Middle Harbour that provide storage for recreational seagoing vessels. These include:

- Marina facilities
- Boat ramps
- Moorings.

Commercial marina facilities generally offer a wide range of premium services for the boating community, while boat ramp facilities attract smaller craft, typically from a larger geographical area.

The boat ramps in Middle Harbour are generally in good condition attracting a range of users that would navigate through all parts of Middle Harbour and the Outer Harbour. These vessels are typically not registered with a community group or club. The sand ramp used for informal launching in Clontarf Reserve is infrequently used, with users limited to surfboat rowers from nearby surf lifesaving clubs and other small craft.

In addition to marinas and boat ramps, numerous mooring fields are located throughout Middle Harbour. These include commercially and privately leased moorings with defined areas for vessels registered with a club or marina. Key facilities are outlined in Table 8-10. Recreational vessels which use these facilities would use the waterway upstream and downstream of Spit Bridge.

**Table 8-10 Marinas, boat ramps and mooring fields within Middle Harbour**

| Facility | Location |
|---|---|
| Marinas | • Middle Harbour Yacht Club in Mosman<br>• Smiths Boatshed Marina in Mosman<br>• Fergusons Boat Shed in Mosman<br>• D'Albora Marina in Mosman<br>• Cammeray Marina in Cammeray<br>• Northbridge Marina in Northbridge<br>• Castlecrag Marina in Castlecrag<br>• Roseville Bridge Marina in Roseville<br>• Clontarf Marina in Clontarf. |
| Boat ramps | • Tunks Park boat ramp in Cammeray<br>• Roseville Bridge boat ramp in Killarney Heights<br>• An informal sand ramp at Clontarf Reserve in Clontarf. |
| Mooring fields | • Fisher Bay<br>• Sandy Bay<br>• The Spit<br>• Pearl Bay<br>• Beauty Point<br>• Quakers Hat Bay<br>• Long Bay<br>• Willoughby Bay<br>• Salt Pan Creek<br>• Northbridge<br>• Sailors Bay<br>• Castlecrag<br>• Pickering Point<br>• Powder Hulk Bay<br>• Seaforth. |

Most of the yachts in the marinas around Spit Bridge (particularly Middle Harbour Yacht Club) and in the nearby mooring fields are used for racing and are registered with Middle Harbour Yacht Club. They are used around once a week on average, with most of the activity occurring downstream of Spit Bridge.

Other moored vessels, including motor cruisers and cruising yachts, are used less frequently and typically do not belong to a community group or club. These vessels travel upstream and downstream of Spit Bridge.

Three houseboats with permanent land access are located near the head of Pearl Bay. Several private jetties, pontoons and mooring pens are located at private residences on the foreshore of Seaforth Bluff, Long Bay and Sailors Bay.

### Commercial operations within Middle Harbour

Most businesses that conduct commercial operations in Sydney Harbour are located in the Inner Harbour (ie the area between Outer Harbour and Parramatta River), particularly around The Bays and Darling Harbour. Vessels associated with commercial operations transit the Outer Harbour, and do not typically enter Middle Harbour. Access to Middle Harbour for deep draft vessels is restricted by water depth over the sand bar at the entrance to Middle Harbour.

A limited number of commercial operators are located in or navigate through Middle Harbour as summarised below.

#### *Water taxis and charter companies*

Several water taxi companies operate within Sydney Harbour, with some operators providing private harbour tours and charter services. A limited number of yacht charter and boat hire companies are located in Middle Harbour, including:

- Champagne Sailing in Clontarf, with pick up locations including Balmoral, Clontarf and Middle Harbour Yacht Club
- Eco Boats Hire in Northbridge.

Vessels from charter companies further afield may also enter Middle Harbour.

#### *Jungle Float mobile water park*

Jungle Float is a floating mobile waterpark that is about 11 metres long and three metres wide and can accommodate groups of up to 40 people. It is anchored about 20 metres off Clontarf Beach when in use. The Jungle Float allows participants to swing, dive, jump and/or slide into the water. Participants are required to swim to the floating waterpark from Clontarf Beach.

### Government operations within Middle Harbour

#### *Royal Australian Navy*

HMAS Penguin, an Australian Defence Force facility, is located at Balmoral in Middle Harbour. Its primary purpose is to provide trained personnel to the fleet. A naval water exclusion zone is established around the facility. The navy also operates facilities in the Inner Harbour and Outer Harbour, but vessels from these facilities rarely enter Middle Harbour.

#### *Water Police, Transport for NSW, and Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources)*

The NSW Police Marine Area Command, Transport for NSW, and the Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources) are located in the Inner Harbour and require access to the waterway to perform their duties. Transport for NSW is the owner of several seawall assets in Sydney Harbour and is responsible for managing seabed leases, which may be held by private leases or commercial organisations such as marinas.

### Navigation restrictions

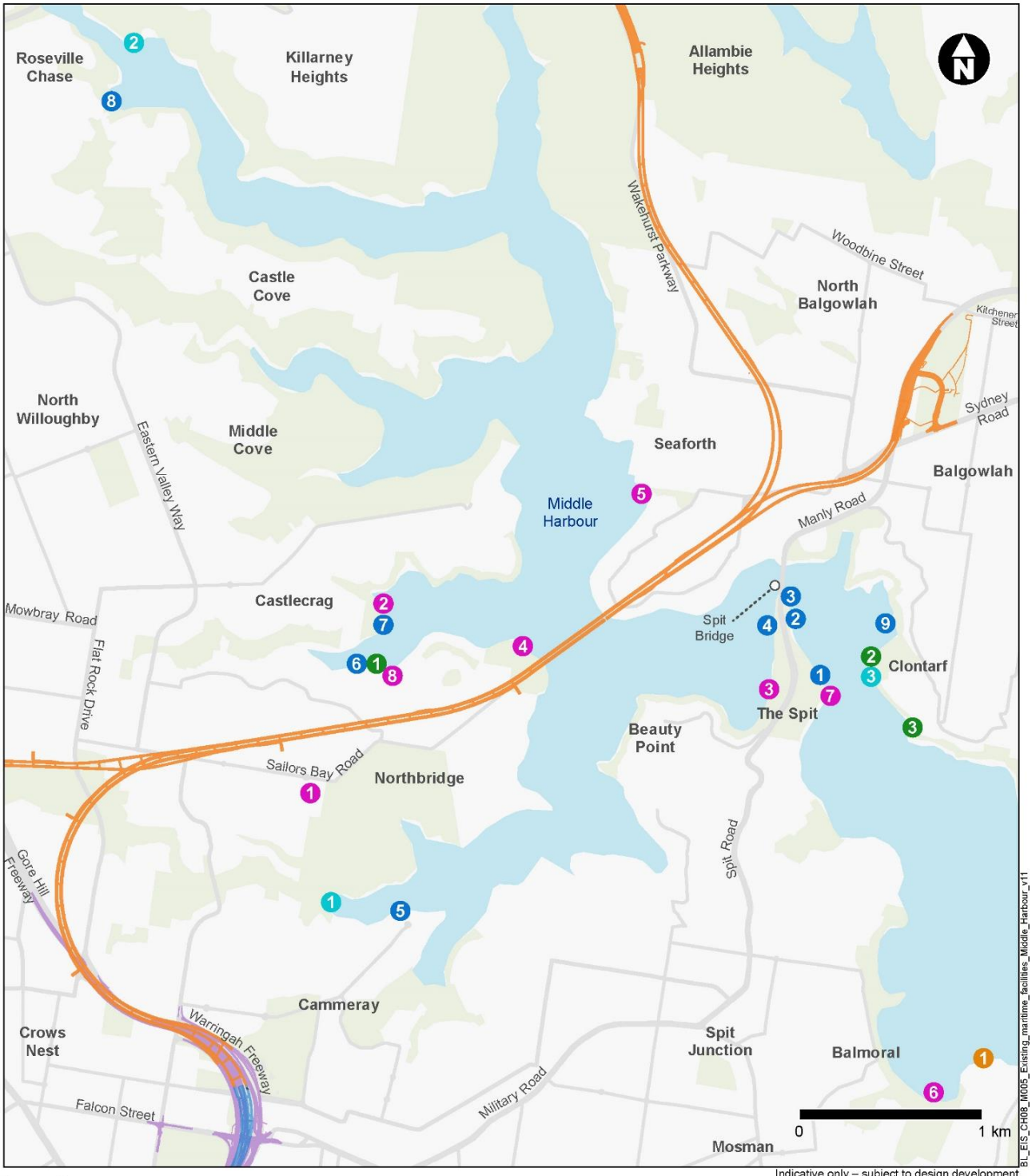
Relevant navigation restrictions within Middle Harbour include:

- An exclusion zone around the HMAS Penguin at Balmoral
- A four knots zone between Clontarf Point and Parriwi Point extending upstream to D'Albora Marina and the eastern end of Peach Tree Bay, including the area around Spit Bridge
- Vessels traveling at more than six knots are required to maintain 30 metres from all vessels, land or structures (including moorings)
- A speed limit of 12 knots is imposed on vessels exceeding 30 metres in length when navigating within Middle Harbour
- Spit Bridge when closed presents a barrier to boats with heights greater than five or six metres above the water level (depending on tides). Passage of boats that are above the clearance height is restricted to scheduled daily bridge openings (see Table 8-9).

Additional restrictions may be imposed by an aquatic event such as a race, competition or exhibition. An aquatic licence issued by Transport for NSW may be required for organised activities on navigable waters that restrict the availability of those waters for normal use by the public. Transport for NSW may elect to establish an exclusion zone around the activity.

The shallow depth at the entrance to Middle Harbour limits the type of vessels that can navigate through the harbour, restricting the passage of larger vessels. Vessels that transit through Middle Harbour, including at the location of the proposed crossing, would generally be up to 25 metres in length. However, most vessels would be less than 10 metres in length.

Access under Spit Bridge has limited width clearance. Vessels wider than 24 metres are unable to navigate between the bridge piers due to the fixed fender protection.




**Legend**

**Operational features**
- Beaches Link

**Connecting projects**
- Western Harbour Tunnel
- Warringah Freeway Upgrade

**Boat launching facilities**
1. Tunks Park, Cammeray
2. Roseville Bridge, Killarney Heights
3. Clontarf Reserve sand ramp, Clontarf

**Community groups and clubs**
1. Northbridge Sea Scouts
2. Sailors Bay Sea Scouts
3. Mosman Rowing Club
4. Northbridge Sailing Club
5. Seaforth Sailing Club
6. Balmoral Sailing Club
7. Middle Harbour Amateur Sailing Club
8. Northbridge Baths

**Commercial operators**
1. Eco Boat Hire Sydney
2. Jungle Float Mobile Water Park
3. Champagne Sailing Sydney

**Government organisations**
1. H.M.A.S Penguin

**Private and commercial marinas**
1. Middle Harbour Yacht Club, The Spit
2. Smiths Boatshed Marina, The Spit
3. Fergusons Boat Shed, The Spit
4. D'Albora Marina, The Spit
5. Cammeray Marina, Cammeray
6. Northbridge Marina, Northbridge
7. Castlecrag Marina, Castlecrag
8. Roseville Bridge Marina, Roseville
9. Clontarf Marina, Clontarf

**Figure 8-6 Existing maritime facilities in Middle Harbour near the project**

### 8.3.5 Balgowlah and surrounds

#### Description

##### *Transport network*

The existing transport network within the Balgowlah and surrounding areas is shown in Figure 8-7 and includes the suburbs of Balgowlah, Mosman, North Balgowlah and Seaforth.

##### *Traffic volumes and patterns*

A summary of existing peak hour traffic volumes for Balgowlah and surrounds in the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) is provided in Table 8-11.

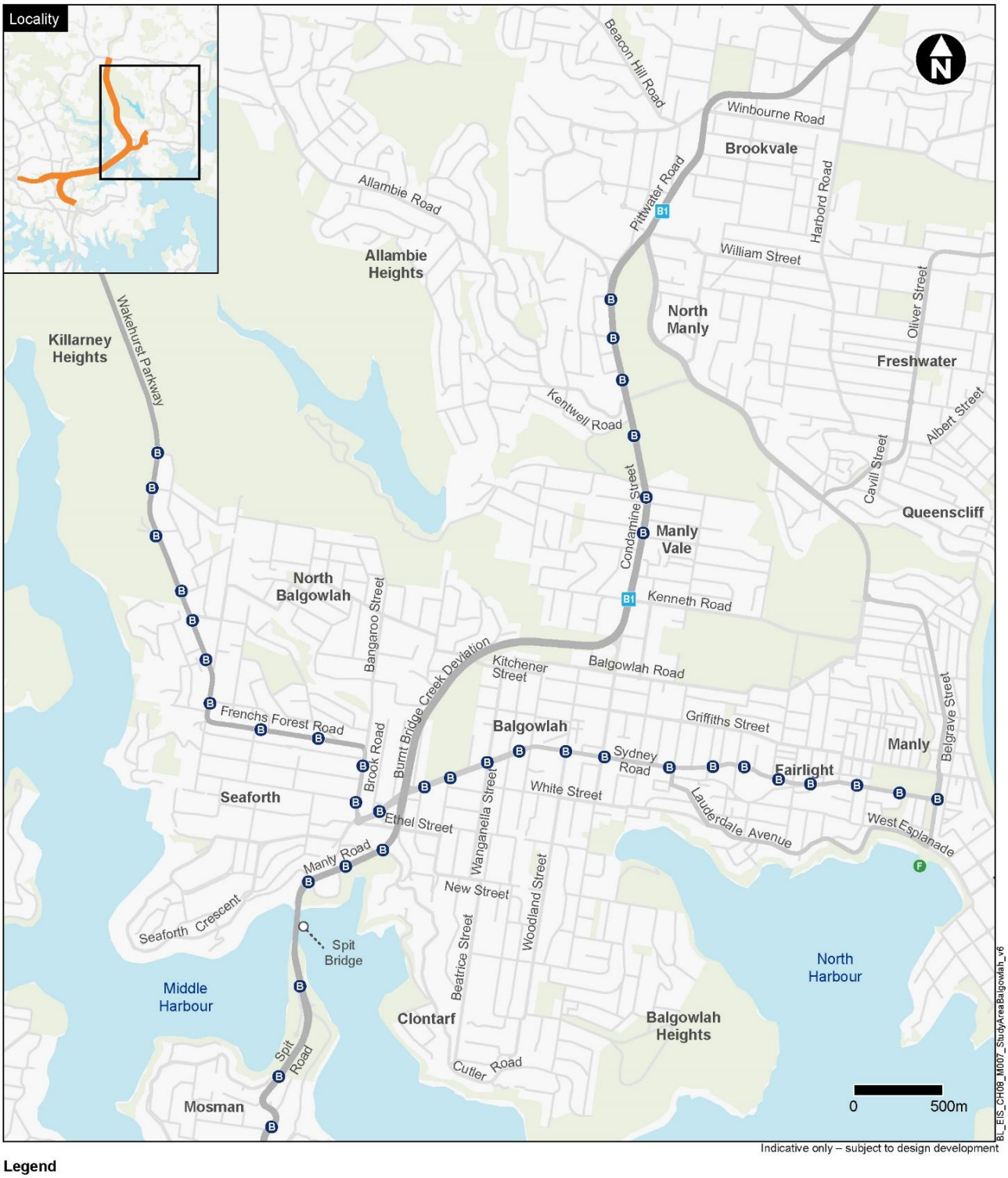
**Table 8-11 Existing (2016) peak hour traffic volumes – Balgowlah and surrounds**

| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| **Balgowlah and surrounds** | | | | | |
| Spit Road south of Parriwi Road | Northbound | 1280 | 11% | 2670 | 6% |
| | Southbound | 2780 | 7% | 1610 | 7% |
| Manly Road south of Sydney Road | Northbound | 1540 | 8% | 3050 | 5% |
| | Southbound | 2760 | 11% | 1650 | 6% |
| Sydney Road east of Manly Road | Eastbound | 460 | 8% | 1010 | 4% |
| | Westbound | 940 | 7% | 750 | 6% |
| Burnt Bridge Creek Deviation west of Condamine Street | Northbound | 970 | 7% | 1790 | 7% |
| | Southbound | 1350 | 13% | 1050 | 6% |

##### *Public transport network*

The Balgowlah and surrounds area includes major bus corridors along Spit Road/Manly Road, Sydney Road and Burnt Bridge Creek Deviation.

Balgowlah and surrounds are also served in part by the Northern Beaches B-Line bus service, which provides a high capacity, limited stops service to Sydney CBD.




**Legend**

**Road classification**

- Motorway
- Major arterial road
- Sub-arterial road
- Collector road
- Local road

**Public transport infrastructure**

- Bus stops on key routes
- Ferry wharf
- B-Line

**Figure 8-7 Transport network within Balgowlah and surrounds**

### *Active transport network*

The pedestrian network in the Balgowlah and surrounds area is well developed with footpaths along most roads and controlled crossings at most signalised intersections. Significant pedestrian activity occurs along Spit West Reserve, around the marinas at the southern end of Spit Bridge, and within the vicinity of the Balgowlah and Manly Vale local town centres on Sydney Road and Condamine Street.

The cycle network in the area consists of a mixture of off-road shared user paths and on-road cycle routes on local and collector roads. Based on pedestrian and cyclist surveys carried out for the project, the shared user path adjacent to the eastern side of Burnt Bridge Creek Deviation near Kitchener Street was identified as being used by a moderate number of pedestrians and cyclists both during weekdays and on weekends. These volumes are attributed to the shared user path providing links to The Spit cycle route, and to the Northern Beaches, accommodating commuter cyclists on weekdays and recreational users on weekends.

## Existing road performance

### *Road network performance*

Military Road, Spit Road, Manly Road, Burnt Bridge Creek Deviation, Condamine Street and Pittwater Road form the primary arterial road corridor between the Northern Beaches and Sydney CBD. Traffic volumes along these roads are highest heading southbound in the AM peak and northbound in the PM peak as a result of commuters travelling between the Northern Beaches and the Sydney CBD. Sydney Road also carries high traffic volumes providing access to Balgowlah and Manly.

The primary constraint for southbound traffic is the Spit Bridge, which frequently causes queues extending from the bridge to the intersection of Manly Road and Sydney Road. This also results in southbound queues on Burnt Bridge Creek Deviation and eastbound and westbound queues on Sydney Road.

Bus priority is provided at the intersection of Manly Road/Burnt Bridge Creek Deviation/Sydney Road, with bus lanes provided in both directions on Burnt Bridge Creek Deviation, southbound bus lanes provided on Manly Road, and westbound bus lanes provided on Sydney Road.

### *Intersection performance*

Modelled intersection performance under 2016 travel demands is provided in Table 8-12. The assessment indicates that most intersections within the Balgowlah and surrounds area currently perform at a satisfactory level of service. The Frenchs Forest Road and Sydney Road intersection currently performs poorly during the PM peak, particularly on the western approach.

**Table 8-12 Modelled intersection performance in the Balgowlah and surrounds area (AM and PM peaks in 2016)**

| Intersection | AM peak (8am 9am) LoS (average delay in seconds) | PM peak (5pm 6pm) LoS (average delay in seconds) |
|---|---|---|
| Sydney Road/Manly Road/Burnt Bridge Creek Deviation | D (52) | D (44) |
| Frenchs Forest Road/Sydney Road | B (19) | **F (>100)** |
| Sydney Road/Condamine Street | B (20) | B (24) |
| Condamine Street/Burnt Bridge Creek Deviation | B (28) | B (19) |
| Sydney Road/Maretimo Street | A (9) | A (9) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

### 8.3.6 Frenchs Forest and surrounds

#### Description

##### *Transport network*

The existing transport network within the Frenchs Forest and surrounds area is shown in Figure 8-8 and includes the suburbs of Frenchs Forest, Killarney Heights and Seaforth.

##### *Traffic volumes and patterns*

In 2015, Transport for NSW commenced construction on the Northern Beaches Hospital road upgrade project which affected traffic conditions near the Northern Beaches Hospital. Construction works on the Northern Beaches Hospital road upgrade project were completed in August 2020. Permanent traffic counts on Warringah Road at Beacon Hill indicate that there was a substantial reduction in traffic volumes in 2016 by up to 17 per cent over the average weekday, indicating that construction activities in Frenchs Forest substantially reduced traffic volumes during the peak construction period. As a result, existing traffic volumes has been conservatively modelled based on 2012 pre-construction levels. Permanent traffic count data shows that by 2017, daily traffic volumes returned to 2012 levels, indicating that traffic conditions have generally returned to preconstruction levels and that there has been negligible growth in peak period traffic volumes through the area. Since completion of the Northern Beaches Hospital road upgrade project, updated data unaffected by COVID-19 is not readily available to assess if the grade separation works have influenced traffic. Traffic data for 2012 was therefore considered suitable to model existing traffic volumes.

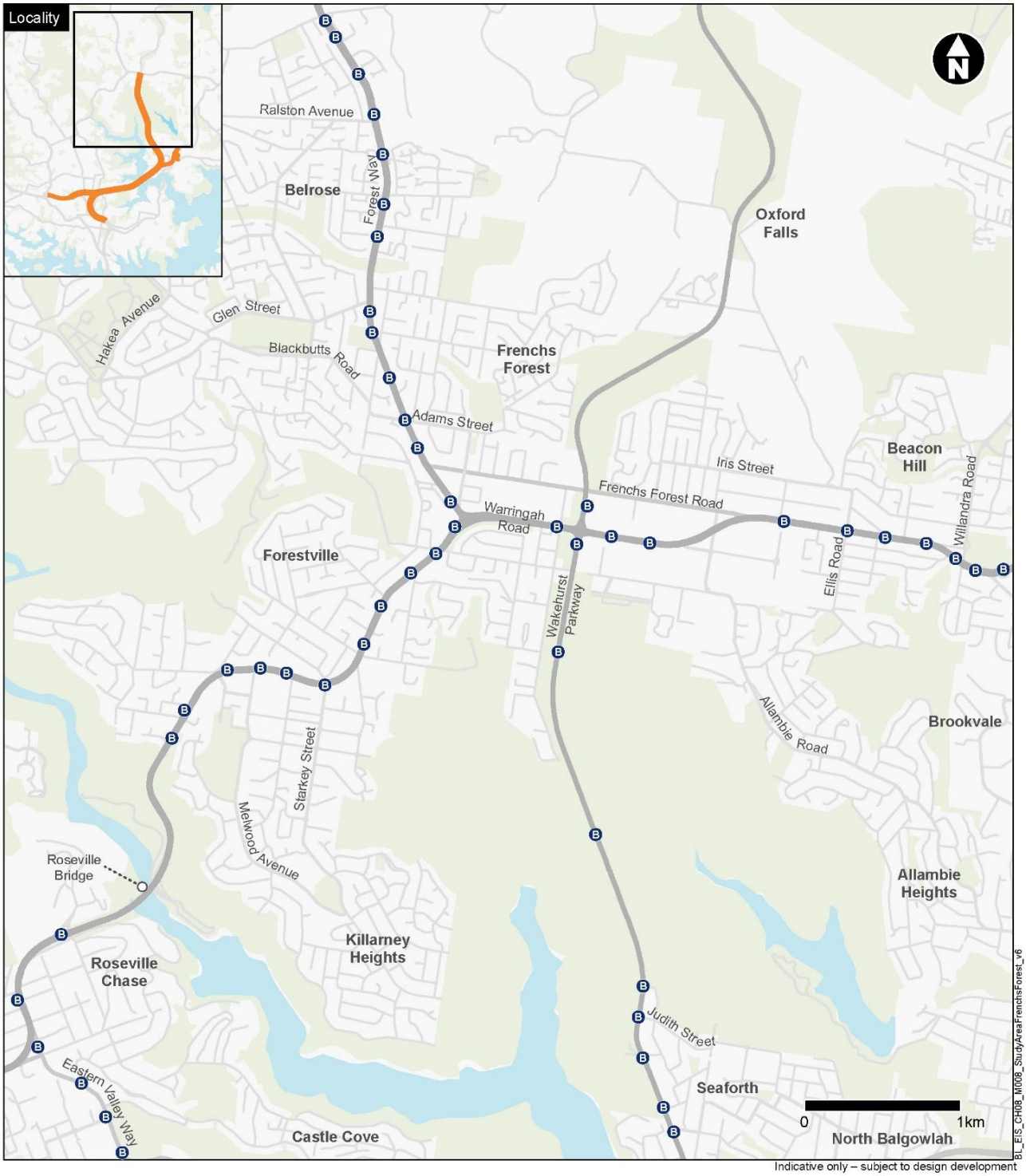
A summary of existing peak hour traffic volumes for Frenchs Forest and surrounds in the AM peak (between 7am and 9am on a normal working weekday) and PM peak (between 4pm and 6pm on a normal working weekday) is provided in Table 8-13.

**Table 8-13 Existing (2016) peak hour traffic volumes – Frenchs Forest and surrounds**

| Road | Direction | AM peak | | PM peak | |
|---|---|---|---|---|---|
| | | Volume (vehicles) | Heavy vehicle percentage | Volume (vehicles) | Heavy vehicle percentage |
| **Frenchs Forest and surrounds** | | | | | |
| Wakehurst Parkway north of Burnt Street | Northbound | 620 | 4% | 680 | 4% |
| | Southbound | 440 | 8% | 670 | 2% |
| Wakehurst Parkway north of Judith Street | Northbound | 830 | 3% | 830 | 3% |
| | Southbound | 580 | 6% | 860 | 2% |
| Wakehurst Parkway north of Kirkwood Street | Northbound | 860 | 2% | 800 | 3% |
| | Southbound | 540 | 7% | 820 | 1% |
| Warringah Road west of Wakehurst Parkway | Eastbound | 2320 | 6% | 3430 | 2% |
| | Westbound | 3080 | 4% | 2820 | 2% |
| Warringah Road east of Wakehurst Parkway | Eastbound | 1690 | 7% | 2140 | 2% |
| | Westbound | 1460 | 5% | 2160 | 2% |

### *Public transport network*

The Frenchs Forest area is well served by buses, with Warringah Road and Forest Way being major bus corridors for services to Sydney CBD, Chatswood, Terrey Hills and Belrose. A number of bus routes also operate along the Wakehurst Parkway. As part of the recent Growth Services Program 2018-2019, several new and expanded services are now in operation and support the Northern Beaches Hospital. Further, a rapid bus service, similar in nature to that of the existing B-Line, is proposed between Dee Why and Chatswood and is anticipated to be operation before the project commences construction.




**Legend**

**Road classification**

- Motorway
- Major arterial road
- Sub-arterial road
- Collector road
- Local road

**Public transport infrastructure**

- Bus stops on key routes

**Figure 8-8 Transport network within the Frenchs Forest area and surrounds**

### *Active transport network*

The pedestrian network in the Frenchs Forest area is limited with no footpaths alongside Wakehurst Parkway or on most local roads. However, footpaths are provided alongside other arterial roads and controlled crossings are provided at most signalised intersections. Significant pedestrian activity occurs around the Warringah Aquatic Centre, and in the vicinity of the Frenchs Forest local town centre on Warringah Road and Forest Way.

The cycle network in the Frenchs Forest area consists of a mixture of off-road shared user paths and on-road cycle routes on local and collector roads. The regional strategic cycle network provides connections between Frenchs Forest and surrounds and Balgowlah, Manly and Narrabeen. Off-road shared user paths are provided at the following locations:

- Karingal Crescent Reserve
- Shared pedestrian and cyclist bridge connecting Karginal Crescent Reserve and Forest Way
- Between Wakehurst Parkway north of Warringah Road and Frenchs Forest Road East, west of Inverness Avenue
- Shared pedestrian and cyclist bridge connecting Warringah Aquatic Centre and Bantry Bay Road
- Allambie Road between Aquatic Drive and Eaton Square
- Shared pedestrian and cyclist bridge across Warringah Road west of the intersection of Forest Way
- Shared pedestrian and cyclist bridge across Warringah Road on the western side of the intersection with Hilmer Street.
- Manly Dam Bike Tracks within Manly Dam Reserve, east of Wakehurst Parkway.

In addition, the Northern Beaches Hospital road upgrade project was completed in August 2020 and included upgrades for pedestrians and cyclists including shared user bridges at Hilmer Street and Forest Way, as well as the provision of shared user paths and footpaths on sections of Warringah Road, Wakehurst Parkway, Forest Way, Aquatic Drive and Allambie Road.

## Existing road performance

### *Road network performance*

Warringah Road and Forest Way carry high traffic volumes throughout the day, with Warringah Road providing a key route to and from North Sydney and the Sydney CBD via Eastern Valley Way. Wakehurst Parkway also forms an alternative north-south route to Pittwater Road, providing a sub-arterial connection between Narrabeen and Seaforth.

Warringah Road and Forest Way are also major bus corridors in the area. A southbound kerbside bus lane is provided on Wakehurst Parkway between Warringah Road and Frenchs Forest Road East and priority signalling for buses is provided westbound on Warringah Road east of Wakehurst Parkway and southbound on Forest Way north of Warringah Road.

The Northern Beaches Hospital road upgrade project, completed in August 2020, included the construction of three grade-separated underpasses on Warringah Road, allowing for traffic heading eastbound and westbound on Warringah Road to bypass the intersections of Wakehurst Parkway, Forest Way and Hilmer Street. The project also involved local road network upgrades and localised widening.

### *Intersection performance*

Due to reductions in traffic volumes in 2016 associated with construction activities of the Northern Beaches Hospital road upgrade project, existing intersection performance has been conservatively modelled based on 2012 preconstruction levels.

The *Northern Beaches Hospital Stage 2 Network Enhancement Works environmental impact statement* (Roads and Maritime Services, 2015c) identifies that road network performance following the grade separation of Warringah Road would be slightly improved in the morning peak period when compared to 2012 road network performance. However, the assessment identified that road network performance would be slightly worse in the evening peak period when compared to 2012 road network performance due to additional traffic generated by the Northern Beaches Hospital. Overall, network performance at Frenchs Forest and surrounds would not be materially changed due to the Northern Beaches Hospital Stage 2 Network Enhancement Works. The use of 2012 for baseline conditions is therefore considered a reasonable proxy for current conditions with the Northern Beaches Hospital Stage 2 Network Enhancement Works operational.

Modelled intersection performance under 2012 travel conditions is provided in Table 8-14. The assessment indicates that several intersections within the Frenchs Forest and surrounds area currently perform at or above capacity.

**Table 8-14 Modelled intersection performance in Frenchs Forest and surrounds (AM and PM peaks in 2012)**

| Intersection | AM peak (8am 9am) LoS (average delay in seconds) | PM peak (5pm 6pm) LoS (average delay in seconds) |
|---|---|---|
| Wakehurst Parkway/Frenchs Forest Road East | **F (>100)** | **E (67)** |
| Warringah Road/Allambie Road | **E (65)** | D (56) |
| Wakehurst Parkway/Warringah Road | **F (>100)** | D (48) |
| Warringah Road/Hilmer Street | **E (58)** | D (49) |
| Warringah Road/Forest Way | **F (>100)** | C (34) |
| Forest Way/Naree Road | A (>5) | A (7) |
| Warringah Road/Brown Street/Currie Road | **F (70)** | A (11) |
| Warringah Road/Starkey Street | C (37) | A (10) |
| Warringah Road/Darley Street | B (20) | B (22) |
| Warringah Road/Forestville Avenue | B (16) | B (28) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

## 8.4 Assessment of potential impacts

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

- Construction vehicles using the surface road network, especially heavy vehicles transporting spoil
- Surface road works requiring temporary traffic, cyclist and/or pedestrian diversions, road occupation and temporary road closures
- Temporary changes to speed limits.

Construction impacts related to maritime traffic and transport are discussed in Section 8.4.3.

Mitigation and management measures detailed in Section 8.5 would be implemented where appropriate during construction to reduce potential traffic and transport impacts during construction.

Details of construction activities and the location and timing of construction works, including temporary construction support site layouts and provision of construction worker parking, are presented in Chapter 6 (Construction work).

### 8.4.1 Warringah Freeway and surrounds

#### Road network impacts

The anticipated routes to and from the Cammeray Golf Course (BL1) and Flat Rock Drive (BL2) construction support sites within the Warringah Freeway and surrounds area are summarised in Chapter 6 (Construction work), along with the respective daily maximum construction vehicle volumes.

##### *Intersection and midblock performance with construction traffic*

The performance of intersections within the Warringah Freeway and surrounds area with the introduction of construction traffic would generally remain the same as conditions without the project. However, the following intersections would experience a change in level of service:

- Warringah Freeway/Brook Street interchange would worsen from LoS B to LoS C during the AM peak
- Brook Street/Merrenburn Avenue would worsen from LoS C to LoS D during the PM peak.

These impacts would be minor and both intersections would continue to operate satisfactorily during construction.

A new signalised intersection would also be provided for access to the Flat Rock Drive construction support site (BL2) and would operate at LoS A during construction.

The intersection performance results for the road network operating under the worst case construction traffic scenario (2024) during the AM and PM peak periods are summarised in Table 8-15.

**Table 8-15 Modelled intersection performance in the Warringah Freeway and surrounds area (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Intersection/ peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Warringah Freeway/Falcon Street interchange** | | | | | | | | |
| AM peak | 13,670 | N/A* | F* | >1 | 14,140 | N/A* | F* | >1 |
| PM peak | 14,000 | N/A* | F* | >1 | 14,650 | N/A* | F* | >1 |
| **Warringah Freeway/Ernest Street interchange** | | | | | | | | |
| AM peak | 6410 | N/A* | C* | 0.60 | 6520 | N/A* | C* | 0.61 |
| PM peak | 5910 | N/A* | D* | 0.58 | 6060 | N/A* | D* | 0.60 |
| **Ernest Street/Merlin Street/BL1 construction support site access** | | | | | | | | |
| AM peak | 2910 | 7 | A | 0.49 | 2980 | 8 | A | 0.49 |
| PM peak | 3220 | 9 | A | 0.78 | 3320 | 10 | A | 0.81 |

| Intersection/ peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Ernest Street/Miller Street** | | | | | | | | |
| AM peak | 3290 | 20 | B | 0.65 | 3330 | 20 | B | 0.65 |
| PM peak | 3700 | 32 | C | 0.79 | 3700 | 32 | C | 0.79 |
| **Warringah Freeway/Miller Street interchange** | | | | | | | | |
| AM peak | 5160 | N/A* | C* | 0.79 | 5200 | N/A* | C* | 0.81 |
| PM peak | 5270 | N/A* | D* | 0.89 | 5270 | N/A* | D* | 0.89 |
| **Warringah Freeway/Brook Street interchange** | | | | | | | | |
| AM peak | 5240 | N/A* | B* | 0.82 | 5430 | N/A* | C* | 0.85 |
| PM peak | 6530 | N/A* | C* | 0.89 | 6730 | N/A* | C* | 0.89 |
| **Brook Street/Merrenburn Avenue** | | | | | | | | |
| AM peak | 3340 | 92 | F | >1 | 3460 | >100 | F | >1 |
| PM peak | 3240 | 40 | C | >1 | 3380 | 47 | D | >1 |
| **Flat Rock Drive/BL2 construction support site access** | | | | | | | | |
| AM peak | - | | | | 2590 | 5 | A | 0.56 |
| PM peak | - | | | | 2770 | 5 | A | 0.67 |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F
*Interchanges were modelled as a network, where level of service is based on speed efficiency (SIDRA level of service criteria for networks) and not average vehicle delay.

The midblock performance (level of service) during construction would be unchanged when compared to the performance under conditions without the project at all locations except for:

- Miller Street north of Ernest Street in the southbound direction, where midblock performance would reduce from LoS B to LoS C during the AM peak
- Ernest Street west of Merlin Street in the eastbound direction, where midblock performance would reduce from LoS B to LoS C during AM peak
- Falcon Street west of Merlin Street in the eastbound direction, where midblock performance would reduce from LoS D to LoS E during the PM peak
- Falcon Street west of Merlin Street in the westbound direction, where midblock performance would reduce from LoS B to LoS C during the PM peak
- Brook Street south of Merrenburn Avenue in the southbound direction, where midblock performance would reduce from LoS C to LoS D during the PM peak.

Almost all midblock locations listed above would continue to operate with spare capacity and at a satisfactory level of service during construction, except for Falcon Street west of Merlin Street in the eastbound direction during the PM peak. However, this section of road is already operating close to the LoS D/E threshold; the additional vehicles are not expected to cause any major additional capacity issues for this road during construction.

The midblock performance results for the road network operating under the worst case construction traffic scenario (2024) during the AM and PM peak are summarised in Table 8-16.

**Table 8-16 Modelled midblock performance in the Warringah Freeway and surrounds area (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Location/ direction | Capacity (PCU) | AM Peak | | | | | | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | |
| | | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS |
| **Miller Street north of Ernest Street** | | | | | | | | | | | | | |
| Northbound[1] | 900 (AM) 1900 (PM) | 660 | 0.74 | D | 660 | 0.74 | D | 880 | 0.47 | C | 880 | 0.47 | C |
| Southbound[2] | 2900 (AM) 1900 (PM) | 1180 | 0.41 | B | 1220 | 0.42 | C | 1380 | 0.73 | D | 1380 | 0.73 | D |
| **Ernest Street east of Merlin Street** | | | | | | | | | | | | | |
| Eastbound | 1900 | 1250 | 0.66 | D | 1300 | 0.68 | D | 1580 | 0.83 | E | 1580 | 0.83 | E |
| Westbound | 1900 | 1030 | 0.54 | C | 1030 | 0.54 | C | 890 | 0.47 | C | 890 | 0.47 | C |
| **Ernest Street west of Merlin Street** | | | | | | | | | | | | | |
| Eastbound | 1900 | 780 | 0.41 | B | 820 | 0.43 | C | 2120 | >1 | F | 2190 | >1 | F |
| Westbound | 2900 | 2120 | 0.73 | D | 2170 | 0.75 | D | 1060 | 0.36 | B | 1120 | 0.39 | B |
| **Falcon Street west of Merlin Street** | | | | | | | | | | | | | |
| Eastbound | 3900 | 2590 | 0.67 | D | 2740 | 0.70 | D | 3140 | 0.80 | D | 3330 | 0.85 | E |
| Westbound | 5900 | 3520 | 0.60 | D | 3670 | 0.62 | D | 2370 | 0.40 | B | 2560 | 0.43 | C |
| **Brook Street south of Merrenburn Avenue** | | | | | | | | | | | | | |
| Northbound | 1900 | 900 | 0.48 | C | 990 | 0.52 | C | 1940 | >1 | F | 2030 | >1 | F |
| Southbound | 1900 | 2150 | >1 | F | 2240 | >1 | F | 1120 | 0.59 | C | 1210 | 0.64 | D |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F
1: Miller Street north of Ernest Street in the northbound direction has a clearway in operation during the evening peak period only.
2: Miller Street north of Ernest Street in the southbound direction has a clearway in operation during the morning peak period only.

### *Impacts on local roads and parking*

As part of the Western Harbour Tunnel and Warringah Freeway Upgrade project, the Ernest Street/Merlin Street intersection would be modified with the addition of a north approach allowing site access to the Cammeray Golf Course construction support site (BL1). This would be a secondary access point, with primary access for heavy vehicles to be provided directly to and from the Warringah Freeway. Up to 10 parking spaces on Ernest Street would be removed as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project to provide suitable access to the Cammeray Golf Course construction support site (BL1), with access maintained while the construction support site is operational. Clearways operate on Ernest Street during peak periods; therefore, any closure of the kerbside lane associated with the Cammeray Golf Course construction support site (BL1) would only result in loss of parking outside peak periods. The availability of parking on nearby local roads such as Ernest Street (east of Merlin Street), Oaks Avenue and Park Avenue would also reduce the impact of losing these parking spaces outside of peak periods. As such, the overall impact would be considered negligible.

Car parking areas for construction workers would be provided at the Cammeray Golf Course (BL1) and Flat Rock Drive (BL2) construction support sites. Worker parking would be maximised within the constraints of the respective temporary construction support site. The number of car parking spaces would be determined during construction planning.

Where on-site parking is not provided or where provision of on-site parking cannot accommodate the full construction workforce, the workforce would be actively encouraged to avoid parking on the surrounding road network. To minimise the potential parking impacts on the surrounding road network, parking will be actively managed using the following mitigation measures:

- The construction workforce would be encouraged to use public transport where feasible, with key bus corridors including Pacific Highway, Warringah Freeway, Miller Street, Falcon Street and Military Road. In addition, the T1 North Shore and T9 Northern Lines are accessible from North Sydney, St Leonards and Waverton railway stations
- Where public transport availability to temporary construction support sites is limited, shuttle bus transfers may also be provided from public transport centres where required.

### Impacts on public transport

In Cammeray, there are no bus routes that travel on Ernest Street in the vicinity of the Cammeray Golf Course construction support site (BL1) and therefore there would be negligible impacts to the bus network due to construction vehicles travelling to and from this site. The use of traffic signals for the Flat Rock Drive construction support site (BL2) access would impact buses that use Flat Rock Drive and Brook Street. This would increase bus travel times slightly as buses could be required to stop at the new traffic lights while construction vehicles access the site. Overall impacts would be negligible given that the intersection would generate an additional five seconds of delay on average.

No direct impacts on heavy rail services or ferry services are anticipated during construction.

### Impacts on active transport

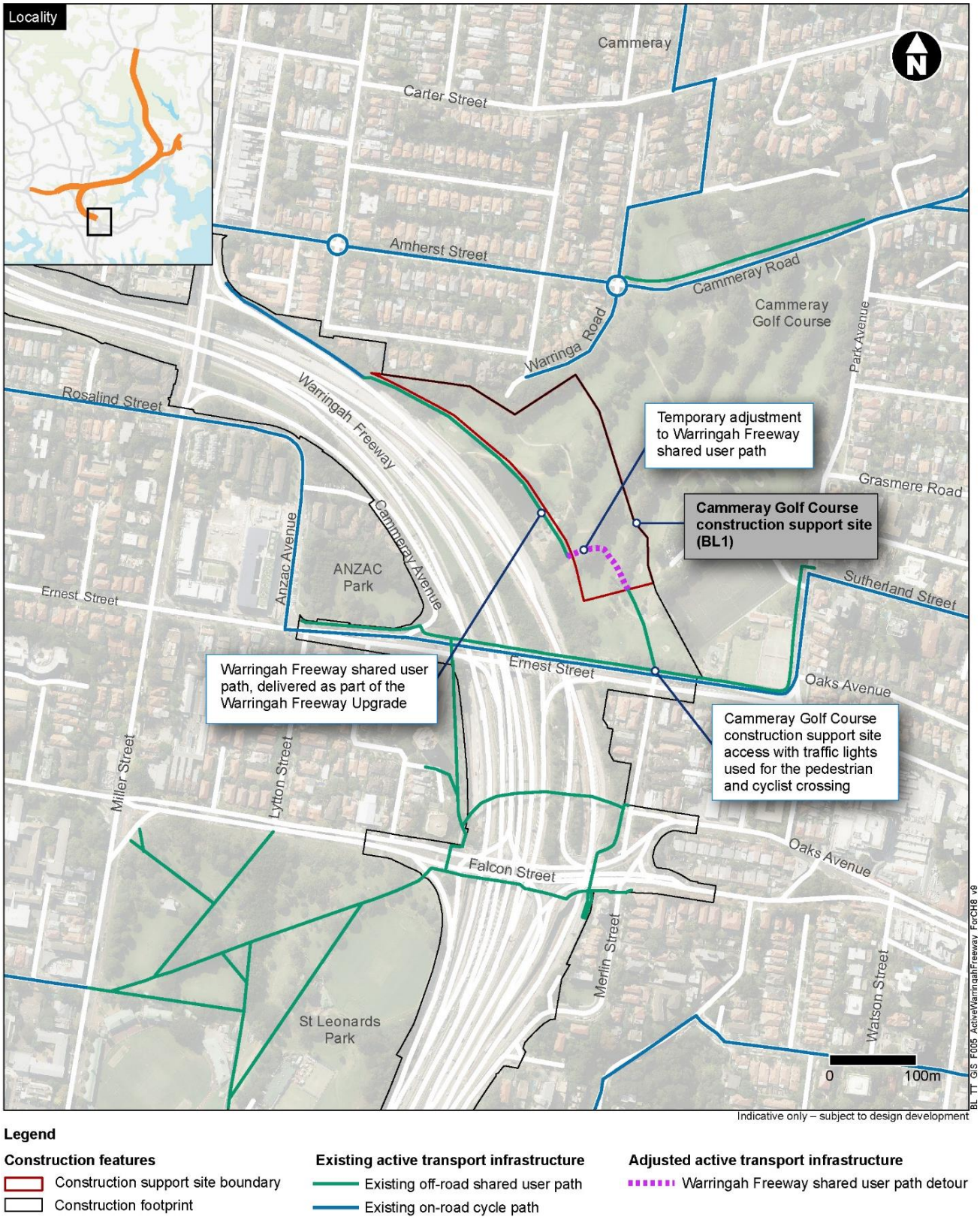
Potential impacts on the active transport network within the Warringah Freeway and surrounds area during construction are summarised in Figure 8-9. Potential impacts on active transport around Naremburn are summarised in Figure 8-10.

Conflicts between pedestrians and/or cyclists using the footpaths or shared user paths near the Cammeray Golf Course construction support site (BL1) and Flat Rock Drive construction support site (BL2) would be managed through traffic lights to control of movements at the site entry/exit.

The access arrangements at Cammeray Golf Course construction support site (BL1) would be established as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project. The shared user path along Warringah Freeway near Cammeray Golf Course would be realigned to travel along the rear of the Cammeray Golf Course construction support site (BL1) until the Ernest Street/Merlin Street intersection as part of the Warringah Freeway Upgrade. Minor impacts to

pedestrians and cyclists are anticipated given that existing connectivity would be maintained and a short additional travel distance of up to 100 metres. In addition, heavy vehicles at the Cammeray Golf Course construction support site (BL1) would be directed to access the site directly to and from the Warringah Freeway.

The temporary adjustment of the Flat Rock Reserve shared user path (parallel to Flat Rock Drive, on the western side of the construction support site) would be required to accommodate the Flat Rock Drive construction support site (BL2). This path would be temporarily realigned along the western perimeter of the construction support site, resulting in an additional travel distance of up to 100 metres (refer to Figure 8-10). The existing walking tracks along the eastern perimeter of the site would be largely maintained with two minor temporary diversions required. Given that existing connectivity would be maintained and the small potential increase in travel distance, impacts on pedestrians and cyclists using the shared user path are anticipated to be minor.



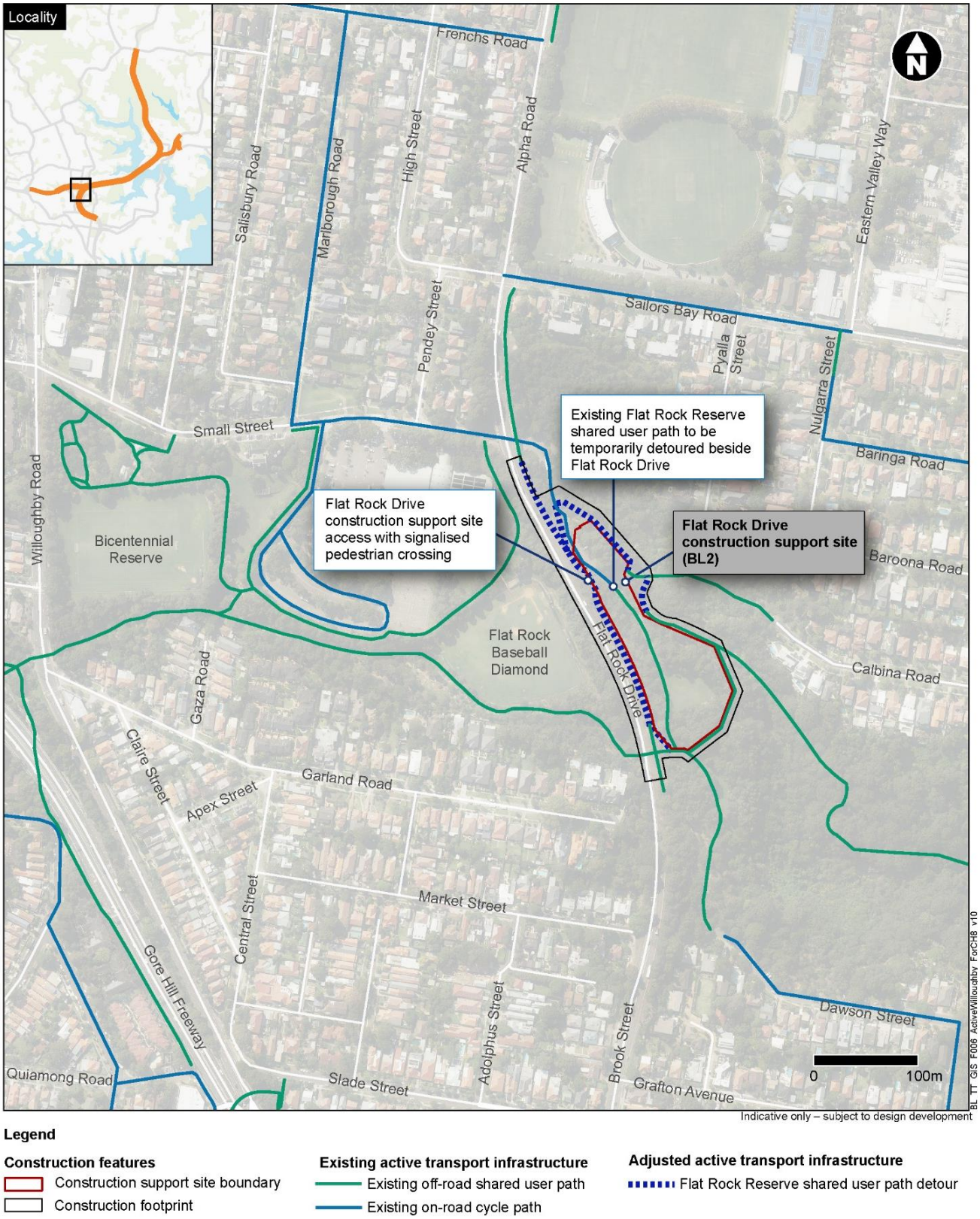

**Legend**

**Construction features**
- Construction support site boundary
- Construction footprint

**Existing active transport infrastructure**
- Existing off-road shared user path
- Existing on-road cycle path

**Adjusted active transport infrastructure**
- Warringah Freeway shared user path detour

**Figure 8-9 Active transport impacts within the Warringah Freeway and surrounds area during construction**




**Legend**

**Construction features**
- Construction support site boundary
- Construction footprint

**Existing active transport infrastructure**
- Existing off-road shared user path
- Existing on-road cycle path

**Adjusted active transport infrastructure**
- Flat Rock Reserve shared user path detour

**Figure 8-10 Active transport impacts around Naremburn during construction**

## 8.4.2 Gore Hill Freeway and Artarmon

### Road network impacts

The anticipated routes to and from the Punch Street (BL3), Dickson Avenue (BL4), Barton Road (BL5), and Gore Hill Freeway median (BL6) construction support sites are summarised in Chapter 6 (Construction work), along with the respective daily maximum construction vehicle volumes.

#### *Intersection and midblock performance with construction traffic*

The performance of intersections within the Gore Hill Freeway and Artarmon area with the introduction of construction traffic would generally remain the same as conditions without the project. However, the following intersections would experience a change in level of service:

- Gore Hill Freeway/Reserve Road interchange would worsen from LoS E to LoS F during the AM peak. The intersection already performs poorly during the AM peak
- Reserve Road/Dickson Avenue would worsen from LoS B to LoS C during the PM peak
- Herbert Street/Frederick Street would worsen from LoS B to LoS C during the PM peak.

The impacts at the Reserve Road/Dickson Avenue and Herbert Street/Frederick Street intersections would be minor and both intersections would continue to operate satisfactorily during construction.

The intersection performance results for the road network operating under the worst case construction traffic scenario (2024) during the AM and PM peak periods are summarised in Table 8-17.

**Table 8-17 Modelled intersection performance in the Gore Hill Freeway and Artarmon area (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Intersection/ peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Gore Hill Freeway/Reserve Road interchange** | | | | | | | | |
| AM peak | 3890 | N/A* | E* | >1 | 4200 | N/A* | F* | >1 |
| PM peak | 3990 | N/A* | F* | >1 | 4200 | N/A* | F* | >1 |
| **Reserve Road/Dickson Avenue** | | | | | | | | |
| AM peak | 1980 | 17 | B | 0.57 | 2160 | 20 | B | 0.68 |
| PM peak | 2000 | 27 | B | 0.74 | 2130 | 29 | C | 0.82 |
| **Reserve Road/Frederick Street** | | | | | | | | |
| AM peak | 1140 | 9 | A | 0.43 | 1230 | 9 | A | 0.48 |
| PM peak | 1300 | 10 | A | 0.42 | 1400 | 10 | A | 0.46 |
| **Herbert Street/Frederick Street** | | | | | | | | |
| AM peak | 1390 | 22 | B | 0.76 | 1490 | 24 | B | 0.81 |
| PM peak | 1750 | 28 | B | 0.79 | 1850 | 31 | C | 0.87 |

| Intersection/ peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Herbert Street/Cleg Street** | | | | | | | | |
| AM peak | 1110 | 12 | A | 0.43 | 1210 | 12 | A | 0.45 |
| PM peak | 1480 | 17 | B | 0.48 | 1580 | 18 | B | 0.51 |

*Interchanges were modelled as a network, where level of service is based on speed efficiency (SIDRA level of service criteria for networks) and not average vehicle delay
Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

The midblock performance (level of service) during construction would be unchanged from performance under conditions without the project at all locations, except for the following:

- Reserve Road north of Frederick Street in the southbound direction would worsen from LoS D to LoS E in the AM peak, and from LoS C to LoS D in the PM peak
- Herbert Street north of Frederick Street in the northbound and southbound direction would worsen from LoS C to LoS D in the PM peak
- Cleg Street east of Herbert Street in the eastbound direction would worsen from LoS A to LoS B during the PM peak.

The midblock performance results for the road network operating under the worst case construction traffic scenario (2024) during the AM and PM peak periods are summarised in Table 8-18.

**Table 8-18 Modelled midblock performance in the Gore Hill Freeway and Artarmon area (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Location/ direction | Capacity (PCU) | AM Peak | | | | | | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | |
| | | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS |
| **Reserve Road north of Dickson Avenue** | | | | | | | | | | | | | |
| Northbound | 1900 | 610 | 0.32 | B | 680 | 0.36 | B | 1180 | 0.62 | D | 1230 | 0.65 | D |
| Southbound | 1900 | 1290 | 0.68 | D | 1430 | 0.75 | D | 680 | 0.36 | B | 780 | 0.41 | B |
| **Reserve Road north of Frederick Street** | | | | | | | | | | | | | |
| Northbound | 900 | 370 | 0.42 | C | 420 | 0.46 | C | 680 | 0.76 | D | 730 | 0.81 | D |
| Southbound | 900 | 670 | 0.74 | D | 750 | 0.83 | E | 500 | 0.55 | C | 580 | 0.64 | D |
| **Frederick Street east of Reserve Road** | | | | | | | | | | | | | |
| Eastbound | 900 | 430 | 0.47 | C | 510 | 0.57 | C | 570 | 0.63 | D | 650 | 0.72 | D |
| Westbound | 900 | 410 | 0.46 | C | 460 | 0.51 | C | 430 | 0.48 | C | 470 | 0.53 | C |
| **Herbert Street north of Frederick Street** | | | | | | | | | | | | | |
| Northbound | 900 | 260 | 0.29 | B | 350 | 0.38 | B | 470 | 0.52 | C | 550 | 0.61 | D |
| Southbound | 900 | 550 | 0.62 | D | 600 | 0.66 | D | 510 | 0.57 | C | 550 | 0.62 | D |
| **Cleg Street east of Herbert Street** | | | | | | | | | | | | | |
| Eastbound | 900 | 110 | 0.13 | A | 180 | 0.20 | A | 200 | 0.22 | A | 270 | 0.30 | B |
| Westbound | 900 | 130 | 0.15 | A | 130 | 0.15 | A | 180 | 0.20 | A | 180 | 0.20 | A |

| Location/ direction | Capacity (PCU) | AM Peak | | | | | | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | |
| | | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS |
| **Dickson Avenue east of Reserve Road** | | | | | | | | | | | | | |
| Eastbound | 900 | 260 | 0.29 | B | 320 | 0.35 | B | 180 | 0.20 | A | 200 | 0.22 | A |
| Westbound | 900 | 150 | 0.16 | A | 200 | 0.22 | A | 240 | 0.27 | B | 250 | 0.28 | B |
| **Reserve Road south of Barton Road** | | | | | | | | | | | | | |
| Northbound | 900 | 390 | 0.43 | C | 400 | 0.45 | C | 660 | 0.73 | D | 680 | 0.75 | D |
| Southbound | 900 | 510 | 0.56 | C | 520 | 0.58 | C | 420 | 0.47 | C | 430 | 0.48 | C |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

### *Impacts on local roads and parking*

The installation of traffic lights at the intersection of Pacific Highway with Dickson Avenue would result in the following impacts on traffic:

- Temporary lane closures on Pacific Highway during removal of existing median and line-marking, minor pavement works and relocation of the existing bus stop on Pacific Highway west of Dickson Avenue
- Temporary closure of Dickson Avenue during linemarking, minor kerb adjustment and minor pavement works
- Removal of about six motorbike parking spaces and three time-limited (four-hour) car parking spaces.

The existing mail zone on Dickson Avenue would be permanently relocated in proximity to the existing zone. Relocation of the mail zone would be carried out in consultation with Australia Post.

Temporary lane and road closures would be carried out outside peak periods and the impacts of these closures would be low.

Several roads would form part of construction vehicle routes within the Gore Hill Freeway and Artarmon area, including:

- Reserve Road
- Dickson Avenue
- Frederick Street
- Herbert Street
- Punch Street
- Hampden Road
- Barton Road
- Butchers Lane.

Most heavy vehicles accessing the construction area would be travelling to and from the Punch Street construction support site (BL3), with all other sites operating as smaller support sites and generating a substantially lower number of heavy vehicle movements. Relatively low impacts are anticipated on Hampden Road, Barton Road, Butchers Lane and Reserve Road north of Gore Hill Freeway given the low number of construction vehicles on these roads (maximum of 120 light vehicle and 60 heavy vehicle movements per day).

At peak production, the Punch Street construction support site (BL3) would generate a maximum of 580 light vehicle and 370 heavy vehicle movements per day while the Dickson Avenue construction support site (BL4) would generate a maximum of 500 light vehicle and 90 heavy vehicle movements per day at peak production. This would occur for a relatively short duration during peak construction period, with typical truck movements generally becoming less frequent throughout the course of construction. These vehicles would travel on Reserve Road south of Gore Hill Freeway, Dickson Avenue, Frederick Street, Herbert Street, Punch Street or Cleg Street. Across the broader network, construction traffic would access the construction site via the motorway network, where practical, to minimise impacts on local roads. Although these construction traffic volumes are relatively high in the context of existing traffic volumes, impacts on the local road network are anticipated to be low as these roads would operate with spare capacity during construction and form a direct route for construction vehicles to access the arterial road network.

Lambs Road between Punch Street and Cleg Street would be closed to allow for the Punch Street construction support site (BL3). Existing access to this section of Lambs Road is via Cleg Street and Punch Street, and therefore access impacts due to this closure would be minor. Periodic short-term closures of Reserve Road, Hampden Road, Dickson Avenue and Punch Street would also be

required during construction. Given the extensive local road network in Artarmon, vehicles would have multiple alternative routes available during these interim closures. Potential detour roads include Herbert Street, Carlotta Street, Campbell Street, Frederick Street and Cleg Street.

Construction works in Artarmon would require the temporary and permanent removal of on-street parking spaces including the following:

- The closure of Lambs Road in conjunction with the requirement to detour pedestrians and cyclists due to adjustments to the Gore Hill Freeway shared user path resulting in the permanent loss of up to 25 parking spaces on Lambs Road and Punch Street
- Construction works at Artarmon Park requiring about six on-street parking spaces on Hampden Road to be removed temporarily for the duration of construction
- Short-term temporary removal of an additional 20 on-street parking spaces on Hampden Road during northern abutment works
- The potential temporary removal of up to 10 parking spaces on other local roads such as Cleg Street, Dickson Avenue and Barton Road to provide suitable access to the temporary construction support sites in the Artarmon area.

The cumulative loss of parking spaces associated with the establishment of temporary construction support sites may have some impact on on-street parking in surrounding streets in Artarmon that currently have high parking demand. The availability of on-street parking in the vicinity of the temporary construction support sites has the potential to be reduced for the duration of construction.

Some car parking would be provided at Punch Street (BL3), Dickson Street (BL4), and Barton Road (BL5) and Gore Hill Freeway median (BL6) construction support sites. Worker parking would be maximised within the constraints of the respective temporary construction support site. The number of car parking spaces would be determined during construction planning.

Where on-site parking is not provided or where provision of on-site parking cannot accommodate the full construction workforce, the workforce would be actively encouraged to avoid parking on the surrounding road network. To minimise the potential parking impacts on the surrounding road network, parking will be actively managed using the following mitigation measures:

- Construction workforce would be encouraged to use public transport where feasible, with key bus corridors including Pacific Highway, Gore Hill Freeway and Epping Road. In addition, the T1 North Shore and T9 Northern Lines are accessible from Artarmon and St Leonards railway stations
- Where public transport availability to temporary construction support sites is limited, shuttle bus transfers may also be provided from public transport centres where required.

It is noted that the acquisition of property for the Punch Street (BL3) and Dickson Avenue (BL4) construction support sites would result in a minor reduction in parking demand that would otherwise be generated by businesses currently located at these sites.

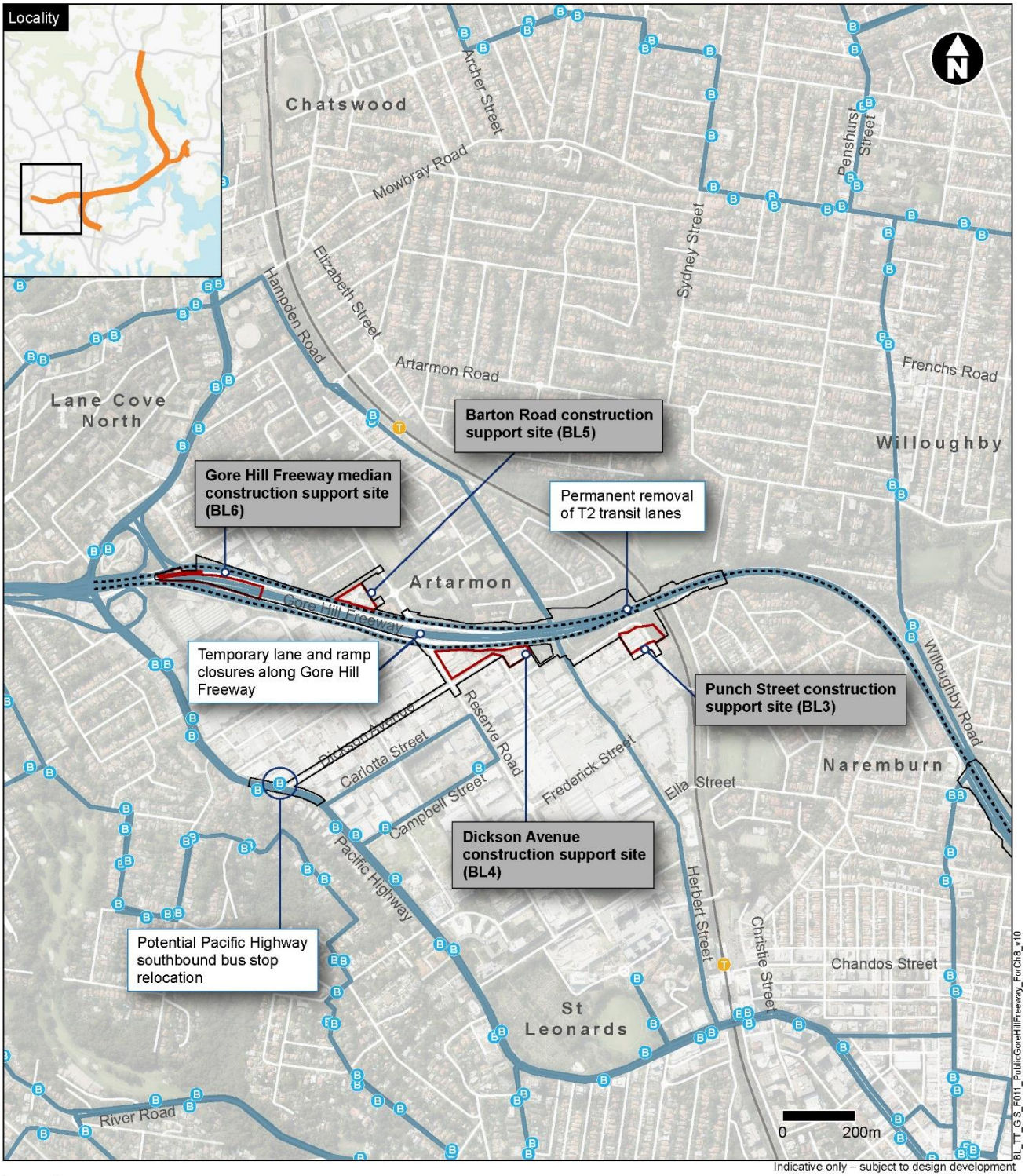
### Impacts on public transport

Impacts on public transport within the Gore Hill Freeway and Artarmon area are shown in Figure 8-11.

Construction works in the Gore Hill Freeway and Artarmon area would require interim lane and ramp closures along the Gore Hill Freeway, which may impact bus travel times and reliability. Where practical, works would be scheduled outside peak periods to minimise disruption to bus services. The T2 transit lanes currently in operation in both directions along the Gore Hill Freeway would be converted to general traffic lanes to allow for construction of the Gore Hill Freeway Connection and to improve lane utilisation, however their removal is not expected to materially impact bus travel times.

The southbound bus stop located on Pacific Highway near Dickson Avenue would be permanently relocated during the construction works required to upgrade the Pacific Highway/Dickson Avenue intersection. Bus stop relocation would be determined in consultation with relevant stakeholders, including other divisions of Transport for NSW, and advanced notification would be provided to affected bus customers. Bus stops would be relocated within walking distance from their existing position to minimise disruption, where reasonable and feasible.

No direct impacts on heavy rail services are anticipated during construction.




**Legend**

**Construction features**
- Construction support site boundary
- Construction footprint

**Public transport infrastructure**
- Bus route
- T2 transit lane
- Heavy rail
- Bus stop
- Train station

**Figure 8-11 Public transport impacts within the Gore Hill Freeway and Artarmon area during construction**

### Impacts on active transport

Impacts on the active transport network within the Gore Hill Freeway and Artarmon area are shown in Figure 8-12.

Modifications to the active transport network around Artarmon would be required during construction of the Gore Hill Freeway Connection, resulting in the following potential impacts:

- Reinstatement of the eastern footpath on Hampden Road, including diversion of pedestrians to the western footpath
- Temporary adjustment of the southern footpath on Punch Street adjacent to the Punch Street construction support site (BL3) boundary. Users would be diverted to Clegg Street resulting in an increase in travel distance of about 70 metres, which is considered a minor impact
- Temporary adjustment of the shared user path along Gore Hill Freeway between Reserve Road and Station Street impacting up to 150 pedestrians and cyclists who currently use the shared user path during the weekday peak periods. Alternative routes would divert these users via Station Street, Francis Road, Lambs Road, Cleg Street and Reserve Road, resulting in an additional travel distance of about 550 metres. This would have a moderate impact on pedestrians and a minor impact on cyclists, and would be managed by providing advanced notification to the community and appropriate linemarking and signage to clearly show the proposed detour route to pedestrians and cyclists.

Northern abutment works on Hampden Road would impact cyclists who currently travel on the road shoulder on either side of Hampden Road. During construction, one lane in each direction would be provided and cyclists would be required to travel on-road in traffic. Impacts would be minor given that these works are short in duration and parking would be removed on both sides of the road.

Periodic diversions of pedestrians to footpaths opposite construction activities or use of traffic control may also be required to ensure the safety of pedestrians, particularly on Punch Street, Dickson Avenue and Reserve Road. Residents may also be escorted through the work sites when accessing properties to ensure safe passage. Targeted engagement with affected residents would be carried out before and throughout the construction works in accordance with the relevant community and stakeholder engagement protocols for the project.

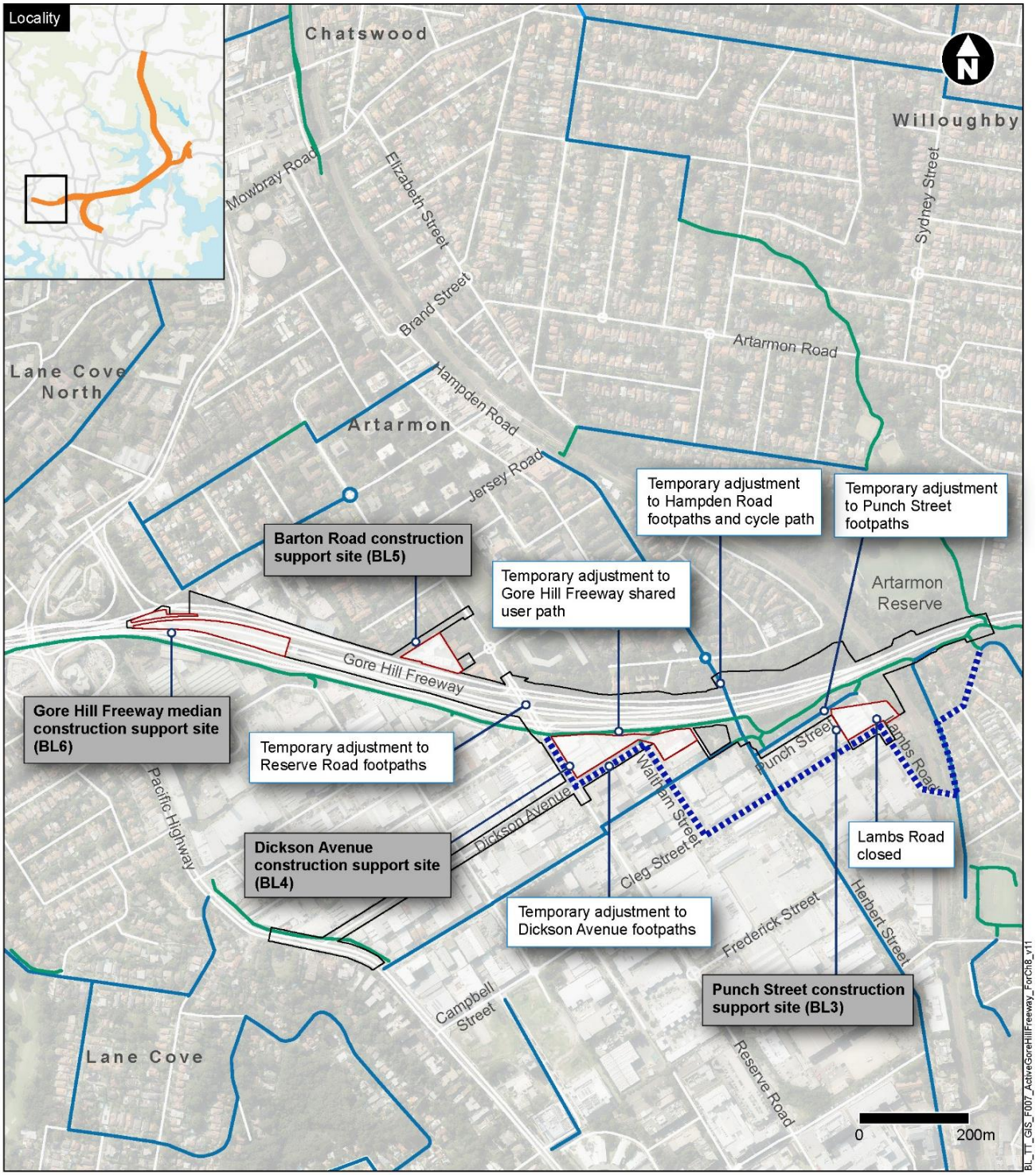



**Figure 8-12 Active transport impacts within the Gore Hill Freeway and Artarmon area during construction**

### 8.4.3 Northbridge to Seaforth (Middle Harbour crossing)

#### Overview of maritime movements and activities

This section describes potential impacts from maritime movements and associated activities during construction of the immersed tube tunnel and establishment and operation of the Middle Harbour south cofferdam (BL7), Middle Harbour north cofferdam (BL8) and Spit West Reserve construction support site (BL9), along with the temporary mooring facility east of Clive Park in Middle Harbour to be used as a storage facility for immersed tube tunnel segments. This would result in an increase in marine traffic in Middle Harbour. Maritime construction vessel routes and volumes are summarised in Chapter 6 (Construction works).

The construction vessels would primarily include:

- Construction barges (including barges with cranes) for delivering construction materials, removing dredged and excavated material, or for other construction activities
- Dredging vessels
- Tugboats for manoeuvring barges
- Transport vessels for workers.

Movement of spoil barges would be controlled by the Port Authority of NSW's Vessel Traffic Service, which provides continuous monitoring of marine vessels within Middle Harbour.

The construction activities within Middle Harbour would require the establishment of localised maritime speed restrictions around construction equipment and facilities. Changes to maritime speeds would result in increased transit time for recreational, commercial and government vessels passing through the construction works area in Middle Harbour. The increased transit time would be relatively minor.

Potential road related impacts from the use of Spit West Reserve construction support site (BL9) are discussed in Section 8.4.4.

#### Maritime navigation impacts

Construction activities that would impact navigation in Middle Harbour are shown in Figure 8-13 and include the following:

- Construction of Middle Harbour north and south cofferdam temporary structures (BL7 and BL8) including excavation within the cofferdams. This would also include construction of the interface structures within the cofferdams and the establishment of appropriately controlled marine traffic exclusion zones required to ensure the safety of both the waterway users and the project's construction workforce
- Establishment and operation of the Spit West Reserve construction support site (BL9)
- Transport of partially constructed steel shell immersed tube tunnel units to Spit West Reserve construction support site (BL9)
- Dredging activities between Northbridge and Seaforth Bluff in preparation for the installation of immersed tube tunnels
- Piling for immersed tube tunnel unit supports between Northbridge and Seaforth Bluff, restricting navigation widths to about 100 metres
- Installation of the immersed tube tunnel elements, which would be carried out during up to six closures (likely two full closures and four partial closures) of Middle Harbour between Northbridge and Seaforth for a period of up to 48 hours during weekdays
- Barge movements to and from the project temporary construction support sites

- A temporary mooring facility east of Clive Park in Middle Harbour to be used as a storage facility for completed immersed tube tunnel units
- Boat movements transporting the construction workforce.

Prolonged periods of high maritime construction activity would occur over about three months of the construction program while the following activities are carried out:

- Concreting of interface structures
- Dredging of sediment and rock
- Transport of partially completed and completed immersed tube tunnel units.

Exclusion zones would be set up around the cofferdams, reducing navigation width to about 220 metres between the cofferdams. These zones would be marked by lit yellow buoys as specified by the Harbour Master to clearly identify the exclusion zones and facilitate the safe passage of vessels travelling within the vicinity of the cofferdams. Dredging activities and the installation of immersed tube tunnel support piles would also restrict navigational movements. The use of primary silt curtains during dredging activities would reduce navigation widths to about 100 metres. Impacts due to the reduced navigation widths would be manageable, with specific mitigations detailed in Section 8.5.

Navigation impacts in the Outer Harbour would not be considered substantial due to the lower frequency of construction vessel movements and the increased space the Outer Harbour provides for manoeuvrability.

#### *Simulation model*

A model was prepared to simulate the transport of the partially constructed steel shell immersed tube tunnel units and identify any restrictions and towage requirements for the safe movement of vessels to and from the Outer Harbour, using the navigation channel through and between the Spit Bridge piers to berths at Spit West Reserve construction support site (BL9). The model found that the transportation of the partially constructed immersed tube tunnel units to the Spit West Reserve construction support site (BL9), and transportation of the completed immersed tube tunnel elements subsequently to the temporary mooring location before immersion, would be feasible and could be carried out safely based on the proposed methodology (refer to Chapter 6 (Construction works)).

### Impacts on recreational users, community groups and clubs

Generally, recreational users, community groups and clubs downstream of the Spit Bridge would not be substantially impacted by construction activities in Middle Harbour due to the limited construction activities and associated vessel interactions in this part of the harbour.

Upstream of the Spit Bridge, Mosman Rowing Club would be located adjacent to the Spit West Reserve construction support site (BL9) and in the vicinity of construction vessel movements between the temporary construction support site, cofferdams, dredging and support piling works and the temporary mooring location. This has the potential to impact rowing club operations if not appropriately managed during construction. Measures to reduce and manage impacts on the operation of the Mosman Rowing Club would include avoiding impacts on the land based (ie via Spit West Reserve) or water based approaches to the club and maintaining the current 50 metre width of the navigation channel between the moorings on approach to the club where possible. Figure 8-13 shows the proposed rowing route and adjacent construction facilities and movements within Middle Harbour. This and other suitable management measures as required would be developed in consultation with the Mosman Rowing Club during construction planning.

Construction work, in particular dredging activities and the use of associated silt curtains, has the potential to impact the operation of the Northbridge Sailing Club. This club hosts races for dinghies and other sail craft that typically occupy the waterway in the immediate vicinity of the proposed Middle Harbour crossing. Opportunities to minimise and manage potential impacts, including the relocation of their racecourses to upstream of the Middle Harbour crossing, would be investigated prior to construction in consultation with the club.

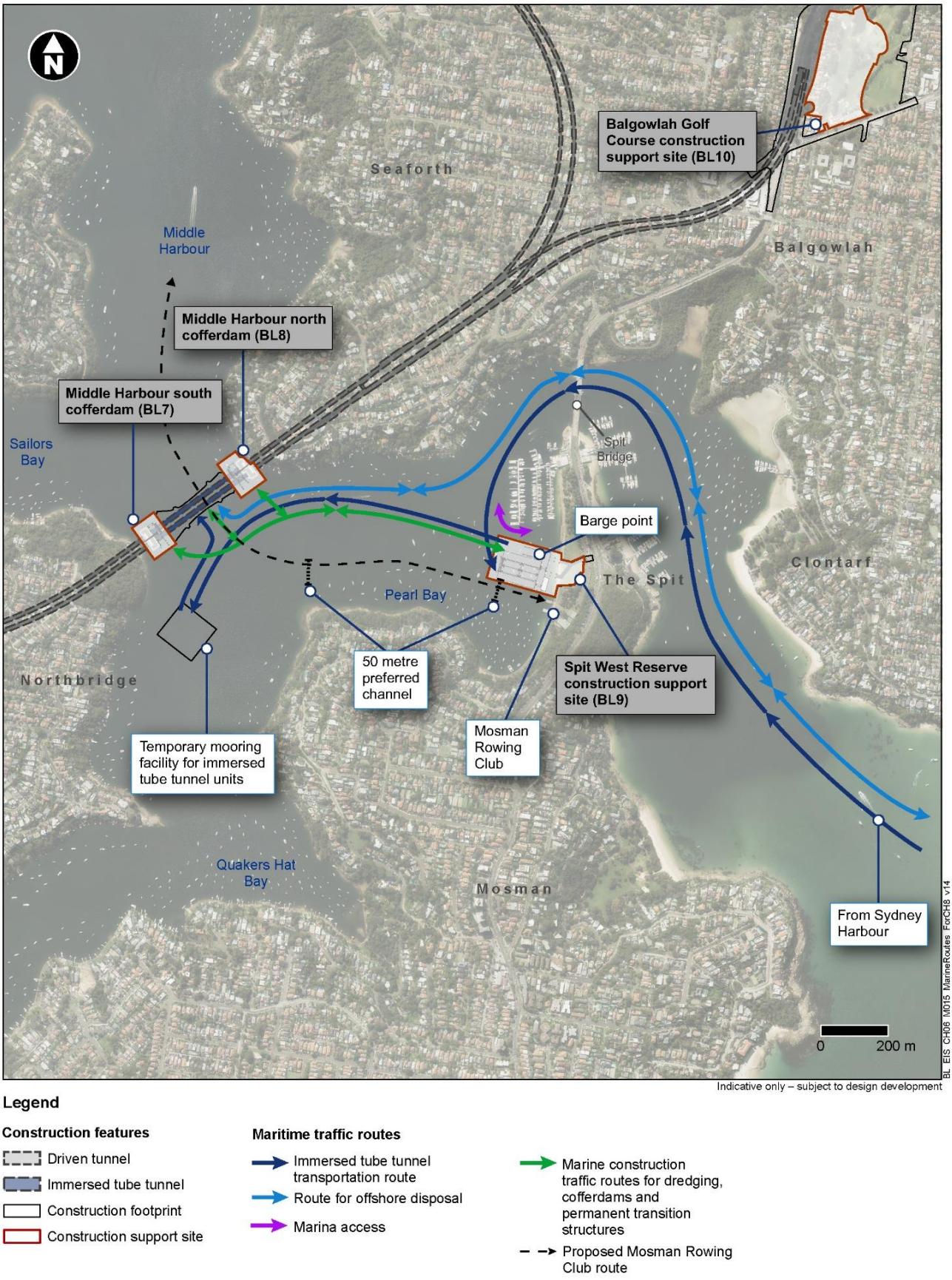



**Figure 8-13 Maritime navigation impacts during construction**

### Impacts on commercial operations within Middle Harbour

Except for Eco Boat Hire at Northbridge, there is minimal commercial boating traffic that would be impacted by the construction activities. Furthermore, Eco Boat Hire charter small vessels that would always be permitted to traverse the crossing location during construction due to their size. The exception would be during the two full closures of the Middle Harbour crossing for immersion of the two central tunnel units which would be limited to about 48 hours per closure. There are no larger commercial operators known to navigate within the vicinity of, or through, the crossing location. Impacts on commercial operations within Middle Harbour are considered negligible.

Construction equipment and vessel movements would give way to larger vessels in the Outer Harbour or offshore areas (eg vessel movements associated with offshore disposal of dredged material) and would follow the Harbour Master's directions. Impacts on commercial operators in the Outer Harbour are also considered negligible due to the lower frequency of interaction with construction vessel movements and the increased space the Outer Harbour provides for manoeuvrability.

### Impacts on government operations within Middle Harbour

#### *Royal Australian Navy*

The construction activities associated with the harbour crossing would not impact on navigation to and from HMAS Penguin at Balmoral. This is due to the HMAS Penguin being located away from the main construction activities, the width of the harbour at this location reducing the proximity to construction vessel movements, and the low number of naval vessels accessing the facility, reducing the potential interaction with construction vessel movements.

#### *Water Police, Transport for NSW, and Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources)*

Impacts on government users would be limited to a minor increase in travel times resulting from imposed speed restrictions during construction. Speed restrictions would not apply to Water Police in an emergency.

### Impacts on swing moorings and marina berths

About 45 swing moorings located in Pearl Bay would be temporarily relocated for about 48 months during construction due to the location of a casting facility off Spit West Reserve. About 10 swing moorings in Seaforth would also require temporary relocation due to the Middle Harbour north cofferdam (BL8). These moorings would be relocated for about 48 months, and likely just to the west of their existing locations in Middle Harbour, in consultation with the lease holders and therefore impacts on boat users due to the displaced moorings is considered to be minor.

Deliveries of immersed tube tunnel units between the temporary construction support sites may require a small number of additional swing moorings west of Bradys Point to be temporarily relocated. If required, arrangements would be determined in consultation with the lease holder(s). Impacts on any additional relocated moorings would be limited to a relatively small change to their location.

The location of the Middle Harbour north cofferdam (BL8) at Seaforth would also prohibit access to three private marina berths. Temporary alternative marina berths would be provided for about 48 months at marinas nearby.

## 8.4.4 Balgowlah and surrounds

### Road network impacts

The anticipated routes to and from the Spit West Reserve (BL9), Balgowlah Golf Course (BL10), and Kitchener Street (BL11) construction support sites are summarised in Chapter 6 (Construction work), along with the respective daily maximum construction vehicle volumes.

### *Intersection and midblock performance with construction traffic*

The performance of intersections (level of service) within the Balgowlah and surrounds area with the introduction of construction traffic would generally remain the same as conditions without the project. The intersection Manly Road/Sydney Road/Burnt Bridge Creek Deviation would worsen from LoS C to LoS D during the PM peak. In addition, the intersection of Spit Road/Parriwi Road/Spit West Reserve car park/BL9 construction support site access would worsen from a LoS B to LoS C also during the PM peak.

Direct access from the Balgowlah Golf Course construction support site (BL10) to Burnt Bridge Creek Deviation would be provided, which would reduce the potential traffic impacts possible at the Manly Road/Sydney Road/Burnt Bridge Creek Deviation intersection were access to the temporary construction support site provided from Sydney Road.

The Sydney Road/Maretimo Street intersection would improve from LoS E to LoS A during the AM peak and from LoS F to LoS A during the PM peak. This improvement would occur as a result of the proposed traffic signals at the intersection during construction and the addition of a northern approach that would provide access to the Balgowlah Golf Course construction support site (BL10). However, traffic signals at this intersection would increase delays for vehicles travelling east–west on Sydney Road that do not experience any delay under the existing configuration. The additional delays under traffic signal operation are considered to be minor.

The intersection performance results for the road network operating under the worst case construction traffic scenario (2024) during the AM and PM peak periods are summarised in Table 8-19.

**Table 8-19 Modelled intersection performance in Balgowlah and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Intersection/ peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Spit Road/ Parriwi Road/ Spit West Reserve car park/ BL9 construction support site access** | | | | | | | | |
| AM peak | 4850 | 8 | A | 0.73 | 5070 | 8 | A | 0.76 |
| PM peak | 5370 | 21 | B | 0.89 | 5700 | 31 | C | 0.94 |
| **Manly Road/ Sydney Road/ Burnt Bridge Creek Deviation** | | | | | | | | |
| AM peak | 4740 | 49 | D | 0.91 | 4860 | 54 | D | 0.95 |
| PM peak | 5680 | 34 | C | 0.92 | 5840 | 45 | D | 0.99 |
| **Sydney Road/ Maretimo Street/ BL10 construction support site access** | | | | | | | | |
| AM peak | 1460 | 70 | E | 0.24 | 1560 | 10 | A | 0.35 |
| PM peak | 1830 | >100 | F | 0.27 | 1970 | 12 | A | 0.50 |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

The midblock performance during construction would be comparable to performance under conditions without the project at all locations, with the exception of Sydney Road east of Manly Road in the eastbound direction which would reduce from LoS C to LoS D during the PM peak. However, it is expected that Sydney Road in this location and direction would still operate with spare capacity and at a satisfactory level of service during construction.

The midblock performance results for the road network operating under the worst case construction traffic scenario (2024) are summarised in Table 8-20 during the AM and PM peak periods.

**Table 8-20 Modelled midblock performance in Balgowlah and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Location/ direction | Capacity (PCU) | AM Peak | | | | | | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | |
| | | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS |
| **Spit Road south of Parriwi Road** | | | | | | | | | | | | | |
| Northbound | 2900 | 3110 | >1 | F | 3250 | >1 | F | 1820 | 0.63 | D | 2010 | 0.69 | D |
| Southbound | 2900 | 1520 | 0.52 | C | 1670 | 0.58 | C | 2960 | >1 | F | 3160 | >1 | F |
| **Manly Road south of Sydney Road** | | | | | | | | | | | | | |
| Northbound | 2900 | 1720 | 0.59 | D | 1830 | 0.63 | D | 3400 | >1 | F | 3550 | >1 | F |
| Southbound | 2900 | 3270 | >1 | F | 3390 | >1 | F | 1840 | 0.63 | D | 1990 | 0.69 | D |
| **Sydney Road east of Manly Road** | | | | | | | | | | | | | |
| Eastbound | 1900 | 520 | 0.28 | B | 590 | 0.31 | B | 1080 | 0.57 | C | 1160 | 0.61 | D |
| Westbound | 2900 | 1060 | 0.37 | B | 1130 | 0.39 | B | 830 | 0.28 | B | 910 | 0.31 | B |
| **Burnt Bridge Creek Deviation west of Condamine Street** | | | | | | | | | | | | | |
| Northbound | 2900 | 1070 | 0.37 | B | 1070 | 0.37 | B | 2040 | 0.70 | D | 2040 | 0.70 | D |
| Southbound | 2900 | 1620 | 0.56 | C | 1620 | 0.56 | C | 1150 | 0.40 | B | 1160 | 0.40 | B |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

### *Impacts on local roads and parking*

All roads in the Balgowlah area that form part of construction vehicle routes are state or regional roads.

The Sydney Road/Maretimo Street intersection would be modified during construction, with an additional approach to allow access to the Balgowlah Golf Course construction support site (BL10) from Sydney Road. Providing traffic signals at the intersection would be beneficial to vehicles performing a right turn into or out of Maretimo Street including to and from the Northern Beaches Secondary College Balgowlah Boys Campus, which currently have to give way to multiple conflicting movements under the priority controlled intersection arrangement. In addition, construction vehicles exiting the temporary construction support site would be required to give way to vehicles turning left from Maretimo Street and would not conflict with vehicles turning right. Traffic movements north-south (and vice versa) through the intersection between Maretimo Street and the Balgowlah Golf Course construction support site (BL10) (and future access road) would not be permitted.

Access to the Kitchener Street construction support site (BL11) to and from the Burnt Bridge Creek Deviation is considered unlikely to result in significant impacts to traffic.

Car parking areas for construction workers would be provided at the Balgowlah Golf Course construction support site (BL10). Therefore, no loss of parking on adjacent local streets is anticipated during construction. Public parking spaces would be removed from the existing Balgowlah Golf Course car park during construction. These spaces are used for both the golf course and for the nearby Balgowlah Oval, but as the golf course would no longer be in operation during construction and alternative parking is available on Pickworth Avenue, impacts would be negligible.

The Spit West Reserve construction support site (BL9) and Kitchener Street construction support site (BL11) would have limited parking for supervision staff. The construction workforce at the Middle Harbour south cofferdam (BL7), Middle Harbour north cofferdam (BL8), Spit West Reserve construction support site (BL9) and Kitchener Street construction support site (BL11) would park at the Balgowlah Golf Course construction support site (BL10) and be transported to the site by shuttle bus (where required). The Spit West Reserve construction support site (BL9) would be accessed from the existing Spit West Reserve entry from Spit Road.

The construction workforce would also be encouraged to use public transport where possible, with key bus corridors (including the Northern Beaches B-Line) including Military Road, Spit Road, Manly Road, Sydney Road, Burnt Bridge Creek Deviation and Condamine Street.

### Impacts on public transport

Impacts on public transport within the Balgowlah and surrounds area are shown in Figure 8-14.

Minor adjustments to bus stops on Sydney Road may be required during construction. As a major bus corridor, bus stops on Sydney Road serve buses that provide connections to Sydney CBD, North Shore, Manly, Brookvale/Dee Why area and Mona Vale. Additional minor adjustments to bus stops may be required on Maretimo Street and would be confirmed during further design development and construction planning. These adjustments may require bus customers to walk small additional distances, slightly increasing their travel times. Disruption to bus customers would be minimised by relocating the bus stops to the closest practical alternative location. Due to the minimal relocation distances, residual impacts would be minor. Any changes to bus stop locations would be communicated to the local community and developed in consultation with relevant stakeholders including other divisions of Transport for NSW.

Construction works would also impact Burnt Bridge Creek Deviation between Sydney Road and Kitchener Street bridge, which is a major bus corridor with bus lanes operating in both directions. The current bus lanes on Burnt Bridge Creek Deviation would operate on temporary alignments near the general traffic lanes. Given that the temporary alignments would be of a similar distance to the current configuration of Burnt Bridge Creek Deviation, impacts on bus travel times would be negligible.

Community and stakeholder consultation would be carried out before the start of works to consult with and inform all road users, including bus operators, of the upcoming network changes and proposed detours.

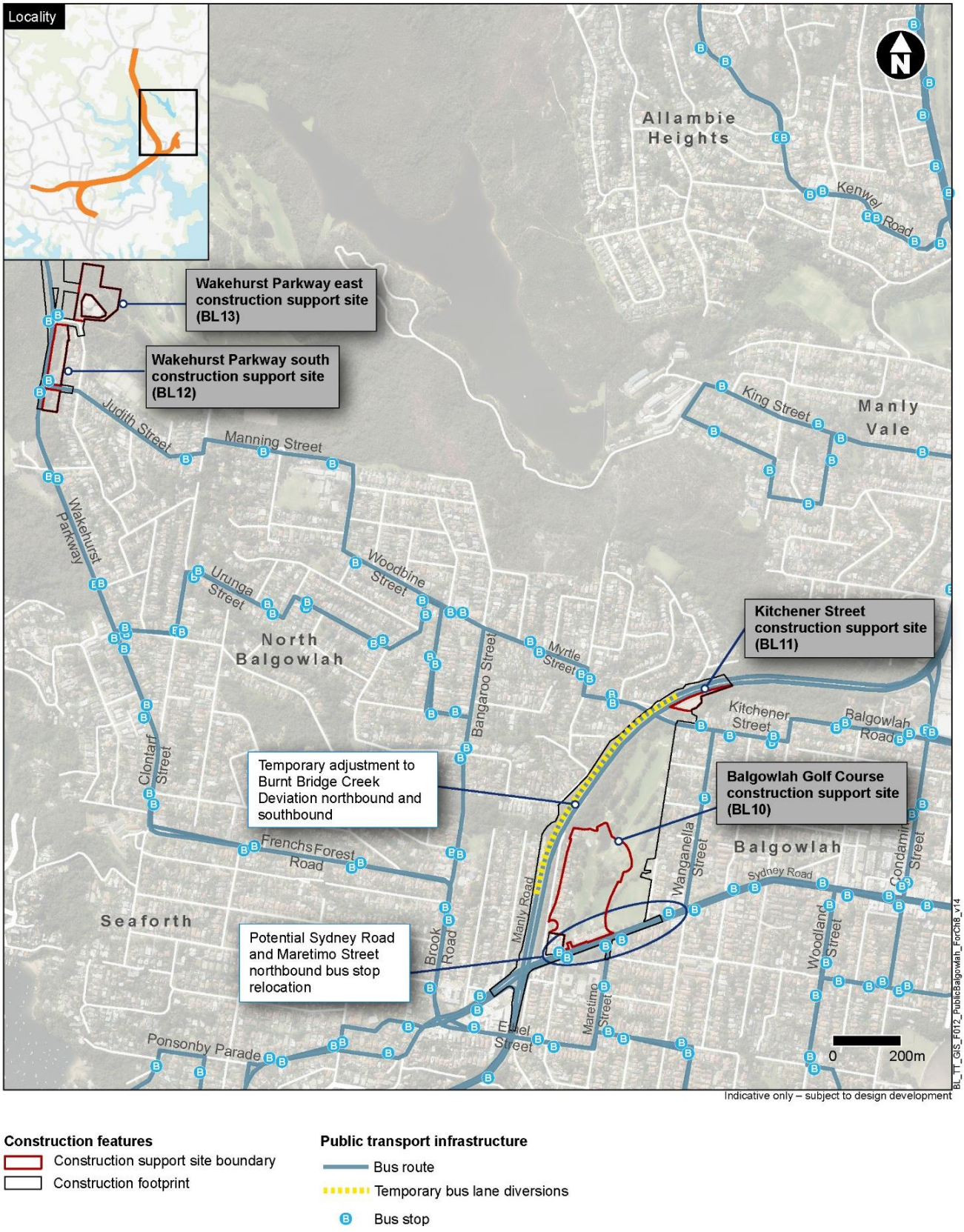



**Figure 8-14 Public transport impacts within Balgowlah and surrounds during construction**

### Impacts on active transport

Impacts on active transport network within the Balgowlah and surrounds area are shown in Figure 8-15.

Changes to the active transport network around Balgowlah during surface works would include:

- Temporary adjustment to paths at Spit West Reserve around the Spit West Reserve construction support site (BL9), specifically Fig Tree Lane, resulting in an increase in travel distance of up to 100 metres, which would be considered a minor impact due to the short detour distance
- A 50 metres temporary shared user path would be constructed within the Balgowlah Golf Course when the shared user path along the existing Burnt Bridge Creek Deviation is adjusted for the box culvert extension and the existing shared user underpass of Burnt Bridge Creek Deviation is extended. The extension of the existing shared user underpass beneath the Burnt Bridge Creek Deviation at Burnt Bridge Creek would be staged to maintain access at all times. Subject to final planning for staging of these works, additional short term detours may be required due to construction access restrictions
- A signalised pedestrian crossing would be provided at the entrance to the Balgowlah Golf Course construction support site (BL10) off Sydney Road via the traffic signals provided for the Sydney Road/Maretimo Street/Access Road intersection. This would ensure safe passage from users of the Sydney Road pedestrian bridge, including students from Northern Beaches Secondary College – Balgowlah Boys Campus, to the Balgowlah Oval.

Impacts on pedestrians and cyclists are expected to be minor given that existing connectivity would be maintained and additional travel distances via the temporary shared user path would be minimal. Appropriate linemarking and signage would be used to identify diversions and, where required, traffic controllers would ensure safe passage for users.

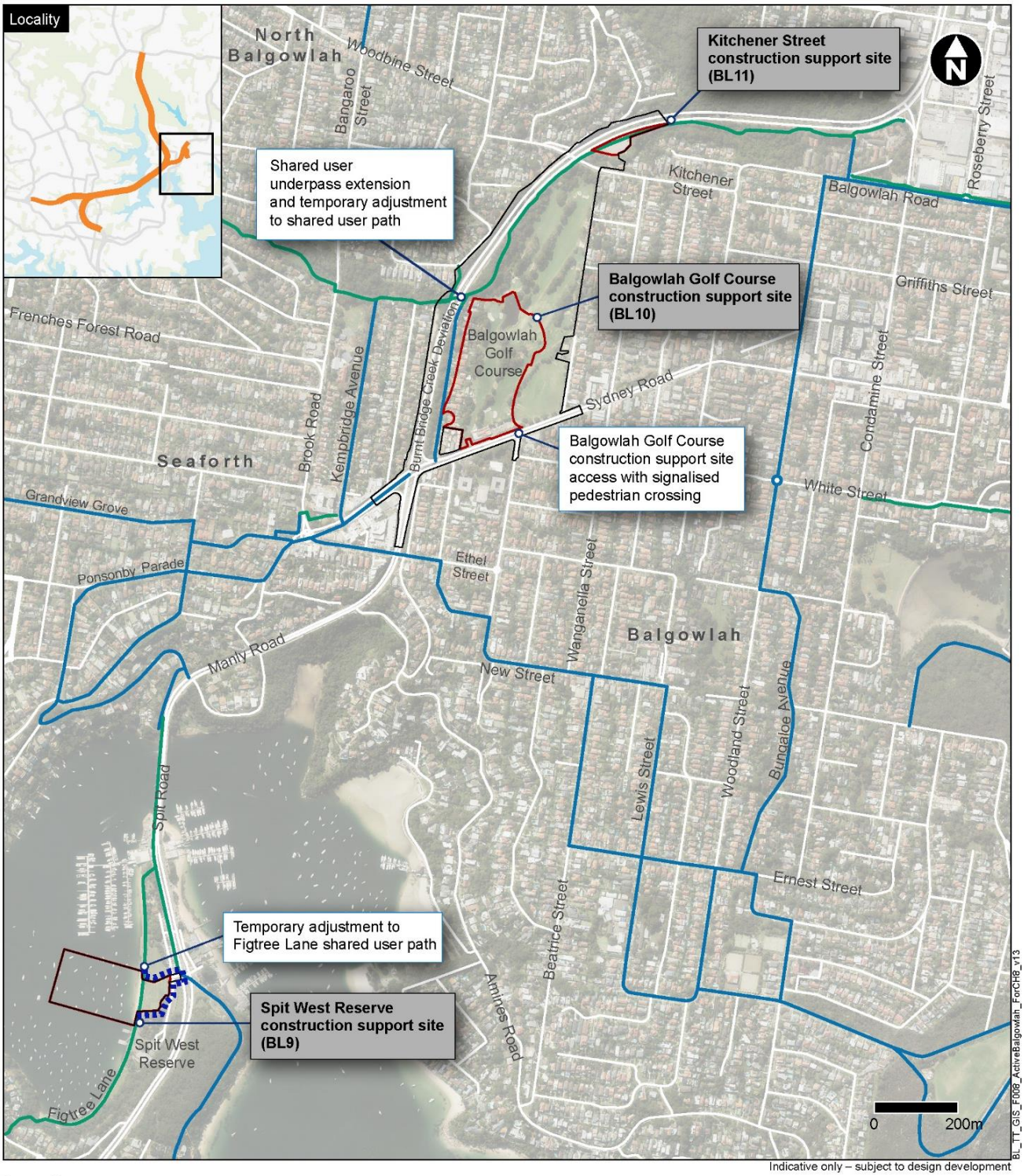



**Figure 8-15 Active transport impacts within Balgowlah and surrounds during construction**

### 8.4.5 Frenchs Forest and surrounds

#### Road network impacts

The anticipated routes to and from the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites within the Frenchs Forest area and surrounds are summarised in Chapter 6 (Construction work), along with the respective daily maximum construction vehicle volumes.

##### *Intersection and midblock performance with construction traffic*

The performance of intersections within the Frenchs Forest and surrounds area with the introduction of construction traffic would generally remain the same as under conditions without the project.

The closure of Kirkwood Street to general traffic at its intersection with Wakehurst Parkway is predicted to result in a redistribution of traffic to Judith Street or Burnt Street. Given the relative difficulty in performing a right turn manoeuvre out of Judith Street across Wakehurst Parkway, the assessment has assumed that existing local traffic that currently turns right out of Judith Street and Kirkwood Street would use the traffic signals at Burnt Street instead. The impacts to the performance of the Wakehurst Parkway/Judith Street intersection are considered negligible and would worsen from LoS B to LoS C during the AM peak, however would improve from LoS D to LoS C in the PM peak.

The performance of the Wakehurst Parkway/Burnt Street intersection during construction would continue to operate at an acceptable level of service notwithstanding the small volume of additional detoured vehicles generated by the changes described above.

A new intersection with traffic signals would be constructed to provide access to the Wakehurst Parkway east construction support site (BL13). During construction, this intersection would operate at LoS C during the AM peak and LoS A during the PM peak.

With construction traffic included on the road network, the Wakehurst Parkway/Warringah Road intersection would continue to operate at LoS D during the AM peak and LoS E during the PM peak, taking into account the opening of the underpass arrangements along Warringah Road as part of the Northern Beaches Hospital road upgrade project. During the PM peak the intersection is forecast to continue to operate close to capacity. The remainder of intersections in the Frenchs Forest and surrounds area would not experience a change in level of service as a result of the construction of the project.

The intersection performance results for the road network operating under the worst case construction traffic scenario (2024) are summarised in Table 8-21 during the AM and PM peak periods.

**Table 8-21 Modelled intersection performance in Frenchs Forest and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Intersection/peak period | Base case 2024 (without construction traffic) | | | | Construction case 2024 (with construction traffic) | | | |
|---|---|---|---|---|---|---|---|---|
| | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C | Demand flow (vehicles per hour) | Average delay (seconds) | LoS | V/C |
| **Wakehurst Parkway/Burnt Street/Seaforth Oval car park** | | | | | | | | |
| AM peak | 1160 | 7 | A | 0.42 | 1470 | 21 | B | 0.67 |
| PM peak | 1430 | 6 | A | 0.47 | 1610 | 17 | B | 0.60 |
| **Wakehurst Parkway/Judith Street/BL12 construction support site access** | | | | | | | | |
| AM peak | 1520 | 27 | B | 0.76 | 1640 | 30 | C | 0.51 |
| PM peak | 1800 | 49 | D | 0.82 | 1870 | 33 | C | 0.53 |
| **Wakehurst Parkway/Kirkwood Street/BL12 construction support site access** | | | | | | | | |
| AM peak | 1470 | 52 | D | 0.65 | 1510 | 45 | D | 0.46 |
| PM peak | 1670 | 71 | **F** | 0.54 | 1710 | 59 | **E** | 0.44 |
| **Wakehurst Parkway/ BL13 construction support site access** | | | | | | | | |
| AM peak | - | - | - | - | 1580 | 30 | C | 0.91 |
| PM peak | - | - | - | - | 1810 | 11 | A | 0.70 |
| **Wakehurst Parkway/Warringah Road** | | | | | | | | |
| AM peak | 4080 | 43 | D | 0.79 | 4220 | 44 | D | 0.86 |
| PM peak | 4770 | 57 | **E** | 0.95 | 4940 | 69 | **E** | 1.00 |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

The midblock performance during construction would be comparable to conditions without the project at all locations, except for:

- Wakehurst Parkway north of Judith Street in the northbound direction would change from LoS E to LoS F during AM peak and PM peak
- Wakehurst Parkway north of Kirkwood Street in the northbound direction would change from LoS E to LoS F during AM peak and PM peak
- Wakehurst Parkway north of Kirkwood Street in the southbound direction would change from LoS E to LoS F during PM peak.

Wakehurst Parkway north of Judith Street and north of Kirkwood Street is already operating close to LoS E/F. A small increase in traffic volume and volume to capacity ratio due to construction vehicles and general traffic diverted due to the temporary long-term closure of Kirkwood Street would not have any major additional impact on traffic performance.

The midblock performance results for the road network operating under the worst case construction traffic scenario during the AM and PM peak hours are summarised in Table 8-22.

**Table 8-22 Modelled midblock performance in Frenchs Forest and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2024)**

| Location/ direction | Capacity (PCU) | AM Peak | | | | | | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | | Base case 2024 (without construction traffic) | | | Construction 2024 (with construction traffic) | | |
| | | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS | Volume (PCU) | V/C | LoS |
| **Wakehurst Parkway north of Judith Street** | | | | | | | | | | | | | |
| Northbound | 900 | 880 | 0.97 | E | 970 | >1 | F | 860 | 0.96 | E | 910 | >1 | F |
| Southbound | 900 | 670 | 0.74 | D | 690 | 0.77 | D | 910 | >1 | F | 930 | >1 | F |
| **Wakehurst Parkway north of Kirkwood Street** | | | | | | | | | | | | | |
| Northbound | 900 | 900 | 1.00 | E | 960 | >1 | F | 830 | 0.92 | E | 920 | >1 | F |
| Southbound | 900 | 630 | 0.70 | D | 700 | 0.77 | D | 860 | 0.96 | E | 950 | >1 | F |
| **Warringah Road west of Wakehurst Parkway[2]** | | | | | | | | | | | | | |
| Eastbound | 3900 | 1670 | 0.43 | C | 1,750 | 0.45 | C | 1940 | 0.50 | C | 2030 | 0.52 | C |
| Westbound | 2900 | 620 | 0.21 | A | 710 | 0.24 | A | 1410 | 0.49 | C | 1510 | 0.52 | C |
| **Warringah Road east of Wakehurst Parkway[2]** | | | | | | | | | | | | | |
| Eastbound | 2900 | 710 | 0.24 | A | 720 | 0.25 | A | 580 | 0.20 | A | 590 | 0.20 | A |
| Westbound | 2900 | 620 | 0.21 | A | 620 | 0.21 | A | 1030 | 0.36 | B | 1030 | 0.36 | B |

Note 1: Cells shaded in dark grey denote an unsatisfactory LoS E or F
Note 2: Assumed capacity on Warringah Road refers to capacity on the surface lanes adjacent to the Wakehurst Parkway intersection. Eastbound capacity on Warringah Road west of Wakehurst Parkway is greater than the eastbound capacity east of Wakehurst Parkway due to the presence of the additional short right-turn lanes.

### *Impacts on local roads and parking*

The closure of the northern section of Kirkwood Street would be required during construction to accommodate the Wakehurst Parkway south construction support site (BL12) and associated construction activities. The impact on diverted vehicles would be minor given that several nearby alternative local roads are available, including Judith Street and Burnt Street. Access to the properties owned by Sydney Water and Telstra would also be slightly impacted, with vehicles required to access the properties via Judith Street and Kirkwood Street south.

Spoil trucks exiting the Wakehurst Parkway east construction support site (BL13) would be required to travel north on Wakehurst Parkway, minimising the impact of spoil truck movements on surrounding local roads. Spoil trucks would not be permitted to travel south through Frenchs Forest Road and Sydney Road.

Allambie Road (north of Warringah Road) and Frenchs Forest Road east are local roads that would act as part of the egress route from the Wakehurst Parkway north construction support site (BL14). Minor impacts are anticipated on these roads given the low number of construction vehicle movements of about 90 light vehicle and 50 heavy vehicle movements (egress only) per day.

Blasting may be required along Wakehurst Parkway and would require the short-term closure (up to 10 minutes) of sections of Wakehurst Parkway to general traffic. Any road closures would be carried out under traffic control and outside peak periods to ensure safety and minimise disruption to the road network.

Car parking areas for construction workers would be provided at the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites. Worker parking would be maximised within the constraints of the respective temporary construction support site. Parking for site vehicles associated with the realignment and upgrade of the Wakehurst Parkway would be managed as the works sites move and would be contained within the relevant work sites. The number of car parking spaces would be determined during construction planning.

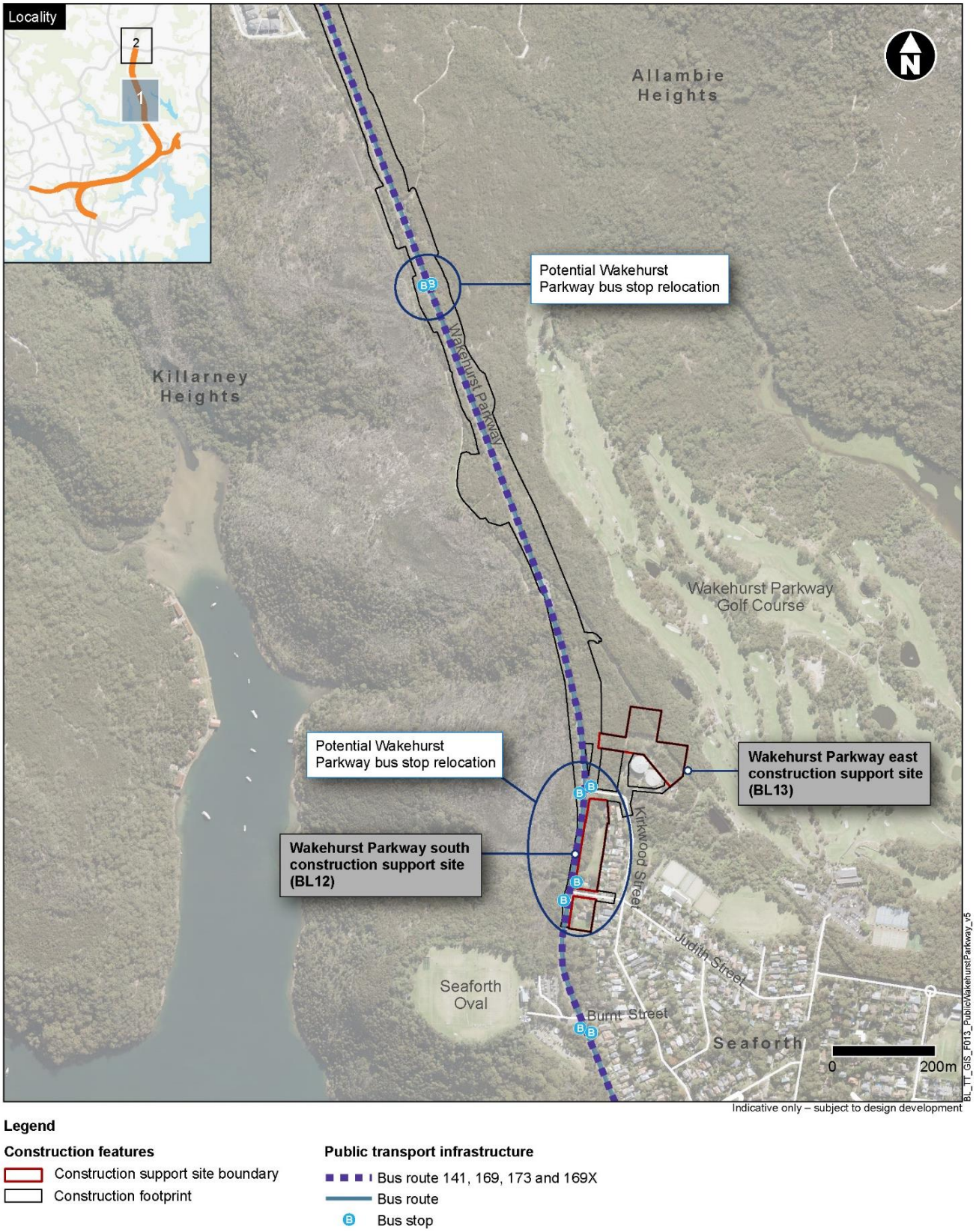
Notwithstanding, the construction workforce would be encouraged to use public transport where feasible, with key bus corridors including Warringah Road and Forest Way. Where public transport availability to temporary construction support sites is limited, shuttle bus transfers may also be provided from public transport centres where required.

### Impacts on public transport

Impacts on public transport within the Frenchs Forest and surrounds area are shown in Figure 8-16 and Figure 8-17.

Bus stops within the construction footprint along Wakehurst Parkway in Seaforth, Killarney Heights and Frenchs Forest would be temporarily relocated during construction. This includes bus stops for bus services operating along Wakehurst Parkway (routes 141, 169, 173 and 169X) which provide connections to Austlink Corporate Centre, Narraweena, Manly and Sydney CBD. Adjustments to bus stops may require bus customers to walk small additional distances which would slightly increase their travel times. Bus stops would be relocated as close as practical to their existing positions to minimise disruption. As such, these impacts are expected to be minor.

Other bus stops on adjacent roads may also require temporary relocation during construction. This would be determined during construction staging and planning in consultation with relevant stakeholders, including other divisions of Transport for NSW, and advanced notification would be provided to affected bus customers. Bus stops would be relocated within walking distance of their existing position to minimise disruption where reasonable and feasible.




**Legend**

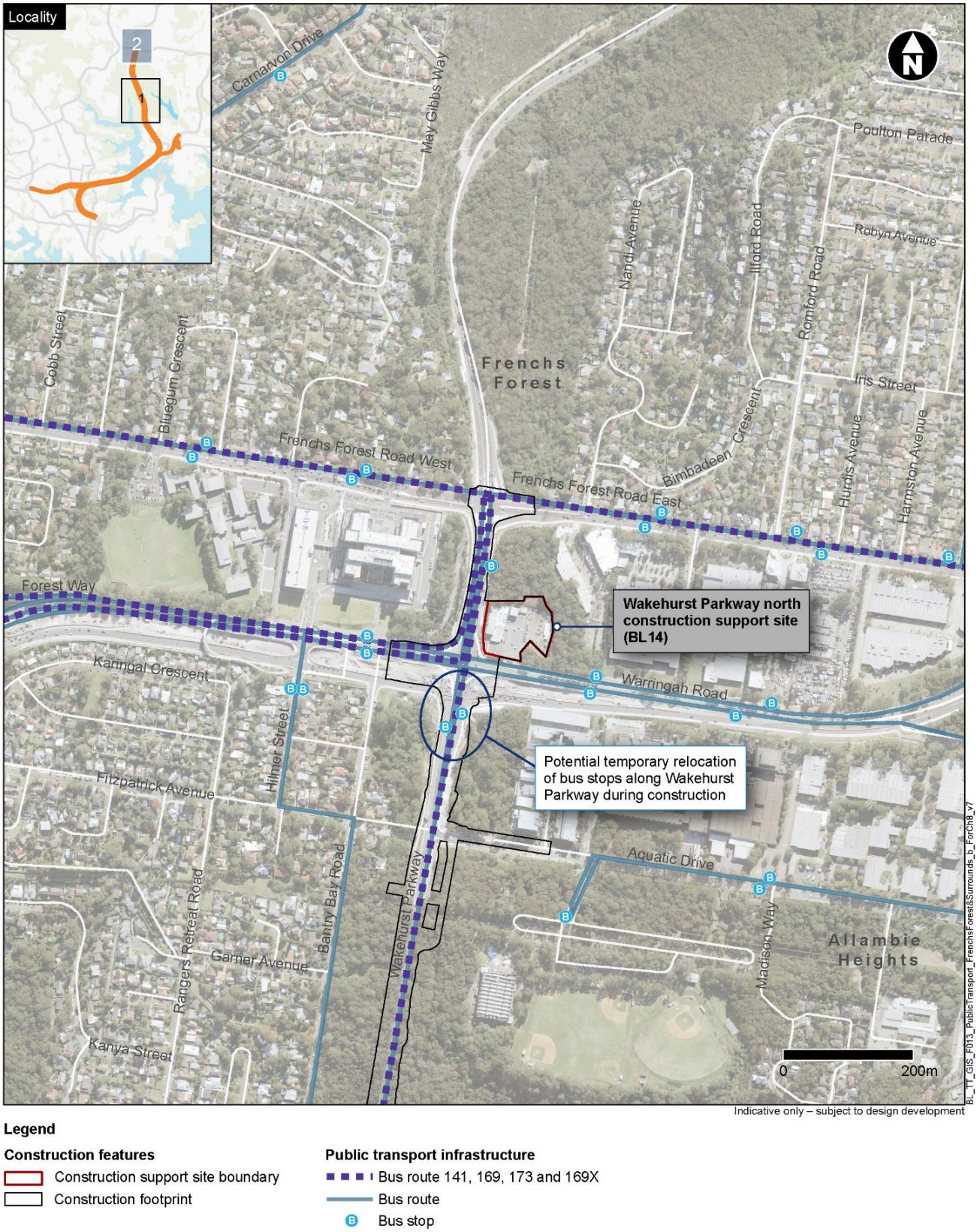
**Construction features**

- Construction support site boundary
- Construction footprint

**Public transport infrastructure**

- Bus route 141, 169, 173 and 169X
- Bus route
- Bus stop

**Figure 8-16 Public transport impacts within Frenchs Forest and surrounds (southern area) during construction (map 1)**




**Legend**

**Construction features**

- Construction support site boundary
- Construction footprint

**Public transport infrastructure**

- Bus route 141, 169, 173 and 169X
- Bus route
- Bus stop

**Figure 8-17 Public transport impacts within Frenchs Forest and surrounds (northern area) during construction (map 2)**

### Impacts on active transport

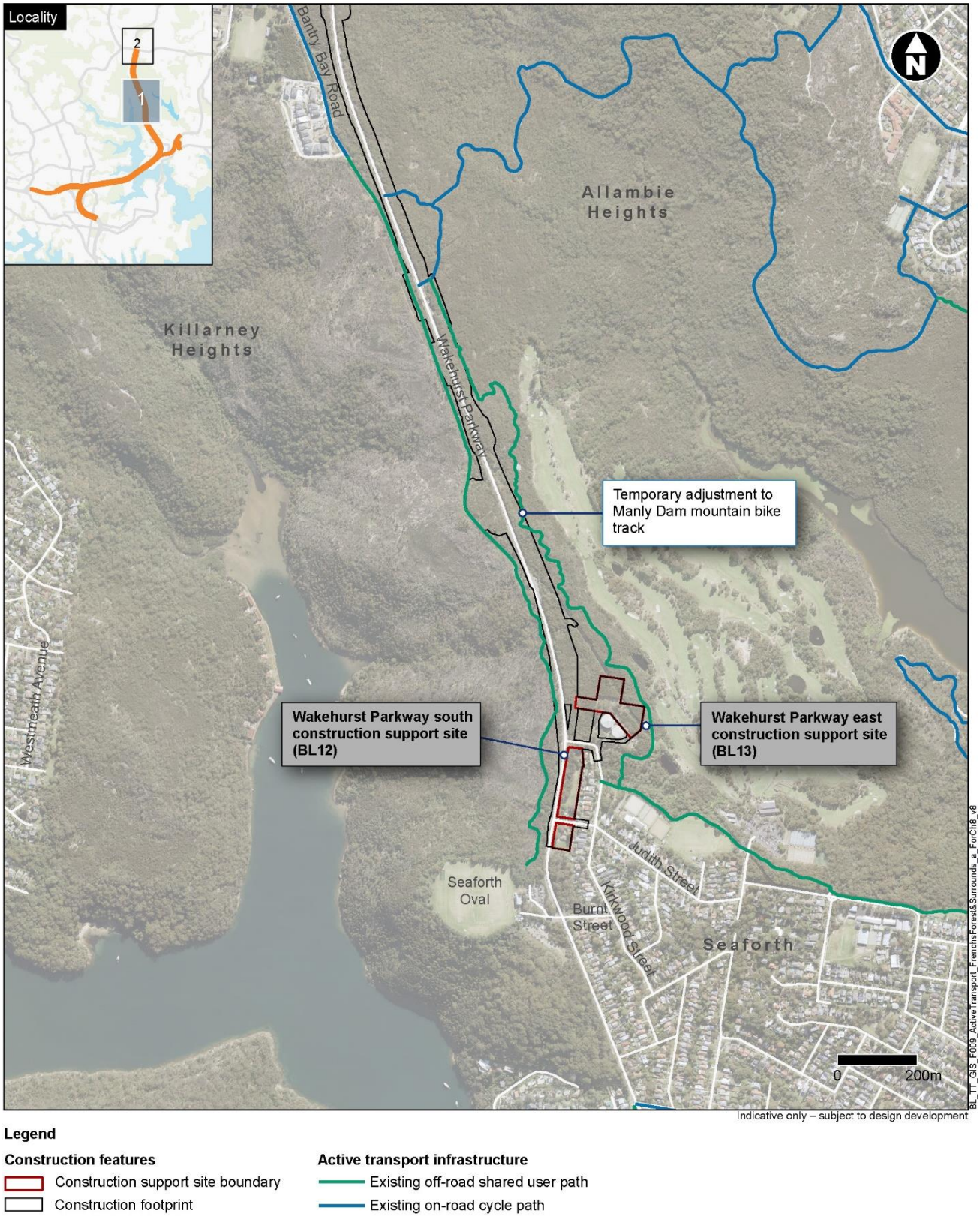
Impacts on active transport network within the Frenchs Forest and surrounds area are shown in Figure 8-18 and Figure 8-19.

New traffic lights would be installed to provide access to the Wakehurst Parkway east construction support site (BL13). Conflicts between pedestrians and cyclists using the footpath near this site and construction vehicles would be managed through the control of movements at the site entry/exit.

Temporary adjustment of some of the mountain bike tracks on either side of Wakehurst Parkway may be required. Minor detour routes would be implemented, and advanced notification of track closures provided at key locations. Construction of the three permanent shared user path underpasses along Wakehurst Parkway would be prioritised where feasible.

The existing shared user path adjacent to the Wakehurst Parkway north construction support site (BL14) would also be temporarily impacted during the use of the site. Affected areas would include the off-road shared user paths along Wakehurst Parkway, north of Warringah Road which may require minor detours. Pedestrian and cyclist access would be maintained during construction and the increase in travel distance would be negligible.

Additionally, the shared user path bridge over Wakehurst Parkway connecting the Warringah Aquatic Centre and Bantry Bay Road would be demolished and a new and lengthened replacement overpass constructed as part of the project. Construction would be staged to ensure pedestrian and cyclist access over Wakehurst Parkway would be maintained at all times.




**Legend**

**Construction features**

- Construction support site boundary
- Construction footprint

**Active transport infrastructure**

- Existing off-road shared user path
- Existing on-road cycle path

**Figure 8-18 Active transport impacts within Frenchs Forest and surrounds (southern area) during construction (map 1)**

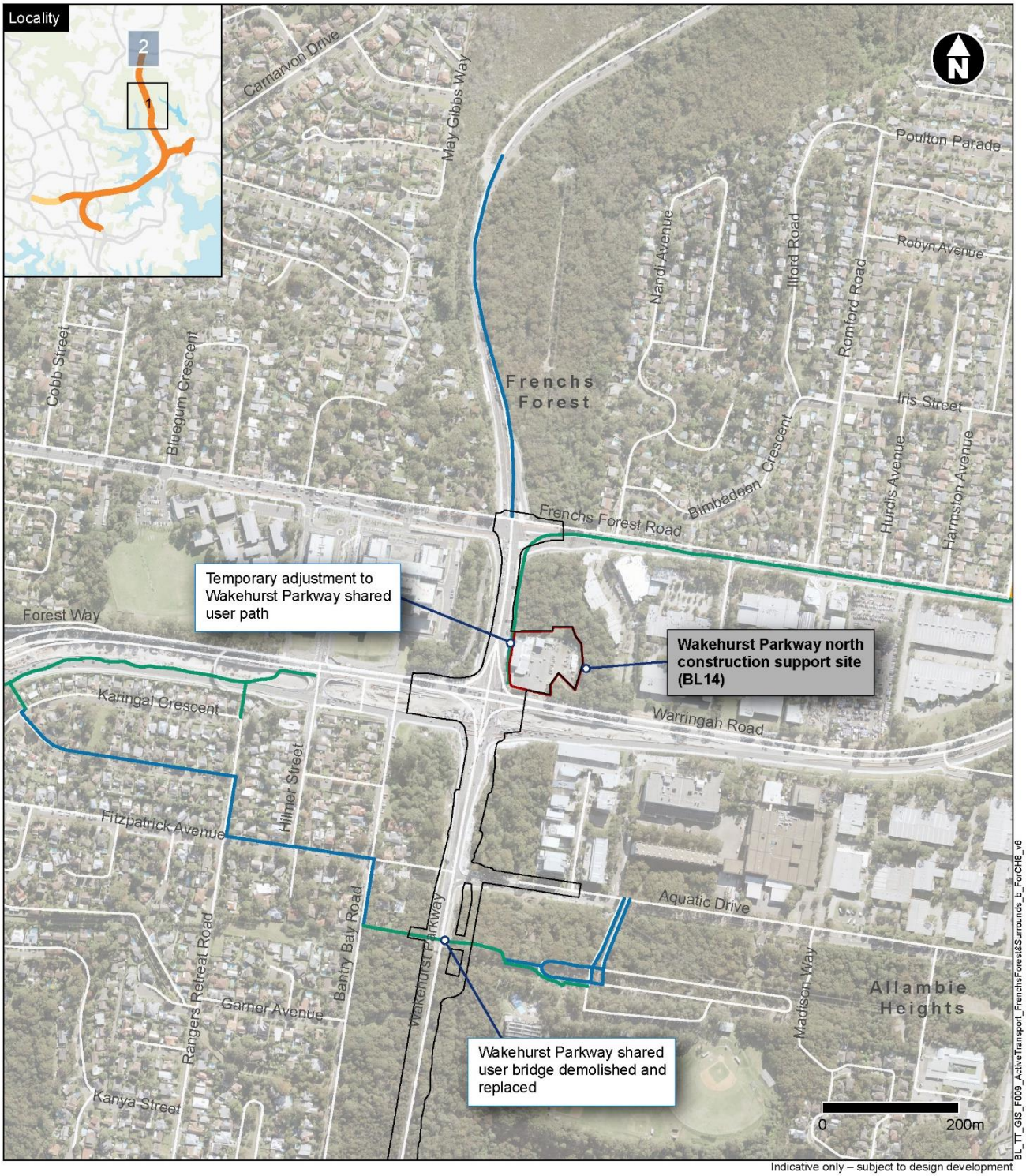



**Figure 8-19 Active transport impacts within Frenchs Forest and surrounds (northern area) during construction (map 2)**

### 8.4.6 Cumulative impacts of the project and the Western Harbour Tunnel and Warringah Freeway Upgrade project (Warringah Freeway and surrounds)

Peak cumulative construction traffic is expected in 2024, if construction of the project and the Western Harbour Tunnel and Warringah Freeway Upgrade project (subject to separate assessment and approval) are carried out concurrently.

#### Road network performance

Analysis of network performance in the AM and PM peak periods with the project and the Western Harbour Tunnel and Warringah Freeway Upgrade project indicates that, when compared to forecast 2024 peak period without the project conditions, cumulative construction activities in the Warringah Freeway and surrounds area have the potential to:

- Increase traffic demand by about one per cent
- Create less than one additional stop per trip
- Reduce average trip speeds by about four per cent.

Cumulative construction activities are therefore only expected to have minor and manageable impacts on overall network performance in the area.

#### General travel times

Modelled travel times during AM and PM peaks for key routes relevant to the project are presented in Table 8-23.

Under the cumulative construction 2024 scenario, travel times would increase by less than one minute for most routes. Predicted travel time increases between one and three minutes are expected for the following routes:

- Warringah Freeway: Gore Hill Freeway to Sydney Harbour Bridge (AM peak)
- Warringah Freeway: Gore Hill Freeway to Sydney Harbour Tunnel (AM peak)
- Warringah Freeway: Falcon Street to Sydney Harbour Bridge (PM peak)
- Miller Street: Amherst Street to Berry Street (AM peak)
- Miller Street: Berry Street to Amherst Street (PM peak).

**Table 8-23 Modelled AM and PM peaks traffic travel times for key routes relevant to the project**

| Route/ Peak period | Direction | Base case 2024 (without construction traffic) (minutes : seconds) | Cumulative construction 2024 (with construction traffic) (minutes : seconds) |
|---|---|---|---|
| **Sydney Harbour Bridge to Warringah Freeway/Falcon Street interchange** | | | |
| AM peak | Northbound | 04:42 | 04:39 |
| | Southbound | 04:02 | 04:01 |
| PM peak | Northbound | 03:43 | 03:45 |
| | Southbound | 04:16 | 05:32 |
| **Sydney Harbour Tunnel to Warringah Freeway/Falcon Street interchange** | | | |
| AM peak | Northbound | 03:51 | 03:57 |
| | Southbound | 04:06 | 04:03 |

| Route/ Peak period | Direction | Base case 2024 (without construction traffic) (minutes : seconds) | Cumulative construction 2024 (with construction traffic) (minutes : seconds) |
|---|---|---|---|
| PM peak | Northbound | 03:36 | 03:42 |
| | Southbound | 14:27 | 15:05 |
| **Sydney Harbour Bridge to Gore Hill Freeway/Pacific Highway interchange** | | | |
| AM peak | Northbound | 06:13 | 06:13 |
| | Southbound | 08:48 | 10:53 |
| PM peak | Northbound | 05:31 | 05:59 |
| | Southbound | 16:15 | 16:13 |
| **Sydney Harbour Tunnel to Gore Hill Freeway/Pacific Highway interchange** | | | |
| AM peak | Northbound | 05:22 | 05:28 |
| | Southbound | 08:50 | 11:21 |
| PM peak | Northbound | 05:19 | 06:01 |
| | Southbound | 19:51 | 20:20 |
| **Berry Street to Amherst Street via Miller Street** | | | |
| AM peak | Northbound | 04:10 | 04:05 |
| | Southbound | 07:48 | 09:22 |
| PM peak | Northbound | 04:34 | 05:36 |
| | Southbound | 13:45 | 10:39 |

As shown in Table 8-23, for Miller Street southbound the base case was observed to experience longer travel times in comparison to the 2024 cumulative construction scenario. Falcon Street/Military Road westbound between Ben Boyd Road and Miller Street is predicted experience a slight increase in congestion in the 2024 cumulative construction scenario when compared to the 2024 base case resulting in less throughput and delays at the Falcon Street left turn onto Miller Street. As the performance of the Miller Street corridor is sensitive to the traffic arrival rates from side streets, this reduction in throughput results in the observed improvement to the Miller Street southbound travel time in the 2024 cumulative construction scenario.

### Intersection performance

The intersection performance results for the road network under the ‘Base case 2024’ (without construction vehicles) and ‘Cumulative construction 2024’ (with construction vehicles and proposed intersection modifications during construction) scenarios are detailed in Appendix F (Technical working paper: Traffic and transport) for the AM and PM peak periods.

In summary, the addition of construction traffic for both projects would impact the level of service at the following intersections:

- Willoughby Road/Gore Hill Freeway interchange would be reduced from LoS E to LoS F during the AM peak, and from LoS C to LoS D during the PM peak
- Brook Street/Warringah Freeway off ramp would be reduced from LoS E to LoS F during the AM peak
- Amherst Street/West Street would be reduced from LoS A to LoS B during the PM peak
- Amherst Street/Miller Street would be reduced from LoS B to LoS C during the PM peak

- Miller Street/Warringah Freeway off ramp would be reduced from LoS A to LoS C during the AM peak
- Miller Street/Falcon Street would be reduced from LoS D to LoS E during the AM peak
- Military Road/Ben Boyd Road would be reduced from LoS C to LoS D during the PM peak
- Mount Street/Arthur Street would be reduced from LoS E to LoS F during the PM peak
- Pacific Highway/Berry Street would be reduced from LoS B to LoS C during the PM peak
- Pacific Highway/Bay Road would be reduced from LoS E to LoS F during the AM peak
- High Street/Alfred Street North would be reduced from LoS A to LoS B during the AM peak
- Ernest Street/Ben Boyd Road would be reduced from LoS C to LoS D during the AM peak, and from LoS A to LoS B during the PM peak.

During the AM peak, intersections which would experience a material increase in average vehicle delay (around 30 to 40 seconds) during construction include Willoughby Road/Gore Hill Freeway interchange, intersection of Brook Street and Merrenburn Avenue and Brook Street/Warringah Freeway ramp.

During the PM peak, some intersections within the North Sydney area would experience a minor increase in average vehicle delay.

### Road network changes and access arrangements

The Cammeray Golf Course construction support site (BL1) would be used for the Beaches Link and Gore Hill Freeway Connection project and the Western Harbour Tunnel and Warringah Freeway Upgrade project (subject to separate assessment and approval). This would result in cumulative traffic volumes generated to and from this site. The potential for cumulative travel impacts associated within these projects, including haulage roads and intersections traversed by construction vehicles during concurrent works, has been assessed in this section. If both projects are under construction concurrently, works at the Cammeray Golf Course construction support site (BL1) would be planned and programmed to manage any overlap between the two projects and minimise impacts on the surrounding road network and road users.

### Impacts on public transport

In relation to bus times, cumulative construction activities in the Warringah Freeway and surrounds have the potential to impact corridor travel times by less than one minute for most routes. However, when compared to forecast 2024 peak period base conditions, there would be an increase in travel times between one and three minutes for the following routes:

- Southbound via Miller Street to the Sydney Harbour Bridge (AM peak)
- Northbound via the Warringah Freeway and Military Road to Ben Boyd Road (PM peak).

The most substantial potential impact is on southbound travel times via the Warringah Freeway. For Warringah Freeway routes, increased traffic demand, including potential additional traffic movements across the southbound bus lane south of Falcon Street, could increase congestion, which could impact bus travel times. This issue would be mitigated by considered and tailored construction traffic planning based on actual traffic conditions and confirmed cumulative activities at the time of construction.

### Impacts on active transport and maritime activities

Impacts on active transport and maritime activities would be similar to those discussed in each of the sections above given the minimal overlap in construction activities associated with this project and the Western Harbour Tunnel and Warringah Freeway Upgrade project.

### 8.4.7 Cumulative impacts of the project and other projects

Peak construction activity for the project would not overlap with peak construction activities for other committed major infrastructure projects such as Sydney Metro City & Southwest and the M4-M5 Link.

There is potential for some overlap with the construction of the Sydney Metro West or other major projects within the Sydney metropolitan area, including the Channel 9 site staged residential development. Spoil trucks and other construction vehicles associated with these projects have the potential to generate cumulative impacts on the broader road network. Overall, given that spoil trucks for the project and any overlapping major projects would predominantly use only major arterial roads, potential cumulative impacts would be minor.

### 8.4.8 Special events impacts

Construction works would have minimal impacts on special events as the temporary construction support sites and traffic routes would not be located near venues or locations that regularly schedule events that require traffic or public transport event plans.

Water based races within Middle Harbour held by the recreational clubs along the foreshore may be impacted by marine construction traffic, as identified in Section 8.4.3.

## 8.5 Environmental management measures

Environmental management measures relating to construction traffic and transport impacts are outlined in Table 8-24. Environmental management measures relating to cumulative impacts, including coordination of haulage routes and road occupancy, are detailed in Chapter 27 (cumulative impacts).

**Table 8-24 Environmental management measures - construction traffic and transport**

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| CTT1 | Pre-construction | Construction traffic | A road condition report will be prepared, in consultation with relevant councils and road owners, identifying existing conditions of local roads that will be used by heavy vehicles associated with the project and mechanisms to repair damage to the road network (beyond normal wear and tear) caused by these movements. | BL/GHF |
| CTT2 | Pre-construction | Maritime construction | Transport for NSW will consult with the owners and/or leaseholders and/or licence holders of jetties and moorings that require temporary relocation to determine alternative arrangements. Moorings impacted during construction will be temporarily relocated elsewhere in Middle Harbour in consultation with the lease holder(s) and coordination with the Port Authority of NSW. All efforts will be made to relocate facilities as close to their original locations as possible. Impacted mooring licence holders may be entitled to a fee waiver or fee reimbursement where appropriate. | BL |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| CTT3 | Construction | Maritime construction traffic | Construction vessels will be required to operate in a manner that minimises wash to areas of shoreline. | BL |
| CTT4 | Construction | Maritime construction traffic | Construction marine traffic activities will be scheduled to avoid times and locations of high recreational marine traffic where feasible and reasonable. | BL |
| CTT5 | Construction | Maritime construction traffic | Harbour closures scheduling will be carried out in consultation with Port Authority of NSW, other divisions of Transport for NSW and other relevant stakeholders. | BL |
| CTT6 | Construction | Construction traffic | Ongoing consultation, as relevant to the location, will be carried out with Greater Sydney Operations, the Port Authority of NSW, local councils, emergency services and bus operators to minimise traffic and transport impacts. | BL/GHF |
| CTT7 | Construction | Construction traffic | The community will be notified in advance of proposed transport network changes, and maritime restrictions through appropriate media and other appropriate forms of community liaison. | BL/GHF |
| CTT8 | Construction | Construction traffic | Construction road traffic will be managed to minimise impacts of movements during peak periods where feasible and reasonable. | BL/GHF |
| CTT9 | Construction | Construction traffic | Vehicle movements to and from construction sites will be managed to ensure pedestrian, cyclist and road user safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasion, police presence. | BL/GHF |
| CTT10 | Construction | Construction traffic | Directional signage, barriers and/or linemarking will be used as required to direct and guide motorists, cyclists and pedestrians past construction sites and on the surrounding network. This will be supplemented by Variable Message Signs to advise all road users of potential delays, traffic diversions, speed restrictions or alternative routes. | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| CTT11 | Construction | Construction traffic | Where provision of construction on-site parking cannot accommodate the full construction workforce, construction worker parking will be actively managed to minimise impacts on parking on local roads. Depending on the location, this will include encouraging the use of public transport and may include provision of shuttle buses for workforce transport where appropriate. | BL/GHF |
| CTT12 | Construction | Construction traffic | Any adjustments to existing bus stops will be determined in consultation with relevant stakeholders including other divisions of Transport for NSW and advanced notification would be provided to affected bus customers. Relocations will be as close to their existing position where feasible and reasonable. | BL/GHF |
| CTT13 | Construction | Construction traffic | Truck marshalling areas will be identified and used where feasible and reasonable, to minimise potential queueing and traffic and access disruptions in the vicinity of construction support sites. | BL/GHF |
| CTT14 | Construction | Construction traffic | Activities requiring temporary partial road closures will be carried out outside of peak periods and/or during night time to minimise the impact of these activities on the road network where feasible and reasonable. | BL/GHF |
| CTT15 | Construction | Construction traffic | Direct impacts to existing pedestrian and cycling facilities will be minimised where reasonable and feasible. Any detours and adjustments will be designed with consideration of user safety and convenience. | BL/GHF |
| CTT16 | Construction | Maritime construction impacts | Consultation will be carried out with surrounding water based users of Middle Harbour including Mosman Rowing Club and Northbridge Sailing Club to minimise construction impacts. | BL |

Note: BL = Beaches Link, GHF = Gore Hill Freeway Connection

NSW GOVERNMENT

Transport for NSW

# Beaches Link and Gore Hill Freeway Connection

## Chapter 9

## Operational traffic and transport

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# 9 Operational traffic and transport

This chapter outlines the potential traffic and transport impacts arising from the operation of the Beaches Link and Gore Hill Freeway Connection and identifies measures which address these impacts. Potential construction traffic and transport impacts are discussed in Chapter 8 (Construction traffic and transport).

A detailed traffic and transport assessment has been carried out for the project and is included in Appendix F (Technical working paper: Traffic and transport).

The Secretary's environmental assessment requirements as they relate to operational traffic and transport, and where in the environmental impact statement these have been addressed, are detailed in Table 9-1.

Avoiding or minimising impacts has been a key consideration throughout the design and development process for the Beaches Link and Gore Hill Freeway Connection project. A conservative approach has generally been used in the assessments, with potential impacts presented before implementation of environmental management measures. The environmental management measures proposed to minimise the potential impacts in relation to operational traffic and transport are included in Section 9.5.

**Table 9-1 Secretary's environmental assessment requirements – operational traffic and transport**

| Secretary's environmental assessment requirements | Where addressed |
|---|---|
| 2. The Proponent must assess and model the operational transport impacts of the project including, but not necessarily limited to:<br>a. forecast travel demand and traffic volumes (expressed in terms of total numbers and heavy and light vehicle numbers) for the project and the surrounding road, cycle and public transport network, including potential shifts of traffic movements on alternate routes outside the proposal area (such as toll avoidance) and impact of permanent street closures directly attributable to the SSI; | Operational traffic and transport impacts for the project and surrounding network are discussed in **Section 9.4**. Further details on forecast traffic volumes and tolling scenarios and implications is provided in **Appendix F** (Technical working paper: Traffic and transport). |
| b. accessibility impacts in commercial centres within the vicinity of the project; | Accessibility impacts are discussed in **Chapter 21** (Socio-economics). Forecast 30-minute catchments by road for strategic centres in the vicinity of the project are provided in **Appendix F** (Technical working paper: Traffic and transport). |
| c. travel time analysis; | An assessment on impacts to travel time is provided in **Section 9.4**. |
| d. performance of key interchanges and intersections by undertaking a level of service analysis at key locations; | Interchange and intersection performance during operation is discussed in **Section 9.4**. |

| Secretary's environmental assessment requirements | Where addressed |
|---|---|
| e. wider transport interactions (local and regional roads, cycling, public and freight transport); | **Chapter 3** (Strategic context and project need) describes the relationship and/or integration of the project with existing and proposed public and freight transport services. **Section 9.1** outlines how the project considers specific transport strategies.<br>**Section 9.4** provides an assessment of future traffic and transport interactions. |
| f. induced traffic and operational implications for existing and proposed public transport (particularly with respect to strategic bus corridors and bus routes and permanent closure/relocation of bus stops) and consideration of opportunities to improve public transport; | Implications and impacts on public transport are described in **Section 9.4**. |
| g. impacts on cyclists and pedestrian access and safety; | Impacts on pedestrians and cyclists, including access and safety, are described in **Section 9.4**. |
| h. property and business access and on street parking; and | Road network changes, operational impacts to parking, and access arrangements are described in **Section 9.4**. Impacts to properties and businesses are detailed in **Chapter 21** (Socio-economics). |
| i. an explanation for the scope of the modelled area, including justification of the nominated boundaries. | The assessment methodology is summarised in **Section 9.2** and outlined in detail in **Appendix F** (Technical working paper: Traffic and transport). |

## 9.1 Strategic transport planning context

Details regarding the project's compatibility with key Australian Government and State strategic planning and transport policies are provided in Chapter 3 (Strategic context and project need).

A summary of more specific transport strategies relevant to the project are provided below.

### 9.1.1 North Sydney Integrated Transport Program

The *North Sydney Integrated Transport Program* (NSITP or the North Sydney Program) is a multi-agency collaboration between Transport for NSW, North Sydney Council, Greater Sydney Commission and Government Architect of NSW, to guide future integrated transport planning and investment in the North Sydney CBD and interconnected areas over the next 20 years and beyond. Led by Transport for NSW since 2018, it aims to deliver a shared place-based vision for the North Sydney CBD.

The North Sydney Program is being developed to support and facilitate the outcomes envisaged by the *Greater Sydney Region Plan* (Greater Sydney Commission, 2018a) and *Future Transport Strategy 2056* (NSW Government, 2018). The timing for deliverables in the North Sydney Program would be cognisant of the Western Harbour Tunnel and Beaches Link program of works delivery timeframes.

The North Sydney Program considers strategic public transport connections to the North Sydney CBD, land use and public domain objectives, improved pedestrian amenity and safety, road network changes, improved access for cyclists to and through the CBD, convenient interchanges between bus and rail services, management of kerbside access to support business activity across the day, and place outcomes within the CBD. As such, a key focus of the North Sydney Program is to ensure major projects, such as the Western Harbour Tunnel and Beaches Link program of works, integrate with the North Sydney CBD in a manner that supports the globally connected 'Harbour CBD' and enables delivery of befitting place-based outcomes.

The development of the North Sydney Program is ongoing, with validation of the vision for North Sydney currently underway with several scenarios being considered to support the place-based outcomes. As part of the collaboration, the multi-agency group will ensure the future integrated transport network and place-based vision for North Sydney is supported through projects such as the Beaches Link and Gore Hill Freeway Connection project. Further refinements to movement and place outcomes within the North Sydney CBD may occur as part of the North Sydney Program.

To minimise the impact of the Western Harbour Tunnel and Beaches Link program of works on the North Sydney CBD, planning and design to date has been developed to:

- Continue to provide motorway access only via existing major road corridors
- Focus on the utilisation of existing road space to maintain network efficiency and balance the needs of all road users while minimising road widenings
- Ensure operational impacts are minimised (and critical performance issues avoided), by spreading the demand generated by new infrastructure across multiple locations
- Provide network efficiencies and safer outcomes by simplifying network operations, prioritising strategic movements, and minimising conflicts
- Adopt 'movement and place' principles to help reprioritise access and support efficient connections for traffic, pedestrians, and other transport customers.

The proposed network integration works would result in a resilient network that can accommodate key road transport customers, while at the same time promoting walking, cycling and public transport access to and within the North Sydney CBD. In the event that road transport demand is lower or demands otherwise differ as land use and transport developments mature, this approach would also provide flexibility to adjust the future transport network in response to customer needs.

Transport for NSW will continue to work with North Sydney Council and key stakeholders through agreed governance structures to investigate options to improve movement and place outcomes though the North Sydney Program, further leveraging the strategic benefits of the Western Harbour Tunnel and Beaches Link program of works.

### 9.1.2 Northern Beaches Hospital Precinct Structure Plan

The *Northern Beaches Hospital Precinct Structure Plan* (Northern Beaches Council, 2017b) defines the desired future land uses and consequent multi-modal transport operation and infrastructure requirements to, from and through Frenchs Forest. The plan also acknowledges that a suite of regional transport network upgrades including both public transport and road upgrades would be required to maintain effective transport connections to, from and through Frenchs Forest in the medium to long term.

The project would support the implementation of the plan through supporting medium to long term growth in the area (including a proposed 5360 new dwellings in the next 20 years) by providing a new, safe high-speed road link between the precinct and broader metropolitan Sydney and removing North Sydney and Sydney CBD bound traffic from Warringah Road, thereby improving connectivity and accessibility surrounding the Northern Beaches Hospital. Further details are provided in Section 9.4.6.

### 9.1.3 Sydney's Bus Future

*Sydney's Bus Future* (Transport for NSW, 2013a) presents a three-stage approach to improve service outcomes, focusing on improving customer experience, integrating bus services across Sydney and serving future growth. Bus initiatives include the bus rapid transit services for the Northern Beaches (eg Northern Beaches B-Line) to improve capacity and efficiency for bus users.

By reducing network congestion, improving network resilience and increasing reliability in peak periods, the project would make buses a more attractive transport option, supporting and encouraging a mode shift to public transport. The project would also allow new public transport routes to be developed in response to diverse travel demands and future social and economic development, as express buses would be permitted to use the tunnel. The project provides the opportunity to supplement existing services with the opportunity for express buses to use the Beaches Link tunnel to North Sydney, St Leonards and Sydney CBD, as well as to the north-west to employment areas like Macquarie Park via Gore Hill Freeway and Lane Cove Tunnel. There would also be the opportunity for express bus services using the project to interchange with Sydney Trains and the new Sydney Metro at North Sydney and Crows Nest.

The Northern Beaches B-Line began operation in 2017 which provides frequent and more reliable services between the Northern Beaches and Sydney CBD. The project would support the continued operation of the B-Line program along with other existing and proposed bus services by improving travel times and reliability on key routes connecting the Northern Beaches to key centres including Spit Road/Military Road and Warringah Road/Eastern Valley Way.

The reduced vehicle congestion on Warringah Road between Frenchs Forest and Roseville would support the possible implementation of a proposed rapid bus service, similar in nature to the existing B-Line, between Dee Why and Chatswood.

### 9.1.4 Sydney's Cycling Future

*Sydney's Cycling Future* (Transport for NSW, 2013b) identifies priority cycleways to improve connection to major centres for trips of up to five kilometres. The strategy also includes walking and cycling projects linking to public transport interchanges and stops. Sydney's Cycling future is identified in the *Future Transport Strategy 2056* (NSW Government, 2018), outlining initiatives such as secure bike storage to increase active transport.

The project would provide a new shared user path along Wakehurst Parkway between Seaforth/North Balgowlah and the developing Northern Beaches Hospital Precinct, improving connectivity to the new strategic centre.

The project would also result in reduced congestion on surface roads, which would contribute to improved conditions for cyclists.

### 9.1.5 Sydney's Walking Future

*Sydney's Walking Future* (Transport for NSW, 2013c) is the NSW Government's long-term plan to promote walking as a transport mode throughout Sydney and an integral component in the planning of urban growth precincts and new transport infrastructure. The project would support the objectives of *Sydney's Walking Future* by providing improved pedestrian infrastructure along the Wakehurst Parkway along with new and realigned shared user paths within the proposed new and improved open space and recreation facilities at Balgowlah. Amenity improvements resulting from reduced vehicle congestion would also improve the attractiveness of walking as a transport mode.

### 9.1.6 Transport for NSW Walking and Cycling Program

The *Walking and Cycling Program 2020-2021* (Transport for NSW, 2019a) supports the walking and cycling outcomes set out in the *Future Transport Strategy 2056* (NSW Government, 2018). The key objectives of the 2020/21 Walking and Cycling Program are to:

- Ensure walking and cycling are the most convenient option for short trips to key destinations and within centres
- Reduce congestion on our roads and public transport networks by delivering projects that encourage walking and cycling mode shift
- Enable efficient, safe and reliable journey times by prioritising infrastructure that supports pedestrian or cycling movement on certain corridors, consistent with the Movement and Place Framework
- Deliver projects that make walking and cycling safe, comfortable and convenient transport modes that are accessible to a wide range of users
- Enable positive health, wellbeing, social and environmental outcomes.

Under the Walking and Cycling Program, key stakeholders can apply for funding for active transport projects. The proposed scope of the project would complement other active transport planning being carried out as part of this program.

## 9.2 Assessment methodology

### 9.2.1 Overview

The assessment methodology of operational traffic and transport impacts considered four core components:

- Road traffic
- Public transport
- Pedestrian and cyclists (active transport)
- Maritime traffic.

The method and outputs of assessment for each of these components are summarised in Table 9-2.

**Table 9-2 Overview of approach to the operational traffic and transport assessment**

| Project impacts | Method of assessment | Assessment output |
|---|---|---|
| Road traffic | Analysis of road network performance based on strategic traffic forecasting and operational traffic modelling. | Quantitative assessment of road network performance with and without the project. |
| Local roads and parking | Analysis of changes to local road access arrangements, loss of parking spaces and availability of comparable alternative parking in nearby locations.<br>The analysis considers permanent impacts. Temporary impacts (ie during construction) are considered in Chapter 8 (Construction traffic and transport). | Qualitative assessment of local road changes.<br>Estimate of number of lost parking spaces.<br>Qualitative assessment of the impact of parking overflow to parking in nearby locations. |

| Project impacts | Method of assessment | Assessment output |
|---|---|---|
| Public transport | Analysis of service accessibility (rail and road public transport modes) and service timeliness and efficiency (road public transport mode) based on operational traffic modelling. | Qualitative assessment of service accessibility and semi-quantitative assessment of service timeliness and efficiency (increase or decrease in number of stops or change in stop coverage). |
| Pedestrians and cyclists (active transport) | Analysis of pedestrian and cycle demands and changes to shared user paths and other pedestrian and cycle facilities. | Semi-quantitative assessment of impacts on pedestrian and cycling networks and accessibility. |
| Maritime traffic | Analysis of changes in water depths in Middle Harbour with the immersed tube tunnels in place and the potential impact on maritime traffic. | Qualitative assessment of impacts on future waterway navigation and commercial and recreational usage. |

### 9.2.2 Road traffic assessment methodology

The potential impacts of the project on road network performance were assessed through strategic traffic forecasting and operational traffic modelling. The assessment 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. An overview of the modelling methodology used in the assessment of the project is provided in Figure 9-1, with further details provided in Appendix F (Technical working: Traffic and transport).

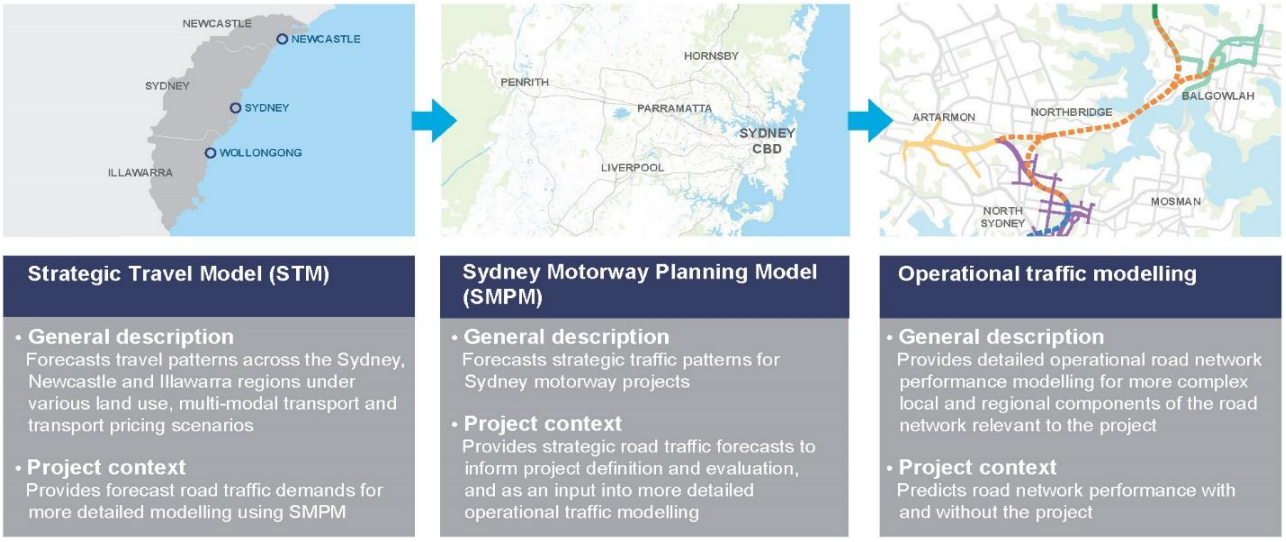



**Figure 9-1 Overview of transport modelling approach**

#### Operational traffic modelling scenarios

Future year networks and traffic demand were developed for 2027 (planned year of opening) and 2037 (year of planned opening plus 10 years) to assess the future performance of the project. Future performance was assessed for the AM peak (7am to 9am on a normal working weekday) and PM peak (4pm to 6pm on a normal working weekday) for the following model scenarios:

- Without the project ('Do minimum')
- With the project ('Do something')
- With the project and other planned or proposed projects ('Do something cumulative').

The ‘Do something’ scenario included the Warringah Freeway Upgrade component of the proposed Western Harbour Tunnel and Warringah Freeway Upgrade project, on the basis that the project requires this to function. The modelled operational scenarios are summarised in Table 9-3.

**Table 9-3 Operational road traffic modelling scenarios**

| Scenario | Description | 2016 | 2027 | 2037 |
|---|---|---|---|---|
| ‘Base year’ | Developed for calibration purposes and quantification of existing network performance | ✓ | | |
| ‘Do minimum’[1] | Includes approved, under construction and/or recently opened motorway projects (NorthConnex and WestConnex) but without Western Harbour Tunnel and Warringah Freeway Upgrade, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and M6 Motorway (Stage 1) projects. Also reflects operational effects of approved, under construction and/or recently completed major projects (eg Sydney Metro City & Southwest and Northern Beaches Hospital road upgrade project). | | ✓ | ✓ |
| ‘Do something’[1] | Includes NorthConnex, WestConnex, Beaches Link and Gore Hill Freeway Connection and Warringah Freeway Upgrade projects but without Western Harbour Tunnel, Sydney Gateway and M6 Motorway (Stage 1) projects. Also includes Sydney Metro City & Southwest and Northern Beaches Hospital road upgrade project. | | ✓ | ✓ |
| ‘Do something cumulative’ | Traffic model scenario with NorthConnex, WestConnex, Western Harbour Tunnel and Warringah Freeway Upgrade, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and M6 Motorway [2, 3] projects. Also includes Sydney Metro City & Southwest and Northern Beaches Hospital road upgrade project. | | ✓ | ✓ |

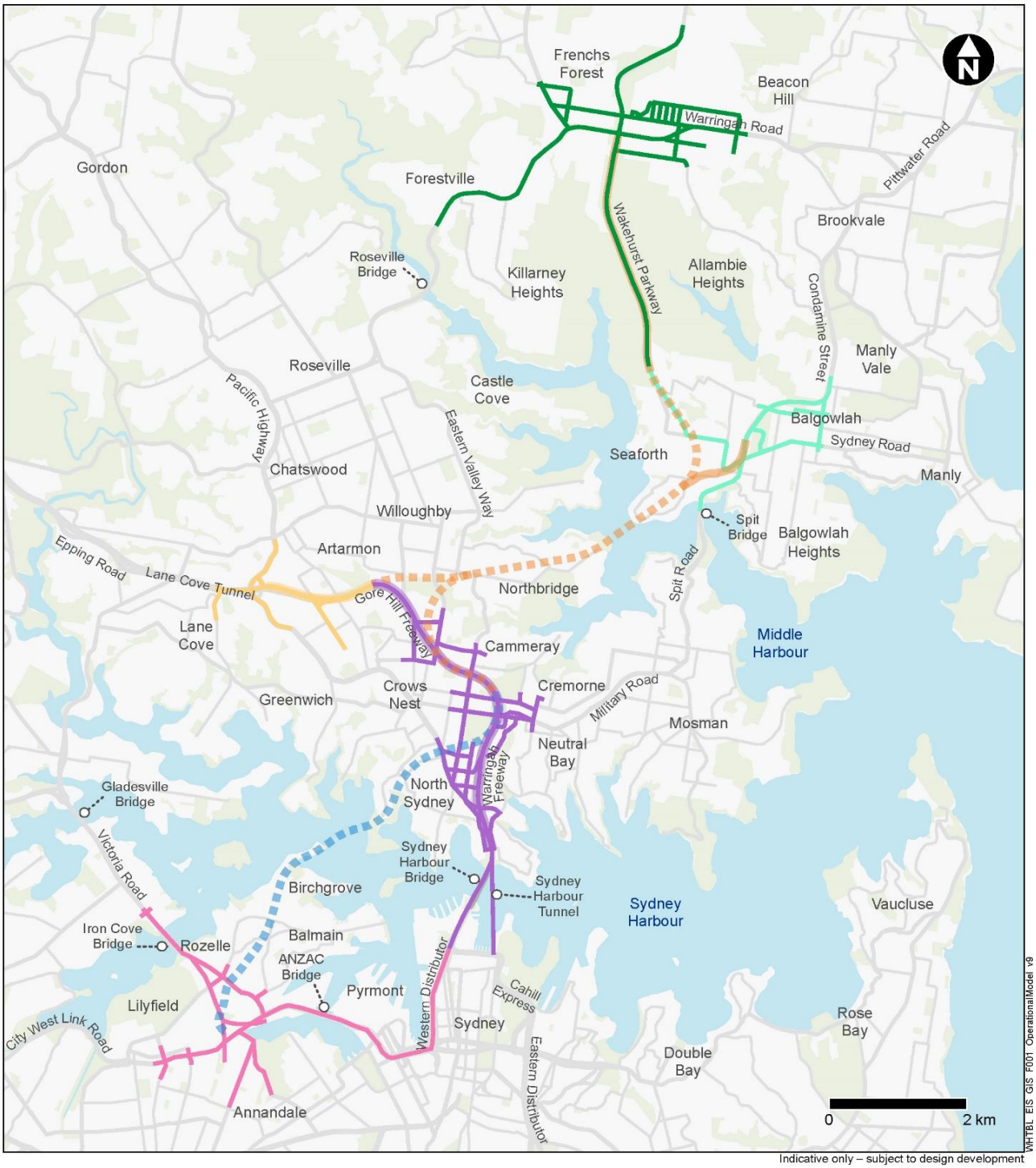
Note 1: The M6 Motorway (Stage 1) and Sydney Gateway projects were not included in the ‘Do minimum’ or ‘Do something’ scenarios as they were not approved projects at the time the modelling and analysis assumptions were confirmed. Since the confirmation of these assumptions for this assessment, the M6 Motorway (Stage 1) and Sydney Gateway projects have been approved. Sensitivity testing has shown that these projects would not have a material impact on the Beaches Link and Gore Hill Freeway Connection project ‘Do minimum’ or ‘Do something’ traffic assessments; they are included in the ‘Do something cumulative’ traffic assessment.
Note 2: M6 Motorway (Stage 1) is considered as part of the 2027 ‘Do something – cumulative’ scenario
Note 3: M6 Motorway (full project) is considered as part of the 2037 ‘Do something – cumulative’ scenario

The 2016 baseline year represents transport network conditions at the time of the traffic and transport assessment. Ongoing and continuous traffic surveys carried out by Transport for NSW indicate that the 2016 baseline year is appropriate for modelling purposes as there is little material difference between 2016 and existing (2020) traffic conditions in the project area.

As outlined in Figure 9-1, the Sydney Motorway Planning Model (SMPM) forecasts strategic traffic patterns for Sydney motorway projects and was used in this assessment. The SMPM is a network-wide model that includes recently completed and future infrastructure projects, and population and employment growth forecasts provided by the Transport for NSW Transport Performance and Analytics division, consistent with demographics released by NSW Department of Planning, Industry and Environment. The project traffic and transport assessment therefore took into consideration planned population and employment demand and growth throughout Sydney over the next 20 years. The SMPM also took into account change in traffic associated with project-related induced demand (new trips), which equates to about 0.3 per cent of additional daily trips in the Sydney metropolitan area in 2037.

A tunnel model for the project was used to assess the future year performance of the proposed road layout within the tunnelled carriageways, including merge and diverge locations and the impact of grades. Four surface interface model areas (Warringah Freeway and surrounds, Gore Hill Freeway and Artarmon, Balgowlah and surrounds, and Frenchs Forest and surrounds) were used to assess 2027 and 2037 road network performance, both with and without the project.

Figure 9-2 shows the operational road traffic model areas for the Western Harbour Tunnel and Beaches Link program of works. All operational road traffic model areas except for the Western Harbour Tunnel, and Rozelle and surrounds (relevant for the Western Harbour Tunnel and Warringah Freeway Upgrade project) were subject to assessment for this project. Cumulative assessment of potential impacts related to operational traffic and transport includes the consideration of potential impacts resulting from the Western Harbour Tunnel and Warringah Freeway Upgrade project.




**Legend**

**Operational features**

- Western Harbour Tunnel
- Beaches Link
- Warringah Freeway Upgrade
- Gore Hill Freeway Connection

**Operational model areas**

- Rozelle and surrounds
- Warringah Freeway and surrounds
- Gore Hill Freeway and Artarmon
- Balgowlah and surrounds
- Frenchs Forest and surrounds

## Figure 9-2 Operational road traffic model areas

### 9.2.3 Assessment criteria

The criteria used to assess road network performance were as follows:

- At a network level – traffic demand, average speed, number of stops (the number of times vehicles within the road network are required to stop during peak periods) and general travel times
- At an intersection level – level of service (LoS) and average delay (expressed in seconds per vehicle).

The assessment criteria for network performance and intersection and midblock level of service is described in detail in Chapter 8 (Construction traffic and transport) and Appendix F (Technical working paper: Traffic and transport).

## 9.3 Existing environment

The existing traffic and transport environment for the project is described in Chapter 8 (Construction traffic and transport). The existing environment is described within the context of the broader strategic transport network, along with more detailed analysis across of the following local areas:

- Warringah Freeway and surrounds
- Gore Hill Freeway and Artarmon
- Northbridge to Seaforth (Middle Harbour crossing)
- Balgowlah and surrounds
- Frenchs Forest and surrounds.

## 9.4 Assessment of potential impacts

The operational traffic and transport impacts of the project are outlined below in the context of the broader road network, along with detailed analysis of local area impacts. Impacts are assessed for future year scenarios with the project ('Do something') compared to the scenario without the project ('Do minimum'), as well as the cumulative future year scenario with the addition of the Western Harbour Tunnel and other planned, proposed and recently opened transport projects ('Do something cumulative') as described in Section 9.2.2.

### 9.4.1 Broader road network

#### Road network performance

##### *'Do something' scenario*

The project is forecast to reduce traffic demands on the existing arterial roads into and out of the Northern Beaches peninsula, with the largest reductions in traffic demand being on the Spit Road and Military Road corridor. In general, users of existing connections to the Northern Beaches peninsula, including Eastern Valley Way and the Spit Road and Military Road corridor, would benefit from reduced congestion and improved road safety, as a result of the project lowering daily traffic demand on existing routes by introducing a new, higher standard of road as an alternative (the project). This is reflected in the forecast travel times for key trips across the network in the AM peak and PM peak, as shown in Figure 9-3 and Figure 9-4.

Overall modelled traffic demand across Middle Harbour with the project in 2037 indicate that:

- Peak period traffic demand on Spit Road and Warringah Road would decrease substantially as a result of the project, by up to 33 per cent and 23 per cent, respectively

- Peak period traffic demand on Mona Vale Road would decrease by up to eight per cent as a result of the project
- Daily traffic demand on Eastern Valley Way would decrease by up to 30 per cent as a result of the project
- Daily traffic demand on Brook Street (north of Merrenburn Avenue) would decrease by up to four per cent (increasing to up to 14 per cent in the 'Do something cumulative' scenario).

It is noted that through changing trip patterns and reduced demand on some routes, the project would provide the opportunity for Transport for NSW network management teams and other stakeholders to investigate further opportunities for local road improvements and adjustments.

The project supports the strategic vision presented in the *Future Transport Strategy 2056* (NSW Government, 2018) for the road network for Greater Sydney by supporting key movements by road for public transport, private vehicles and freight. The reduction in private vehicle travel times would also be reflected in reduced travel times for buses and would increase the size of equivalent public transport catchments, which could be further extended by express buses potentially operating through the Beaches Link tunnel.

Analysis of the 30-minute catchments for the 'Do something' scenarios show that overall the project would substantially increase accessibility from the Northern Beaches to nearby strategic centres, including Chatswood, St Leonards, Macquarie Park and North Sydney. However, the project on its own would not substantially increase the extent of the 30-minute catchments around strategic centres south of Sydney Harbour (but would do so as part of a complementary multi-modal transport strategy including rail, bus, and road projects being delivered by the NSW Government). The Gore Hill Freeway Connection component of the project would facilitate additional traffic travelling through the corridor. This change would represent increased connectivity and capacity in the network, although travel times and speeds (ie the rate of travel) are not expected to improve in this area.

The project would substantially change the volume of traffic travelling on arterial roads in the Greater Sydney Region. Due to the increased accessibility provided by the project, the project would result in an overall increase in traffic demand into and out of the Northern Beaches peninsula. However, trips through the Beaches Link tunnel would be made on a higher standard of road compared to other urban arterial roads. This would have an impact on the number of crashes on the arterial road network, with crashes across the network estimated to reduce by up to 562 incidents per year as a result of the project. A summary of forecast growth at key locations for the 2027 and 2037 is provided in Table 9-4.

### *'Do something cumulative' scenario*

The project when combined with the Western Harbour Tunnel and Warringah Freeway Upgrade project would not result in substantially more traffic travelling into and out of the Northern Beaches peninsula. Under the 'Do something cumulative' scenario demand on Warringah Road, Spit Road/Military Road corridor, Brook Street, and Eastern Valley Way would be further reduced, with more of this traffic travelling via the Beaches Link tunnel. The forecast travel times shown in Figure 9-3 and Figure 9-4 indicate travel times along key routes near the project would be reduced under the 'Do something cumulative' scenario when compared to the 'Do something' scenario, as vehicles travelling south would have the additional option of using the Western Harbour Tunnel.

Overall, the 'Do something cumulative' scenario would increase the accessibility between Manly and the Sydney CBD (and beyond) due to the improved capacity and connectivity across Sydney Harbour provided by the Western Harbour Tunnel, but have limited impact on other centres (compared to the 'Do something' scenario). The 'Do something cumulative' scenario would substantially reduce travel times for private vehicles between the Northern Beaches and destinations south of Sydney Harbour, linking people with jobs, education and services. There would be a similar benefit to bus travel times and a resulting increase in the size of equivalent public transport catchments.

**Table 9-4 Modelled daily traffic demands at key locations**

| Road | Location | Direction | 'Do minimum 2027' | 'Do something 2027' | 'Do something cumulative 2027' | 'Do minimum 2037' | 'Do something 2037' | 'Do something cumulative 2037' |
|---|---|---|---|---|---|---|---|---|
| Spit Road | Spit Bridge | Combined | 74,500 | 48,500 | 46,500 | 80,000 | 52,000 | 49,500 |
| Warringah Road | Roseville Bridge | Combined | 83,000 | 62,000 | 61,500 | 87,000 | 66,000 | 65,500 |
| Mona Vale Road | St Ives Showground | Combined | 59,500 | 54,500 | 53,000 | 62,500 | 56,500 | 55,500 |
| Beaches Link tunnel | Killarney Heights | Combined | N/A | 58,000 | 64,000 | N/A | 64,500 | 71,500 |
| Eastern Valley Way | Castle Cove | Combined | 33,000 | 21,000 | 20,000 | 35,500 | 25,000 | 25,500 |
| Brook Street | Naremburn (north of Merreburn Avenue) | Combined | 35,500 | 33,500 | 29,000 | 37,500 | 36,000 | 32,500 |

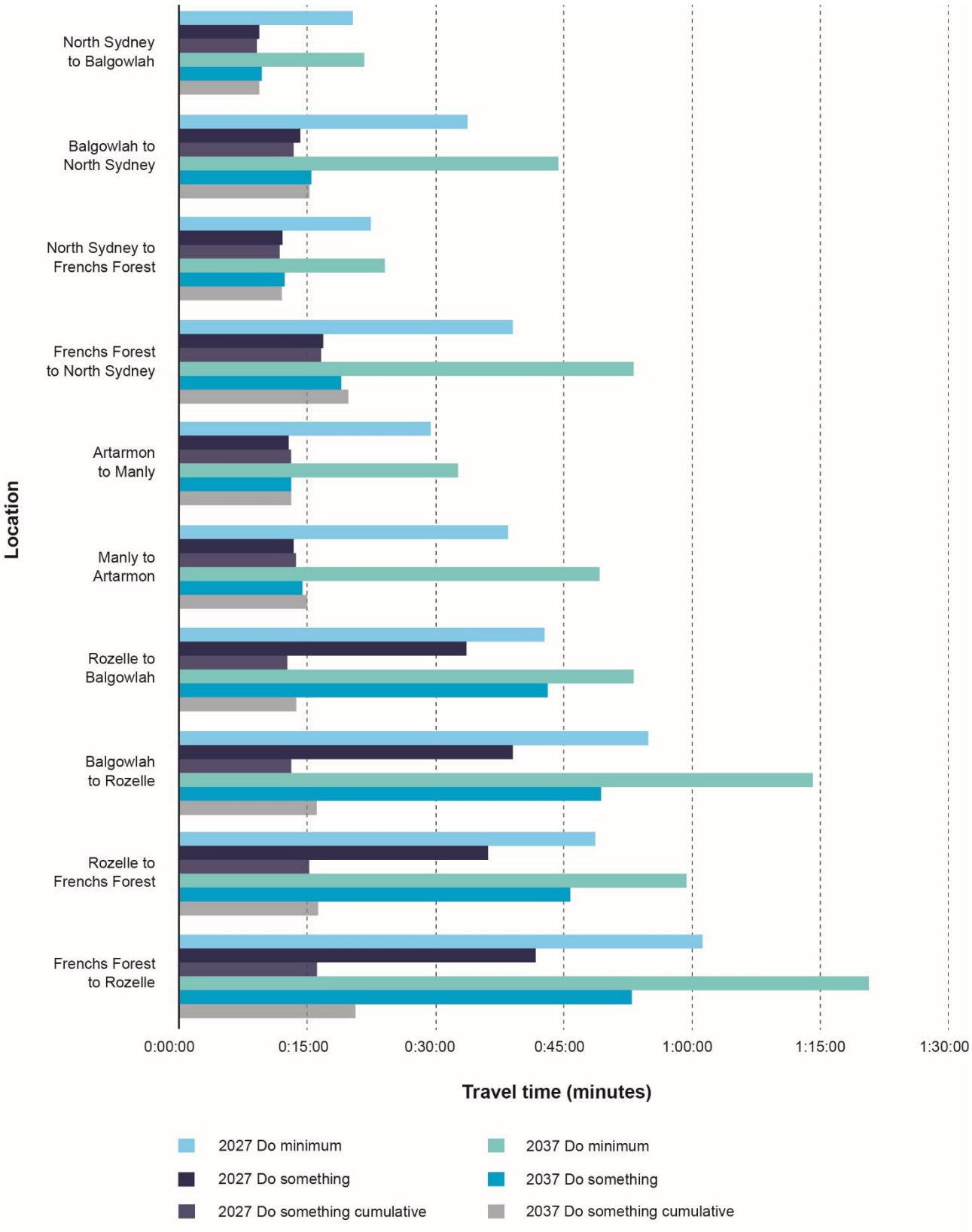



**Figure 9-3 Forecast AM peak period (8am-9am) travel times along key road network corridors**

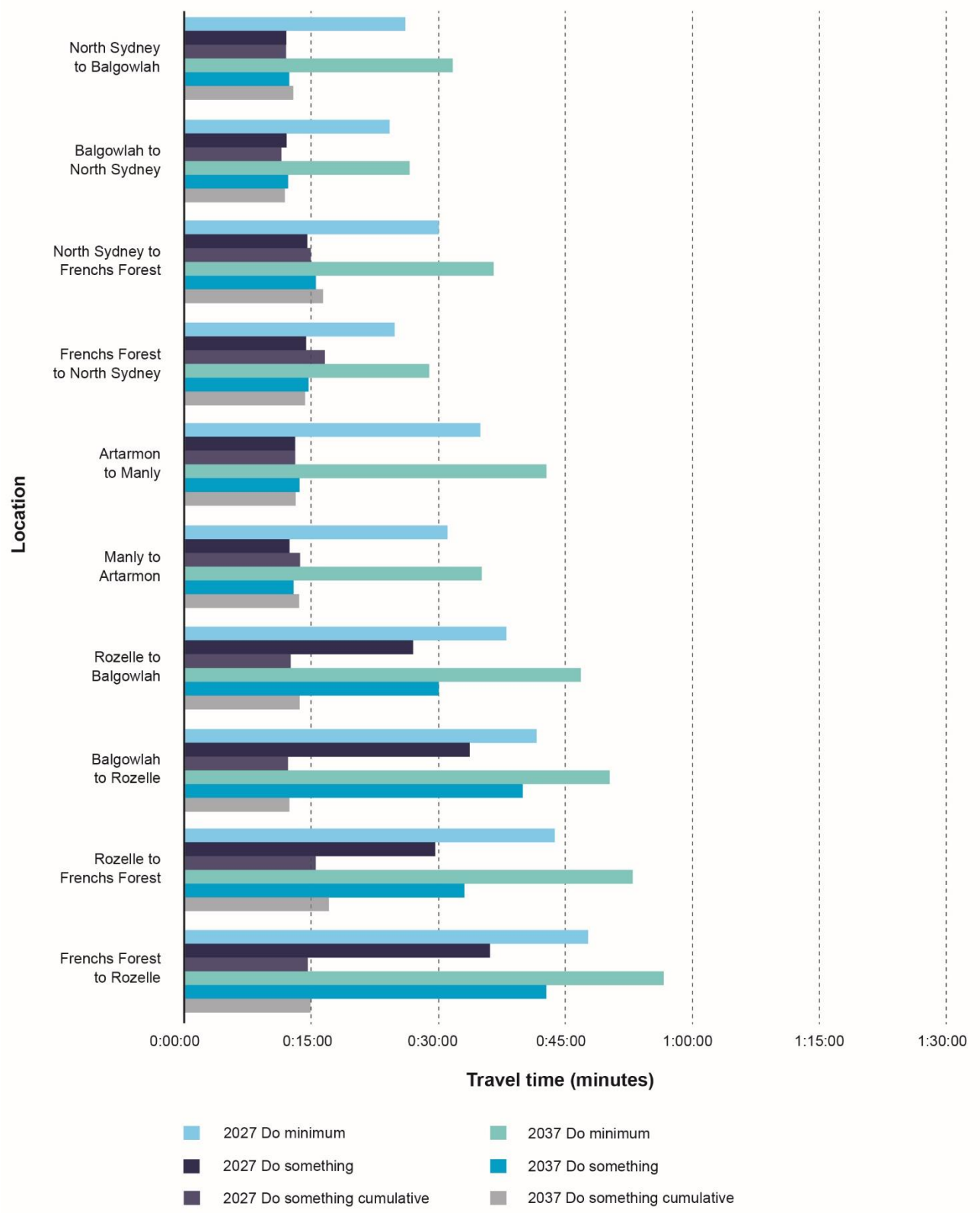



**Figure 9-4 Forecast PM peak period (5pm-6pm) travel times along key road network corridors**

### Heavy vehicles and freight

As outlined in Chapter 8 (Construction traffic and transport), the largest portion of truck movements into and out of the Northern Beaches peninsula in 2016 occurred via Mona Vale Road, likely due to lower congestion and its proximity to the M1 Pacific Motorway and industrial areas in Mona Vale, Warriewood, Belrose and Terrey Hills. Conversely, Spit Road and Military Road carried lower volumes of heavy vehicles due to access restrictions for large articulated trucks and persistent congestion on this route.

The project would result in most heavy vehicle trips on the existing arterial road network to and from the Northern Beaches peninsula transferring to the project, with the largest proportional reductions in traffic volumes being on Spit Road/Military Road corridor. Analysis of the modelled forecast heavy vehicle demands crossing Middle Harbour under the 'Do something' scenario shows:

- Peak period heavy vehicle demand on Spit Road/Military Road corridor and Warringah Road would decrease substantially as a result of the project, by up to 74 per cent and 62 per cent, respectively
- Peak period heavy vehicle demand on Mona Vale Road would decrease by up to 35 per cent as a result of the project
- Peak period of heavy vehicle demand into and out of the Northern Beaches would not change substantially as a result of the project.

While the project would not generally change the heavy vehicle demand travelling into and out of the Northern Beaches peninsula, it would substantially reduce the travel times of these freight trips and increase their productivity. The movement of heavy vehicle trips from surface arterial roads to the motorway tunnels would increase the amenity of the existing arterial road network to and from the Northern Beaches peninsula. This movement would also reduce interactions between general traffic, heavy vehicles, public transport vehicles, pedestrians and cyclists. This reduced interaction would improve road safety and reduce the severity of crashes on the arterial road network.

## 9.4.2 Warringah Freeway and surrounds

### Road network performance

#### *'Do something' scenario*

Key outcomes of the modelled future road network performance in the Warringah Freeway and surrounds area under the 'Do something' scenario include:

- Peak period travel demand is forecast to increase by up to two per cent by 2037
- Average travel speeds through the Warringah Freeway and surrounds area would decrease by up to six per cent in the AM peak, but increase by up to 23 per cent in the PM peak
- The number of stops during peak periods is forecast to increase in the AM peak by up to 29 per cent, indicating that the additional demand facilitated by the project could increase localised delays. This is due to the transfer of traffic from existing surface roads to the project, which would increase the rate of demand on the Sydney Harbour Bridge and Sydney Harbour Tunnel. In the absence of the capacity and connectivity upgrades provided by the Western Harbour Tunnel under the 'Do something cumulative' scenario, this increase in demand would increase delays on the existing harbour crossings, with upstream effects on adjacent network connections
- In the PM peak the project would provide additional capacity for outbound traffic crossing Sydney Harbour and leaving the Lower North Shore, relieving existing corridors including Military Road and Eastern Valley Way. As a result, there would be substantial improvements in terms of average network speed and number of stops.

### *'Do something cumulative' scenario*

The introduction of the Western Harbour Tunnel would generally result in improved network performance in the Warringah Freeway and surrounds area when compared with the 'Do something' scenario. Key outcomes of the modelled road network performance in the Warringah Freeway and surrounds area, under the 'Do something cumulative' scenario (compared with the 'Do something' scenario) includes:

- Peak period travel demand through the Warringah Freeway and surrounds area would increase by up to 15 per cent by 2037 as a result of the introduction of the Western Harbour Tunnel
- The project would result in a greater portion of forecast demand being able to travel during the AM peak
- Average travel speeds through the Warringah Freeway and surrounds area would improve by up to 30 per cent as a result of the introduction of the Western Harbour Tunnel
- The number of stops during peak periods would substantially decrease as a result of the introduction of the Western Harbour Tunnel, particularly in the AM peak.

Overall, the Western Harbour Tunnel and Beaches Link program of works would improve network capacity and connectivity across Sydney Harbour. It would reduce demand and delays on Sydney Harbour Bridge and Sydney Harbour Tunnel and improve network performance throughout the Warringah Freeway and surrounds area during peak periods.

## Traffic travel times

### *'Do something' scenario*

Modelled travel times during AM and PM peaks for key routes through the Warringah Freeway and surrounds area are presented in Table 9-5.

The modelled travel times under the 'Do something' scenario show:

- AM peak travel times from the Warringah Freeway to the Cahill Expressway would increase as a result of the project due to increased inbound demand on the Sydney Harbour Bridge and Sydney Harbour Tunnel. In the absence of the capacity and connectivity upgrades provided by the Western Harbour Tunnel, this increase in demand would increase delays on the existing harbour crossings and upstream motorway corridor
- PM peak travel times for the majority of routes along the Warringah Freeway would remain similar or improve as a result of the project, due to the additional outbound capacity and simplification of weaving and merging arrangements provided as part of the Warringah Freeway Upgrade.

### *'Do something cumulative' scenario*

The introduction of the Western Harbour Tunnel would generally result in improved travel times when compared to the 'Do something' scenario. Analysis of modelled travel times for routes through the Warringah Freeway and surrounds area under the 'Do something cumulative' scenario (refer to Table 9-5) predicts:

- Travel times along Warringah Freeway would generally improve due to the transfer of trips to Western Harbour Tunnel, with some of this traffic travelling directly between Beaches Link and Western Harbour Tunnel. This would relieve capacity constraints on the Warringah Freeway, Sydney Harbour Bridge, and Sydney Harbour Tunnel both northbound and southbound
- Localised increases in travel times for local trips within North Sydney such as the Miller Street corridor, as a result of changes to traffic patterns and access arrangements to, from and within North Sydney.

**Table 9-5 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through the Warringah Freeway and surrounds area**

| Route/ Peak period | Direction | Do minimum 2027' | Do something 2027' | Do something cumulative 2027' | Do minimum 2037' | Do something 2037' | Do something cumulative 2037' |
|---|---|---|---|---|---|---|---|
| **Sydney Harbour Bridge to Warringah Freeway/Falcon Street interchange** | | | | | | | |
| AM peak | Northbound | 04:40 | 05:47 | 03:33 | 04:51 | 04:56 | 04:12 |
| | Southbound | 04:03 | 04:06 | 04:07 | 04:02 | 04:13 | 04:06 |
| PM peak | Northbound | 04:02 | 03:26 | 03:25 | 07:51 | 04:51 | 03:28 |
| | Southbound | 06:09 | 04:44 | 04:37 | 05:02 | 04:41 | 04:33 |
| **Sydney Harbour Tunnel to Warringah Freeway/Falcon Street interchange** | | | | | | | |
| AM peak | Northbound | 03:55 | 11:50 | 03:31 | 04:08 | 12:07 | 04:27 |
| | Southbound | 04:03 | 04:17 | 04:27 | 04:02 | 04:18 | 04:26 |
| PM peak | Northbound | 03:57 | 03:22 | 03:24 | 07:36 | 03:25 | 03:31 |
| | Southbound | 14:54 | 05:52 | 05:28 | 14:59 | 07:41 | 05:35 |
| **Sydney Harbour Bridge to Gore Hill Freeway/Pacific Highway interchange** | | | | | | | |
| AM peak | Northbound | 06:13 | 07:41 | 05:26 | 06:16 | 06:45 | 05:29 |
| | Southbound | 13:35 | 13:29 | 08:02 | 15:22 | 13:46 | 07:54 |
| PM peak | Northbound | 05:35 | 05:26 | 05:21 | 06:45 | 06:53 | 05:24 |
| | Southbound | 13:56 | 06:18 | 06:10 | 17:31 | 07:28 | 06:10 |
| **Sydney Harbour Tunnel to Gore Hill Freeway/Pacific Highway interchange** | | | | | | | |
| AM peak | Northbound | 05:26 | 16:21 | 05:18 | 05:30 | 17:03 | 05:23 |
| | Southbound | 11:39 | 11:20 | 07:59 | 12:37 | 11:30 | 08:08 |
| PM peak | Northbound | 05:28 | 05:17 | 05:12 | 06:46 | 05:22 | 05:14 |
| | Southbound | 25:21 | 07:23 | 07:00 | 30:09 | 13:50 | 07:07 |
| **Berry Street to Amherst Street via Miller Street** | | | | | | | |
| AM peak | Northbound | 03:42 | 03:56 | 04:06 | 03:53 | 04:07 | 04:03 |
| | Southbound | 04:25 | 04:04 | 06:01 | 05:43 | 04:05 | 07:01 |
| PM peak | Northbound | 03:52 | 04:39 | 04:46 | 03:50 | 01:22 | 05:14 |
| | Southbound | 05:01 | 05:30 | 04:35 | 08:39 | 05:01 | 05:37 |

## Intersection performance

### *'Do something' scenario*

Modelled intersection performance for key intersections in the Warringah Freeway and surrounds area under the 'Do something' scenario is presented in Table 9-6 and indicates:

- Average delays around some local intersections along Berry Street and Pacific Highway could increase by around 30 to 40 seconds from additional traffic using these intersections as a result of the project
- Intersection performance along Brook Street near the Warringah Freeway would improve substantially during the AM peak as a result of the project. This is due to the changes in access to Brook Street from the Warringah Freeway, which under the Warringah Freeway Upgrade would be limited to trips from the Sydney Harbour Bridge and Berry Street. In the PM peak, localised congestion on the Warringah Freeway may continue to impact the efficiency of this interchange
- Intersections along the Pacific Highway would experience increased delays at some locations in the AM peak as a result of the project. This is due to the changes to traffic patterns and access arrangements to, from and within North Sydney as a result of the Warringah Freeway Upgrade
- The intersection of Ben Boyd Road and Military Road has the potential to experience longer delays as a result of the Warringah Freeway Upgrade project, due to the reconfiguration of Warringah Freeway, which would change the accessibility of the Ernest Street ramps to and from the Warringah Freeway. Traffic that currently uses the Ourimbah Road corridor as an alternative to Military Road would no longer be able to access all the same destinations that are currently accessible from Ernest Street.

Although the project would generally improve network performance for roads within and around North Sydney, it would not resolve existing localised performance issues at several intersections. The proposed road integration works and resulting improved traffic performance in the North Sydney area have been developed in the context of the growing North Sydney CBD environment.

While there would be some localised delays at some intersections at peak times, this would be offset by the substantial travel time benefits provided by the project at the broader network level.

The project seeks to maintain an appropriate level of traffic movement within the Warringah Freeway and surrounds area while also preserving capacity and connectivity for other customers whose needs conflict with traffic, particularly pedestrians.

Options to further improve traffic performance at intersections throughout the area have been investigated. However, these alternative options would result in further impacts on other customers. The proposed works are therefore considered to provide an equitable and balanced outcome from the perspective of maintaining a balanced and integrated transport network through North Sydney.

Further refinements to movement and place outcomes within the North Sydney CBD may occur as part of works associated with the North Sydney Program, an ongoing multi-agency collaboration between Transport for NSW, North Sydney Council, Greater Sydney Commission and the Government Architect of NSW to guide future integrated transport planning and investment in the North Sydney CBD and interconnected areas (see Section 9.1.1 for more information).

### *'Do something cumulative' scenario*

The introduction of the Western Harbour Tunnel would generally result in improved intersection performance when compared to the 'Do something' scenario. Modelled intersection performance under the 'Do something cumulative' scenario is presented in Table 9-6. Overall:

- Most intersections would perform similarly to the 'Do something' scenario
- Some intersections on the Pacific Highway, Walker Street, Miller Street and Berry Street could experience increased localised delays with the introduction of the Western Harbour Tunnel due to increased demand and changes to local traffic patterns
- Intersections along the Falcon Street and Military Road corridor would generally perform marginally better with the introduction of the Western Harbour Tunnel, as trips from the Pittwater Road corridor bypassing the Sydney CBD would avoid Spit Road/Military Road and use the direct connection from the project to Western Harbour Tunnel.

Although some traffic would be impacted by an increase in localised intersection delays, road users would generally benefit from substantial overall travel time savings on the broader network (eg via the Beaches Link and Gore Hill Freeway Connection project, Western Harbour Tunnel, ANZAC Bridge, and Sydney Harbour Bridge). Traffic impacted at individual intersections in the North Sydney area is therefore still anticipated to receive a substantial net benefit due to the broader connectivity and efficiency improvements.

As discussed above, further refinements to movement and place outcomes within the North Sydney CBD may occur as part of works associated with the North Sydney Program.

**Table 9-6 Modelled intersection performance on the Warringah Freeway and surrounds area (AM peak (8am–9am) and PM peak (5pm–6pm) during operation in 2027 and 2037)**

| Intersection/ peak period | Do minimum 2027 LoS (average delay in seconds) | Do something 2027 LoS (average delay in seconds) | Do something cumulative 2027 LoS (average delay in seconds) | Do minimum 2037 LoS (average delay in seconds) | Do something 2037 LoS (average delay in seconds) | Do something cumulative 2037 LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Willoughby Road/Gore Hill Freeway interchange** | | | | | | |
| AM peak | **F (>100)** | B (27) | A (9) | **F (>100)** | B (21) | A (10) |
| PM peak | C (38) | A (10) | A (11) | **F (76)** | A (10) | A (11) |
| **Brook Street/Warringah Freeway on ramp** | | | | | | |
| AM peak | **F (>100)** | A (13) | A (8) | **F (>100)** | **E (70)** | **E (64)** |
| PM peak | B (14) | A (9) | A (<5) | B (17) | **F (92)** | B (25) |
| **Brook Street/Warringah Freeway off ramp** | | | | | | |
| AM peak | **E (61)** | B (21) | A (9) | **E (67)** | A (9) | B (16) |
| PM peak | B (22) | B (17) | B (17) | B (20) | **F (87)** | C (29) |
| **Brook Street/Merrenburn Avenue** | | | | | | |
| AM peak | **F (>100)** | C (31) | B (26) | **F (>100)** | **E (70)** | D (50) |
| PM peak | A (11) | D (53) | B (17) | A (13) | **E (59)** | C (39) |

| Intersection/ peak period | Do minimum 2027 LoS (average delay in seconds) | Do something 2027 LoS (average delay in seconds) | Do something cumulative 2027 LoS (average delay in seconds) | Do minimum 2037 LoS (average delay in seconds) | Do something 2037 LoS (average delay in seconds) | Do something cumulative 2037 LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Amherst Street/West Street** | | | | | | |
| AM peak | A (5) | A (7) | D (50) | A (5) | **F (>100)** | **F (>100)** |
| PM peak | A (9) | **F (89)** | D (43) | A (14) | **F (>100)** | **F (73)** |
| **Amherst Street/Miller Street** | | | | | | |
| AM peak | B (21) | C (38) | C (42) | B (20) | **E (58)** | D (44) |
| PM peak | C (29) | D (47) | D (43) | C (31) | D (52) | D (48) |
| **Miller Street/Warringah Freeway on ramp** | | | | | | |
| AM peak | A (7) | A (<5) | A (<5) | A (6) | A (<5) | A (5) |
| PM peak | A (6) | A (6) | A (6) | A (6) | A (6) | A (7) |
| **Miller Street/Warringah Freeway off ramp** | | | | | | |
| AM peak | A (12) | A (5) | A (8) | A (13) | A (5) | A (8) |
| PM peak | B (15) | A (9) | A (7) | B (15) | A (9) | A (8) |
| **Miller Street/Ernest Street** | | | | | | |
| AM peak | B (25) | D (44) | C (42) | C (32) | C (40) | C (41) |
| PM peak | C (41) | C (36) | C (34) | D (43) | C (35) | C (39) |
| **Miller Street/Falcon Street** | | | | | | |
| AM peak | C (35) | B (27) | C (30) | C (38) | B (25) | D (44) |
| PM peak | D (44) | **F (82)** | C (38) | D 49) | **F (95)** | D (48) |
| **Ernest Street/Warringah Freeway on ramp** | | | | | | |
| AM peak | A (5) | B (19) | C (28) | A (5) | D (48) | C (34) |
| PM peak | B (15) | A (12) | A (13) | B (15) | A (12) | A (13) |
| **Ernest Street/Warringah Freeway off ramp (off ramp in PM, on ramp AM)** | | | | | | |
| AM peak | A (5) | B (19) | B (28) | A (5) | D (48) | C (34) |
| PM peak | B (17) | A (13) | A (14) | B (17) | A (14) | B (15) |
| **Falcon Street/Warringah Freeway ramps** | | | | | | |
| AM peak | C (29) | C (36) | C (42) | B (15) | D (45) | D (51) |
| PM peak | **F (72)** | **E (70)** | D (52) | **F (>100)** | **E (68)** | **E (60)** |
| **Watson Street/Military Road** | | | | | | |
| AM peak | B (18) | C (38) | C (28) | B (26) | C (37) | C (30) |
| PM peak | D (46) | D (50) | C (37) | **E (59)** | D (46) | C (38) |

| Intersection/ peak period | Do minimum 2027 LoS (average delay in seconds) | Do something 2027 LoS (average delay in seconds) | Do something cumulative 2027 LoS (average delay in seconds) | Do minimum 2037 LoS (average delay in seconds) | Do something 2037 LoS (average delay in seconds) | Do something cumulative 2037 LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Military Road/Ben Boyd Road** | | | | | | |
| AM peak | B (15) | D (47) | D (47) | B (23) | D (44) | D (43) |
| PM peak | D (54) | **E (65)** | D (55) | **E (70)** | **F (>100)** | **F (83)** |
| **Falcon Street/Merlin Street** | | | | | | |
| AM peak | B (24) | D (46) | C (39) | C (32) | D (47) | D (54) |
| PM peak | **F (>100)** | **F (94)** | **F (83)** | **F (>100)** | **F (93)** | **F (88)** |
| **Berry Street/Walker Street** | | | | | | |
| AM peak | C (29) | **F (76)** | C (41) | C (39) | D (46) | D (50) |
| PM peak | D (44) | **F (82)** | **E (69)** | **F (73)** | **F (81)** | **F (74)** |
| **Berry Street/Miller Street** | | | | | | |
| AM peak | D (55) | D (49) | **E (58)** | **E (69)** | C (39) | **E (57)** |
| PM peak | D (46) | C (35) | D (54) | **F (70)** | **F (76)** | **E (63)** |
| **Mount Street/Arthur Street** | | | | | | |
| AM peak | D (46) | D (46) | B (18) | **E (59)** | C (33) | C (33) |
| PM peak | D (49) | B (17) | B (21) | **F (92)** | B (18) | **F (>100)** |
| **Mount Street/Walker Street** | | | | | | |
| AM peak | C (36) | D (47) | C (35) | D (48) | C (41) | D (43) |
| PM peak | C (32) | D (47) | **F (78)** | **F (75)** | **E (59)** | **F (96)** |
| **Pacific Highway/High Street/Arthur Street** | | | | | | |
| AM peak | B (19) | **E (57)** | B (18) | C (38) | D (45) | B (19) |
| PM peak | D (46) | A (14) | B (16) | **E (61)** | B (23) | B (21) |
| **Pacific Highway/Walker Street/Blue Street** | | | | | | |
| AM peak | C (36) | D (55) | C (33) | **E (65)** | D (49) | C (32) |
| PM peak | D (40) | **E (65)** | D (54) | **F (80)** | **F (79)** | **E (60)** |
| **Pacific Highway/Miller Street/Mount Street** | | | | | | |
| AM peak | C (38) | **F (79)** | **E (62)** | C (41) | **F (72)** | **E (62)** |
| PM peak | C (41) | **E (57)** | D (50) | **E (58)** | **F (78)** | **E (66)** |
| **Pacific Highway/Berry Street** | | | | | | |
| AM peak | **E (56)** | B (17) | **E (60)** | D (52) | B (16) | **E (60)** |
| PM peak | B (23) | B (15) | **F (85)** | **E (56)** | C (34) | **F (87)** |

| Intersection/ peak period | Do minimum 2027 LoS (average delay in seconds) | Do something 2027 LoS (average delay in seconds) | Do something cumulative 2027 LoS (average delay in seconds) | Do minimum 2037 LoS (average delay in seconds) | Do something 2037 LoS (average delay in seconds) | Do something cumulative 2037 LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Pacific Highway/Bay Road** | | | | | | |
| AM peak | D (55) | B (23) | D (42) | **F (77)** | B (23) | **F (88)** |
| PM peak | B (15) | B (22) | B (27) | C (41) | C (40) | C (33) |
| **Miller Street/McLaren Street** | | | | | | |
| AM peak | B (23) | C (40) | **E (56)** | **F (72)** | C (42) | **E (62)** |
| PM peak | B (21) | C (39) | C (37) | D (55) | **F (76)** | D (50) |
| **Miller Street/Ridge Street** | | | | | | |
| AM peak | C (38) | C (33) | **E (63)** | D (53) | D (45) | **E (70)** |
| PM peak | C (40) | B (15) | B (21) | **F (91)** | **E (57)** | C (39) |
| **Miller Street/Carlow Street** | | | | | | |
| AM peak | A (13) | A (8) | B (15) | A (13) | A (8) | C (28) |
| PM peak | A (8) | A (6) | A (7) | B (19) | D (55) | A (7) |
| **High Street/Clark Road** | | | | | | |
| AM peak | B (18) | C (32) | C (36) | D (55) | C (37) | C (38) |
| PM peak | | D (50) | D (56) | **F (97)** | D (52) | **E (65)** |
| **High Street/Alfred Street North** | | | | | | |
| AM peak | A (13) | D (49) | B (19) | **E (62)** | C (32) | B (18) |
| PM peak | **F (>100)** | C (41) | C (42) | **F (>100)** | C (42) | D (46) |
| **Mount Street/Alfred Street North** | | | | | | |
| AM peak | A (<5) | B (16) | B (14) | A (<5) | B (16) | A (14) |
| PM peak | A (12) | A (14) | A (12) | A (10) | A (14) | A (13) |
| **Ernest Street/Ben Boyd Road** | | | | | | |
| AM peak | A (12) | A (11) | B (18) | A (12) | B (14) | B (26) |
| PM peak | D (44) | A (10) | A (10) | **F (94)** | C (38) | D (46) |
| **Pedestrian crossing at Military Road** | | | | | | |
| AM peak | A (6) | A (<5) | A (5) | A (5) | A (<5) | A (6) |
| PM peak | B (27) | A (5) | A (<5) | C (34) | A (5) | A (5) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

## Road network changes and access arrangements

### *'Do something' scenario*

The project would connect directly via on and off ramps to the Warringah Freeway at Cammeray, north of Ernest Street Bridge. The project would also connect to the Western Harbour Tunnel via a direct underground connection in the Warringah Freeway and surrounds area.

The remaining road network changes in the Warringah Freeway and surrounds area, including connection to North Sydney, Bradfield Highway and Cahill Expressway would be associated with the Warringah Freeway Upgrade component of the Western Harbour Tunnel and Warringah Freeway Upgrade project (subject to separate assessment and approval), which is required for the project to be operational.

The Warringah Freeway Upgrade is proposed to substantially improve the safety and efficiency of the motorway and arterial road interfaces. The upgrade would involve extensive upgrades to surface roads and existing connections that would:

- Connect and integrate with the Western Harbour Tunnel and Beaches Link
- Improve wayfinding and separate traffic on the freeway based on trip function (through traffic, traffic for arterial distribution and traffic for local destinations).

The upgrades would include the removal of the existing tidal flow arrangements on the Warringah Freeway, while the existing tidal flow arrangements on the Sydney Harbour Bridge would not be affected by the project. The upgraded Warringah Freeway would simplify traffic flow and improve wayfinding by providing the following traffic lanes:

- A northbound outer carriageway comprising:
  - An outer western carriageway, carrying northbound traffic from the Sydney Harbour Bridge to the Beaches Link northbound on ramp and facilitating local distribution to local destinations such as North Sydney and Crows Nest
  - Inner western carriageways, carrying northbound traffic from the Sydney Harbour Bridge and Sydney Harbour Tunnel
- A central carriageway carrying northbound and southbound motorway traffic between the Western Harbour Tunnel, Gore Hill Freeway and Willoughby Road
- A southbound outer carriageway comprising:
  - Inner eastern carriageways carrying southbound traffic to the Sydney Harbour Tunnel and for facilitating distribution to local destinations such as Neutral Bay
  - An outer eastern carriageway, carrying southbound traffic for the Sydney Harbour Bridge (both the Bradfield Highway and Cahill Expressway) and for distribution to local destinations such as North Sydney and Kirribilli
  - A dedicated bus lane between Miller Street, Cammeray and the Sydney Harbour Bridge, Milsons Point which would carry southbound buses and other permitted bus lane vehicles.

Following the upgrades, connections between the upgraded Warringah Freeway and the arterial road network would be provided at all existing interchange locations. However, changes to existing Warringah Freeway accesses would be carried out as part of the Warringah Freeway Upgrade project at Falcon Street, Miller Street, Brook Street, Berry Street and Alfred Street North.

Figure 9-5 provides an overview of these connections and their associated access arrangements.

Further details of access arrangements following the completed upgrading of the Warringah Freeway as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project is provided in Section 7.4.4 of Appendix F (Technical working paper: Traffic and transport).

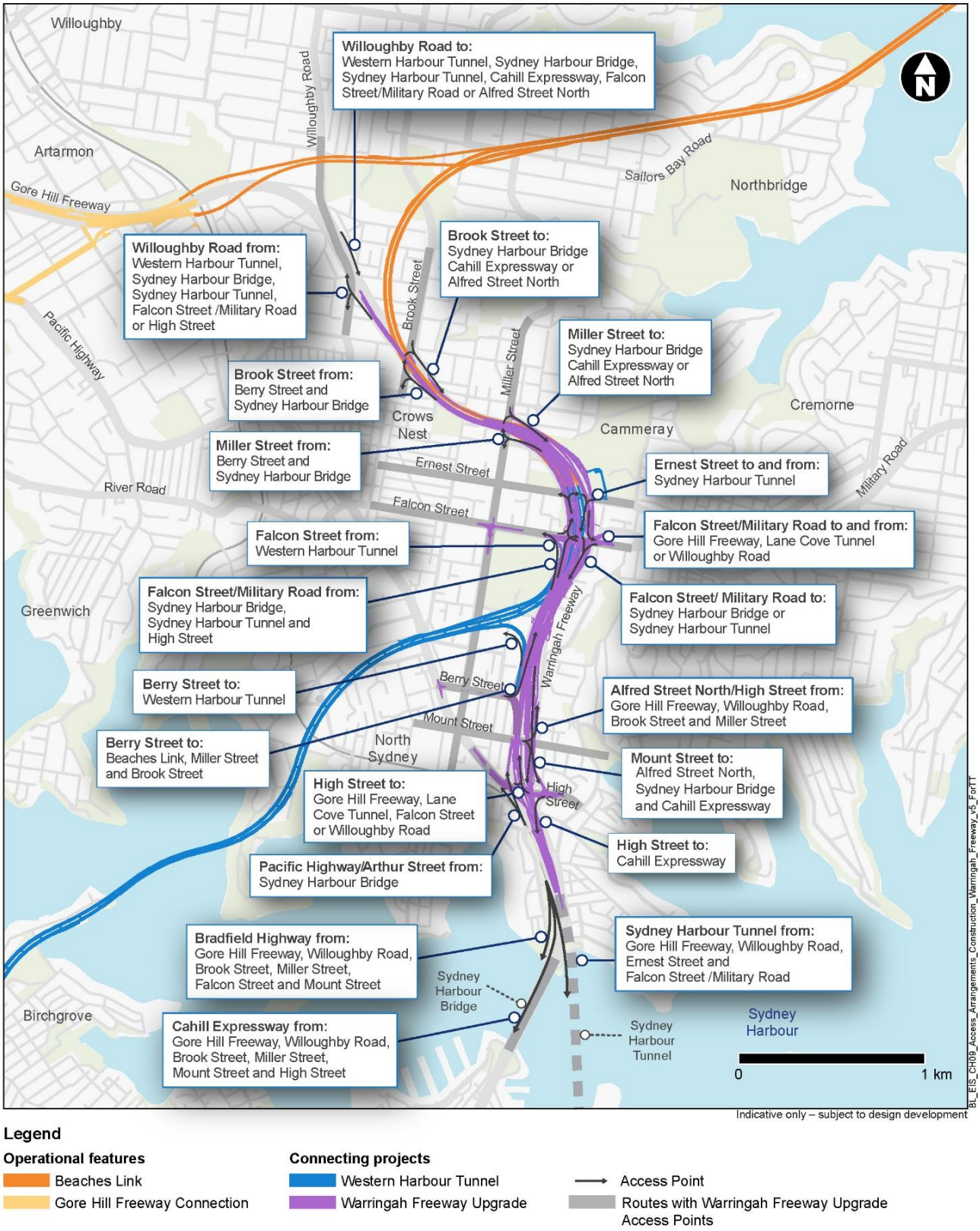



**Figure 9-5 Access arrangements upon completion of construction works at the Warringah Freeway**

### *'Do something cumulative' scenario*

In the 'Do something cumulative' scenario, the Western Harbour Tunnel would connect to North Sydney via an on ramp from Berry Street for vehicles travelling southbound and via an off ramp to Falcon Street for vehicles travelling north.

Additional access restrictions and local road changes under the 'Do something cumulative' scenario would be as follows:

- The existing Falcon Street westbound off ramp from the Warringah Freeway would be converted to the northbound off ramp from Western Harbour Tunnel, thereby removing connectivity between the Warringah Freeway and Sydney Harbour Tunnel northbound and Falcon Street westbound. Adjacent interchanges north and south of Falcon Street would provide similar connectivity
- Berry Street east of Walker Street would be reconfigured with the provision of two traffic lanes connecting to the Western Harbour Tunnel, one traffic lane providing connection to the Warringah Freeway northbound and Arthur Street southbound, and one traffic lane connecting to Arthur Street southbound only.

In general, these access restrictions would result in minor increases in travel distance and time for the affected trips. However, these changes would result in improved traffic performance and reduced congestion through the North Sydney road network and would contribute to a road network arrangement that balances the needs of all customers including public transport passengers, pedestrians and cyclists.

## Impacts on public transport

### *'Do something' scenario*

In the 'Do something' scenario, modelled future bus travel times for key routes through the Warringah Freeway and surrounds area indicate the following:

- Travel times on bus routes through North Sydney may incur localised impacts due to changed traffic patterns at the perimeter of North Sydney CBD
- Travel times for southbound buses through North Sydney via Pacific Highway and Berry Street would improve due to the changes to the arrangements at the intersection of Berry Street and Miller Street, which would simplify signal phasing and remove the existing conflict between right turning buses and pedestrians
- Travel times for buses from Gore Hill Freeway to the Sydney Harbour Bridge would improve substantially, particularly southbound in the AM and PM peaks. This is due to the reconfiguration of the southbound bus lane between Miller Street and the Cahill Expressway, which would be separated from the general traffic lanes, thereby removing two existing weave movements between buses and cars. Buses would no longer be required to merge from left to right to access the bus lane from the north and cars would no longer be able to cross the bus lane between Falcon Street and the Cahill Expressway
- Travel times for buses to and from Falcon Street would generally improve as a result of the upgrade of this interchange and reconfiguration of the southbound bus lane, which removes the existing conflict with general traffic, and as a result of the reduction in traffic demand to the Willoughby Road and Falcon Street ramps, which would otherwise cause increasing congestion, blocking access to the northbound bus off ramp to Falcon Street.

As part of the Warringah Freeway Upgrade, a new dedicated southbound bus lane on the Warringah Freeway would extend from Miller Street to the Sydney Harbour Bridge, with new bus lane connections at Falcon Street and Mount Street. This would remove direct interaction between buses and general traffic on the approach to the Sydney Harbour Bridge, thereby improving southbound bus operations on the Warringah Freeway.

Bus lanes at the Falcon Street interchange would be maintained with the diverging diamond configuration, which would support the Northern Beaches B-Line and other bus services.

The northbound bus only lane that operates during the weekday AM peak on Arthur Street would also be removed as part of the upgrade, however bus services would have the ability to access the Sydney Harbour Bridge via the general traffic lanes provided.

The Warringah Freeway Upgrade would also relocate existing bus layover facilities on the Warringah Freeway north of Ernest Street to within a widened section of the motorway near Cammeray Golf Course and on the Cahill Expressway south of High Street. Similar layover space would be provided as per the existing arrangement.

Overall, the impacts of the project on buses would be generally positive, with travel time savings for the high-demand bus routes from Gore Hill Freeway and Military Road corridors, although in some instances there is the potential for some marginal localised increases in bus travel times through the North Sydney CBD area.

#### *'Do something cumulative' scenario*

Under the 'Do something cumulative' scenario, the modelled future bus travel times in the Warringah Freeway and surrounds area indicates the following:

- Bus travel times through North Sydney could experience some localised delays that may occur during the busiest peak periods as a result of the introduction of the Western Harbour Tunnel
- Bus travel times along the Warringah Freeway would generally improve compared to the 'Do something' scenario, due to the reduction of demand on Warringah Freeway caused by trips transferring to the project and Western Harbour Tunnel
- Bus travel times for trips travelling between Warringah Freeway and Military Road would remain largely unchanged compared to the 'Do something' scenario. The introduction of the Western Harbour Tunnel would not substantially change traffic conditions for these routes, which would retain the same level of priority.

### Impacts on active transport

#### *'Do something' scenario*

The changes to the active transport network within the Warringah Freeway and surrounds area would be due to the Warringah Freeway Upgrade component of the Western Harbour Tunnel and Warringah Freeway Upgrade project. This would include:

- A new shared user path would be provided on the southern side of the High Street bridge and signalised pedestrian crossings at the Alfred Street North/High Street intersection
- A new shared user bridge to the north of Ernest Street at Cammeray, connecting Cammeray Golf Course with ANZAC Park, would provide the same pedestrian and cycle connectivity as the existing shared user path and cycleway on the Ernest Street bridge
- Replacement of the Ridge Street bridge with a wider structure with dedicated cycle lanes and a pedestrian path and replacement of the Falcon Street shared user bridge with a new structure
- Consolidating pedestrian crossings into a central median shared user path at the Falcon Street interchange
- Improved pedestrian crossings at the Falcon Street interchange ramp connections and increased pedestrian safety with fencing along the footpath
- A new dedicated cycleway on the eastern side of Warringah Freeway between Miller Street and Falcon Street
- The pedestrian and cycle underpass on the eastern side of the Falcon Street Bridge would be permanently removed. The alternative route via Military Road would result in users having to travel an additional 380 metres, increasing their travel time. However, existing pedestrian and

cyclist volumes at this underpass are low and the overall impacts of the closure are expected to be minor.

#### *'Do something cumulative' scenario*

There would be no additional impacts on the active transport network under the 'Do something cumulative' scenario when compared to the 'Do something' scenario.

### 9.4.3 Gore Hill Freeway and Artarmon

#### Road network performance

#### *'Do something' scenario*

Key outcomes of the modelled road network performance in the Gore Hill Freeway and Artarmon area under the 'Do something' scenario include:

- Peak period traffic demand through the Gore Hill Freeway and Artarmon area would increase by up to 13 per cent by 2037
- Average travel speeds would improve by up to 19 per cent in the AM peak by 2037 due to the conversion of the existing eastbound T2 transit lane to a general traffic lane, but would not change substantially in the PM peak
- The number of stops would remain generally similar to the 'Do minimum' scenario, except during the 2037 AM peak, when they would reduce substantially. This is due to the conversion of the existing eastbound T2 transit lane to a general traffic lane, providing additional capacity in the AM peak to meet forecast demand.

Under the 'Do something' scenario, the Gore Hill Freeway Connection component of the project in Artarmon would facilitate additional traffic travelling through the corridor at a generally similar or reduced level of delay. This change would represent increased connectivity and capacity in the network, with the rate of travel expected to remain similar or increase slightly when compared to 'Do minimum' scenario.

The project would also substantially increase accessibility for the Northern Beaches to nearby strategic centres such as Chatswood, St Leonards and Macquarie Park, through improved connectivity via Reserve Road and the Gore Hill Freeway. In addition, the project would provide the opportunity for express bus services in the Beaches Link tunnel between the Northern Beaches and strategic centres, via the Gore Hill Freeway, such as Macquarie Park.

#### *'Do something cumulative' scenario*

Key outcomes of the assessment of the Gore Hill Freeway and Artarmon area under the 'Do something cumulative' scenario (when compared with the 'Do Something' scenario) include:

- Peak period traffic demand through the area would increase by up to 2.5 per cent by 2037
- Average travel speeds through the area would not substantially change in the AM peak when compared to the 'Do something' scenario, but would decrease by up to seven per cent in the PM peak due to increased traffic demand on the Gore Hill Freeway generated by the Western Harbour Tunnel
- The number of stops would not materially change in the AM peak but increase in the PM peak when compared to a 'Do minimum' scenario. This is also due to the increased traffic volumes heading west from Gore Hill Freeway, which would require increased priority at the intersection of Epping Road and Longueville Road so that queues from this intersection do not interfere with the operation of the Gore Hill Freeway. This change to intersection operation would increase queues on Longueville Road and Parklands Avenue.

Network performance measures for the Gore Hill Freeway and Artarmon study area indicate that the network integration works associated with the project would facilitate additional traffic travelling through the corridor while maintaining a similar level of overall network performance. The introduction of Western Harbour Tunnel would increase demand in the area, marginally reducing network speeds during PM peaks. The additional regional connectivity from the Artarmon area added by the Western Harbour Tunnel and Beaches Link program of works would create only localised residual impacts to traffic through the Artarmon area.

### Traffic travel times

#### *'Do something' scenario*

Modelled travel times during AM and PM peaks for key routes through the Gore Hill Freeway are presented in Table 9-7.

Travel times along the Gore Hill Freeway through Artarmon are not predicted to change substantially under the 'Do something' scenario, with the exception of westbound trips from Gore Hill Freeway to the Lane Cove Tunnel, which would marginally improve in the AM peak due to the reduction in traffic volumes from the Reserve Road interchange to the Lane Cove Tunnel.

#### *'Do something cumulative' scenario*

Table 9-7 indicates travel times along the Gore Hill Freeway through Artarmon would not change substantially as a consequence of the 'Do something cumulative' scenario (when compared with the 'Do something' scenario), with the exception of the westbound travel to Longueville Road in the PM peak, which would experience a relatively minor increase. Additional traffic demand as a result of the introduction of the Western Harbour Tunnel would mean that delays at the intersection of Epping Road and Longueville Road would need to be managed to avoid propagation to Gore Hill Freeway.

**Table 9-7 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through the Gore Hill Freeway and Artarmon area**

| Route/ Peak period | Direction | Do minimum 2027' | Do something 2027' | Do something cumulative 2027' | Do minimum 2037' | Do something 2037' | Do something cumulative 2037' |
|---|---|---|---|---|---|---|---|
| **Longueville Road to Gore Hill Freeway** | | | | | | | |
| AM peak | Eastbound | 01:28 | 01:28 | 01:29 | 01:24 | 01:28 | 01:29 |
| | Westbound | 01:24 | 01:22 | 01:23 | 01:28 | 01:22 | 01:23 |
| PM peak | Eastbound | 01:26 | 01:26 | 01:26 | 01:25 | 01:26 | 01:27 |
| | Westbound | 01:23 | 01:23 | 01:23 | 01:23 | 01:23 | 02:02 |
| **Lane Cove Tunnel to Gore Hill Freeway** | | | | | | | |
| AM peak | Eastbound | 01:18 | 01:16 | 01:16 | 01:24 | 01:17 | 01:17 |
| | Westbound | 01:17 | 01:17 | 01:18 | 02:16 | 01:18 | 01:18 |
| PM peak | Eastbound | 01:22 | 01:16 | 01:16 | 01:23 | 01:16 | 01:18 |
| | Westbound | 01:12 | 01:17 | 01:17 | 01:12 | 01:17 | 01:17 |

## Intersection performance

### *'Do something' scenario*

Modelled intersection performance for key intersections in the Gore Hill Freeway and Artarmon area under the 'Do something' scenario is presented in Table 9-8, and indicate the following:

- The intersection of Epping Road, Longueville Road and Parklands Avenue would continue to operate with substantial delays during AM peak and PM peak due to continued high levels of traffic demand. As a result, queues extending on Parklands Avenue and Longueville Road may increase as priority is given to the east–west movements through this intersection
- The intersection of Longueville Road and Pacific Highway would operate satisfactorily as a result of the project, indicating that additional traffic volumes at the intersection of Epping Road and Longueville Road would not impact on performance at this adjacent intersection
- The Gore Hill Freeway/Reserve Road interchange would continue to operate at a similar or improved level of service with the project in operation due to the proposed capacity and traffic signal operation upgrades.

Overall, the project would result in increased demand through the Gore Hill Freeway and Artarmon area and would facilitate this additional travel without substantially increasing delays at critical intersections on the arterial road network.

### *'Do something cumulative' scenario*

Modelled intersection performance for key intersections in the Gore Hill Freeway and Artarmon area under the 'Do something cumulative' scenario is presented in Table 9-8, and indicate the following:

- The Epping Road/Longueville Road/Parklands Avenue intersection would continue to operate at a poor level of service as a result of continued high traffic demand through this intersection
- Increased delays from the Epping Road/Longueville Road intersection are likely to result in increased localised delays at the Longueville Road/Pacific Highway intersection during the PM peak
- The Gore Hill Freeway/Reserve Road interchange would continue to operate at capacity during the PM peak, with the potential for increased queuing due to the increased traffic demand in the corridor. This has the potential to increase delays at adjacent intersections along Reserve Road, with the intersection at Dickson Road and Reserve Road operating at LoS F.

Increased traffic demand would result in some increased delays at intersections in the Gore Hill Freeway and Artarmon area. These intersections could be optimised to ensure the Gore Hill Freeway would continue to operate satisfactorily, however a consequence of this optimisation would be longer delays on side streets and surface roads during peak periods.

Although traffic may be impacted by an increase in localised intersection delays under the 'Do something cumulative' scenario, strategic modelling indicates that road users would benefit from substantial travel time savings on the broader network (eg via Western Harbour Tunnel and improved efficiency of the Warringah Freeway and beyond). Consequently, road users who travel on and around the Gore Hill Freeway would still benefit from the construction of the Western Harbour Tunnel due to the increased connectivity to the area and on the surrounding broader road network.

**Table 9-8 Modelled intersection performance on the Gore Hill Freeway and Artarmon area (AM peak (8am–9am) and PM peak (5pm–6pm) during operation in 2027 and 2037)**

| Intersection/ peak period | 'Do minimum 2027 LoS (average delay in seconds) | 'Do something 2027 LoS (average delay in seconds) | 'Do something cumulative 2027' LoS (average delay in seconds) | 'Do minimum 2037 LoS (average delay in seconds) | 'Do something 2037 LoS (average delay in seconds) | 'Do something cumulative 2037 LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Epping Road/Longueville Road/Parkland Avenue** | | | | | | |
| AM peak | D (52) | **F (73)** | **F (75)** | **F (83)** | **F (74)** | **F (77)** |
| PM peak | **F (80)** | **E (66)** | **F (81)** | **F (87)** | **F (71)** | **F (>100)** |
| **Longueville Road/Pacific Highway** | | | | | | |
| AM peak | C (40) | D (49) | C (39) | D (54) | C (33) | C (38) |
| PM peak | C (42) | C (38) | D (45) | D (49) | C (42) | **F (86)** |
| **Pacific Highway/Howarth Road/Norton Lane** | | | | | | |
| AM peak | B (20) | A (8) | A (10) | B (28) | A (9) | A (11) |
| PM peak | A (42) | A (38) | A (45) | A (49) | A (42) | A (86) |
| **Pacific Highway/Gore Hill Freeway interchange** | | | | | | |
| AM peak | B (29) | C (32) | B (25) | C (41) | B (24) | B (25) |
| PM peak | C (29) | B (17) | B (29) | B (23) | B (17) | B (29) |
| **Reserve Road/Gore Hill Freeway interchange** | | | | | | |
| AM peak | E (61) | D (46) | D (52) | D (47) | D (55) | **E (60)** |
| PM peak | D (29) | D (17) | D (29) | **E (23)** | D (17) | D (29) |
| **Reserve Road/Dickson Road** | | | | | | |
| AM peak | A (14) | B (21) | B (24) | B (19) | B (29) | B (27) |
| PM peak | **F (73)** | D (50) | **F (87)** | **F (85)** | **E (66)** | **F (95)** |
| **Reserve Road/Barton Road** | | | | | | |
| AM peak | **E (69)** | **F (87)** | **F (77)** | **F (>100)** | **F (84)** | **F (85)** |
| PM peak | **F (>100)** | **E (69)** | **F (>100)** | **F (>100)** | **F (>100)** | **F (>100)** |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

## Road network changes and access arrangements

### *'Do something' scenario*

At its western end, the project would connect to the Gore Hill Freeway at Artarmon, west of the T1 North Shore and Western line and T9 Northern line. The connection would include:

- Eastbound on ramps to Beaches Link from the Lane Cove Tunnel, Epping Road, and Reserve Road, providing three access points from Artarmon and beyond
- Westbound off ramps from Beaches Link onto Reserve Road and the Lane Cove Tunnel, providing access points to Artarmon and beyond.

The Gore Hill Freeway Connection component of the project would also involve local road changes to integrate the project with the existing road network as follows:

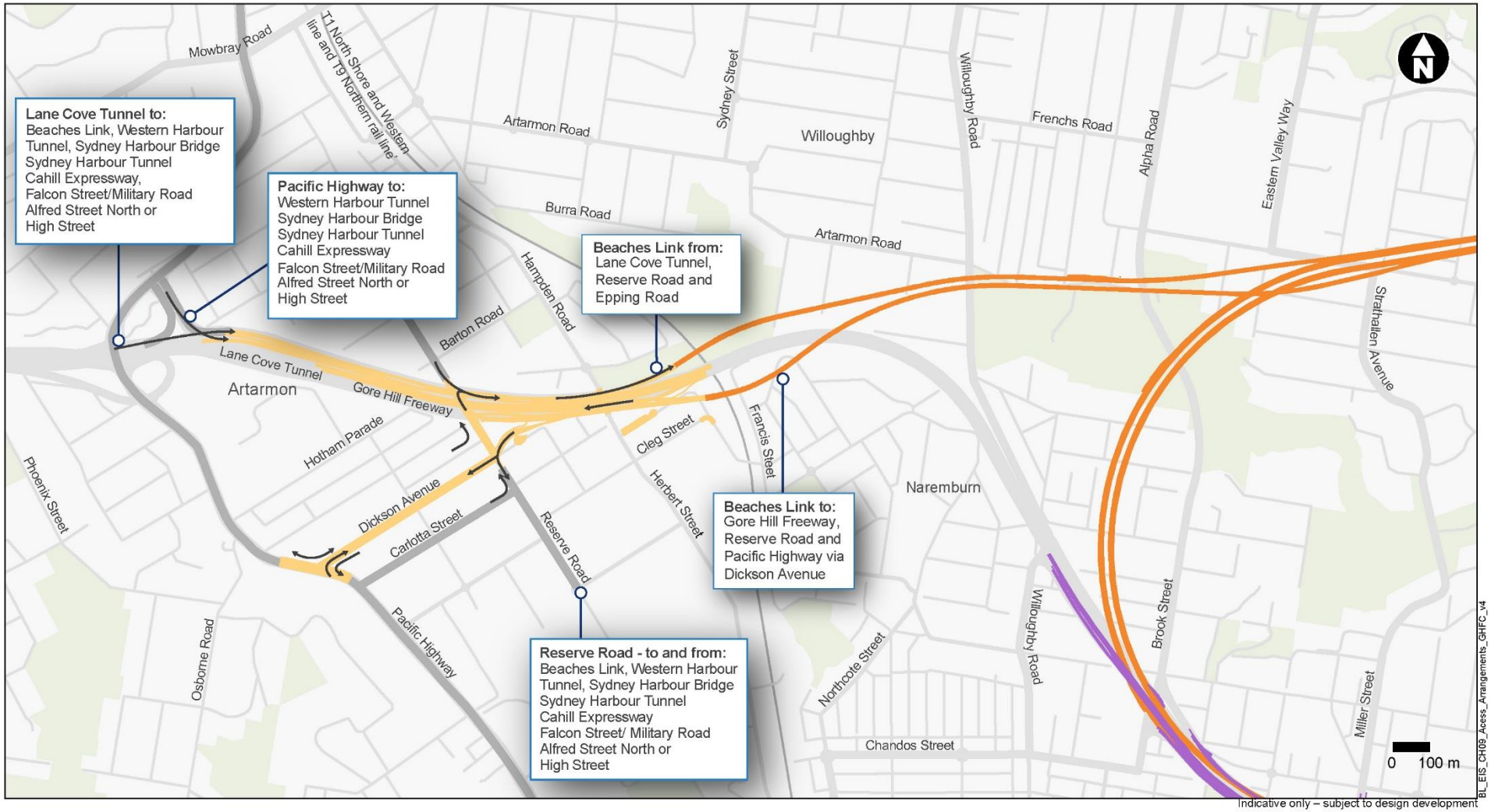
- Dickson Avenue east of Reserve Road would be converted to a cul-de-sac, and property access from Reserve Road would be removed to accommodate the westbound off ramp onto Reserve Road. Access to properties would be provided via Hesky Lane and the surrounding road network, such as Taylor Lane, Cleg Street, Herbert Street and Waltham Street. Access to Dickson Avenue west of Reserve Road would be maintained
- The Reserve Road/Dickson Avenue intersection would be modified to accommodate the westbound off ramp onto Reserve Road
- Lambs Road would be disconnected from the road network between Punch Street and Cleg Street to facilitate the installation of tunnel support facilities. Lambs Road would connect directly onto Cleg Street at its northern end while a cul-de-sac would be installed on Punch Street at its eastern end. Vehicles would be redirected from Lambs Road to Punch Street and Herbert Street. This would not substantially increase the travel time, with the additional distance is limited to around 480 metres
- Traffic signals would be provided for the Pacific Highway/Dickson Avenue intersection to increase safety and connectivity.

Additional capacity would be provided at the Reserve Road bridge where the existing footpaths would be converted to traffic lanes, a new footpath would be constructed on the eastern side of the bridge and the T2 transit lanes on the Gore Hill Freeway in both directions would be removed.

Twenty five on-street parking spaces removed on Lambs Road and Punch Street during construction would not be reinstated. About 10 on-street parking spaces for cars and six on-street parking spaces for motorcycles would also be removed at the Pacific Highway/Dickson Avenue intersection during construction and would not be reinstated. Given the availability of parking on surrounding streets this impact is anticipated to be absorbed by the surrounding network.

Beaches Link operational facilities including the motorway control centre at the Gore Hill Freeway would provide sufficient off-street parking for staff and would therefore avoid any additional on-street parking demand as a result of the project. Therefore, there would be no additional impacts on parking once the project is operational.

These network changes and access arrangements are shown in Figure 9-6.




**Legend**

**Operational features**
- Gore Hill Freeway Connection
- Beaches Link

**Connecting projects**
- Warringah Freeway Upgrade

- Access Point
- Routes with Warringah Freeway Upgrade Access Points

## Figure 9-6 Access arrangements upon completion of construction works at Gore Hill Freeway

#### *'Do something cumulative' scenario*

There would be no additional road network changes within the Gore Hill Freeway and Artarmon area under the 'Do something cumulative' scenario compared to the 'Do something' scenario.

### Impacts on public transport

#### *'Do something' scenario*

The existing T2 transit lanes in the area would be converted to general traffic lanes as part of the project. Forecast bus travel times for key routes through the Gore Hill Freeway and Artarmon area indicate that the conversion of the T2 transit lanes would not have a material impact on travel times during the AM and PM peaks towards the Sydney CBD (Lane Cove Tunnel to Gore Hill Freeway).

The project also offers the opportunity for express bus services in the Beaches Link tunnel between the Northern Beaches and strategic centres (such as Macquarie Park) via the Gore Hill Freeway.

The southbound bus stop on Pacific Highway would be permanently relocated once traffic signals are provided for the Pacific Highway/Dickson Avenue intersection. The bus stop would be relocated within 50 metres of its existing location and only minor impacts are therefore anticipated given the minor increase in travel distance.

#### *'Do something cumulative' scenario*

Forecast bus travel times for key routes through the Gore Hill Freeway and Artarmon area indicate that bus travel times would not change substantially under the 'Do something cumulative' scenario, and increased traffic flows through the area would not materially impact bus travel times for key routes.

### Impacts on active transport

#### *'Do something' scenario*

The following pedestrian and cyclist infrastructure would be provided as part of the project:

- The existing shared user path on the southern side of the Gore Hill Freeway would be replaced in areas directly impacted by the project between the T1 North Shore and Western line and T9 Northern line. Pedestrian fencing would be installed along the northern side of the shared user path to improve safety of the active transport network
- The existing pedestrian footpath along the eastern side of the Reserve Road bridge would be replaced, maintaining existing connectivity.

#### *'Do something cumulative' scenario*

There would be no additional changes to the active transport network within the Gore Hill Freeway and Artarmon area under the 'Do something cumulative' scenario when compared to the 'Do something' scenario.

## 9.4.4 Northbridge to Seaforth (Middle Harbour crossing – maritime traffic)

There would be no operational impacts on maritime movements and activities as a result of the project.

The project would result in a reduction in water depth of around 10 metres at some locations within the proposed harbour crossing. This is not expected to have an impact on navigation, given the current depth is typically greater than 20 metres chart datum at the crossing location, and vessels in this part of the harbour are already constrained by shallow water depths downstream, with the maximum water depth at the entrance to Middle Harbour being around 3.5 metres at low tide to 5.1 metres at high tide below chart datum.

Moorings impacted during construction would be reinstated as close as practical to their current locations.

### 9.4.5 Balgowlah and surrounds

#### Road network performance

##### *'Do something' scenario*

Key outcomes of the modelled road network performance in the Balgowlah and surrounds area under the 'Do something scenario' include:

- Peak period traffic demand would increase by up to 15 per cent by 2037
- Average travel speeds would improve by up to 77 per cent in the AM peak and 49 per cent in the PM peak by 2037 due to the shift in traffic demand to the project road network. The transfer of this demand from surface arterial roads to the project would reduce congestion and improve travel speeds for local trips
- The number of stops would reduce substantially by up to 56 per cent in the AM peak and 22 per cent in the PM peak. This is due to the reduction in traffic on the surface roads, particularly through the intersection of Manly Road and Sydney Road, which is the primary source of delays in the area.

The assessment indicates that the operation of the project would facilitate additional traffic travelling through the corridor within the Balgowlah and surrounds area at greatly reduced levels of delay, and would benefit both regional and local trips. This would result in improved travel times on key routes through the area as a result of the project.

##### *'Do something cumulative' scenario*

Key outcomes of the modelled road network performance in the Balgowlah and surrounds area under the 'Do something cumulative' scenario (when compared with the 'Do something' scenario) include:

- Peak period traffic demand would not substantially change
- Average travel speeds would not substantially change.

Network performance measures for the Balgowlah and surrounds area indicate that the project would facilitate additional traffic through the area. Extending connectivity further with the inclusion of the Western Harbour Tunnel would result in similar travel times and speeds to the 'Do something' scenario.

#### Traffic travel times

##### *'Do something' scenario*

Modelled travel times during AM and PM peaks for key routes through the Balgowlah and surrounds area are presented in Table 9-9. Analysis of the modelled general traffic travel times indicates that performance on most key routes throughout the modelled area is expected to improve as a result of the project.

##### *'Do something cumulative' scenario*

Table 9-9 indicates there would be minimal change in general traffic travel times as a result of the introduction of Western Harbour Tunnel when compared to the 'Do something' scenario.

**Table 9-9 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through Balgowlah and surrounds area**

| Route/ Peak period | Direction | Do minimum 2027' | Do something 2027' | Do something cumulative 2027' | Do minimum 2037' | Do something 2037' | Do something cumulative 2037' |
|---|---|---|---|---|---|---|---|
| **Spit Bridge to Burnt Bridge Creek Deviation/Condamine Street** | | | | | | | |
| AM peak | Northbound | 03:09 | 03:27 | 03:25 | 04:08 | 03:29 | 03:28 |
| | Southbound | 06:15 | 03:44 | 03:48 | 11:46 | 03:38 | 03:40 |
| PM peak | Northbound | 05:24 | 03:54 | 04:00 | 05:48 | 04:00 | 03:47 |
| | Southbound | 07:49 | 05:41 | 04:57 | 11:12 | 05:13 | 05:10 |
| **Spit Bridge to Wakehurst Parkway/Judith Street (via Frenchs Forest Road)** | | | | | | | |
| AM peak | Northbound | 05:55 | 06:23 | 06:33 | 06:47 | 06:03 | 05:58 |
| | Southbound | 07:37 | 06:31 | 06:36 | 09:22 | 06:30 | 06:30 |
| PM peak | Northbound | 09:57 | 08:28 | 07:17 | 10:19 | 08:13 | 07:39 |
| | Southbound | 14:19 | 14:05 | 14:16 | 16:07 | 14:20 | 14:23 |

## Intersection performance

### *'Do something' scenario*

Modelled intersection performance for key intersections in the Balgowlah and surrounds area under the 'Do something' scenario is presented in Table 9-10, and indicates:

- Demand at the roundabout-controlled Frenchs Forest Road/Sydney Road intersection would continue to exceed capacity, resulting in relatively poor performance during PM peak periods
- The intersection of Sydney Road, Manly Road and Burnt Bridge Creek Deviation would improve in the AM peak but continue to operate at a poor level of service during the PM peak, when average delays would be comparable to those under the 'Do minimum' scenario. The proximity of this intersection to the Frenchs Forest Road/Sydney Road intersection would result in queues from each intersection impacting the capacity and performance of the other
- All other intersections would operate at similar level of service to those under the 'Do minimum' scenario.

Analysis of the modelled general traffic travel times indicates that travel times on most key routes throughout the modelled area are expected to improve as a result of the project. While some intersections would continue to experience a poor level of service, when combined with the above travel time benefits, the project would result in an overall improvement to network performance.

### *'Do something cumulative' scenario*

Modelled intersection performance in the Balgowlah and surrounds area under the 'Do something cumulative' scenario is presented in Table 9-10 and indicates:

- Most intersections in the area would generally continue to operate at a similar level of delay when compared to the 'Do something' scenario
- Reduced traffic volumes from Spit Road associated with the introduction of the Western Harbour Tunnel would reduce the extent of queueing at the roundabout of Sydney Road and Frenchs Forest Road. This would reduce the impact on adjacent intersections,

including Sydney Road/Manly Road/Burnt Bridge Creek Deviation and Sydney Road/Maretimo Street during the PM peak.

**Table 9-10 Modelled intersection performance on the Balgowlah and surrounds area(AM peak (8am–9am) and PM peak (5pm–6pm) during operation in 2027 and 2037)**

| Intersection/ peak period | 'Do minimum 2027' LoS (average delay in seconds) | 'Do something 2027' LoS (average delay in seconds) | 'Do something cumulative 2027 LoS (average delay in seconds) | 'Do minimum 2037' LoS (average delay in seconds) | 'Do something 2037' LoS (average delay in seconds) | 'Do something cumulative 2037' LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Sydney Road/Manly Road/Burnt Bridge Creek Deviation** | | | | | | |
| AM peak | D (48) | B (26) | B (28) | **E (68)** | B (27) | B (26) |
| PM peak | **F (93)** | **F (86)** | **E (62)** | **F (>100)** | **F (93)** | **F (73)** |
| **Frenchs Forest Road/Sydney Road** | | | | | | |
| AM peak | B (21) | B (29) | B (25) | C (32) | B (28) | C (40) |
| PM peak | **F (>100)** | **F (>100)** | **F (>100)** | **F (>100)** | **F (>100)** | **F (>100)** |
| **Sydney Road/Condamine Street** | | | | | | |
| AM peak | C (33) | B (24) | B (23) | B (26) | C (29) | B (26) |
| PM peak | C (33) | C (39) | C (42) | C (40) | D (48) | D (45) |
| **Condamine Street/Burnt Bridge Creek Deviation** | | | | | | |
| AM peak | B (19) | B (31) | C (32) | C (32) | C (38) | C (36) |
| PM peak | B (17) | C (35) | C (40) | B (16) | C (38) | C (41) |
| **Access Road/Sydney Road/Maretimo Street** | | | | | | |
| AM peak | A (10) | B (23) | C (29) | A (9) | B (28) | B (27) |
| PM peak | A (9) | B (20) | B (20) | C (30) | B (27) | C (30) |
| **Access Road/Burnt Bridge Creek Deviation** | | | | | | |
| AM peak | N/A | A (11) | A (10) | N/A | A (14) | A (14) |
| PM peak | N/A | A (11) | A (11) | N/A | A (12) | A (11) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E or F

## Road network changes and access arrangements

### *'Do something' scenario*

In the 'Do something' scenario, the project would connect to Burnt Bridge Creek Deviation at Balgowlah, just north of its intersection with Sydney Road. This would include a two-lane southbound on ramp and a three-lane northbound off ramp. Local road changes would be required to integrate the project with the existing road network as follows:

- Provision of a new access road in Balgowlah, providing local access and connectivity to the new open space and recreation facilities and connecting the tunnel portals/Burnt Bridge Creek Deviation and Sydney Road. The new access road would accommodate travel in either direction

- A new intersection with traffic signals connecting the new access road with Burnt Bridge Creek Deviation and the tunnel portals adjacent to the northern end of Dudley Street. This would include right turn lanes into the new access road from the Beaches Link off ramp and left turn lanes out of the new access road to the Beaches Link on ramp and Burnt Bridge Creek Deviation southbound. Non-tunnel northbound traffic on Burnt Bridge Creek Deviation would bypass these traffic signals
- A new signalised intersection would be provided at the southern end of the new access road to accommodate its connection with Sydney Road. Traffic movements north-south (and vice versa) through the intersection between Maretimo Street and the access road would not be permitted. The new intersection would include a pedestrian crossing across the new access road on the northern side of Sydney Road. Pedestrian connectivity between the new open space and recreation facilities, the Northern Beaches Secondary College – Balgowlah Boys Campus and Maretimo Street would be provided via the existing pedestrian bridge to the west of the new access road and would continue to provide north-south connectivity for pedestrians in the area. Pedestrian connectivity across Sydney Road to and from Maretimo Street would not be provided at the intersection
- Relocating the existing cul-de-sac at Dudley Street further south to accommodate construction of the new tunnel portals and the associated realignment of Burnt Bridge Creek Deviation.

Potential access impacts associated with the relocation of the cul-de-sac on Dudley Street are expected to be minor given remaining properties would still be accessible from Dudley Street.

Surface connections at Balgowlah would attract traffic demand from both east and west of Burnt Bridge Creek Deviation. The additional traffic from North Balgowlah could cross at Kitchener Street to access the new access road from Sydney Road east. This could increase traffic volumes on local roads between Kitchener Street and Sydney Road. Local area traffic management would assist in minimising increased traffic on local roads. Local area traffic management on Wanganella Street, Rickard Street and West Street could result in traffic using Woodland Street and Condamine Street instead, which would be more appropriate to the function of these roads. Local traffic management measures proposed would be discussed further and agreed with Northern Beaches Council during detailed design.

#### *'Do something cumulative' scenario*

There would be no additional road network changes within Balgowlah and surrounds under the 'Do something cumulative' scenario (when compared to the 'Do something' scenario).

### Impacts on public transport

#### *'Do something' scenario*

In the 'Do something' scenario, bus travel times would be maintained or improved as a result of the project, as existing bus priority in the area would be maintained and traffic congestion reduced in the Balgowlah and surrounds area.

#### *'Do something cumulative' scenario*

In the 'Do something cumulative' scenario bus travel times may increase marginally along Frenchs Forest Road during the PM peak as a result of the increased traffic travelling through the Sydney Road/Frenchs Forest Road roundabout, when compared to the 'Do something' scenario.

All other bus routes would be generally unaffected by the changes in traffic as a result of the 'Do something cumulative' scenario when compared to the 'Do something' scenario.

### Impacts on active transport

#### *'Do something' scenario*

Pedestrian and cyclist facilities provided as part of the 'Do something' scenario would generally improve the extent of the overall active transport network in Balgowlah and surrounds. The following is proposed as part of the project:

- New shared user paths would be provided along the eastern side of the new access road
- A portion of the existing shared user path along Burnt Bridge Creek within the existing golf course would require minor adjustment due to a localised adjustment of the creek alignment
- The existing box culvert crossing of Burnt Bridge Creek Deviation and adjacent pedestrian underpass beneath Burnt Bridge Creek Deviation would both be extended under the realigned road, maintaining existing connectivity across the widened Burnt Bridge Creek Deviation. This would connect to the existing shared user path at Dudley Street. Pedestrian fencing would be provided along the outside of the shared user path and the realigned section of Burnt Bridge Creek Deviation
- New signal controlled pedestrian crossings across the new access road at its interfaces with Sydney Road and Burnt Bridge Creek deviation would maintain connectivity to the existing Balgowlah Oval from Northern Beaches Secondary College – Balgowlah Boys Campus
- An at grade signalised crossing of the access road would provide access to the intersections of the Burnt Bridge Creek Deviation and the new public car park within the open space and recreation facilities area at Balgowlah.

The final layout of the new and improved open space and recreation facilities at Balgowlah including shared user paths are subject to a dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council to give the community an opportunity to provide input (refer to Chapter 6 (Construction work) for further details). This consultation would be separate to the consultation for the environmental impact statement. This process would start after the environmental impact statement public exhibition period and well in advance of construction starting. As part of this consultation process, a community reference group will be established, with representative stakeholder groups and the community, to support Transport for NSW and Northern Beaches Council with the development of this important public space.

#### *'Do something cumulative' scenario*

There would be no additional changes to the active transport network under the 'Do something cumulative' scenario when compared to the 'Do something' scenario.

## 9.4.6 Frenchs Forest and surrounds

### Road network performance

#### *Northern Beaches Hospital road upgrade project*

The assessment of the Frenchs Forest and surrounds area without the project includes the road network performance benefits from the recently completed Northern Beaches Hospital road upgrade project. 'Do minimum 2027' results indicate that:

- Peak period traffic demand through the area is forecast to increase by 10 per cent
- Overall network speeds would be improved by up to 40 per cent
- Travel speeds along Warringah Road and other key corridors would be improved by more than 50 per cent in some cases.

The results of the 'Do minimum 2037' scenario illustrate similar benefits, but also indicate that continued long-term background demand growth in the area would reduce road network performance over time. Between 2027 and 2037:

- Demand is forecast to increase by an additional five per cent
- Network speeds would consequently reduce by around five to 10 per cent.

Overall, the 'Do minimum' results indicate that despite continuous growth in background demand over the next 20 years, network performance in the area would still be substantially improved when compared to existing conditions, due to the Northern Beaches Hospital road upgrade project.

### *'Do something' scenario*

Key outcomes of the modelled road network performance in the Frenchs Forest and surrounds area under the 'Do something' scenario includes the following:

- Peak period traffic demand through the Frenchs Forest and surrounds area would increase by up to 10 per cent by 2037
- Average travel speeds through the Frenchs Forest and surrounds area may decrease by up to 13 per cent. This is primarily a consequence of the change in traffic patterns and demand as a result of the project. A substantial proportion of traffic that currently travels east–west along Warringah Road would travel from east to south and from south to east along Wakehurst Parkway and Warringah Road and through the intersection of Warringah Road and Wakehurst Parkway instead of passing through the underpass. Similarly, southbound traffic on Forest Way that would turn right onto Warringah Road would instead turn left, then right from Warringah Road to Wakehurst Parkway, increasing localised delays at the intersection of Warringah Road and Wakehurst Parkway
- The number of stops would increase by up to 26 per cent as a result of the project due to the change in the pattern of demand with more trips travelling through surface road intersections rather than through the underpass.

The new underpasses at Forest Way and Wakehurst Parkway would not be impacted for the main east/west traffic route on Warringah Road. However, the changes to traffic patterns associated with the project would generally result in increased localised delays on the Warringah Road surface lanes between Forest Way and Wakehurst Parkway and reduced travel speeds through the area. This would be due to the change in the pattern of traffic demand from mostly east and west to mostly east and south, reflecting a change in the main southbound route from Warringah Road to Wakehurst Parkway and the new motorway tunnels introduced by the project. This would transfer traffic demand from a largely grade-separated movement through several additional intersections, resulting in localised delays.

Although some localised delays may be experienced during peak periods, broader modelling indicates that most road users would benefit from substantial travel time savings on the broader network due to the strategic benefits provided by Beaches Link.

### *'Do something cumulative' scenario*

Key outcomes of the modelled road network performance in the Frenchs Forest and surrounds area, under the 'Do something cumulative' scenario (compared with the 'Do something' scenario) includes the following:

- AM and PM peak period traffic demand would increase marginally by up to two per cent
- Average travel speeds through the area could decrease by as much as 12 per cent, largely due to additional demand and redistribution of traffic from Warringah Road (Roseville Bridge) to the project. This would increase the volume of traffic through the intersection of Warringah Road and Wakehurst Parkway, and reduce the volume travelling through the underpass along Warringah Road

- The number of stops would increase under the 'Do something cumulative' scenario by up to 15 per cent. This would be a consequence of the small distribution of traffic from the Warringah Road grade separation to the Warringah Road and Wakehurst Parkway intersection.

There would not be a substantial increase in overall travel demand, but the additional redistribution of demand from Warringah Road to the project would result in some additional localised delay through the network. This is a result of these trips being transferred from the Warringah Road grade separation to the Warringah Road and Wakehurst Parkway surface intersection, which would be operating at capacity.

The strategic benefits of the project are expected to substantially offset localised impacts. The potential localised increases in travel times on the key corridors of Warringah Road and Wakehurst Parkway within the area are expected to be less than five minutes. Conversely, average travel time savings between key centres, eg Dee Why to and from Macquarie Park, are expected to be around 20 minutes. In this example, a 15-minute net saving would be created by the project providing new high capacity connectivity and reducing congestion on existing regional routes.

Notwithstanding this, Transport for NSW is continuing to investigate options to mitigate potential localised network performance issues in the area, and further leverage the overall benefits and opportunities of the project. This work is cognisant of and reliant on the outcomes of the ongoing implementation of the *Northern Beaches Hospital Precinct Structure Plan* (Northern Beaches Council, 2017b), which highlights that future precinct development beyond Stage 1 of the development is dependent on further delivery of improved transport infrastructure and a continued modal shift from private to public transport (refer to Section 9.1.2).

### Traffic travel times

#### *'Do something' scenario*

Modelled travel times during the AM and PM peaks for key routes through the Frenchs Forest and surrounds area are presented in Table 9-11.

The modelled travel times under the 'Do something' scenario show the following:

- Overall travel times for general traffic on Warringah Road and Forest Way would remain generally unaffected by the project, indicating that potentially increased delays at the intersections along Wakehurst Parkway would not impact east–west trips
- In the AM peak, southbound travel times along Wakehurst Parkway would increase as a result of the project due to the change in traffic pattern that would increase the volumes of traffic turning right from Warringah Road to Wakehurst Parkway, conflicting with the increase in southbound traffic on Wakehurst Parkway
- In the PM peak, travel times for general traffic along Wakehurst Parkway would remain comparable or would improve as a result of the project because the primary southbound movements in the PM peak do not conflict as they do in the AM peak and would have additional capacity provided on Wakehurst Parkway south of Warringah Road.

Overall, traffic modelling predicts that potentially increased localised delays at intersections would be offset by the broader improvement in connectivity and reduction in congestion created by the project.

#### *'Do something cumulative' scenario*

Table 9-11 indicates travel times would generally be maintained following the introduction of the Western Harbour Tunnel. There would, however, be some changes, including:

- Increased travel times on Wakehurst Parkway southbound through the area
- Increased demand at the intersections with Frenchs Forest Road and Warringah Road that would create localised delays during the busiest peak periods in 2037.

**Table 9-11 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through the Frenchs Forest and surrounds area**

| Route/ Peak period | Direction | Do minimum 2027' | Do something 2027' | Do something cumulative 2027' | Do minimum 2037' | Do something 2037' | Do something cumulative 2037' |
|---|---|---|---|---|---|---|---|
| **Wakehurst Parkway/Judith Street to Wakehurst Parkway/Dreadnought Road** | | | | | | | |
| AM peak | Northbound | 04:27 | 04:17 | 04:11 | 06:59 | 04:27 | 04:00 |
| | Southbound | 04:29 | 09:13 | 10:07 | 05:05 | 07:36 | 10:14 |
| PM peak | Northbound | 04:37 | 05:35 | 06:15 | 07:02 | 05:30 | 05:39 |
| | Southbound | 04:10 | 03:20 | 03:40 | 04:04 | 03:24 | 09:12 |
| **Warringah Road/Forestville Avenue to Ellis Road/Warringah Road** | | | | | | | |
| AM peak | Eastbound | 05:25 | 05:26 | 05:21 | 05:24 | 05:22 | 06:39 |
| | Westbound | 05:55 | 05:24 | 05:30 | 06:11 | 05:53 | 06:13 |
| PM peak | Eastbound | 06:05 | 06:09 | 05:58 | 06:22 | 06:42 | 06:21 |
| | Westbound | 05:15 | 05:24 | 05:19 | 05:36 | 05:15 | 05:24 |

## Intersection performance

### *'Do something' scenario*

Modelled future performance for key intersections in the Frenchs Forest and surrounds area under the 'Do something' scenario is presented in Table 9-12. Changes to traffic patterns and demand would result in the following intersections operating at a relatively poor level of service during peak hours, when compared to the scenario without the project:

- Wakehurst Parkway and Frenchs Forest Road East (particularly during the AM peak)
- Wakehurst Parkway and Warringah Road
- Warringah Road and Hilmer Street (due to queues from Wakehurst Parkway) (during 2037 PM peak only).

These intersections would experience increased localised delays as a result of the changes in traffic patterns that would arise from the project. However, the project would reduce congestion and delays at intersections along the broader Warringah Road corridor due to the substantial reductions in traffic volumes along Warringah Road to the west of Forest Way.

### *'Do something cumulative' scenario*

Modelled future performance for key intersections in the Frenchs Forest and surrounds area under the 'Do something cumulative' scenario is presented in Table 9-12 and indicate the following when compared with the 'Do something' scenario:

- The intersections of Wakehurst Parkway and Warringah Road, and Wakehurst Parkway and Frenchs Forest Road East would operate with higher average delays due to the redistribution of traffic from Warringah Road to the project
- Delays at the Forest Way/Naree Road intersection would increase as a result of the increase in demand through the area.

The 'Do something cumulative' scenario would result in increased localised delays at intersections when compared with the 'Do something' scenario, primarily as a result of the redistribution of traffic from Warringah Road to the project, but also due to an increase in forecast demand through the area created by the Western Harbour Tunnel.

Although there would be an increase in localised intersection delays, road users would generally benefit from substantial overall travel time savings on the broader network (eg via the project, Warringah Road, Wakehurst Parkway and beyond, particularly through the connectivity to Western Harbour Tunnel). Consequently, traffic impacted at individual intersections in the area is still anticipated to receive a substantial net benefit due to the broader connectivity and efficiency improvements.

**Table 9-12 Modelled intersection performance on the Frenchs Forest and surrounds area (AM peak (8am–9am) and PM peak (5pm–6pm) during operation in 2027 and 2037)**

| Intersection/ peak period | 'Do minimum 2027' LoS (average delay in seconds) | 'Do something 2027' LoS (average delay in seconds) | 'Do something cumulative 2027 LoS (average delay in seconds) | 'Do minimum 2037' LoS (average delay in seconds) | 'Do something 2037' LoS (average delay in seconds) | 'Do something cumulative 2037' LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Wakehurst Parkway/Frenchs Forest Road East** | | | | | | |
| AM peak | D (44) | **F (>100)** | **F (>100)** | **E (66)** | **F (86)** | **F (>100)** |
| PM peak | D (46) | D (45) | D (45) | D (46) | C (43) | **F (98)** |
| **Warringah Road/Allambie Road** | | | | | | |
| AM peak | D (44) | D (50) | D (54) | D (46) | D (51) | D (50) |
| PM peak | D (46) | D (52) | D (50) | D (49) | D (52) | D (48) |
| **Wakehurst Parkway/Warringah Road** | | | | | | |
| AM peak | **E (58)** | **F (93)** | **F (94)** | **F (78)** | **F (73)** | **F (81)** |
| PM peak | C (33) | **F (75)** | **F (86)** | C (41) | **E (59)** | **E (60)** |
| **Warringah Road/Hilmer Street** | | | | | | |
| AM peak | A (14) | B (18) | C (35) | C (38) | D (50) | D (57) |
| PM peak | A (12) | B (17) | B (21) | A (13) | **F (88)** | **F (73)** |
| **Warringah Road/Forest Way** | | | | | | |
| AM peak | B (18) | A (15) | B (18) | B (21) | B (16) | B (26) |
| PM peak | B (24) | B (24) | C (33) | B (26) | C (31) | B (24) |
| **Forest Way/Naree Road** | | | | | | |
| AM peak | B (24) | D (56) | D (57) | C (36) | D (54) | **E (69)** |
| PM peak | B (19) | B (28) | B (24) | B (27) | B (28) | D (53) |
| **Warringah Road/Brown Street/Currie Road** | | | | | | |
| AM peak | B (20) | B (16) | B (17) | B (23) | B (18) | B (17) |
| PM peak | A (10) | A (9) | A (9) | A (11) | A (9) | A (10) |
| **Warringah Road/Starkey Street** | | | | | | |
| AM peak | B (23) | B (20) | B (21) | B (26) | B (21) | B (25) |
| PM peak | B (20) | B (20) | B (18) | B (19) | B (20) | B (19) |

| Intersection/ peak period | 'Do minimum 2027' LoS (average delay in seconds) | 'Do something 2027' LoS (average delay in seconds) | 'Do something cumulative 2027 LoS (average delay in seconds) | 'Do minimum 2037' LoS (average delay in seconds) | 'Do something 2037' LoS (average delay in seconds) | 'Do something cumulative 2037' LoS (average delay in seconds) |
|---|---|---|---|---|---|---|
| **Warringah Road/Darley Street** | | | | | | |
| AM peak | B (28) | B (27) | B (29) | C (30) | B (26) | B (26) |
| PM peak | B (19) | B (17) | B (15) | B (19) | B (19) | B (15) |
| **Warringah Road/Forestville Avenue** | | | | | | |
| AM peak | A (10) | A (14) | A (14) | A (14) | A (14) | A (14) |
| PM peak | C (35) | B (29) | B (21) | D (46) | C (35) | C (34) |

Note: Cells shaded in dark grey denote an unsatisfactory LoS E and F

### Road network changes and access arrangements

#### *'Do something' scenario*

In the 'Do something' scenario, the project would connect to Wakehurst Parkway at Killarney Heights, north of Kirkwood Street. This connection would include a two-lane southbound on ramp and a two-lane northbound off ramp. This would involve minor local road changes to the intersections of Wakehurst Parkway with Kirkwood Street, Fitzpatrick/Aquatic Drive, Warringah Road and Frenchs Forest Road East and Frenchs Forest Road West to integrate the project with the existing surface road network as follows:

- Provision of additional capacity on Wakehurst Parkway, which would be upgraded to two lanes in each direction between the tunnel portal and Warringah Road
- Removal of the right turn movement from Wakehurst Parkway northbound onto Frenchs Forest Road eastbound, resulting in an additional travel distance of up to 1.3 kilometres via Warringah Road and Allambie Road for affected trips
- Alterations to line marking, adjustments to medians and asphalt resurfacing along local roads.

Given the minimal changes required to local roads, these impacts would be considered minor.

#### *'Do something cumulative' scenario*

There would be no additional road network changes within the Frenchs Forest and surrounds area under the 'Do something cumulative' scenario, when compared to the 'Do something' scenario.

### Impacts on public transport

#### *'Do something' scenario*

In the 'Do something' scenario, bus travel times for key routes through the Frenchs Forest and surrounds area would not be materially impacted by the project. Regional and local buses that are serviced by the Warringah Road and Eastern Valley Way corridors would benefit from improved travel times and reliability as a result of reduced traffic demand and congestion on these roads as a result of the project.

Four new dedicated bus bays and two associated shared user path underpasses would be provided along Wakehurst Parkway, improving bus safety and reducing conflict between stopped buses and general traffic.

### *'Do something cumulative' scenario*

In the 'Do something cumulative' scenario, bus travel times would generally be maintained during the PM peak, compared to the 'Do something' scenario. In the AM peak, when compared with the 'Do something' scenario, there would be some localised impacts on travel times due to the increased demand created by the Western Harbour Tunnel, with increased intersection delays along Warringah Road and Wakehurst Parkway.

The 'Do something cumulative' scenario would reduce traffic demand heading to the Sydney CBD and employment centres like Macquarie Park via the alternative Warringah Road and Eastern Valley Way corridors to the west and south of Frenchs Forest. Both corridors carry regional and local buses, and these services would benefit from improved travel times and reliability as result of reduced congestion.

## Impacts on active transport

### *'Do something' scenario*

Under the 'Do something' scenario, the following changes to the active transport network within the Frenchs Forest and surrounds area would be carried out as part of the project:

- A new shared user path on the eastern side of Wakehurst Parkway from the northern end of Kirkwood Street to Warringah Road
- A new shared user underpass beneath Wakehurst Parkway near Yarraman Avenue
- A new shared user bridge over the drainage culvert and fauna underpass (constructed as part of the Northern Beaches Hospital road upgrade project) on the eastern side of Wakehurst Parkway about 150 metres south of Warringah Road
- Three new shared user underpasses beneath Wakehurst Parkway, connecting Garigal National Park and Manly Dam Reserve
- Replacement of the existing pedestrian bridge with a new longer pedestrian bridge over Wakehurst Parkway, about 350 metres south of Warringah Road.

The modified and new pedestrian and cycle crossings proposed would improve the safety and connectivity of the active transport network to, from, and within the Frenchs Forest and surrounds area.

### *'Do something cumulative' scenario*

There would be no additional changes to the active transport network under the 'Do something cumulative' scenario when compared to the 'Do something' scenario.

## 9.5 Environmental management measures

Environmental management measures relating to operational traffic and transport impacts are outlined in Table 9-13.

**Table 9-13 Environmental management measures – operational traffic and transport**

| Ref | Phase | Impact | Environmental management measures | Location* |
|---|---|---|---|---|
| OT1 | Operation | Operational traffic | A review of operational network performance will be carried out 12 months and five years from the opening of the project to confirm the operational impacts of the project on surrounding arterial roads and major intersections. The assessment will be based on updated traffic data at the time and the methodology used will be comparable with that used in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement. Where required, additional feasible and reasonable mitigation measures will be identified in consultation with Department of Planning, Industry and Environment and the relevant council to manage any additional traffic performance impacts identified during the review of operational network performance. | BL/GHF |
| OT2 | Operation | Impacts on local roads | Where required, Transport for NSW will investigate local area traffic management measures to minimise the impact of the project on the surrounding local road network. Such measures will be determined in consultation with relevant councils and implemented where feasible and reasonable. | BL/GHF |

*BL = Beaches Link, GHF = Gore Hill Freeway Connection

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## Chapter 10

## Construction noise and vibration

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# 10 Construction noise and vibration

This chapter considers the potential noise and vibration impacts from the construction of the project and identifies management measures to minimise these impacts. Potential noise and vibration impacts associated with the operation of the project are included in Chapter 11 (Operational noise and vibration).

A detailed noise and vibration assessment has been carried out for the project and is included in Appendix G (Technical working paper: Noise and vibration). The impacts associated with underwater noise are considered in Chapter 13 (Human health) and Chapter 19 (Biodiversity).

The Secretary's environmental assessment requirements as they relate to construction noise and vibration and where in the environmental impact statement these have been addressed, are detailed in Table 10-1.

Avoiding or minimising impacts has been a key consideration throughout the design and development process for the Beaches Link and Gore Hill Freeway Connection project. A conservative approach has generally been used in the assessments, with potential impacts presented before implementation of environmental management measures. The environmental management measures proposed to minimise the potential impacts in relation to construction noise and vibration are included in Section 10.7.

**Table 10-1 Secretary's environmental assessment requirements – construction noise and vibration**

| Secretary s requirement | Where addressed in EIS |
|---|---|
| **Noise and Vibration – Amenity** | |
| 1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must take into consideration and address the redistribution of traffic (including on local feeder roads) and operational plant and equipment, and must include consideration of impacts to sensitive receivers and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise). | Relevant NSW noise and vibration guidelines used in the assessment are discussed in **Section 10.4.**<br>Impacts from redistribution of traffic (including on local feeder roads) and operational plant and equipment are documented in **Chapter 11** (Operational noise and vibration). |
| 2. An assessment of construction noise and vibration impacts which must address:<br>a. the nature of construction activities (including transport, tonal or impulsive noise–generating works and the removal of operational noise barriers, as relevant); | The nature of construction activities and potential noise and vibration impacts are outlined in **Section 10.6,** while additional detail is provided in **Appendix G** (Technical working paper: Noise and vibration). |
| b. the intensity and duration of noise and vibration impacts (both air and ground borne). This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue; | The intensity and duration of potential noise and vibration impacts are described in **Section 10.6**, however further detail is provided within **Appendix G** (Technical Working Paper: Noise and vibration). |

| Secretary s requirement | Where addressed in EIS |
|---|---|
| | Environmental management measures related to construction fatigue are in **Section 10.7**. Construction fatigue is also discussed in **Chapter 27** (Cumulative impacts). |
| c. the identification of receivers, existing and likely, during the construction period; | **Section 10.5** outlines the identification of receivers, both existing and likely, while **Section 10.6** outlines potential impacts on such receivers. |
| d. the nature, sensitivity and impact to receivers; | **Section 10.5** and **Section 10.6** present information on the nature, sensitivity and impact on receivers, however further detail is provided within **Appendix G** (Technical Working Paper: Noise and vibration). |
| e. 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); | Information regarding 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) is outlined **Section 10.6** as well as within **Appendix G** (Technical Working Paper: Noise and vibration). |
| f. the potential for works outside standard construction hours, including predicted levels, exceedances, number of potentially affected receivers, and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009); | **Section 10.6** as well as **Appendix G** (Technical Working Paper: Noise and vibration) present details on the potential (and parameters) for works outside of standard construction hours. |
| g. a cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities); | **Section 10.6** as well as Appendix G (Technical working paper: Noise and vibration) present details on the cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities). |
| h. a cumulative noise and vibration assessment of the impacts from the project and the construction of other relevant development in the vicinity of the proposal; | **Section 10.6** as well as **Appendix G** (Technical working paper: Noise and vibration) presents detail on the cumulative noise and vibration assessment of impacts from the project and the construction of other relevant development in the vicinity of the proposal.<br>**Chapter 27** (Cumulative impacts) assesses the cumulative construction noise and other relevant developments in the vicinity of the proposal. |
| i. details and analysis of the effectiveness of mitigation measures to adequately manage identified impacts, including | **Section 10.6** and **Appendix G** (Technical working paper: Noise and vibration) present details and analysis of the effectiveness of |

| Secretary s requirement | Where addressed in EIS |
|---|---|
| cumulative impacts as identified in (g) and (h) and a clear identification of residual noise and vibration following application of mitigation measures; and | mitigation measures (as outlined in **Section 10.9**). |
| j. a description of how community preferences have been taken into account in the design of mitigation measures and consider tailored mitigation, management and communication strategies for vulnerable community members. | **Appendix E** (Technical working paper: Community consultation framework) presents details of how community preferences would be taken into account in the design of mitigation measures and commitments to tailored mitigation, management and communication strategies for vulnerable community members. |
| 3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required. | **Section 10.4** and **Section 10.6** outline how blast impacts are capable of complying with respect to relevant guidelines. Further detail is provided within **Appendix G** (Technical Working Paper: Noise and vibration). |
| **Noise and Vibration – Structural** | |
| 1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage). | **Section 10.6** as well as **Appendix G** (Technical working paper: Noise and vibration) presents details on the assessment of construction and operation noise and vibration impacts in respect to relevant NSW noise and vibration guidelines as well as the consideration of impacts on the structural integrity of buildings and heritage significance items.<br>**Chapter 11** (Operational noise and vibration) presents information with respect to the operational phase.<br>**Chapter 14** (Non-Aboriginal heritage) presents an assessment of impacts to items of significance as a result of vibration.<br>**Chapter 15** (Aboriginal cultural heritage) provides an assessment of impacts to items of significance as a result of vibration. |
| 2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required. | **Section 10.3** and **Section 10.6** outlines how blast impacts are capable of complying with respect to relevant guidelines. Further detail is provided within **Appendix G** (Technical Working Paper: Noise and vibration). |

## 10.1 Acoustic terminology

Common acoustic terms used throughout this chapter and Chapter 11 (Operational noise and vibration) are explained in Table 10-2.

**Table 10-2 Acoustic terminology**

| Term | Definition |
|---|---|
| Ambient noise | The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far. |
| dB(A) | dB(A) stands for A-weighted decibel, a unit used to measure noise. A summary of noise levels in the context of comparable activities is shown in Figure 10-1 to assist in the interpretation of the noise levels presented in this chapter. In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect. A 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However, individuals may perceive the same sound differently since many factors can influence an individual's response, including:<br>• The specific characteristics of the noise (eg frequency, intensity, duration of the noise event)<br>• Time of day noise events occur<br>• Individual sensitivities and lifestyle<br>• Reaction to an unfamiliar sound<br>• Understanding of whether the noise is avoidable and the notions of fairness. |
| $L_{A90}$ | $L_{A90}$ is the level of noise exceeded for 90 per cent of the time. The bottom 10 per cent of the sample is the $L_{A90}$ noise level expressed in units of dB(A). |
| $L_{Aeq(period)}$ | $L_{Aeq(period)}$ is the A-weighted equivalent noise level. It is the summation of noise events and integrated over a period of time. |
| $L_{Amax}$ | $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period. |
| Noise catchment area (NCA) | Noise catchment area is an area where noise and vibration sensitive receivers have similar acoustic environment. Refer to Section 10.3.1 for more information on NCAs. |
| Rating background level (RBL) | Rating background level is the background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night time periods and is used to set the $L_{Aeq(15\ minute)}$ noise management levels for residential receivers. |

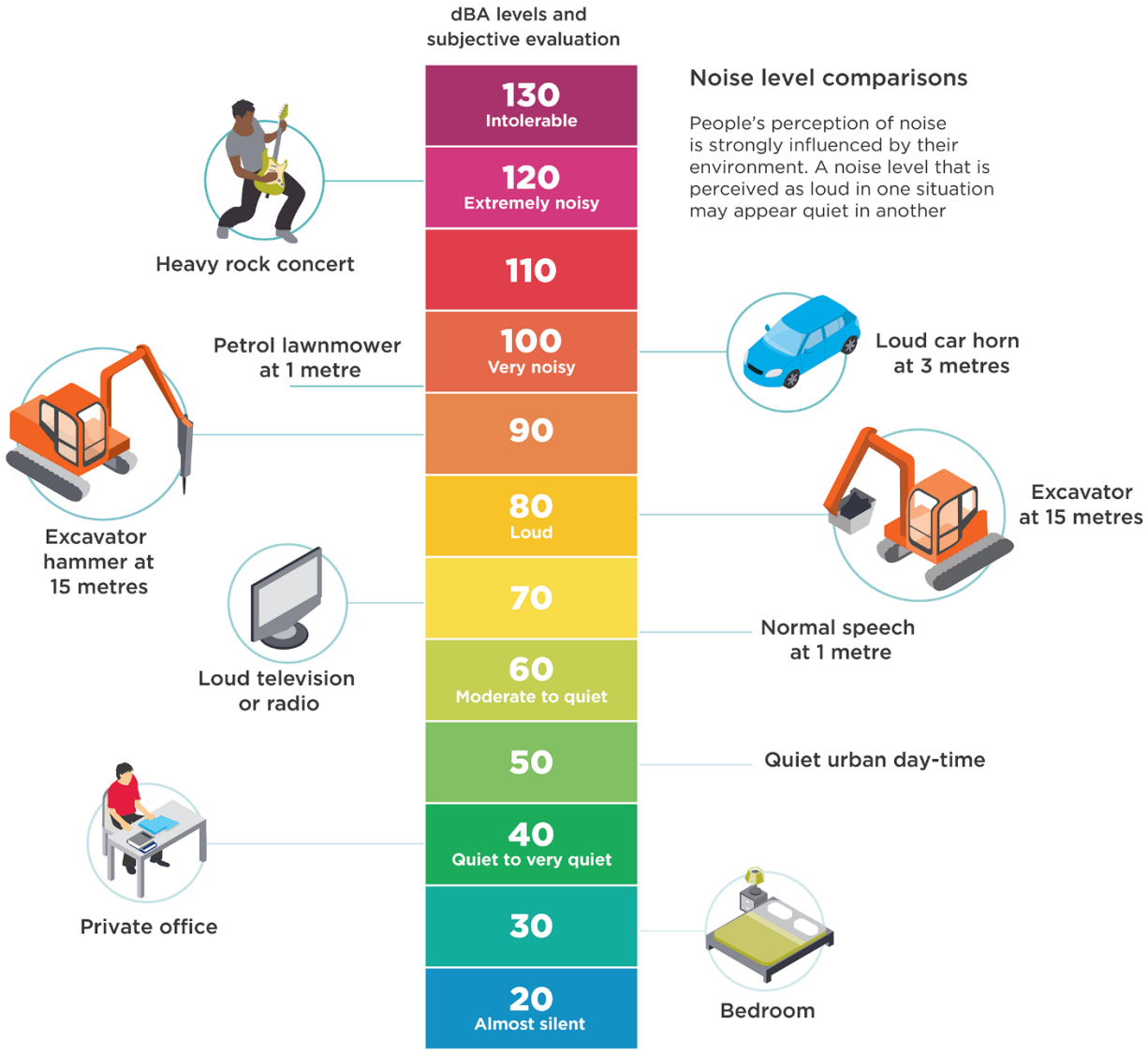



**Figure 10-1 Noise level comparison**

## 10.2 Legislative and policy framework

Construction noise and vibration from State significant infrastructure projects is regulated by the Department of Planning, Industry and Environment through project approval requirements under the *Environmental Planning and Assessment Act 1979* and by the NSW Environment Protection Authority through environment protection licences issued under the *Protection of the Environment Operations Act 1997*. In addition, the Protection of the Environment Operations (Noise Control) Regulation 2017 includes controls on noise from motor vehicles and marine vessels, while the *Heavy Vehicle (Vehicle Standards) National Regulation (NSW)* includes controls on noise from heavy vehicles.

The *Interim Construction Noise Guideline* (DECC, 2009a) provides guidance on assessing and managing construction noise, and to assist setting conditions in approvals and licences. The guideline covers noise and ground-borne noise impacts (including construction traffic within the construction footprint) and identifies noise management levels that guide the need to apply reasonable and feasible mitigation and management measures to minimise noise impacts. For construction vibration, *Assessing Vibration: a technical guideline* (DECC, 2006) provides guidance on managing the risk of vibration impacts on human comfort.

The *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a) integrates and adapts, for Transport for NSW projects, the direction and guidance provided by several other policies, guidelines and standards, including the *Interim Construction Noise Guideline* (DECC, 2009a), *Assessing Vibration: a technical guideline* (DECC, 2006), and Australian criteria for blasting (AS 2187.2 2006 (Standards Australia, 2006)). The *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a) is the key document providing guidance for the assessment and mitigation of construction noise and vibration on this project. It is supported by the *NSW Road Noise Policy* (DECCW, 2011), which addresses construction road traffic noise impacts (on public roads) and sleep disturbance, and the *Noise Criteria Guideline* (Roads and Maritime Services, 2015f), which provides an assessment process for construction traffic noise impacts.

## 10.3 Assessment methodology

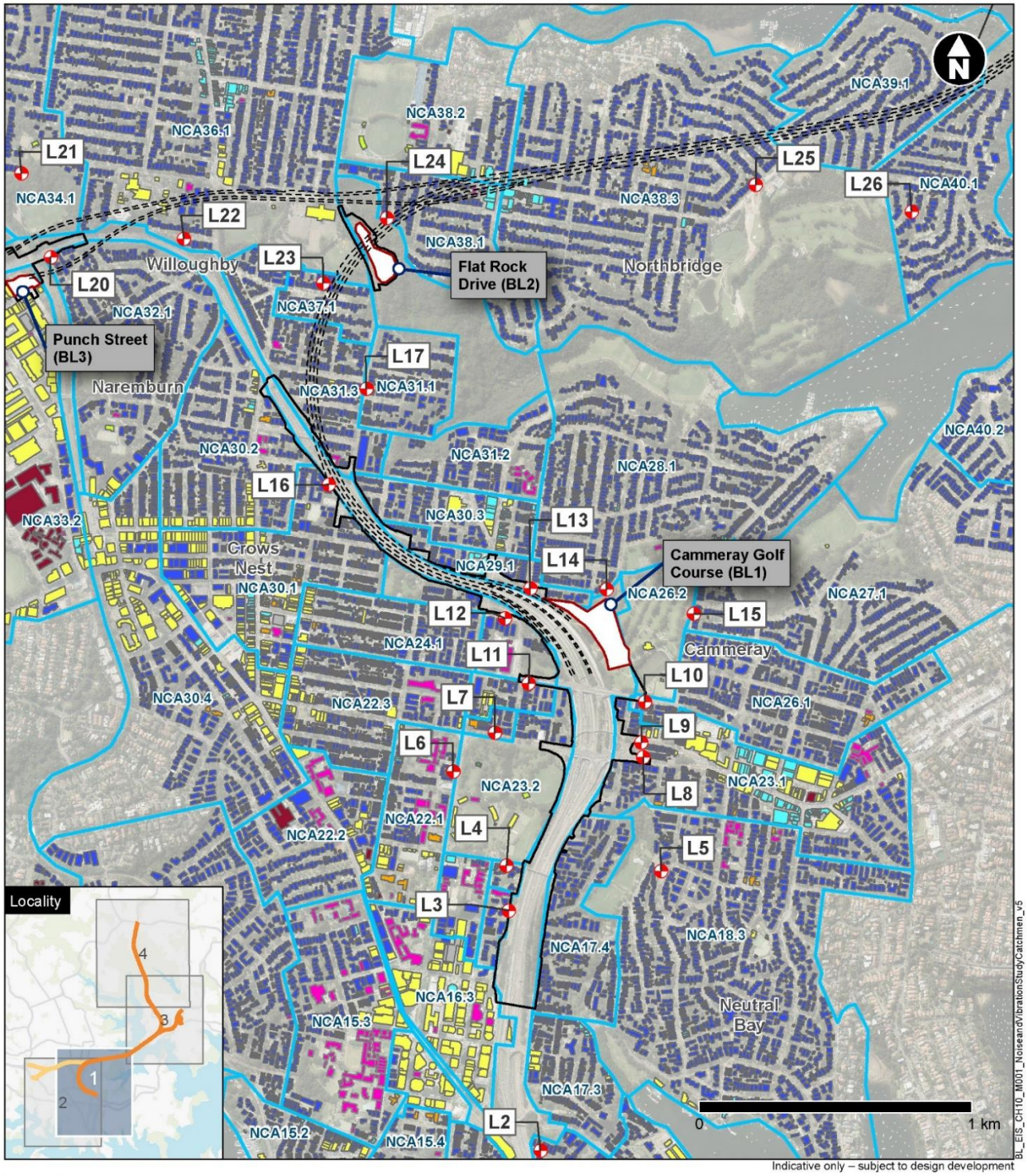
### 10.3.1 Noise sensitive receivers and noise catchment areas

The location and type of noise sensitive receivers near temporary construction support sites, construction sites and haulage routes were identified using a combination of aerial photography and visual inspections. These noise sensitive receivers were then grouped into noise catchment areas (NCAs) along the project alignment, being areas of similar acoustic environments. The noise catchment areas are shown in Figure 10-2 to Figure 10-5.

### 10.3.2 Background noise monitoring

Noise monitoring was carried out at 47 locations between June 2017 and April 2019 to establish existing background and existing traffic noise levels within the noise catchment areas. The noise monitoring locations are shown in Figure 10-2 to Figure 10-5. Noise monitoring carried out from 2017 is considered representative of the 2020 noise environment and is applicable for the purposes of the construction and operational noise assessment.

Further details of the noise monitoring are provided in Section 2 and Annexure C of Appendix G (Technical working paper: Noise and vibration).




**Legend**

- Construction footprint
- Construction support site boundary
- Tunnel section

**Noise assessment features**

- Noise monitoring location
- Noise catchment area (NCA)

**Receiver type**

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

**Figure 10-2 Noise catchment areas and monitoring locations (map 1)**

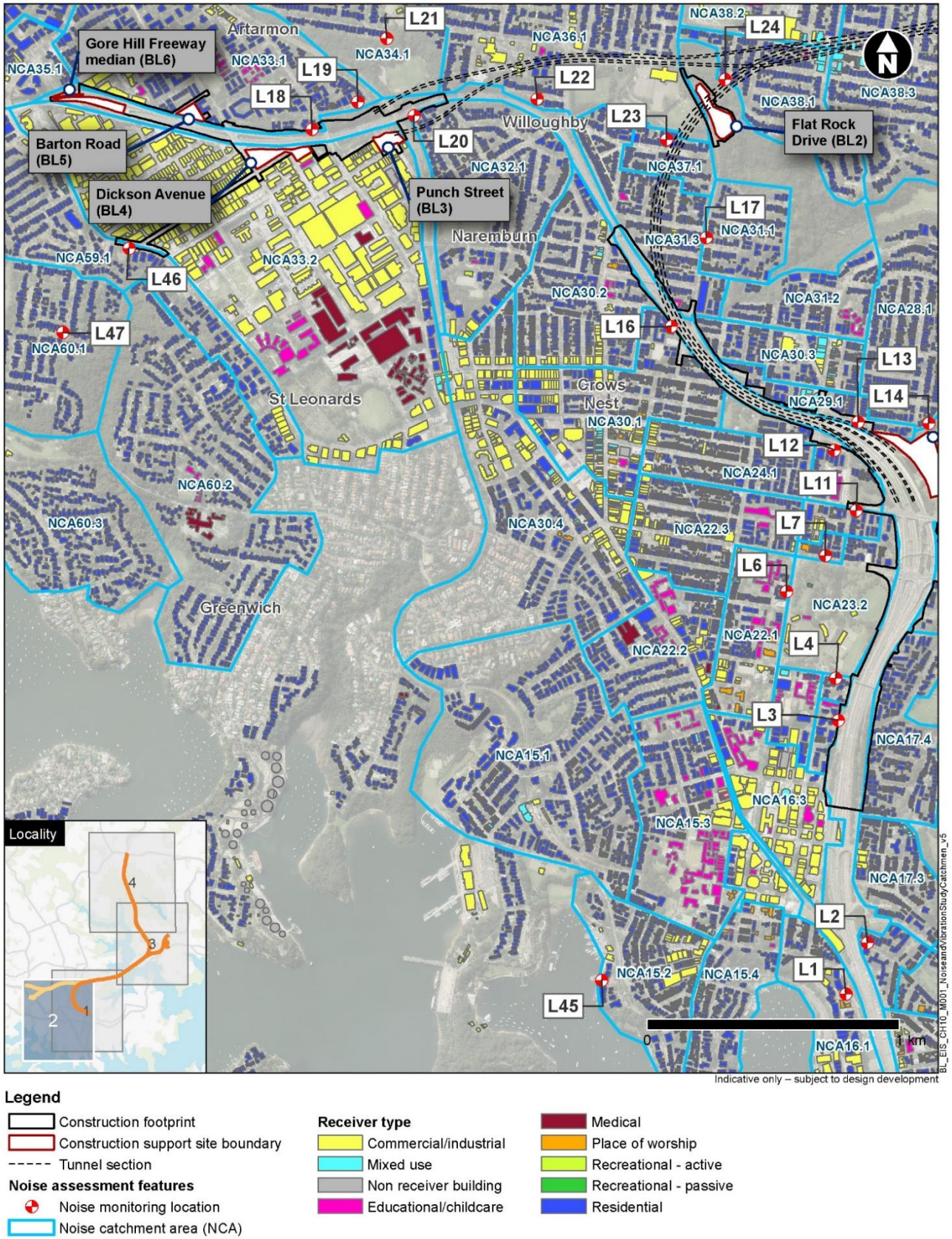



**Figure 10-3 Noise catchment areas and monitoring locations (map 2)**

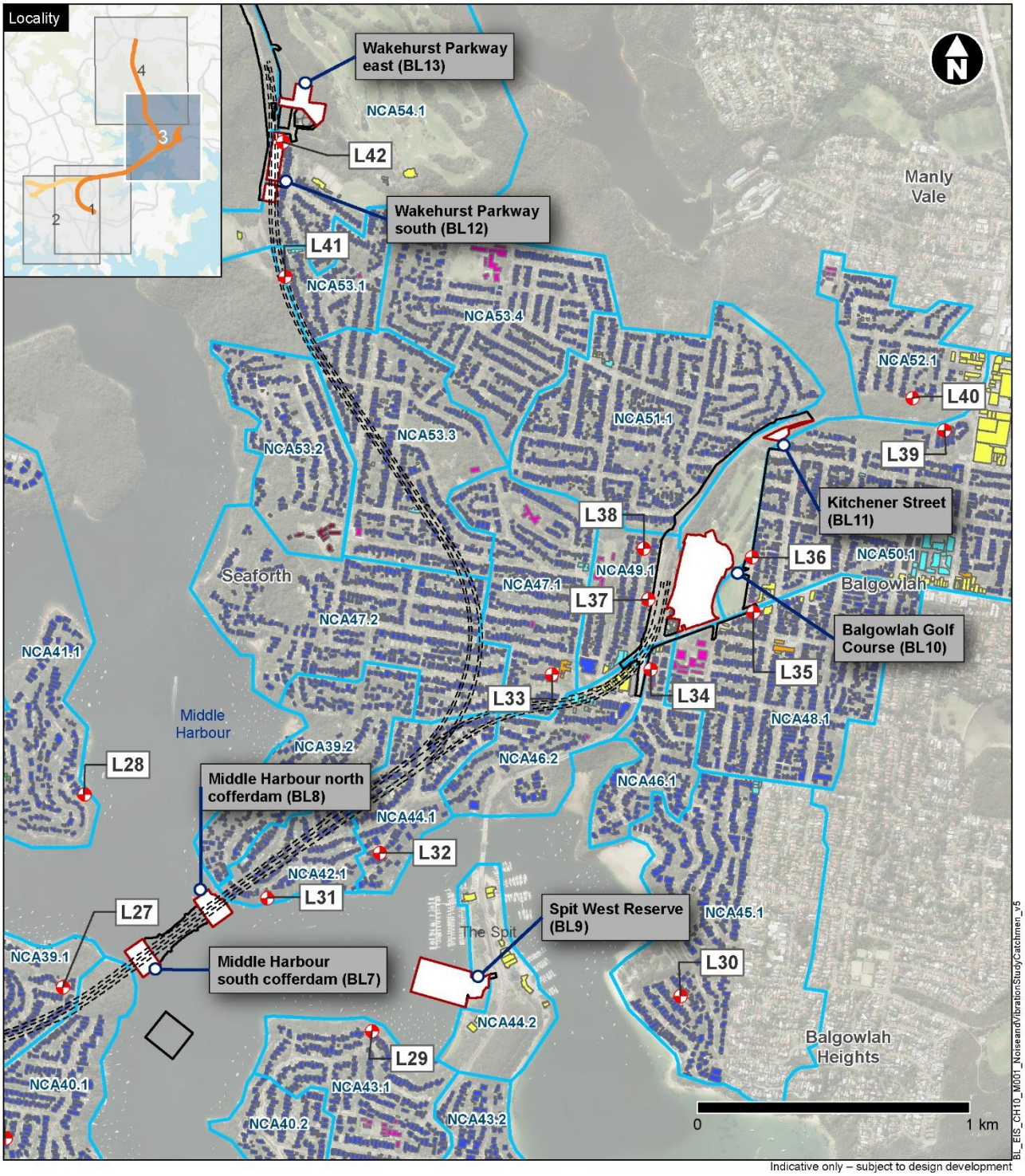



**Figure 10-4 Noise catchment areas and monitoring locations (map 3)**

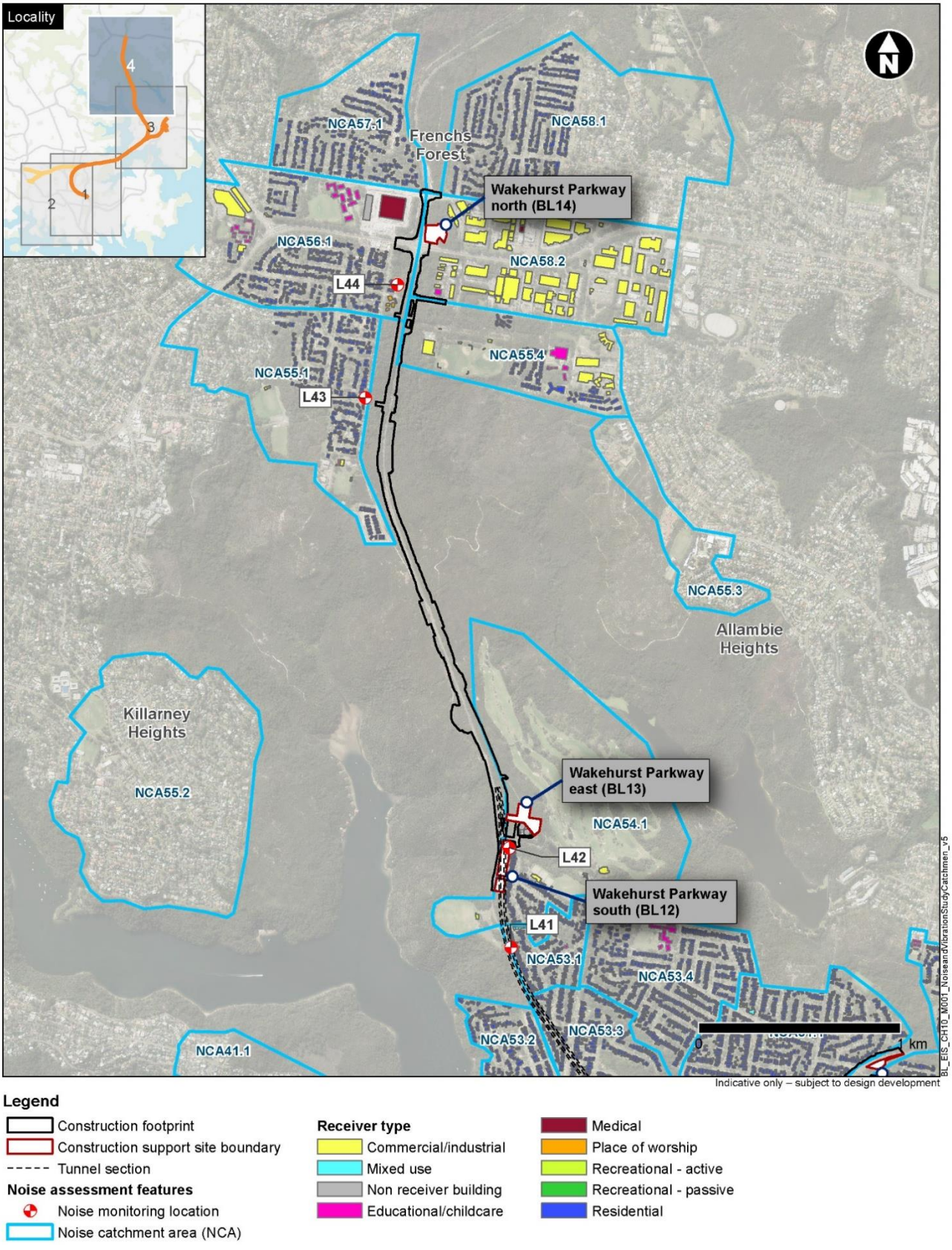



**Figure 10-5 Noise catchment areas and monitoring locations (map 4)**

### 10.3.3 Construction noise and vibration assessment

The construction noise and vibration assessment for the project considered the potential impacts associated with airborne noise, ground-borne noise and vibration, and included the following key steps:

- Identification of potentially affected noise and vibration sensitive receivers for each construction area and temporary construction support site
- Determination of noise and vibration objectives for residential and non-residential receivers
- Identification of indicative construction stages/scenarios including locations, working hours and the plant and equipment to be used
- Identification of other nearby construction projects that might also contribute noise levels in areas affected by the project if construction activities occur at the same time (cumulative noise impacts)
- Prediction of construction airborne noise, ground-borne noise, construction traffic noise and vibration impacts for the identified construction stages/scenarios
- Identification of environmental management measures to be implemented to avoid, minimise and mitigate noise and vibration impacts during construction.

For the prediction of airborne noise impacts from temporary construction support sites, consideration was given to realistic worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009a). The realistic worst case scenario is conservative because it assumes all equipment expected to be used at a given site would be operating simultaneously, at a worst case intensity, and with a worst case orientation during a 15 minute period and at the closest possible location to an affected sensitive receiver. While the realistic worst case scenario might occur, noise levels at any one location would typically vary throughout construction as different plant and equipment is used and the activities move around the works area. Therefore, actual construction noise levels most of the time are likely to be lower than modelled within Appendix G (Technical working paper: Noise and vibration) and presented in this chapter.

For the prediction of airborne noise impacts from surface road works outside temporary construction support sites (eg surface road works in the Warringah Freeway, Gore Hill Freeway Connection surface road works, Balgowlah surface road works and surface road works associated with the connection and realignment and upgrade of the Wakehurst Parkway), consideration was given to both realistic typical and worst case construction noise impact scenarios. The realistic worst case scenarios are used to predict worst case noise impacts in terms of magnitude and distribution that might be expected from a given activity. As stated above, however, this might only occur part of the time and potentially for short durations. The typical impact scenarios were developed to represent the impacts from noise intensive construction activities when the loudest plant and equipment items (eg rock hammers or road saws) are not being used. These scenarios are likely to be more reflective of typical noise impacts that would more commonly occur during a particular construction activity. Figure 10-6 provides an example of how both typical and worst case noise scenarios could occur in a given period of time. The example provided is for utility modification works occurring at night.

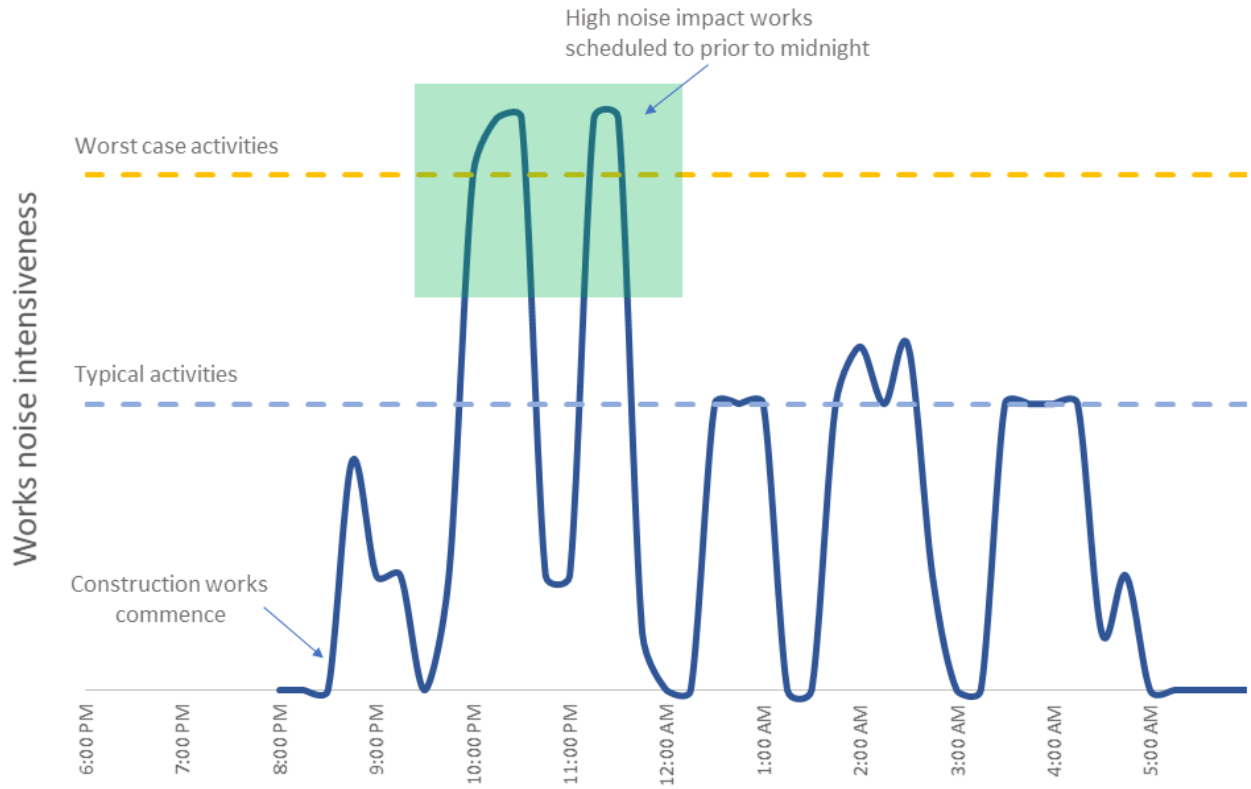



**Figure 10-6 Example of noise intensiveness for typical and worst case construction noise impact scenarios**

## 10.4 Assessment objectives and criteria

The construction noise and vibration assessment objectives and criteria applied to the project are summarised in the following sections and consider recommendations provided in the guidelines, policies and standards discussed in Section 10.2.

### 10.4.1 Airborne noise

#### Residential receivers

The noise management levels for residential receivers set in accordance with the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a) are provided in Table 10-3. Construction noise impacts on residential receivers are assessed using these noise management levels, set with reference to time of day and background noise (Rating Background Level (RBL)). The RBL for each location was determined based on the quietest period of the day, evening or night assessment period in accordance with the *Noise Policy for Industry* (NSW EPA, 2017a). Where noise levels are above the noise management level, reasonable and feasible noise mitigation needs to be considered. Reasonable and feasible noise mitigation includes site specific measures for noise management, mitigation and treatment measures such as construction noise barriers, acoustic sheds, acoustic enclosures, and restricted construction hours and activities.

There is also a highly noise affected level for construction, above which further mitigation needs to be considered, such as additional consultation and notification, additional respite periods, and alternative accommodation.

**Table 10-3 Noise management levels at residential receivers**

| Time of day | Applicable noise management level ($L_{Aeq\ (15\ minute)}$)[1] |
|---|---|
| Recommended standard construction hours:<br>Monday to Friday 7am to 6pm<br>Saturday 8am to 1pm<br>No work on Sundays or public holidays | Noise affected<br>RBL + 10 dB(A)[2] |
| | Highly noise affected<br>75 dB(A) |
| Outside recommended standard construction hours | Noise affected<br>RBL + 5 dB (A) |

Note 1: $L_{Aeq(15\ minute)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a period of 15 minutes

Note 2: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities.

As discussed in Chapter 6 (Construction works), recent planning approval conditions for State significant infrastructure projects have included an extension to standard construction hours on Saturdays, allowing certain activities to be carried out until 6pm. This approval condition has been provided on other major infrastructure projects such as Sydney Gateway, M6 Motorway (Stage 1) and WestConnex M4-M5 Link. Should the project construction contractor elect to use this additional allowance on Saturdays, site specific construction noise and vibration impact statements prepared for the project (refer to Section 10.7) would assess any associated noise impacts, and appropriate noise mitigation measures would be adopted accordingly.

### Non-residential receivers

The noise management levels for non-residential receivers set in accordance with the *Interim Construction Noise Guideline* (DECC, 2009a) are provided in Table 10-4. These levels apply only during hours when the non-residential premises are being used.

The difference between an internal noise level and the external noise level is assumed to be 10 dB(A), which provides a conservative assumption that windows are open for ventilation. Buildings where windows are fixed or cannot otherwise be opened may achieve a greater noise level performance.

**Table 10-4 Noise management levels at other noise sensitive land uses**

| Land use | Where objective applies | Noise management level $L_{Aeq\ (15\ minute)}$[1] |
|---|---|---|
| Classrooms at schools, and other educational institutions | Internal noise level | 45 dB(A)[2] |
| Hospital wards and operating theatres | Internal noise level | 45 dB(A) |
| Places of worship | Internal noise level | 45 dB(A) |
| Childcare centre | External noise level | 50 dB(A) |
| Active recreation areas<br>(eg sports fields/activities which generate their own noise and are generally less sensitive to external noise) | External noise level | 65 dB(A) |
| Passive recreation areas<br>(eg area used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation) | External noise level | 60 dB(A) |

| Land use | Where objective applies | Noise management level $L_{Aeq\ (15\ minute)}$[1] |
|---|---|---|
| Community centres | Depends on the intended use of the centre | Refer to the 'maximum' internal levels in AS2107 for specific uses |
| Commercial premises (including offices and retail outlets) | External noise level | 70 dB(A) |
| Industrial premises | External noise level | 75 dB(A) |
| Special noise and/or vibration sensitive (eg laboratories, recording studios) | Depends on the intended use | Refer to the 'maximum' internal levels in AS2107 for specific uses. |

Note 1: $L_{Aeq(15\ minute)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a period of 15 minutes
Note 2: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities.

### Sleep disturbance criterion

A night time sleep disturbance 'screening criterion' noise goal of RBL + 15 dB(A) is used to identify the receivers where there is potential for sleep disturbance.

Where the sleep disturbance screening criterion is exceeded, further assessment is conducted to determine whether the 'awakening reaction' level of $L_{Amax}$ 65 dB(A) would be exceeded and the likely number of these events. The awakening reaction level is the level above which sleep disturbance is considered likely.

### Definition of 'feasible and reasonable'

As defined by the *Noise Policy for Industry* (NSW EPA, 2017a) a feasible mitigation measure is one that can be engineered and is practical to build and/or implement given project constraints such as safety, maintenance and reliability requirements and may also include options such as amending operational practices. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. Noise impacts, noise mitigation benefits, cost effectiveness of noise mitigation and community views are considered when making this judgement.

## 10.4.2 Construction traffic noise

For locations within the construction footprint, where noise levels would increase by more than 2 dB(A) due to maximum construction traffic volumes or a temporary detour due to a road closure, further assessment was completed as per the *Noise Criteria Guideline* (Roads and Maritime, 2015f).

## 10.4.3 Ground-borne noise

Ground-borne noise is generated by vibration transmitted through the ground into a structure and is more likely to be noticeable during the evening and night periods, when masking by airborne noise is less likely. Ground-borne noise objectives set in accordance with the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a) are provided in Table 10-5.

**Table 10-5 Ground-borne noise objectives**

| Receiver type | Ground borne noise objectives ($L_{Aeq(15\ minute)}$)[1] |
|---|---|
| Residential (day – 7am to 6pm) | Not applicable |
| Residential (evening – 6pm to 10pm) | 40 dB(A)[2] internal |
| Residential (night – 10pm to 7am) | 35 dB(A) internal |
| Hospital wards and operating theatres | 45 dB(A) |
| Childcare centres | 40 dB(A) |
| Classrooms at schools and other educational institutions | 45 dB(A) |
| Places of worship | 45 dB(A) |
| Community centre | 45 dB(A) |
| Commercial premises (including offices) | 50 dB(A) |
| Commercial premises (including retail outlets) | 55 dB(A) |
| Other noise-sensitive receivers | Refer to the 'maximum' internal levels in AS/NZS 2107 for specific uses |

Note 1: $L_{Aeq(15\ minute)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a period of 15 minutes
Note 2: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities.

### 10.4.4 Vibration

For assessment purposes, a conservative vibration damage screening level for structurally sound structures of 7.5 mm/s (peak particle velocity) has been adopted to identify where further investigation is required. For structures where the screening level is predicted to be exceeded, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be done during further construction planning to determine the applicable safe vibration level and approach to construction near the structure.

A conservative vibration damage screening level of 2.5 mm/s has also been adopted for heritage items. Where vibration at any heritage structure is predicted to exceed the screening level, the structure would be investigated during further construction planning to determine the susceptibility of the structure to vibration-induced damage. A site-specific construction approach would be developed to minimise the potential for damage and implemented during vibration intensive activities in the vicinity as required.

The recommended minimum working distances for construction plant in Table 10-6 consider both human comfort and impacts to structures and are referenced from the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a), British Standard *BS 7385 Part 2–1993 Evaluation and measurement for vibration in buildings Part 2* (British Standards Institution, 1993), German Standard *DIN 4150: Part 3–1999 Structural vibration – Effects of vibration on structures* (German Institute for Standardisation, 1999) and the United States Department of Transportation *Federal Transit Administration Noise and Vibration manual* (FTA, 2018).

Where specified construction plant and 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 outside of the construction site. Where vibration intensive activities are required within the recommended minimum working distances, more detailed consideration of potential vibration impacts and the construction approach would occur during further design development and construction planning.

**Table 10-6 Recommended minimum working distances for vibration intensive plant and equipment**

| Plant and equipment | Rating description | Minimum working distance in metres | | |
|---|---|---|---|---|
| | | Potential for cosmetic damage impacts | | Potential for human response impacts[3] (outside construction site) |
| | | Structurally sound[1] (eg residential and light commercial) | Structurally unsound[2] (eg unsound heritage structures) | |
| Vibratory roller | < 50kN (typically 1-2t) | 5 | 11 | 15-20 |
| | < 100kN (typically 2-4t) | 6 | 13 | 20 |
| | < 200kN (typically 4-6t) | 12 | 15 | 40 |
| | < 300kN (typically 7-13t) | 15 | 31 | 100 |
| | > 300kN (typically 13-18t) | 20 | 40 | 100 |
| | > 300kN (typically >18t) | 25 | 50 | 100 |
| Compactor | 32t (non-vibratory) | 15 | 30 | 40 |
| Bulldozer | 70t bulldozer with ripper | 2 | 10 | 20 |
| Excavators | < 30t (travelling/digging) | 10 | 15 | 15 |
| Small hydraulic hammer | 300kg on 5-12t excavator | 2 | 5 | 7 |
| Medium hydraulic hammer | 900kg on 12-18t excavator | 7 | 15 | 23 |
| Large hydraulic hammer | 1600kg on 18-34t excavator | 22 | 30 | 73 |
| Vibratory pile driver | Sheet piles | 2-20 | 5-30 | 20-50 |
| Impact piling hammer | Typical driven pile[4] | 20 | 30 | 110 |
| | 338kJ per stroke (23t hammer with 1.5m stroke) | 70 | 140 | 330 |
| Pile boring | ≤800mm | 2 | 5 | N/A |
| Jackhammer | Hand held | 1 | 3 | 5 |
| Roadheader | Tunnelling | 5 | 5 | 10 |
| Rock drilling | Tunnelling | 5 | 5 | 10 |
| Hydraulic hammer | Tunnelling (35t excavator benching with large rock–hammer) | 10 | 20 | 50 |
| Truck traffic | On uneven construction haul roads | 5 | 10 | 20 |

| Plant and equipment | Rating description | Minimum working distance in metres | | |
|---|---|---|---|---|
| | | Potential for cosmetic damage impacts | | Potential for human response impacts[3] (outside construction site) |
| | | Structurally sound[1] (eg residential and light commercial) | Structurally unsound[2] (eg unsound heritage structures) | |
| Blasting operations | Over irregular surfaces | To be determined during test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions | | |

Note 1: Criteria referenced from British Standard BS 7385 Part 2–1993 Evaluation and measurement for vibration in buildings Part 2 (British Standards Institution, 1993)
Note 2: Criteria referenced from German Standard DIN 4150 Structural Damage – Safe Limits for Short–term Building Vibration (including heritage items) (German Institute for Standardisation, 1999)
Note 3: Criteria referenced from Assessing Vibration: a technical guideline (DECC, 2006)
Note 4: Referenced to a 'typical' pile driver (impact) taken from US Department of Transportation Federal Transit Administration Noise and Vibration manual (FTA, 2018).

### 10.4.5 Blasting noise and vibration management levels

Underground blasting may be used for discrete elements of subsurface excavation. Controlled blasting has also been identified as an alternative to rock hammering in deep cut areas along the Wakehurst Parkway.

Criteria from AS 2187.2-2006 *Explosives - Storage and use - Part 2 Use of explosives* (Standards Australia, 2006) have been adopted for the project, including recommended limits for structural damage and human comfort, blasting operation hours, and underwater pressure. This is considered to be the appropriate blasting criteria for linear civil construction projects and has been included as a condition of approval on all stages of the WestConnex program of works. The limits for structural damage and human comfort presented in AS 2187.2-2006 are similar to those presented in the *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* (ANZEC, 1990) for long term projects, but AS 2187.2-2006 provides further guidance for consideration of the duration of blasting within a project where only a small amount of blasting is required or blasting may occur for less than one year.

## 10.5 Existing noise environment

The existing acoustic environment of the construction footprint and surrounds varies. The areas surrounding the construction footprint are mostly residential, except for clusters of commercial and industrial receivers around Artarmon and Frenchs Forest.

The acoustic environment in these residential areas is mostly influenced by noise from major roads. Traffic volumes on these major roads, and resulting noise levels, are generally highest in the morning between 7am and 9am, and lowest between 2am and 3am. Traffic noise on major roads during periods of high traffic volumes is generally continuous, rather than intermittent.

Noise generated by commercial and industrial areas influences the acoustic environment and contributes to higher ambient noise levels in some locations, masking road traffic noise.

The results of the noise monitoring for background and ambient traffic noise levels for the project are provided in Table 10-7. The location of noise monitoring surveys and noise catchment areas are shown on Figure 10-2 to Figure 10-5. The background noise levels are typical of urbanised environments with daytime background noise levels ranging from 36 dB(A)($L_{A90}$) to 73 dB(A)($L_{A90}$), and in most cases several decibels quieter during the evening period. Night time background noise levels are variable, from around 27 dB(A)($L_{A90}$) to 55 dB(A)($L_{A90}$) depending on the proximity of

receiver locations to 24 hour noise sources such as major transport corridors and industrial developments.

A comparison of noise levels to various activities is show in Figure 10-1 to assist in the interpretation of the noise levels presented in this chapter.

**Table 10-7 Background and ambient traffic noise monitoring**

| Suburb | NCA | Noise monitoring location | Rating background level (dB(A))[1](LA90)[2] Day (7am to 6pm) | Rating background level (dB(A))[1](LA90)[2] Evening (6pm to 10pm) | Rating background level (dB(A))[1](LA90)[2] Night (10pm to 7am) | Existing road noise level (dB(A)) Day (7am to 10pm) (LAeq(15 hour))[3] | Existing road noise level (dB(A)) Night (10pm to 7am) (LAeq(9 hour))[4] |
|---|---|---|---|---|---|---|---|
| Milsons Point | 16.1 | Location L1 | 60 | 60 | 50 | – | – |
| McMahons Point | 15.2 | Location L45 | 42 | 41 | 38 | – | – |
| Kirribilli | 17.2 | Location L2 | 55 | 54 | 45 | 62 | 58 |
| North Sydney | 19.1 | Location L3 | 73 | 71 | 55 | 79 | 74 |
| | 20.1 | Location L4 | 52 | 52 | 45 | 60 | 54 |
| | 22.1 | Location L6 | 52 | 47 | 36 | 67 | 61 |
| Neutral Bay | 18.3 | Location L5 | 54 | 52 | 43 | – | – |
| | 23.1 | Location L8 | 61 | 54 | 44 | 71 | 68 |
| | 23.1 | Location L9 | 58 | 54 | 44 | 74 | 70 |
| Cremorne | 27.1 | Location L15 | 49 | 48 | 39 | – | – |
| Cammeray | 26.1 | Location L10 | 58 | 54 | 41 | 71 | 65 |
| | 21.1 | Location L11 | 56 | 52 | 37 | 70 | 64 |
| | 25.1 | Location L12 | 58 | 55 | 43 | 64 | 59 |
| | 29.1 | Location L13 | 64 | 63 | 47 | 70 | 66 |
| | 28.1 | Location L14 | 47 | 45 | 37 | – | – |
| Crows Nest | 21.1 | Location L7 | 53 | 49 | 41 | 70 | 66 |
| | 30.1 | Location L16 | 58 | 56 | 38 | 65 | 60 |

| Suburb | NCA | Noise monitoring location | Rating background level (dB(A))[1]($L_{A90}$)[2] Day (7am to 6pm) | Rating background level (dB(A))[1]($L_{A90}$)[2] Evening (6pm to 10pm) | Rating background level (dB(A))[1]($L_{A90}$)[2] Night (10pm to 7am) | Existing road noise level (dB(A)) Day (7am to 10pm) ($L_{Aeq(15\ hour)}$)[3] | Existing road noise level (dB(A)) Night (10pm to 7am) ($L_{Aeq(9\ hour)}$)[4] |
|---|---|---|---|---|---|---|---|
| Naremburn | 31.1 | Location L17 | 56 | 49 | 37 | 73 | 67 |
| | 32.1 | Location L20 | 59 | 55 | 40 | 65 | 61 |
| | 37.1 | Location L23 | 45 | 44 | 34 | – | – |
| Artarmon | 33.1 | Location L18 | 67 | 63 | 46 | 74 | 69 |
| | 33.1 | Location L19 | 55 | 53 | 40 | 61 | 57 |
| | 34.1 | Location L21 | 44 | 44 | 37 | – | – |
| Greenwich | 59.1 | Location L46 | 60 | 55 | 40 | 72 | 66 |
| Lane Cove | 60.1 | Location L47 | 39 | 37 | 31 | – | – |
| Willoughby | 36.1 | Location L22 | 50 | 48 | 38 | – | – |
| Northbridge | 38.1 | Location L24 | 52 | 48 | 37 | – | – |
| | 38.3 | Location L25 | 43 | 40 | 36 | – | – |
| | 40.1 | Location L26 | 37 | 37 | 33 | – | – |
| | 39.1 | Location L27 | 37 | 34 | 28 | – | – |
| Castlecrag | 41.1 | Location L28 | 36 | 32 | 27 | – | – |
| Mosman | 43.1 | Location L29 | 45 | 43 | 36 | – | – |
| Clontarf | 45.1 | Location L30 | 40 | 38 | 33 | – | – |

| Suburb | NCA | Noise monitoring location | Rating background level (dB(A))[1]($L_{A90}$)[2] Day (7am to 6pm) | Rating background level (dB(A))[1]($L_{A90}$)[2] Evening (6pm to 10pm) | Rating background level (dB(A))[1]($L_{A90}$)[2] Night (10pm to 7am) | Existing road noise level (dB(A)) Day (7am to 10pm) ($L_{Aeq(15\ hour)}$)[3] | Existing road noise level (dB(A)) Night (10pm to 7am) ($L_{Aeq(9\ hour)}$)[4] |
|---|---|---|---|---|---|---|---|
| Seaforth | 42.1 | Location L31 | 42 | 38 | 36 | – | – |
| | 44.1 | Location L32 | 50 | 49 | 40 | – | – |
| | 47.1 | Location L33 | 43 | 39 | 30 | – | – |
| | 49.1 | Location L37 | 45 | 42 | 31 | 56 | 51 |
| | 49.1 | Location L38 | 43 | 40 | 33 | 54 | 49 |
| | 53.1 | Location L41 | 48 | 39 | 28 | 68 | 61 |
| | 54.1 | Location L42 | 45 | 39 | 29 | 55 | 50 |
| Balgowlah | 46.1 | Location L34 | 58 | 54 | 37 | 67 | 64 |
| | 48.1 | Location L35 | 55 | 50 | 32 | 73 | 71 |
| | 50.1 | Location L36 | 47 | 45 | 35 | 55 | 52 |
| | 50.1 | Location L39 | 47 | 45 | 30 | 55 | 51 |
| Manly Vale | 52.1 | Location L40 | 49 | 45 | 36 | 61 | 56 |
| Frenchs Forest | 55.1 | Location L43[5] | 46 | 40 | 30 | 58 | 50 |
| | 56.1 | Location L44[5] | 53 | 48 | 34 | – | – |

Note 1: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 2: $L_{A90}$ is the level of noise exceeded for 90 per cent of the time. The bottom 10 per cent of the sample is the $L_{A90}$ noise level expressed in units of dB(A)
Note 3: $L_{Aeq(15\ hour)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a 15 hour period (7am to 10pm).
Note 4: $L_{Aeq(9\ hour)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a 9 hour period (10pm to 7am)
Note 5: Adopted from the Northern Beaches Hospital, Connectivity and Network Enhancements, Stage 2 project EIS (Roads and Maritime Services, 2015a). See Appendix G (Technical working paper: Noise and vibration) for further detail.

## 10.6 Assessment of potential impacts

### 10.6.1 Overview

This section provides an assessment of the potential noise and vibration impacts associated with the construction work areas and temporary construction support sites for the project.

For each area or site the key outcomes of the assessment for construction airborne noise, ground-borne noise (where relevant), road traffic noise and construction vibration are presented.

### 10.6.2 Mainline and ramp tunnelling ground-borne noise, vibration and blasting impacts

#### Ground-borne noise impacts

Ground-borne $L_{Aeq}$ noise levels have been calculated for receiver buildings located above the mainline tunnels, and above tunnel on and off ramps to the mainline tunnels.

The number of buildings potentially exposed to ground-borne noise above the noise management levels during roadheader tunnelling and other subsurface activities are provided in Table 10-8. The number of buildings reported are based on the peak noise levels that a receiver building would be exposed to when the roadheader is at its closest point to the property.

The results show the following:

- Up to 107 residential receivers could experience ground-borne noise levels between 35 and 40 dB(A) from roadheader tunnelling, which would exceed the night time ground-borne noise management levels, but not the evening ground-borne noise management levels. The majority of these residential receivers are within Seaforth. However, exceedances of this magnitude are very small and unlikely to result in significant amenity impacts to affected sensitive receivers
- Other sensitive receiver buildings and commercial and industrial buildings are not predicted to experience ground-borne noise levels above their relevant ground-borne noise management level.

Ground-borne noise from excavation with roadheaders along the majority of the tunnel alignment would be audible only while the roadheader is directly beneath a particular sensitive receiver. Depending on the location of the receiver and the distance to the tunnel excavation location, ground-borne noise could be audible for a number of weeks as the tunnelling approaches and then moves away. Variation in ground-borne noise with the progression of works is illustrated in Figure 10-7. It is noted, however, that affected sensitive receivers might experience ground-borne noise on multiple occasions associated with excavation of each tunnel tube, and other subsurface excavations such as ventilation shafts, cross passages and niches for tunnel operational infrastructure.

Rock hammers are proposed to be used for clearing the bench of the tunnel and would follow behind the roadheader. Rock hammers might also be required for other subsurface excavations, such as niches and trenches for tunnel operational infrastructure. Table 10-8 shows there are more receivers that could be impacted during rock hammering than roadheader tunnelling. However, rock hammering work has more scope to be programmed outside evening and night time periods where feasible and reasonable to avoid ground-borne noise impacts during those more sensitive periods. Where rock hammers are required to carry out subsurface excavations that leaves exposed rock that needs ground support, there is potential that some rock hammering might be required outside standard construction hours. Such occurrences are not anticipated to the required frequently.

Where rock hammers are required to be used for subsurface excavations outside standard construction hours, a large number of residential receivers could experience ground-borne noise levels that exceed either the night time ground-borne noise management level of 35 dB(A) or the evening ground-borne noise management level of 40 dB(A) as provided in Table 10-8.

The predictions for the use of rock hammers in the tunnel show the following:

- Up to 531 residential receivers could be exposed to ground-borne noise levels above 45 dB(A). The potentially affected residential receivers are mainly within Seaforth and in particular NCA 53.3 (north of Frenchs Forest Road)
- Eight other sensitive receiver buildings could be ground-borne noise affected (ie above ground-borne noise management level)
- 16 commercial buildings could be ground-borne noise affected during rock hammer tunnelling activities.

**Table 10-8 Sensitive receiver buildings potentially affected by ground-borne noise from roadheader rock hammer tunnelling**

| Suburb | NCA | Roadheader tunnelling | | | | | Rock hammer tunnelling | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers |
| | | > 35 to ≤ 40 dB(A)[1] | > 40 to ≤ 45 dB(A) | >45 dB(A) | | | > 35 to ≤ 40 dB(A) | > 40 to ≤ 45 dB(A) | >45 dB(A) | | |
| North Sydney | 23.2 | – | – | – | – | – | – | 1 | – | – | – |
| Neutral Bay | 23.1 | – | – | – | – | – | – | – | – | – | – |
| Crows Nest | 24.1 | – | – | – | – | – | 2 | – | – | – | – |
| | 30.1 | – | – | – | – | – | 28 | 28 | 18 | 1 | – |
| Cammeray | 25.1 | 5 | – | – | – | – | 11 | 13 | 29 | – | – |
| | 28.1 | – | – | – | – | – | 3 | 5 | 1 | – | – |
| | 29.1 | 3 | – | – | – | – | 13 | 18 | 32 | – | – |
| | 30.3 | – | – | – | – | – | 15 | 11 | 1 | 1 | – |
| | 31.2 | – | – | – | – | – | – | – | – | – | – |
| Cremorne | 26.1 | – | – | – | – | – | – | – | – | – | – |
| Naremburn | 30.2 | – | – | – | – | – | 2 | – | – | – | – |
| | 31.1 | – | – | – | – | – | – | – | – | – | – |
| | 31.3 | – | – | – | – | – | 111 | 13 | 2 | 1 | – |
| | 32.1 | 15 | – | – | – | – | 11 | 8 | 28 | – | – |
| | 37.1 | – | – | – | – | – | 32 | 19 | – | – | – |

| Suburb | NCA | Roadheader tunnelling | | | | | Rock hammer tunnelling | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers |
| | | > 35 to ≤ 40 dB(A)[1] | > 40 to ≤ 45 dB(A) | >45 dB(A) | | | > 35 to ≤ 40 dB(A) | > 40 to ≤ 45 dB(A) | >45 dB(A) | | |
| Artarmon | 33.1 | – | – | – | – | – | 2 | 1 | – | – | – |
| | 33.2 | – | – | – | – | – | – | – | – | – | – |
| | 34.1 | – | – | – | – | – | - | – | – | – | – |
| Willoughby | 36.1 | 1 | – | – | – | – | 40 | 29 | 47 | 2 | 1 |
| Northbridge | 38.1 | – | – | – | – | – | 0 | 4 | – | – | – |
| | 38.2 | – | – | – | – | – | – | – | – | – | – |
| | 38.3 | – | – | – | – | – | 25 | – | – | – | – |
| | 39.1 | – | – | – | – | – | 60 | 6 | – | – | – |
| | 40.1 | – | – | – | – | – | 15 | 11 | – | – | – |
| Seaforth | 39.2 | – | – | – | – | – | 17 | 4 | 1 | – | – |
| | 42.1 | – | – | – | – | – | 24 | 59 | 7 | – | – |
| | 44.1 | – | – | – | – | – | 14 | 54 | 40 | – | – |
| | 46.2 | – | – | – | – | – | 19 | 9 | 32 | – | 13 |
| | 47.1 | – | – | – | – | – | 21 | 3 | 21 | 2 | – |
| | 47.2 | – | – | – | – | – | 61 | 37 | 6 | – | – |
| | 49.1 | 3 | - | – | – | – | 16 | 15 | 27 | - | – |
| | 53.1 | 26 | – | – | – | – | 2 | 9 | 44 | – | – |
| | 53.2 | – | – | – | – | – | 8 | 5 | 5 | – | – |

| Suburb | NCA | Roadheader tunnelling | | | | | Rock hammer tunnelling | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers | Residential receivers | | | Other sensitive receivers | Commercial /industrial receivers |
| | | > 35 to ≤ 40 dB(A)[1] | > 40 to ≤ 45 dB(A) | >45 dB(A) | | | > 35 to ≤ 40 dB(A) | > 40 to ≤ 45 dB(A) | >45 dB(A) | | |
| | 53.3 | 42 | – | – | – | – | 36 | 44 | 151 | 1 | – |
| | 54.1 | 12 | – | – | – | – | 6 | 6 | 33 | – | – |
| Clontarf | 46.1 | – | – | – | – | - | 4 | 7 | 6 | - | 2 |
| Balgowlah | 48.1 | – | – | – | – | – | – | – | – | – | – |
| | 50.1 | – | – | – | – | – | – | – | – | – | – |
| North Balgowlah | 51.1 | – | – | – | – | – | – | – | – | – | – |
| | | **107** | **0** | **0** | **0** | **0** | **638** | **419** | **531** | **8** | **16** |

Note 1: dB(A) stands for A-weighted decibel, a unit used to measure noise.

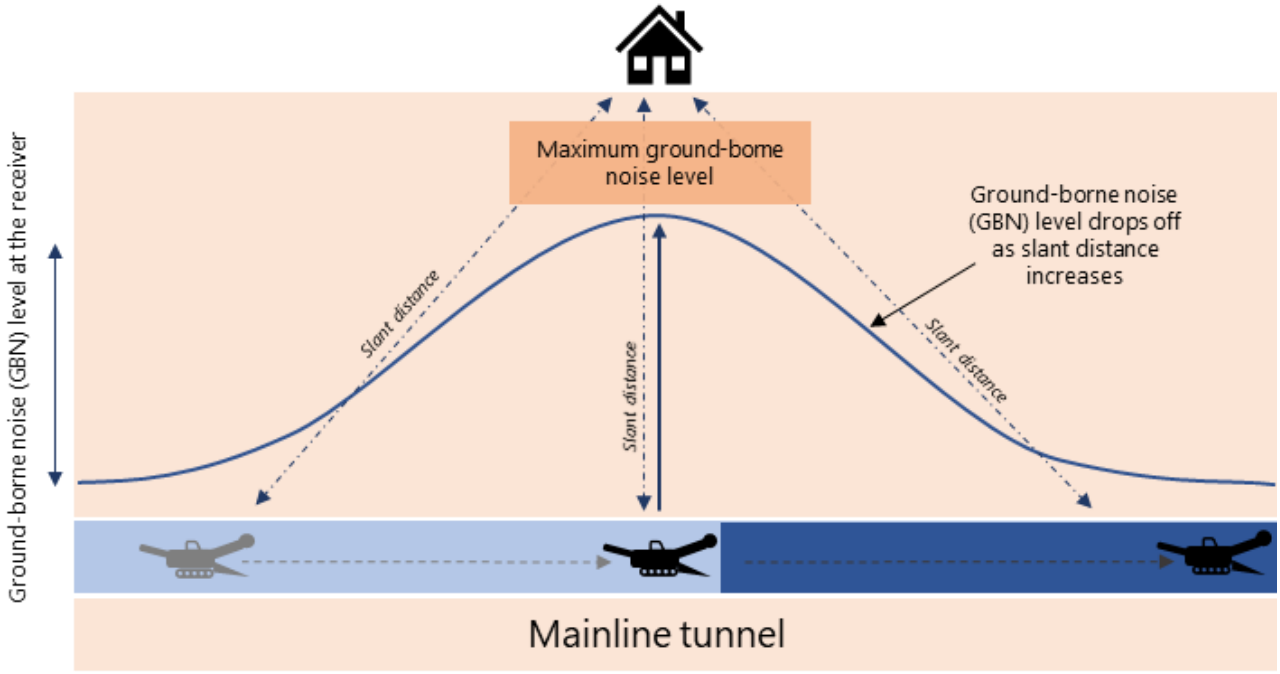



**Figure 10-7 Indicative ground-borne noise impacts as tunnelling progresses**

### Vibration impacts

The number of receiver buildings exceeding the construction vibration screening levels from mainline and ramp tunnelling works is provided in Table 10-9. Vibration impacts from the operation of roadheaders are predicted to be below the vibration limits for human comfort at all receivers. One heritage listed receiver in NCA 33.1 (Artarmon Park potential archaeological deposit (PAD) (45-6-3362)) is located within the minimum working distance for vibration limits for cosmetic damage (unsound structure).

Up to 440 receiver buildings are predicted to be exposed to construction vibration levels above the human comfort criteria (refer to Section 10.4.4) from the operation of rock hammers during tunnelling. For these receivers, standard and additional mitigation measures from the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a) would be implemented, which might include respite. It is noted that vibration is perceived by humans well below levels that could cause property damage.

Vibration levels during rock hammering at two heritage items located in NCA 26.2 (Cammeray Park (including golf course) and NCA 33.1 (Artarmon Park PAD (45-6-3362)) would potentially exceed the vibration screening criterion for cosmetic damage (unsound structure). Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage) for details on the heritage items potentially impacted. Identified heritage items would be further investigated to determine the susceptibility of the items to damage from vibration and to identify appropriate mitigation and management measures as required.

**Table 10-9 Number of receiver buildings exceeding construction vibration screening criteria from mainline tunnel construction**

| Suburb | Noise catchment area | Number of receiver buildings affected by mainline tunnelling | |
|---|---|---|---|
| | | Roadheaders | Rock hammers |
| **Risk of structural or cosmetic damage** | | | |
| | All | – | – |
| **Heritage items requiring further investigation** | | | |
| Cammeray | 26.2 | – | 1 |
| Artarmon | 33.1 | 1 | 1 |
| **Total heritage items requiring further assessment** | | **1** | **2** |
| **Buildings with screening level above risk of human comfort** | | | |
| Cammeray | 25.1 | – | 22 |
| | 29.1 | – | 16 |
| Crows Nest | 30.1 | – | 8 |
| Naremburn | 32.1 | – | 27 |
| Artarmon | 33.2 | – | 1 |
| Willoughby | 36.1 | – | 41 |
| Seaforth | 42.1 | – | 6 |
| | 44.1 | – | 31 |
| | 46.2 | | 35 |
| | 47.1 | – | 22 |
| | 47.2 | - | 4 |
| | 49.1 | – | 25 |
| | 53.1 | – | 36 |
| | 53.2 | – | 3 |
| | 53.3 | – | 124 |
| | 54.1 | – | 32 |
| Clontarf | 46.1 | - | 7 |
| **Total buildings with screening level above risk of human comfort** | | **0** | **440** |

### Impacts from blasting

Blasting may be occasionally required during mainline tunnelling or excavation works.

There are two main impacts from blasting:

- Overpressure travelling as an airwave causing a vibration response in structures such as buildings
- Ground vibration transmitted through the ground that surrounds the blast.

Overpressure and ground vibration have the potential to cause discomfort or annoyance to sensitive receivers near the blast area. At high levels, overpressure and ground vibration have the potential to cause structural damage to building structures.

Blasting might, however, avoid the need to carry out vibration intensive activities, such as excavation with rock hammers, for long durations, thereby avoiding the associated amenity issues due to noise and vibrations. Blasting can, therefore, provide a lower impact alternative to traditional excavation methods. Blasting has been carried out safely and in compliance with the relevant criteria on other recent tunnelling projects in Sydney.

Where blasting is proposed during construction planning, potential overpressure and ground vibration impacts from blasting would be managed through site and blast specific assessments. Overpressure and vibration would be predicted during blast design, which would include test blasts to establish and develop site rules and confirm appropriate blast charges and configurations to ensure the objectives and criteria identified in AS 2187.2-2006 *Explosives – Storage and use – Part 2 Use of explosives* (Standards Australia, 2006) are achieved. All blasting and associated activities would be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a significant risk to nearby structures and sensitive receivers in accordance with the environmental management measures outlined in Section 10.7.

Controlled blasting proposed for Wakehurst Parkway surface road works is discussed in Section 10.6.15.

## 10.6.3 Warringah Freeway surface road works

### Construction works summary

The following works would be required to connect Beaches Link to the Warringah Freeway:

- Construction of Beaches Link cut and cover portal structures and completion of associated ramps and works to tie-in to surface roads
- Upgrade drainage infrastructure at the connection to the Warringah Freeway.

During the works the Cammeray Golf Course construction support site (BL1) would be the main support site. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-10 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during a typical and realistic worst case construction noise intensive work scenario.

As noted previously, for the prediction of airborne noise impacts from construction sites, consideration was given to realistic worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009a). While the noise levels for the realistic worst case might occur at a sensitive receivers during the works, noise levels associated with the typical scenario would occur more frequently.

No receivers are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during typical works, however up to six residential receiver buildings in NCAs 23.2 and 25.1 (within Cammeray, on the western side of the Warringah Freeway) are predicted to be highly noise affected during worst case works when rock hammers are operating for the portal (northbound) construction works.

During standard working hours:

- No receivers are predicted to exceed the noise management level during typical works
- Up to 18 residential receiver buildings are predicted to experience noise levels of up to 20 dB(A) above the noise management level during worst case works.

During cut and cover portal structures works at night:

- Up to 148 residential receiver buildings are predicted to experience noise levels greater than the noise management level during paving and asphalting road works activities
- Up to 1917 receiver buildings would experience noise levels greater than the noise management level during worst case works.

The most likely source of potential sleep disturbance would be from airbrakes or metal rattling during night construction works. The predicted maximum noise levels show exceedances of the sleep disturbance screening levels as follows:

- During typical works, operations such as airbrakes may exceed the sleep disturbance screening level at up to 65 receiver buildings. Noise levels may exceed the awakening reaction levels at up to eight receiver buildings, with the highest number of exceedances occurring in NCAs 23.2, 24.1 and 25.1 (within Cammeray and Crows Nest, on the western side of the Warringah Freeway)
- During the worst case construction activities, up to 692 receiver buildings may exceed the sleep disturbance screening level. Noise levels may exceed the awakening reaction level at up to 46 receiver buildings.

Construction noise levels at non-residential receivers are not predicted to exceed the noise management levels during typical construction works.

For worst case activities, noise management level exceedances may occur at the following non-residential receivers:

- One childcare receiver with buildings located in NCA 28.1 (KU Cammeray Preschool)
- One educational receiver with buildings located in NCA 25.1 (ANZAC Park Public School)
- One recreational receiver in NCA 25.1 (ANZAC Park).

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-10 Number of residential receiver buildings over the noise management levels during Warringah Freeway surface road works (typical and realistic worst case scenarios)**

| Stage activity | Scenario | Highly noise affected >75 dB(A)[3] $L_{Aeq}$[1] | | Day (standard construction hours) $L_{Aeq}$ | | | Day (out of hours) $L_{Aeq}$ | | | | Evening $L_{Aeq}$ | | | | Night $L_{Aeq}$ | | | | Sleep disturbance $L_{Amax}$[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Portal structures/ramps (northbound) | Typical | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 113 | 29 | 6 | 0 | 65 | 8 |
| | Worst case | 6 | 6 | 16 | 2 | 0 | 180 | 16 | 2 | 0 | 266 | 39 | 6 | 0 | 1146 | 710 | 54 | 7 | 692 | 46 |
| Portal structures/ramps (southbound) | Typical | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 10 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted “equivalent noise level”. It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

Depending on the detailed construction methodologies and programs, works on Warringah Freeway associated with both the Beaches Link and Gore Hill Freeway Connection project and Western Harbour Tunnel and Warringah Freeway Upgrade might be required at the same time in close proximity. Elevated noise levels from both projects might affect the same sensitive receivers. If this occurs, those receivers might experience amenity impacts over extended durations (construction fatigue). Also, works outside standard construction hours might be scheduled for both projects so that affected receivers do not get appropriate respite. In order to avoid these cumulative impacts, the project would consider and manage construction activities with consideration of amenity of the affected receivers, and would coordinate works outside standard construction hours with the Western Harbour Tunnel and Warringah Freeway Upgrade works where feasible and reasonable to provide affected revivers with appropriate respite Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate the construction of the project, and construction vehicle movements associated with the Warringah Freeway surface road works are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

### Construction ground-borne noise

Ground-borne noise levels have the potential to be generated by vibration intensive works at the surface road works. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Vibration intensive activities such as rock hammering could be required as part of the Warringah Freeway surface road works. Table 10-11 shows the number of properties that fall within the minimum working distances for the Warringah Freeway surface road works, two of which are identified heritage items (Cammeray Park (including Golf Course) and Northern Suburbs Ocean Outfall Sewer). The locations of the properties and heritage items are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) for details on the heritage items potentially impacted.

**Table 10-11 Number of receiver buildings within minimum working distances for vibration intensive work – Warringah Freeway surface road works**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item[1] | Sound structure | |
| 24.1 | – | – | 2 |
| 23.2 | – | 1 | 1 |
| 25.1 | – | 6 | 19 |
| 26.2 | 2 | – | – |
| 29.1 | – | – | 2 |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

## 10.6.4 Cammeray Golf Course (BL1)

### Construction works summary

The Cammeray Golf Course construction support site (BL1) is located within the north-west portion of the Cammeray Golf Course. This site will have been previously utilised by the Western Harbour Tunnel and Warringah Freeway Upgrade project. This site would then be used for the construction and fitout of the project's motorway facilities at the Warringah Freeway and would provide tunnel and construction support for the Beaches Link component of the project. Works associated with the establishment, use and demobilisation of the site would occur over three years. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-12 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

Two receivers are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during decline piling works. Additionally, during standard construction hours, up to 157 receiver buildings in NCA 29.1 (within Cammeray, on the eastern side of the Warringah Freeway) are predicted to experience noise levels above the noise management level during these works.

Receiver buildings within NCA 28.1 (within Cammeray, on the eastern side of the Warringah Freeway) are expected to be noise affected during standard construction hours throughout most of the construction works at this temporary construction support site. However, construction noise in only expected to be above the daytime noise management level by about 3 dB(A) for the majority of works.

Up to eight receiver buildings in NCA 24.1 (within Crows Nest, on the western side of the Warringah Freeway) and NCAs 26.1 and 28.1 (within Cammeray and Cremorne, on the eastern side of the Warringah Freeway) are predicted to experience noise levels above the noise management level during the night period. This would occur during construction of the cut and cover portals, trough structures, and tunnels, and also during tunnel fitout. Exceedances would be largely due to truck movements as they enter and move along the internal roads within the site to the acoustic shed.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 69 receiver buildings. However, no receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers:

- Up to six receivers are predicted to experience noise levels above the noise management level during access decline piling works. A childcare receiver located in NCA 28.1 (KU Cammeray Preschool) is predicted to experience noise levels above the noise management level by 12 dB(A) during access decline piling and 6 dB(A) during site rehabilitation
- One educational sensitive receiver in NCA 25.1 (ANZAC Park Public School) is up to 2 dB(A) above the noise management level during access decline piling
- Three recreational receivers including the Cammeray Golf Course, Cammeray Playing Field and the Green Park Tennis Courts are predicted to be noise affected. Only the Cammeray Golf Course is predicted to be noise affected by more than 2 dB(A) above the noise management level during any stage of construction.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-12 Number of residential receiver buildings over the noise management levels during construction at Cammeray Golf Course construction support site (BL1) (realistic worst case scenario)**

| Stage activity | Highly noise affected >75 dB(A)[3] ($L_{Aeq}$[1]) | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Site establishment | 0 | – | 7 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Decline, shed and ventilation excavation and construction | 2 | – | 156 | 8 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Civil works and tunnel construction | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 68 | 0 |
| Civil works and tunnel fitout and permanent facilities construction | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 69 | 0 |
| Civil works and permanent facilities fitout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 69 | 0 |
| Site rehabilitation | 0 | – | 10 | 3 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

There is potential for cumulative increases of construction noise from concurrent use of Cammeray Golf Course construction support site (BL1) and works associated with the final stages of the Western Harbour Tunnel and Warringah Freeway Upgrade project. Sensitive receivers in the vicinity have the potential to experience elevated noise levels over extended durations due to the use of the adjacent areas for temporary construction support sites by both projects. There is also potential for increased disturbance associated with works outside standard construction hours that these temporary construction support sites would support.

Site specific mitigation measures would be developed for Cammeray Golf Course construction support site (BL1) with the aim of ensuring that relevant noise management levels are met, minimising the potential for construction fatigue. Works outside standard construction hours, and the associated use of Cammeray Golf Course construction support site (BL1) and the temporary construction support sites associated with the Western Harbour Tunnel and Warringah Freeway Upgrade project, would be coordinated where feasible and reasonable to provide the affected receivers with appropriate respite.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate the construction of the project, and construction vehicle movements associated with the Cammeray Golf Course construction support site (BL1) are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Night time heavy vehicle movements from this site would be limited to four trucks per night. Since the number of truck movements generated by the site is not significant compared to existing heavy vehicle numbers on the Warringah Freeway, the number of maximum noise events that could disturb sleep are not likely to substantially increase. Additionally, all heavy vehicle haulage access to this construction site during tunnel construction and some civil works, would be directly to and from the Warringah Freeway, which would assist in managing potential noise impacts to nearby residential receivers.

### Construction ground-borne noise

For the construction of the tunnel access decline and ventilation tunnels between the temporary construction support site at Cammeray Golf Course (BL1) and the mainline tunnel alignment, ground-borne noise levels are predicted to be below the ground-borne noise management level.

Ground-borne noise may also be generated by vibration intensive works within the temporary construction support site. However, throughout the construction works associated with the temporary construction support site it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby residential receivers.

### Construction vibration

The major activities at Cammeray Golf Course construction support site (BL1) that would include vibration intensive works would include piling associated with access decline excavations and acoustic shed installation, and ventilation tunnel construction, where rock hammers and piling rigs may be needed. Table 10-13 shows one heritage item in NCA 26.2 (Cammeray Park (including Golf Course)) is predicted to be within the minimum working distances for major vibration generating activities. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) for further details on the heritage item potentially impacted.

Two receiver buildings within NCA 26.2 (Cammeray) may also be exposed to vibration levels above the human response screening level. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The risk of annoyance is considered low with duration of rock hammering limited to works associated with the surface level decline construction and acoustic shed construction.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-13 Number of receiver buildings within minimum working distances for vibration intensive work – Cammeray Golf Course construction support site (BL1)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item[1] | Sound structure | |
| 26.2 | 1 | – | 2 |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

## 10.6.5 Gore Hill Freeway Connection surface road works

### Construction works summary

The following works would be required as part of the Gore Hill Freeway Connection surface road works:

- Upgrade and reconfiguration of the Gore Hill Freeway between the T1 North Shore and Western rail line and T9 Northern rail corridor and the Pacific Highway
- Modifications to the Reserve Road and Hampden Road bridges
- Construction of Beaches Link ramps and cut and cover tunnel access structures
- Widening of Reserve Road between the Gore Hill Freeway and Dickson Avenue
- Modification of the Dickson Avenue and Reserve Road intersection to allow for the Beaches Link off ramp
- Upgrades to existing roads around the Gore Hill Freeway to integrate the project with the surrounding road network
- Upgrade of the Dickson Avenue and Pacific Highway intersection
- New and upgraded pedestrian and cyclist infrastructure
- Other operational ancillary facilities, including surface drainage and utility modification works, signage and lighting, CCTV and other traffic management systems, environmental controls and landscape treatments.

The Gore Hill Freeway Connection surface road works also includes the use of the following temporary construction support sites:

- Dickson Avenue site (BL4)
- Barton Road site (BL5)
- Gore Hill Freeway median site (BL5).

The works would take about four years. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-14 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical and realistic worst case construction noise intensive work scenarios.

One residential receiver building in NCA 59.1 (Greenwich) is predicted to experience noise levels greater than 75 dB(A) during typical works at the intersection of Pacific Highway and Dickson Avenue during bus stop relocation, pavement and road modification works. This would occur when works are carried out near the receiver when road saws are in use. Up to eight residential receiver buildings are predicted to experience noise levels greater than 75 dB(A) during worst case works during standard construction hours, which include the use of rock hammers during utility modification works.

For the Gore Hill Freeway Connection surface road works during standard construction hours:

- For typical surface road works, up to eight residential receiver buildings within any one major works area are predicted to exceed the daytime noise management level, however the exceedances would be below 10 dB(A). Notwithstanding, receivers closest to the Gore Hill Freeway would experience existing traffic noise levels above the noise management level. For typical works at temporary construction support sites, no receivers are predicted to exceed the noise management level
- For worst case surface road works, up to 131 residential receiver buildings are predicted to exceed the noise management level. However, the majority of exceedances would be below 10 dB(A) and would occur only during the use of rock hammers or during concrete saw cutting for utility modification works. For worst case works at temporary construction support sites, no receivers are predicted to exceed the noise management level.

Outside standard construction hours:

- For typical surface road works at night time, up to 112 residential receiver buildings are predicted to exceed the noise management level from any one major works area during typical works. For typical works at temporary construction support sites at night time, up to 42 receivers are predicted to exceed the noise management level
- For worst case surface road works, up to 1453 noise affected residential receiver buildings are predicted to exceed the noise management level from any one major works area. The key noise generating activities would be utility modification works, and the use of excavators with rock hammers or concrete saws and pavement/road modifications. When these noise intensive activities are not occurring, the number of potentially noise affected receiver buildings are reduced to only 10 to 20 per cent of the worst case total
- For worst case works at temporary construction support sites at night time, up to 33 residential receiver buildings are predicted to exceed the noise management level for the Dickson Avenue construction support site (BL4), up to 27 residential receiver buildings are predicted to exceed the noise management level for the Barton Road construction support site (BL5) and up to 45 receivers are predicted to exceed the noise management level for the Gore Hill Freeway median temporary construction support site (BL6). The majority of these exceedances would be below 5 dB(A).

The most likely source of potential sleep disturbance from night construction works would be from the use of pneumatic hammers (including rock hammers) or saws during utility modification or road pavement work, or from air brakes from truck movements on site. The predicted maximum noise levels show exceedances of the sleep disturbance screening level across all areas with night construction works for both typical and worst case construction activities as follows:

- Up to 63 receiver buildings are predicted to be above the sleep disturbance screening level during typical construction works
- Up to 19 residential receiver buildings have potential to exceed the awakening reaction level during typical construction works

- Up to 454 receiver buildings are predicted to be above the sleep disturbance screening level during worst case construction activities, with only up to 46 residential receiver buildings have potential to exceed the awakening reaction level during worst case construction work.

For the prediction of airborne noise impacts from construction sites, consideration was given to realistic worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009a). While the noise levels for the realistic worst case might occur at a sensitive receivers during the works, noise levels associated with the typical scenario occur more frequently.

Noise management level exceedances may occur at the following non-residential receivers:

- Six childcare receivers in NCAs 33.1 and 33.2 (within Artarmon both south and north of the Gore Hill Freeway), three of which are predicted to exceed the noise management level by more than 20 dB(A) during worst case works
- Up to a 5 dB(A) increase at two educational receivers (Artarmon Public School and Thrive Learning Centre, Artarmon) in NCA 33.1 and 33.2 for typical and worst case construction works
- One place of worship in NCA 33.1 (St Basil's Anglican Church, Artarmon) for worst case construction works only
- One recreational receiver in NCA 59.1 (Coronation Viewpoint, Greenwich) for typical and worst case construction works and up to 17 dB(A) at recreational parks nearby works at Dickson Avenue and the Pacific Highway
- Up to 27 commercial and industrial receivers in NCAs 33.1 and 33.2 ((within Artarmon both south and north of the Gore Hill Freeway) for typical and worst case construction works.

Three childcare centres (Butterflies Early Learning Childcare Centre, Willoughby/Lane Cove Family Day Care and Innovative Early Learning Artarmon) and one commercial receiver are predicted to exceed the noise management level as a result of activities within the temporary construction support sites. However, due to existing ambient noise levels, it is likely that internal spaces are sufficiently acoustically treated to protect internal spaces from construction noise.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-14 Number of residential receiver buildings over the noise management levels during Gore Hill Freeway Connection surface road works (typical and realistic worst case scenarios)**

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Gore Hill Freeway median (BL6) | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 63 | 7 |
| | Worst case | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 8 | 0 | 0 | 117 | 12 |
| Barton Road (BL5) | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 5 | 0 | 0 | 30 | 9 |
| | Worst case | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 13 | 13 | 1 | 0 | 40 | 14 |
| Dickson Avenue (BL4) | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 7 | 0 | 0 | 28 | 9 |
| | Worst case | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 16 | 0 | 0 | 43 | 16 |
| Gore Hill Freeway eastbound lanes west of Reserve Road | Typical | 0 | 0 | 3 | 0 | 0 | 2 | 3 | 0 | 0 | 4 | 3 | 0 | 0 | 48 | 18 | 5 | 0 | 30 | 10 |
| | Worst case | 3 | 3 | 7 | 3 | 0 | 10 | 7 | 3 | 0 | 25 | 8 | 3 | 0 | 192 | 147 | 18 | 5 | 158 | 36 |
| Gore Hill Freeway eastbound lanes between Reserve Road and Hampden Road | Typical | 0 | 0 | 8 | 0 | 0 | 5 | 8 | 0 | 0 | 6 | 9 | 1 | 0 | 23 | 19 | 9 | 4 | 27 | 19 |
| | Worst case | 8 | 8 | 12 | 8 | 0 | 13 | 12 | 8 | 0 | 24 | 10 | 9 | 1 | 343 | 100 | 19 | 13 | 126 | 37 |

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Gore Hill Freeway eastbound lanes west of Hampden Road | Typical | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 43 | 33 | 1 | 0 | 40 | 5 |
| | Worst case | 1 | 1 | 15 | 1 | 0 | 74 | 15 | 1 | 0 | 88 | 20 | 1 | 0 | 883 | 280 | 33 | 1 | 397 | 37 |
| Gore Hill Freeway westbound lanes and off ramp west of Hampden Road | Typical | 0 | 0 | 2 | 0 | 0 | 6 | 2 | 0 | 0 | 3 | 6 | 0 | 0 | 18 | 24 | 8 | 0 | 28 | 9 |
| | Worst case | 2 | 2 | 13 | 2 | 0 | 19 | 13 | 2 | 0 | 17 | 16 | 6 | 0 | 460 | 118 | 24 | 8 | 141 | 32 |
| Gore Hill Freeway westbound lanes and off ramp east of Hampden Road | Typical | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 66 | 45 | 1 | 0 | 63 | 2 |
| | Worst case | 1 | 1 | 19 | 1 | 0 | 124 | 19 | 1 | 0 | 128 | 34 | 1 | 0 | 1059 | 348 | 45 | 1 | 454 | 46 |
| Modifications to Reserve Road bridge and ramps | Typical | 0 | 0 | 7 | 0 | 0 | 6 | 7 | 0 | 0 | 7 | 9 | 1 | 0 | 36 | 15 | 10 | 3 | 21 | 17 |
| | Worst case | 7 | 7 | 13 | 7 | 0 | 8 | 13 | 7 | 0 | 17 | 11 | 9 | 1 | 619 | 81 | 15 | 13 | 105 | 33 |
| Beaches Link eastbound portal cut and cover and on ramp | Typical | 0 | – | 1 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 20 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Beaches Link westbound southern portal cut and cover and off ramp west of Hampden Road | Typical | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 27 | 26 | 6 | 0 | 31 | 7 |
| | Worst case | 0 | 0 | 14 | 0 | 0 | 23 | 14 | 0 | 0 | 19 | 23 | 1 | 0 | 892 | 158 | 26 | 6 | 243 | 35 |
| Beaches Link westbound southern portal cut and cover and off ramp east of Hampden Road | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 50 | 24 | 0 | 0 | 34 | 1 |
| | Worst case | 0 | 0 | 12 | 0 | 0 | 85 | 12 | 0 | 0 | 98 | 15 | 0 | 0 | 817 | 240 | 24 | 0 | 336 | 29 |
| Motorway Control Centre construction and tunnel support | Typical | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 10 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Beaches Link westbound northern portal cut and cover and off ramp to Reserve Road | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 66 | 23 | 0 | 0 | 37 | 1 |
| | Worst case | 0 | 0 | 31 | 0 | 0 | 106 | 14 | 0 | 0 | 115 | 18 | 0 | 0 | 978 | 293 | 23 | 0 | 384 | 28 |
| Pacific Highway east bus stop relocation, pavement and road modification works | Typical | 0 | 1 | 1 | 0 | 0 | 5 | 1 | 0 | 0 | 8 | 1 | 1 | 0 | 60 | 15 | 2 | 1 | 8 | 4 |
| | Worst case | 1 | 2 | 2 | 1 | 0 | 117 | 20 | 1 | 0 | 224 | 47 | 1 | 1 | 677 | 364 | 15 | 3 | 86 | 9 |

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Pacific Highway west pavement and road modification works | Typical | 0 | – | 2 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 3 | – | 98 | 2 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted “equivalent noise level”. It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities.
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

There is potential for cumulative increases of construction noise from the Gore Hill Freeway Connection surface road works and the construction of the Warringah Freeway Upgrade component of the Western Harbour Tunnel and Warringah Freeway Upgrade project, which includes the use of a temporary construction support site at Waltham Street at Artarmon. Sensitive receivers in NCAs 32.1, 33.1 and 36.1 (residential areas of Naremburn, Artarmon and Willoughby in proximity to the surface works areas) have the potential to experience elevated noise levels over extended durations due to the use of the adjacent areas for temporary construction support sites by both projects. There is also potential for increased disturbance associated with works outside standard construction hours associated with the Gore Hill Freeway Connection surface road works and the Warringah Freeway Upgrade.

Site specific mitigation measures would be developed for the Gore Hill Freeway Connection surface road works with the aim of ensuring that relevant noise management levels are met, minimising the potential for construction fatigue. Works outside standard construction hours would be coordinated with the Warringah Freeway Upgrade where feasible and reasonable to provide the affected receivers with appropriate respite.

There is also potential for construction fatigue from the Gore Hill Freeway Connection surface road works and the Sydney Metro City & Southwest (Chatswood to Sydenham) project. This is due to works associated with the Artarmon substation site as part of the Sydney Metro City & Southwest (Chatswood to Sydenham) project and proximity to the project. Notwithstanding, given there would be a twelve month break between the commencement of construction at the Gore Hill Freeway Connection surface road works and the completion of works for the Artarmon substation site, the risk of construction is considered minor and would be managed Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate the construction of the project, and construction vehicle movements associated with the Gore Hill Freeway Connection surface road works and temporary construction support sites are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible. However, temporary construction support sites that have heavy vehicle movements during the night period have the potential to exceed the sleep disturbance screening levels and awakening reaction levels from air brake releases or metal bangs associated with the loads being carried.

### Construction ground-borne noise

Ground-borne noise levels have the potential to be generated by vibration intensive works at the surface road works and associated temporary construction support sites. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Table 10-15 shows 16 and 84 receiver buildings fall within the minimum working distances for cosmetic damage (sound structures) and human response, respectively. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). One heritage item within the minimum working distances is a potential archaeological deposit (Artarmon Park PAD (45-6-3362)). It is within the minimum working distance for cosmetic damage (unsound structures), assuming that vibration intensive plant such as a large rock hammer would be used. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 15 (Aboriginal heritage) for details on this potential impacted heritage item.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-15 Number of receiver buildings within minimum working distances for vibration intensive work – Gore Hill Freeway Connection surface road works**

| Location | NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|---|
| | | Cosmetic damage | | Human response |
| | | Heritage item | Sound Structure | |
| Gore Hill Freeway eastbound lanes including Epping Road and Pacific Highway on ramps | 33.1 | – | 15 | 38 |
| | 33.2 | – | – | 32 |
| | 35.1 | – | 1 | 14 |
| Gore Hill Freeway westbound lanes including the Epping Road and Pacific Highway off ramp | 33.1 | – | – | 8 |
| | 33.2 | – | 1 | 38 |
| Modifications to Reserve Road bridge and ramps | 33.1 | – | 4 | 19 |
| | 33.2 | – | 4 | 25 |
| Beaches Link eastbound portal cut and cover tunnel and on ramp | 33.1 | 1[1] | – | 4 |
| Beaches Link westbound southern portal cut and cover tunnel and off ramp to Reserve Road | 33.1 | 1[1] | – | 3 |
| | 33.2 | – | 9 | 43 |
| Beaches Link westbound northern portal cut and cover and off ramp to Reserve Road | 33.2 | – | 2 | 17 |
| Intersection of Pacific Highway and Dickson Avenue modification works and bus stop relocation | 33.2 | – | 6 | 18 |
| | 59.1 | – | 3 | 11 |

Note 1: Artarmon Park PAD (45-6-3362).

## 10.6.6 Flat Rock Drive (BL2)

### Construction works summary

The Flat Rock Drive construction support site (BL2) is proposed in Flat Rock Reserve, Northbridge, on the eastern side of Flat Rock Drive, opposite to the Bicentennial Reserve Baseball Diamond. The site would support tunnelling. Works associated with the establishment, use and demobilisation of the site would occur over about five years. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-16 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

During standard construction hours three residential receiver buildings in NCAs 36.1, 37.1 and 38.1 (within Willoughby, Naremburn and Northbridge respectively) are predicted to experience noise levels greater than 75 dB(A) during early works and site establishment. An additional

residential receiver building would be highly noise affected (greater than 75 dB(A)) during road widening works.

During standard construction hours, up to 174 residential receiver buildings in NCAs 36.1, 37.1 and 38.1 (within Willoughby, Naremburn and Northbridge respectively) are predicted to experience noise levels greater than the relevant noise management level. These exceedances are predicted during utility modification, vegetation clearing, access decline excavation and road modification works.

During night time works, noise levels are predicted to be below the noise management levels except during short-term works associated with the road widening and modification of Flat Rock Drive. Up to 698 residential receiver buildings across several NCAs are predicted to exceed noise management levels during these works. The majority of the exceedances (88 per cent) would be less than 15 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 555 receiver buildings across several NCAs from the short-term road works. Twenty-six of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level. Predicted noise levels are intended to be conservative and represent realistic worst case impacts during the project. Night time works would be minimised to reduce potential impacts where possible. Additionally, the number of heavy vehicle movements during night time periods generated by the site is not substantial compared to existing traffic numbers on Flat Rock Drive.

For non-residential receivers:

- A commercial receiver in NCA 36.1 (within Willoughby, west of Flat Rock Drive) is predicted to experience noise levels above the noise management level during site establishment works and road widening works
- Two childcare receivers in within NCA 36.1 (Tree of Life Early Learning School – Willoughby and Koala Cottage) and one within NCA 30.2 (Catholic Care Naremburn Family Centre) are predicted to experience noise levels above the noise management level during early works
- Five recreational receivers in NCAs 31.1 (Dawson Playground), 36.1 (Bicentennial reserve including Willoughby basketball and netball courts and the Flat Rock Baseball Diamond) and 38.2 (Shore playing fields) are predicted to experience noise levels above the noise management levels during the majority of the construction activities.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-16 Number of residential receiver buildings over the noise management levels during construction at Flat Rock Drive construction support site (BL2) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 1 | – | 143 | 31 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 2 | – | 108 | 25 | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Road widening | 1 | 1 | 118 | 27 | 1 | 98 | 33 | 3 | 1 | 103 | 69 | 4 | 1 | 305 | 309 | 79 | 5 | 555 | 26 |
| Piling for access decline and shed | 0 | – | 23 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Access decline construction | 0 | – | 57 | 8 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Acoustic shed construction | 0 | – | 15 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Tunnelling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 143 | 0 |
| Tunnel fitout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 143 | 0 |
| Site rehabilitation | 0 | – | 28 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

There is potential for cumulative increases of construction noise from concurrent use of Flat Rock Drive construction support site (BL2) and works associated with the final stages of the Western Harbour Tunnel and Warringah Freeway Upgrade project. Sensitive receivers in the vicinity have the potential to experience elevated noise levels over extended durations due to the use of Flat Rock Drive construction support site (BL2) and temporary construction support sites and surface works associated with the Western Harbour Tunnel and Warringah Freeway Upgrade project. There is also potential for increased disturbance associated with works outside standard construction hours carried by both projects.

Site specific mitigation measures would be developed for Flat Rock Drive construction support site (BL2) with the aim of ensuring that relevant noise management levels are met, minimising the potential for construction fatigue. Works outside standard construction hours, and the associated use of Flat Rock Drive construction support site (BL2) and the temporary construction support sites surface works associated with the Western Harbour Tunnel and Warringah Freeway Upgrade project, would be coordinated where feasible and reasonable to provide the affected receivers with appropriate respite.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate the construction of the project, and construction vehicle movements associated with the Flat Rock Drive construction support site (BL2) are predicted to increase road traffic noise levels by less than 2 dB(A). Changes of this magnitude are not typically noticeable and are considered to be a minor impact.

Night time heavy vehicle movements to and from this site would be limited to one vehicle per hour (no more than five trucks in total). Since the number of night truck movements generated by the site is insignificant compared to existing heavy vehicle numbers on Flat Rock Drive, the number of maximum noise events that could disturb sleep are not likely to substantially increase.

### Construction ground-borne noise

Ground-borne noise could result from the excavation of the tunnel access decline between the Flat Rock Drive construction support site (BL2) and the tunnel alignment. However, due to the terrain and the depth of the tunnel access decline and the resulting slant distances to nearby occupied receiver buildings, no receiver buildings (occupied buildings) are predicted to experience ground-borne noise above the relevant noise management levels from access decline tunnel construction.

### Construction vibration

For the Flat Rock Drive construction support site (BL2), the major work stages that may include vibration intensive works are site establishment, road widening, construction of the access decline and acoustic shed, and tunnelling. The results included in Table 10-17 indicate:

- Two buildings within NCAs 36.1 (Willoughby) and 37.1 (Naremburn) west of Flat Rock Drive have been identified within the minimum working distance for cosmetic damage (sound structures)
- One heritage item in NCA 37.1 (Flat Rock Creek PAD (45-6-3361)) is predicted to be within the minimum working distances for cosmetic damage (unsound structures)
- Up to eleven properties may be exposed to vibration levels above the human response screening level (ie residents may feel vibration) from rock hammering during early works and site establishment works.

The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be construction of the tunnel access decline and the use of rock hammers for utility modification during early and site establishment works. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 15 (Aboriginal heritage) for further details on the potentially impacted heritage item.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-17 Number of receiver buildings within minimum working distances for vibration intensive work – Flat Rock Drive construction support site (BL2)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item[1] | Sound structure | |
| 36.1 | – | 1 | 3 |
| 37.1 | 1 | 1 | 4 |
| 38.1 | – | – | 4 |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

## 10.6.7 Punch Street (BL3)

### Construction works summary

The Punch Street construction support site (BL3) is proposed within the Artarmon industrial area, adjacent to the rail corridor on the southern side of the Gore Hill Freeway. The site would be a tunnel support and project management site and would be used for the construction of the Gore Hill Freeway Connection and the ramp tunnels for Beaches Link. Works associated with the establishment, use and demobilisation of the site would occur over about three years and nine months. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-18 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

No receiver buildings are predicted to experience noise levels greater than 75 dB(A).

During standard construction hours, up to 97 residential receiver buildings in NCAs 33.1, 34.1 and 36.1 (within Artarmon and Willoughby, north of Gore Hill Freeway) are predicted to experience noise levels above the noise management level. These exceedances are predicted during early works, site establishment works and construction of the acoustic shed.

During out of hours works, noise levels are predicted to be below the noise management levels.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 107 receiver buildings from tunnelling support works. Three of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers:

- Up to 12 commercial buildings in NCA 33.2 (within the Artarmon industrial area) are predicted to experience noise levels above the noise management level during early works, site establishment and the construction of the acoustic shed

- Two childcare receivers in NCA 33.2 (Creative Acorn Early Learning Centre and Butterflies Early Learning Childcare Centre) and one in NCA 36.1 (Tree of Life Early Learning School – Willoughby) are predicted to experience noise levels above the noise management level during site establishment and the construction of the acoustic shed
- One educational receiver in NCA 33.1 (Artarmon Public School) is predicted to experience noise levels above the noise management level during site establishment and the construction of the acoustic shed.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-18 Number of residential receiver buildings over the noise management levels during construction at Punch Street construction support site (BL3) (realistic worst case noise)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside of standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 0 | – | 2 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 0 | – | 97 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Surface level access decline excavation and acoustic shed construction | 0 | – | 38 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Tunnelling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 107 | 3 |
| Tunnel fitout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 107 | 3 |
| Build operational motorway facilities | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Site rehabilitation | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

There is potential for cumulative increases of construction noise from the Punch Street construction support site (BL3) and the construction of the Warringah Freeway Upgrade component of the Western Harbour Tunnel and Warringah Freeway Upgrade project. There is also potential for increased disturbance associated with works outside standard construction hours associated with the Punch Street construction support site (BL3) and the Warringah Freeway Upgrade. Cumulative construction noise increases are likely to occur rarely at shared receivers between both projects, if noise generating activities associated with both projects need to occur simultaneously.

Site specific mitigation measures would be developed for the Punch Street construction support site (BL3) with the aim of ensuring that relevant noise management levels are met, minimising the potential for construction fatigue. Works outside standard construction hours would be coordinated with the Warringah Freeway Upgrade where feasible and reasonable to provide the affected receivers with appropriate respite.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

### Construction traffic noise

Construction vehicle movements associated with the Punch Street construction support site (BL3) are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Over the entire night time period there would be six vehicles (12 movements) typically accessing the temporary construction support site. Since the number of truck movements generated by the site is not significant compared to existing heavy vehicle numbers on Gore Hill Freeway, the number of maximum noise events that could disturb sleep are not likely to substantially increase. Additionally, direct access would be provided from the site to the Gore Hill Freeway as the Gore Hill Freeway Connection works progresses, minimising use of local roads.

### Construction ground-borne noise

For the construction of the tunnel access decline between the Punch Street construction support site (BL3) and the tunnel alignment, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at seven receivers located in NCA 32.1 (within Naremburn, east of the T1 North Shore and Western rail line and T9 Northern rail corridor). These exceedances have the potential to exceed the night time ground-borne noise management level.

### Construction vibration

Table 10-19 shows six and 25 receiver buildings fall within the minimum working distances for cosmetic damage (sound structures) and human response respectively. The majority of the receiver buildings are located within the Artarmon industrial area with further detail presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be the use of a large rock hammer during site establishment stages.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-19 Number of receiver buildings within minimum working distances for vibration intensive work – Punch Street construction support site (BL3)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage structure | Sound structure | |
| **Early works, establish site, build decline and shed** | | | |
| 32.1 | – | – | 3 |
| 33.2 | – | 6 | 22 |

## 10.6.8 Middle Harbour south cofferdam (BL7) and Middle Harbour north cofferdam (BL8)

### Construction works summary

The Middle Harbour south (BL7) and Middle Harbour north (BL8) construction support sites would be located at each end of the Middle Harbour crossing and within the harbour at Northbridge to the south and Seaforth to the north. The cofferdams would facilitate construction of the interface structures between the driven mainline tunnels and the immersed tube tunnel units. Works associated with the establishment, use and demobilisation of these temporary construction support sites would occur over about four years. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-20 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels from the Middle Harbour south cofferdam (BL7) and the Middle Harbour north cofferdam (BL8) construction support sites as well as construction activities associated with the installation of the immersed tube tunnel.

Up to 10 residential receiver buildings in NCAs 39.2 and 42.1 (within Seaforth) are predicted to be highly noise affected experiencing noise levels greater than 75 dB(A) during impact piling (also known as hammer piling) for the installation of the Middle Harbour north cofferdam. To ensure appropriate respite is provided to sensitive receivers in the vicinity, impact piling in any given week would be carried out over no more than either a two hour period each work day or over a 6 hour period on a single work day. Impact piling is expected to be completed over a 12 month period.

During standard construction hours, up to 1075 residential receiver buildings across NCAs either side of the crossing of Middle Harbour are predicted to experience noise levels greater than the noise management level. However, the majority of receivers (82 per cent) would experience exceedances of less than 10 dB(A). The majority of noise affected receivers would result from the installation of the Middle Harbour north and south cofferdams, cofferdam excavation works and immersed tube tunnel foundation works.

Immersion of tube tunnel units would require activities outside standard construction hours as a typical immersion process for one immersed tube tunnel unit would take 24 to 48 hours. Once started, it is not possible to halt the installation process at the end of a daytime work shift. During this time, up to 295 residential receiver buildings in NCAs 39.1, 39.2, 40.1, 40.2, 41.1 and 42.1 (within Northbridge, Castlecrag and Seaforth) are predicted to experience noise levels that exceed noise management levels. However, the majority of the exceedances (66 per cent) would be less than 5 dB(A). It is expected that the six tunnel tube units would be immersed at intervals over a six to nine month period, providing affected sensitive receivers with respite in between individual tube immersions.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 224 receiver buildings across several NCAs either side of the crossing of Middle Harbour from the immersion of tube tunnel units. Thirteen of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

One commercial receiver (Northbridge Sailing Club) within NCA 39.1 is predicted to be noise affected during construction of the Middle Harbour south cofferdam and piling for the foundations for immersed tube tunnel. Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-20 Number of residential receiver buildings over the noise management levels during construction at Middle Harbour (realistic worst case noise intensity scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20bB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25 dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25 dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25 dB(A) | Screening | Awakening |
| Build Middle Harbour north cofferdam | 10 | – | 794 | 175 | 17 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Build Middle Harbour south cofferdam | 0 | – | 882 | 185 | 8 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Dewater cofferdams | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excavate cofferdams | 1 | 0 | 200 | 15 | 7 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Pile moorings | 0 | – | 110 | 14 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cast Interface structures | 0 | – | 54 | 3 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Remove cofferdams | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Prepare foundations | 0 | – | 50 | 6 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Pile foundations | 0 | – | 555 | 206 | 14 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Immerse tunnel units | 0 | 0 | 23 | 0 | 0 | 65 | 23 | 0 | 0 | 94 | 56 | 1 | 0 | 195 | 93 | 7 | 0 | 224 | 13 |

Note 1: $L_{Aeq}$ is the A-weighted “equivalent noise level”. It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Middle Harbour south (BL7) and Middle Harbour north (BL8) construction support sites would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

Impact piling associated with cofferdam construction and immersed tunnel tube support piles has the potential to generate significant noise levels and impacts. Impact piling in any given week would, however, be carried out over no more than either a two hour period each work day or a six hour period on a single work day. Also, once these noise intensive activities are completed, the remaining activities in this locality would be less noise intensive and would have a lower potential to cause amenity impacts. Hence the potential for construction fatigue due to extended duration noise impacts is considered to be low.

All works outside standard construction hours associated with the project occurring around Middle Harbour, including the use of the Spit West Reserve construction support site (BL9), would be managed to ensure that affected receivers are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with these temporary construction support sites.

### Construction traffic noise

The crossing of Middle Harbour would be accessed by barges, usually from the Spit West Reserve construction support site (BL9) and there would therefore be no direct construction road traffic impacts associated with the Middle Harbour south (BL7) and Middle Harbour north (BL8) construction support sites. It is expected that noise from barge movements would not cause substantial amenity or sleep disturbance impacts.

### Construction ground-borne noise

While there is some potential for ground-borne noise from vibration intensive activities, associated airborne noise is expected to dominate noise emitted from the Middle Harbour south (BL7) and Middle Harbour north (BL8) construction support sites. Airborne noise levels would typically be greater than ground-borne noise levels at the nearby residential receivers. No vibration intensive activities are proposed at either temporary construction support site outside standard construction hours. Therefore, no amenity impacts outside standard construction hours due to ground-borne noise are anticipated.

### Construction vibration

Table 10-21 shows six heritage items in NCAs 40.1 and 39.1 (Clive Park and Tidal Pool, Clive Park one (Northbridge), Clive Park two (Northbridge, Cicada Pupa Cave), Clive Park four (Northbridge),Clive Park 8 (Shelter Midden WILL 170) and Clive Park (Midden WILL 169)) and one heritage item within NCA 42.1 (Harbour foreshore) are predicted to be within the minimum working distances for major vibration generating activities. Up to 148 buildings within Northbridge and Seaforth may be exposed to vibration levels above the human response screening level. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site are likely to be impact piling and vibratory piling for the installation of the Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams, cofferdam excavation works and immersed tube tunnel foundation works. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage) for details on the heritage items potentially impacted.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

A number of underwater maritime heritage items are located in proximity to the Middle Harbour crossing and may experience potential direct or indirect impacts from construction works. These

items are not specifically addressed in Appendix G (Technical working paper: Noise and vibration), as both the submerged nature of these heritage items and that they are generally not building structures that require structural integrity for any specific purpose means that the standards and limits for managing structural damage are not directly applicable. For further information on impacts from construction works on these items including the potential for vibration impacts, refer to Appendix K (Technical working paper: Maritime heritage).

**Table 10-21 Number of receiver buildings within minimum working distances for vibration intensive work – Middle Harbour construction support sites**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item[1] | Sound structure | |
| 39.1 | 1 | – | 19 |
| 39.2 | – | 2 | 51 |
| 40.1 | 5 | – | 17 |
| 42.1 | 1 | 6 | 61 |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

## 10.6.9 Spit West Reserve (BL9)

### Construction works summary

The Spit West Reserve construction support site (BL9) is located in the water west of Spit West Reserve, with a small adjoining land-based site. The proposed construction works at the site would include a temporary floating immersed tube tunnel casting facility that would be connected to Spit West Reserve by two temporary fixed jetties. The casting facility would provide space for two immersed tube tunnel units to be cast concurrently. Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about four years and six months. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-22 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

No receivers are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)).

During standard construction hours, up to 131 residential receiver buildings in NCAs 39.2, 40.2, 42.1, 43.1 and 43.2 (within Mosman and Seaforth) are predicted to experience noise levels above the noise management levels, mostly during early works and the construction of the temporary wharf and office building. During other stages, noise impacts would be less, with up to 52 receiver buildings noise affected.

Due to construction limitations of concrete pours associated with the casting of the tunnel units, these activities may be required to extend outside standard construction hours. If concrete pours extend into the evening period up to 171 residential receiver buildings are predicted to be noise affected by 1 to 5 dB(A) with an additional 48 residential receiver buildings noise affected by 6 to 15 dB(A).

Immersion of tube tunnel units would be supported from the Spit West Reserve construction support site (BL9) and would be required during out of hours of work as a typical immersion process for one immersed tube tunnel unit would take 24 to 48 hours. During this time, up to 79 residential receiver buildings across various NCAs surrounding the temporary construction support

site are predicted to exceed noise management levels, however the majority of the exceedances (80 per cent) would be less than 5 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 132 receiver buildings across several NCAs from the immersion of tube tunnel units. None of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers:

- Five commercial receivers located in NCA 44.2 (within The Spit area of Mosman) are predicted to experience noise levels above the noise management level during early works by less than 10 dB(A)
- Up to two recreational receivers located in NCA 44.2 (Spit West Reserve and Pearl Bay Reserve) are predicted to experience noise levels above the noise management level at various construction work stages by less than 20 dB(A).

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-22 Number of residential receiver buildings over the noise management levels during construction at Spit West Reserve construction support site (BL9) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 0 | – | 131 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Construct office and wharf | 0 | – | 52 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Support dredging, pile installation and cofferdam/ interface structure works | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cast and fitout tunnel units | 0 | 0 | 11 | 0 | 0 | 92 | 11 | 0 | 0 | 171 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Support tunnel unit immersion | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 66 | 13 | 0 | 0 | 132 | 0 |
| Site rehabilitation | 0 | – | 45 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Spit West Reserve construction support site (BL9) would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

The predicted noise levels generated by the temporary construction support site are unlikely to result in significant amenity impacts for sensitive receivers in the vicinity. The use of the site is therefore unlikely to result in construction fatigue due to extended duration noise impacts is considered to be low.

All works outside standard construction hours associated with the project occurring around Middle Harbour, including the use of the Spit West Reserve construction support site (BL9), would be coordinated managed to ensure that affected receivers are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with this temporary construction support site.

### Construction traffic noise

While the Spit West Reserve construction support site (BL9) would be accessed outside standard construction hours to support tunnel tube construction and immersion, the volume of construction vehicle movements are likely to be low compared to existing volumes on Spit Road. Therefore, construction vehicle movements are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Heavy vehicle movements are expected during the evening period however no night time heavy vehicle movements would occur at this site. Road traffic related sleep disturbance impacts are not expected to occur.

### Construction ground-borne noise

Ground-borne noise may be generated by vibration intensive works within the Spit West Reserve construction support site (BL9). Given the closest building to the site is around 60 metres away, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers. No vibration intensive activities are proposed at this temporary construction support site outside standard construction hours. Therefore, no amenity impacts outside standard construction hours due to ground-borne noise are anticipated.

### Construction vibration

The most vibration intensive activities at this site are likely to be screw pile driving during wharf building works and the use of rock hammers during establishment works. There are no receiver buildings within the minimum working distances for major vibration generating activities. However, occupants of up to two commercial properties in NCA 44.2 (within The Spit area of Mosman) may be exposed to vibration levels above the human response screening level during early works and the construction of the office and wharf should rock hammers and screw pile driving be used.

A number of underwater maritime heritage items are located in proximity to the Spit West Reserve construction support site (BL9) and may experience potential direct or indirect impacts from construction works. These items are not specifically addressed in Appendix G (Technical working paper: Noise and vibration), as both the submerged nature of these heritage items and that they are generally not building structures that require structural integrity for any specific purpose means that the standards and limits for managing structural damage are not directly applicable. For further information on impacts from construction works on these items including the potential for vibration impacts, refer to Appendix K (Technical working paper: Maritime heritage).

## 10.6.10 Balgowlah Golf Course (BL10)

### Construction works summary

The Balgowlah Golf Course construction support site (BL10) would be located partially within Balgowlah Golf Course and on privately owned lots on Dudley Street. This would be a tunnel support site and project management site. It would also be used for the construction of Beaches Link tunnel connection to Burnt Bridge Creek Deviation and surface works, construction of operational facilities and the development of new and improved open space and recreation facilities and support of the construction of the immersed tube tunnels at the Spit West Reserve construction support site (BL9). Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about five years. Staged construction of the open space and recreation facilities would be delivered progressively and continue for another year after the main construction works have been completed. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-23 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

During standard construction hours, up to 1004 residential receiver buildings in NCAs 47.1, 48.1, 49.1, 50.1 and 51.1 (within Seaforth, Balgowlah and North Balgowlah) are predicted to experience noise levels greater than the noise management level. This would be mostly during site establishment works. The majority of receivers would experience exceedances of less than 10 dB(A). Other activities for which construction noise could affect a number of nearby residential receivers are bulk earthworks, access decline construction and construction of the new recreation facilities.

During standard construction hours two residential receiver buildings within NCA 49.1 (within Seaforth, west of Burnt Bridge Creek Deviation) also have the potential to experience noise levels greater than 75 dB(A) during site establishment works while excavators with rock hammers, chainsaws and mulchers are in use.

During night road works for road and intersection modifications, up to 548 residential receiver buildings are predicted to experience noise levels above the relevant noise management levels. The majority of receivers (96 per cent) are predicted to experience exceedances of less than 15 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 267 receiver buildings across several NCAs surrounding the Balgowlah Golf Course construction support site (BL10) during night road works. Eleven of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

During night time tunnelling and tunnel fitout works, occasional night time concrete truck movements could result in the high instantaneous noise impacts during arrival or departure. Up to 136 receiver buildings are predicted to potentially be exposed to maximum noise levels above the sleep disturbance screening level. No receivers are predicted to exceed the awakening reaction level.

A number of non-residential receivers could be noise affected during establishment and use of this temporary construction support site. Up to 32 non-residential receivers could experience noise level that exceed the relevant noise management levels during site establishment. The identified receivers include:

- Up to two childcare receivers located in NCAs 47.1 (Peacock Street Long Day Care and Seaforth Infants School) are predicted to be would be noise affected by up to 10 dB(A) above the noise management level and one receiver located in in NCA 50.1 (Balgowlah Kinder Haven) is predicted to experience noise levels above the noise management level during various project stages by up to 21 dB(A)

- Up to three educational receivers located in NCAs 48.1 (Northern Beaches Secondary College – Balgowlah Boys Campus), 49.1 (Seaforth Public School) and 50.1 (Punchinello Kindergarten) are predicted to experience noise levels above the noise management level during various project stages by up to 16 dB(A). Multiple buildings at Northern Beaches Secondary College Balgowlah Boys (NCA 48.1) and Seaforth Public School (NCA 49.1) may potentially be impacted.
- One recreational receiver (Balgowlah Oval) is predicted to experience noise levels above the noise management level by up to 14 dB(A)
- Up to three place of worship receivers located in NCAs 47.1 (Seaforth Anglican Church and Seaforth Baptist Church) and 48.1 (The Catholic Community of North Harbour) are predicted to experience noise levels above the noise management level during site rehabilitation by up to 7 dB(A).

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-23 Number of residential receiver buildings over the noise management levels during construction at Balgowlah Golf Course construction support site (BL10) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 0 | – | 299 | 21 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 2 | – | 863 | 137 | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Road/intersection modification | 0 | 0 | 3 | 0 | 0 | 16 | 3 | 0 | 0 | 26 | 10 | 0 | 0 | 388 | 136 | 21 | 3 | 256 | 11 |
| Bulk earthworks | 0 | – | 188 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Build access decline | 0 | – | 332 | 12 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish construction facilities | 0 | – | 10 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Piling for acoustic shed | 0 | – | 35 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Build acoustic shed | 0 | – | 6 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Balgowlah road surface support works | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 136 | 0 |
| Tunnelling | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 136 | 0 |
| Tunnel fitout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 117 | 0 |

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Concrete batching | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 117 | 0 |
| Golf course north works | 0 | 0 | 208 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 136 | 0 |
| Build operational facilities | 0 | – | 14 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Remove acoustic shed | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Decommission site | 0 | – | 5 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Construct new oval | 0 | – | 70 | 2 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Construct new field | 0 | – | 34 | 9 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted “equivalent noise level”. It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Balgowlah Golf Course construction support site (BL10) would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

While the temporary construction support site would be in use for an extended duration, the majority of the activities that would onsite would not be noise intensive. Site specific mitigation measures would be developed for Balgowlah Golf Course construction support site (BL10) with the aim of ensuring that relevant noise management levels are met during site use, minimising the potential for construction fatigue.

The use of the temporary construction support site outside standard construction hours would typically be to support the Balgowlah surface road works described in Section 10.6.11. The use of Balgowlah Golf Course construction support site (BL10) and the Balgowlah surface road works would be coordinated to ensure that affected receivers in the vicinity are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with this temporary construction support site.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate the construction of the project, and construction vehicle movements associated with the Balgowlah Golf Course construction support site (BL10) are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Since the number of night period truck movements generated by the site is small compared to existing heavy vehicle numbers on Sydney Road and Burnt Bridge Creek Deviation, the number of maximum noise events that could disturb sleep are not likely to substantially increase.

### Construction ground-borne noise

For the construction of the tunnel access decline between the Balgowlah Golf Course construction support site (BL10) and the ramp tunnel alignment, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at four receivers located in NCA 49.1 (within Balgowlah, east of Burnt Bridge Creek Deviation), with one receiver potentially experiencing ground-borne noise levels above 40 dB(A). During the construction of the ventilation tunnel and shaft, one residential receiver building within NCA 49.1 (in Seaforth, west of Burnt Bridge Creek Deviation) is predicted to be impacted by ground-borne noise levels above 35 dB(A). Both the tunnel access decline and the ventilation tunnel are not located directly below any residential receivers, limiting the potential ground-borne noise impacts.

### Construction vibration

Table 10-24 shows 37 and 198 receiver buildings fall within the minimum working distances for cosmetic damage (sound structures) and human response respectively. The majority of these receiver buildings are within NCA 50.1 (in Balgowlah, east of Balgowlah Golf Course) with further detail on other properties provided in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be construction of the tunnel access decline and the use of rock hammers for site establishment and excavation works. The risk of annoyance at this site is considered low as piling, earth compaction works and rock hammering would occur for a limited duration only.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-24 Number of receiver buildings within minimum working distances for vibration intensive work – Balgowlah Golf Course construction support site (BL10)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item | Sound structure | |
| 46.1 | – | – | 4 |
| 48.1 | – | 1 | 30 |
| 49.1 | – | 10 | 37 |
| 50.1 | – | 26 | 101 |
| 51.1 | – | – | 26 |

## 10.6.11 Balgowlah surface road works

### Construction works summary

The Balgowlah surface road works are located on and adjacent to the Burnt Bridge Creek Deviation, on the border between Seaforth and Balgowlah. The works would connect the Beaches Link tunnel to Burnt Bridge Creek Deviation, and include works required to properly integrate this new connection into the existing network. Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about three years and three months.

The Balgowlah surface road works also includes the use of Kitchener Street construction support site (BL11).

Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-25 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical and realistic worst case construction noise intensive work scenarios.

During standard construction hours, no residential receiver buildings are predicted to experience noise levels greater than 75 dB(A) during typical works. However, up to 25 residential receiver buildings are predicted to experience noise levels greater than 75 dB(A) during worst case works, such as during the use of rock hammers during excavations of rock or utility modification works.

During standard construction hours:

- The highest predicted noise levels occur for receivers directly adjacent to the works or in close proximity in NCAs 46.1, 48.1, 49.1, 50.1 and 51.1 in Seaforth, Clontarf, Balgowlah and North Balgowlah,
- For typical surface road works, up to 127 residential receiver buildings are predicted to exceed the noise management level. For typical works at the Kitchener Street construction support site (BL11), up to 100 receivers are predicted to exceed the noise management level
- For worst case construction, up to 912 residential receiver buildings are predicted to exceed the noise management level. The highest predicted noise levels occur are associated with excavation or utility modification works when equipment such as road saws or rock hammers are in use. For worst case works at the Kitchener Street construction support site, up to 117 receivers are predicted to exceed the noise management level during oversized deliveries to the site, with most exceedances less than 10 dB(A).

Outside standard construction hours, the key noise generating activities associated with the Balgowlah surface road works would be installation of traffic management controls to facilitate traffic switches, resurfacing works along Burnt Bridge Creek Deviation, support and deliveries for the cut and cover portal construction works, and intersection and road works in the areas where the new access road would connect to the Burnt Bridge Creek Deviation and Sydney Road (activities that cannot take place during standard construction hours to avoid significant traffic disruption in the network):

- For typical surface works during the night time period, up to 2318 residential receiver buildings are predicted to exceed the noise management level. No noise management level exceedances are expected at the Kitchener Street construction support site since the site would operate typically during standard working hours only
- For worst case construction works, up to 4059 residential receiver buildings are predicted to exceed the noise management level at night time.
- During works outside standard construction hours up to nine receivers could be highly noise affected (ie greater than 75 dB(A)) when plant and equipment are close to a receiver building.

For the prediction of airborne noise impacts from construction sites, consideration was given to realistic worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009a). While the noise levels for the realistic worst case might occur at a sensitive receiver during the works, noise levels associated with the typical scenario occur more frequently.

The most likely source of potential sleep disturbance from night construction works would be from the use of rock hammers or concrete saws during utility modification works. The predicted maximum noise levels show exceedances of the sleep disturbance screening level across all areas with night construction works for both typical and worst case construction activities as follows:

- During typical surface works up to 718 buildings are predicted to exceed the sleep disturbance screening level with up to 97 residential receiver buildings have potential to exceed the awakening reaction level during typical construction works
- During worst case surface works up to 1097 buildings are predicted to exceed the sleep disturbance screening level. However only up to 148 residential receiver buildings have potential to exceed the awakening reaction level during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- Up to two childcare centres in NCA 47.1 (Peacock Street Long Day Care and Seaforth Infants School) and one childcare receiver in NCA 50.1 (Balgowlah Kinder Haven) are predicted to be noise affected
- Up to two commercial receivers on Sydney Road in NCA 46.1 and two commercial receivers on Sydney Road in NCA 48.1 are predicted to be noise affected
- Up to four schools located in NCAs 46.1 (Northside Preschool), 48.1 (Northern Beaches Secondary College – Balgowlah Boys Campus), 49.1 (Seaforth Public School) and 50.1 (Punchinello Kindergarten) are predicted to be above the noise management level during various stages of the works, two of which are predicted to more than 10 dB(A) above the noise management level
- Up to 5 dB(A) above the noise management level is predicted at two places of worship in NCA 47.1 (Seaforth Anglican Church and Seaforth Baptist Church), and one places of worship in NCA 48.1 (The Catholic Community of North Harbour)
- Up to 7 dB(A) above the noise management level at the Balgowlah Scout Hall when the works are at the closest location.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-25 Number of residential receiver buildings over the noise management levels during Balgowlah surface road works (typical and realistic worst case scenarios)**

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Existing road corridor (southbound) | Typical | 0 | 0 | 116 | 11 | 0 | 35 | 11 | 0 | 0 | 49 | 31 | 0 | 0 | 259 | 147 | 24 | 0 | 718 | 97 |
| | Worst case | 20 | 0 | 730 | 158 | 24 | 97 | 57 | 1 | 0 | 163 | 88 | 6 | 0 | 573 | 450 | 79 | 5 | 1097 | 148 |
| Existing road corridor (northbound) | Typical | 0 | 1 | 104 | 15 | 1 | 218 | 161 | 32 | 1 | 364 | 251 | 64 | 3 | 984 | 1059 | 212 | 63 | 654 | 99 |
| | Worst case | 25 | 9 | 624 | 148 | 24 | 604 | 376 | 89 | 14 | 762 | 642 | 139 | 24 | 1458 | 1807 | 657 | 137 | 994 | 153 |
| Trough works | Typical | 0 | 0 | 52 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | 0 | 464 | 45 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cut and cover portal works | Typical | 0 | 0 | 37 | 1 | 0 | 43 | 22 | 0 | 0 | 99 | 37 | 1 | 0 | 780 | 434 | 30 | 1 | 196 | 7 |
| | Worst case | 0 | 0 | 401 | 29 | 0 | 54 | 24 | 0 | 0 | 134 | 42 | 1 | 0 | 857 | 509 | 37 | 2 | 455 | 22 |
| Access road | Typical | 0 | 0 | 11 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | 0 | 225 | 17 | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Works area | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Access road intersection at Burnt Bridge Creek Deviation | Typical | 0 | 0 | 5 | 0 | 0 | 22 | 5 | 0 | 0 | 50 | 14 | 1 | 0 | 622 | 191 | 8 | 0 | 90 | 3 |
| | Worst case | 0 | 0 | 99 | 5 | 0 | 449 | 99 | 5 | 0 | 682 | 282 | 15 | 1 | 1217 | 1590 | 220 | 8 | 939 | 27 |
| Sydney Road roadworks | Typical | 1 | 1 | 8 | 1 | 0 | 11 | 8 | 1 | 0 | 25 | 12 | 4 | 0 | 1523 | 1940 | 264 | 41 | 935 | 85 |
| | Worst case | 6 | 6 | 53 | 8 | 1 | 394 | 53 | 8 | 1 | 797 | 217 | 13 | 4 | 1523 | 1940 | 264 | 41 | 935 | 85 |
| Kitchener Street construction support site (BL11) | Typical | 0 | 0 | 94 | 6 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | 0 | 109 | 8 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Balgowlah surface road works would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

While these road works would occur over an extended duration and would generate significant noise levels at times, the majority of the activities that would onsite would not result in significant amenity impacts for nearby receivers, limiting the potential for construction fatigue.

Balgowlah Golf Course construction support site (BL10) would generally support any outside standard construction hours work for the Balgowlah surface road works instead of the Kitchener Street construction support site (BL11). The use of Balgowlah Golf Course construction support site (BL10) and the Balgowlah surface road works would be coordinated to ensure that affected receivers in the vicinity are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with the Balgowlah surface road work.

### Construction traffic noise

Changes in traffic movements due to alterations made to existing traffic arrangements to facilitate construction, and heavy vehicle movements associated with the Balgowlah surface road works between work areas via the Burnt Bridge Creek Deviation, Sydney Road or from the Balgowlah Golf Course construction support site (BL10), are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Reduced speed limit during traffic switching arrangements along the Balgowlah surface road works is likely to reduce road traffic noise levels at residential receiver buildings in NCA 50.1 (within Balgowlah, east of the Balgowlah Golf Course).

### Construction ground-borne noise

Ground-borne noise levels have the potential to be generated by vibration intensive works during surface road works. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Table 10-26 shows up to 44 receiver buildings would be within minimum working distances for cosmetic damage (sound structures). Up to 197 receiver buildings would be within minimum working distance for human response. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be the use of rock hammers for surface road works.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-26 Number of receiver buildings within minimum working distances for vibration intensive work – Balgowlah connection surface road works**

| Location | NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|---|
| | | Cosmetic damage | | Human response |
| | | Heritage item | Sound structure | |
| Existing road corridor (southbound) | 46.1 | – | – | 8 |
| | 49.1 | – | 1 | 40 |
| | 50.1 | – | – | 7 |
| | 51.1 | – | 1 | 50 |
| Existing road corridor (northbound) | 46.1 | – | – | 6 |
| | 49.1 | – | 19 | 51 |
| | 50.1 | – | – | 3 |
| | 51.1 | – | 17 | 75 |
| Trough works | 49.1 | – | – | 16 |
| Cut and cover portal works | 49.1 | – | – | 16 |
| Access road | 48.1 | – | – | 7 |
| | 49.1 | – | – | 2 |
| | 50.1 | – | – | 2 |
| | 51.1 | – | – | 3 |
| Access road intersection at Burnt Bridge Creek Deviation | 49.1 | – | – | 3 |
| | 51.1 | – | – | 4 |
| Sydney Road roadworks | 48.1 | – | 8 | 31 |
| | 49.1 | – | – | 3 |
| | 50.1 | – | – | 5 |

## 10.6.12 Wakehurst Parkway south (BL12)

### Construction works summary

The Wakehurst Parkway south construction support site (BL12) is located on the eastern side of Wakehurst Parkway between just south of Judith Street and Kirkwood Street at Seaforth. Construction works at the site would support the upgrade of Wakehurst Parkway and also the construction of the cut and cover tunnel connection and motorway facilities at Wakehurst Parkway. Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about four years and nine months. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-27 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

Up to 18 residential receiver buildings are predicted to experience noise levels greater than 75 dB(A) during standard construction hours when rock hammers, chainsaws and mulchers are in use as part of the site establishment and early works.

During standard construction hours, up to 54 residential receiver buildings in NCAs 53.1 and 54.1 (within Seaforth) are predicted to experience noise levels above the noise management level during site establishment, early works, and site restoration works. The majority of receivers (56 per cent) would experience increases of less than 10 dB(A).

No works outside standard working hours are proposed at this temporary construction support site.

For non-residential receivers, up to two recreational receivers located at Seaforth Oval in NCA 54.1 (within Seaforth) are predicted to experience noise levels above the noise management level during site establishment and early works by up to 11 dB(A).

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-27 Number of residential receiver buildings over the noise management levels during construction at Wakehurst Parkway south construction support site (BL12) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 9 | – | 15 | 19 | 9 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 18 | – | 30 | 6 | 18 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Support surface works | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Support cut and cover and motorway facilities | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Site rehabilitation | 0 | – | 6 | 17 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted “equivalent noise level”. It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Wakehurst Parkway south construction support site (BL12) would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

While the temporary construction support site would be in use for an extended duration, the majority of the activities that would onsite would not be noise intensive. Site specific mitigation measures would be developed for this temporary construction support site with the aim of ensuring that relevant noise management levels are met during site use, minimising the potential for construction fatigue.

The use of Wakehurst Parkway south construction support site (BL12) outside standard construction hours would typically be to support the Wakehurst Parkway surface road works. The use of the temporary construction support site and the Wakehurst Parkway surface road works would be coordinated to ensure that affected receivers in the vicinity are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with this temporary construction support site.

### Construction traffic noise

Construction traffic associated with the Wakehurst Parkway south construction support site (BL12) is unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

No night time heavy vehicle movements would occur to or from this site. Road traffic related sleep disturbance impacts are not expected to occur.

### Construction ground-borne noise

Ground-borne noise may be generated by vibration intensive works within the Wakehurst Parkway south construction support site (BL12). However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Table 10-28 shows two heritage structures in NCA 54.1 (Bantry Bay Water Pumping Station and the Bantry Bay Reservoir) are predicted to be within the minimum working distances for major vibration generating activities. Up to 27 receiver buildings within NCA 54.1 (Seaforth) may be exposed to vibration above the human response screening level during early works. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be rock hammers for utility modification works. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) for further details on the heritage items potentially impacted.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/ or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-28 Number of receiver buildings within minimum working distances for vibration intensive work – Wakehurst Parkway south construction support site (BL12)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage items[1] | Sound structure | |
| 54.1 | 2 | 21 | 27 |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

## 10.6.13 Wakehurst Parkway east (BL13)

### Construction works summary

The Wakehurst Parkway east construction support site (BL13) is located on the eastern side of Wakehurst Parkway, on land surrounding Sydney Water's Bantry Bay Reservoir site, adjacent to the Wakehurst Parkway Golf Course. This would be a tunnel support site and project management site. The site would be used for the construction of Beaches Link tunnel connection to Wakehurst Parkway, to support the construction of the ramp tunnels for the Beaches Link component of the project. Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about four years and six months. Refer to Chapter 6 (Construction work) for further information.

### Construction airborne noise

Table 10-29 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

No receiver buildings are predicted to experience noise levels greater than 75 dB(A).

During standard construction hours, up to two residential receiver buildings in NCAs 54.1 (located on Kirkwood Street, Seaforth) are predicted to experience noise levels above the noise management level during early works and site establishment.

During night time works, noise levels are predicted to exceed noise management levels during site establishment works at up to 63 residential receiver buildings in NCAs 53.1 and 54.1 (within Seaforth). A high proportion of receivers (about 67 per cent) would experience exceedances of less than 5 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 35 receiver buildings due to site establishment and tunnelling support works. None of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

No non-residential receivers are predicted to experience noise levels above the noise management levels.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-29 Number of residential receiver buildings over the noise management levels during construction at Wakehurst Parkway east construction support site (BL13) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 0 | – | 1 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 8 | 2 | 0 | 0 | 42 | 19 | 2 | 0 | 35 | 0 |
| Establish facilities | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Piling for access decline and acoustic shed | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Build acoustic shed | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Tunnelling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 8 | 0 |
| Tunnel fitout | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 8 | 0 |
| Remove acoustic shed | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Site rehabilitation | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities.
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Wakehurst Parkway east construction support site (BL13) would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

While the temporary construction support site would be in use for an extended duration, the majority of the activities that would occur onsite would not be noise intensive. Site specific mitigation measures would be developed for this temporary construction support site with the aim of ensuring that relevant noise management levels are met during site use, particularly outside standard construction hours, minimising the potential for construction fatigue.

No cumulative airborne construction noise impacts are anticipated associated with this temporary construction support site.

### Construction traffic noise

Construction traffic associated with the Wakehurst Parkway east construction support site (BL13) is unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Over the entire night time period there would be eight heavy vehicle movements (four vehicles). Since the number of night truck movements generated by the site is not significant compared to existing heavy vehicle numbers on Wakehurst Parkway, the number of maximum noise events that could disturb sleep are not likely to substantially increase.

### Construction ground-borne noise

Ground-borne noise would be generated from the construction of the tunnel access decline between the temporary construction support site and mainline tunnel and by vibration intensive works within the temporary construction support site. No sensitive receivers are predicted experience ground-borne noise levels above the noise management level.

### Construction vibration

Table 10-30 shows two heritage structures in NCA 54.1 (Bantry Bay Water Pumping Station and the Bantry Bay Reservoir) are predicted to be within the minimum working distances for major vibration generating activities. The most vibration intensive activity at this site is likely to be construction of the tunnel access decline, construction of the acoustic shed and the use of rock hammers for utility modification during early works. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) for further details on the heritage items potentially impacted.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-30 Number of receiver buildings within minimum working distances for vibration intensive work – Wakehurst Parkway east construction support site (BL13)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item[1] | Sound structure | |
| 54.1 | 2 | – | - |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

### 10.6.14 Wakehurst Parkway north (BL14)

#### Construction works summary

The Wakehurst Parkway north construction support site (BL14) is located on the north east corner of Wakehurst Parkway and Warringah Road at Frenchs Forest. Construction works at the site would be related to the Wakehurst Parkway surface road works, minor intersection works at Wakehurst Parkway/Warringah Road and Wakehurst Parkway/Frenchs Forest Road and construction of the permanent tunnel support facilities. The site would also support the construction and operation of a temporary concrete batching plant. Works associated with the establishment, use and demobilisation of this temporary construction support site would occur over about five years. Refer to Chapter 6 (Construction work) for further information.

#### Construction airborne noise

Table 10-31 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels.

No receivers are expected to experience noise levels greater than 75 dB(A).

During standard construction hours, up to 31 residential receiver buildings in NCAs 56.1 and 57.1 (within Frenchs Forest, south and north of Warringah Road, west of Wakehurst Parkway) are predicted to experience noise levels above the noise management level during early works. All receivers are predicted to experience noise exceedances of less than 10 dB(A).

During night time support for the Wakehurst Parkway road surface works, no noise management level exceedances are predicted.

Maximum noise levels could exceed the sleep disturbance screening level at up to 161 receiver buildings from truck deliveries at night during surface activities. No receivers are expected to receive noise above the awakening reaction level.

Noise management level exceedances may occur at the following non–residential receivers:

- Three commercial receivers located in NCA 58.2 (within Frenchs Forest, east of Wakehurst Parkway)
- One childcare receiver located in NCA 58.2 (Kindalin Early Childhood Learning Centre)
- One educational receiver located in NCA 57.1 (The Forest High School)
- One recreational receiver in NCA 56.1 (Brick Pit Reserve)
- Four place of worship receivers in NCA 56.1
- One other sensitive receiver in NCA 56.1 (Northern Beaches Hospital).

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-31 Number of residential receiver buildings over the noise management levels during construction at Wakehurst Parkway north construction support site (BL14) (realistic worst case scenario)**

| Stage activity | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Early works | 0 | 0 | 31 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Establish site | 0 | 0 | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Surface activities | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 161 | 0 |
| Build maintenance facility | 0 | 0 | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Site rehabilitation | 0 | 0 | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Wakehurst Parkway north construction support site (BL14) would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely. Also, the temporary construction support site would be in a location where the most affected receivers are not particularly noise sensitive.

The use of Wakehurst Parkway north construction support site (BL14) outside standard construction hours would typically be to support the Wakehurst Parkway surface road works. The use of the temporary construction support site and the Wakehurst Parkway surface road works would be coordinated to ensure that affected receivers in the vicinity are provided with appropriate respite.

No cumulative airborne construction noise impacts are anticipated associated with this temporary construction support site.

### Construction traffic noise

Construction traffic associated with the Wakehurst Parkway east construction support site (BL13) is unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Night time heavy vehicle movements from this site would be limited to one vehicle per hour, which is not a substantial number when compared to existing heavy vehicle movements on Warringah Road and Wakehurst Parkway. Nearby receivers are not likely to notice the increase in the number of maximum noise events caused by the additional truck movements generated by the site.

Sleep disturbance impacts from construction traffic are not likely to occur.

### Construction ground-borne noise

Ground-borne noise levels have the potential to be generated during early works, where rock hammering may be needed for utilities adjustments. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Table 10-32 shows two receiver buildings in NCA 58.2 (within Frenchs Forest, east of Wakehurst Parkway) are predicted to be within the minimum human response working distances for major vibration generating activities. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be use of rock hammers for utility modifications.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-32 Number of receiver buildings within minimum working distances for vibration intensive work – Wakehurst Parkway north construction support site (BL14)**

| NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|
| | Cosmetic damage | | Human response |
| | Heritage item | Sound structure | |
| 58.2 | – | – | 2 |

### 10.6.15 Wakehurst Parkway surface road works

#### Construction works summary

The Wakehurst Parkway connection and upgrade is located on the Wakehurst Parkway, between Killarney Heights and Frenchs Forest. Works would include on and off ramps along with tunnel portals, ventilation facility and widening and upgrading of the Wakehurst Parkway through to Warringah Road. Works associated with the establishment, use and demobilisation of this temporary construction support site would take about three years and nine months. Refer to Chapter 6 (Construction work) for further information.

#### Construction airborne noise

Table 10-33 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during realistic worst case and typical construction noise intensive work scenario.

During standard construction hours one residential receiver building is predicted to experience noise levels greater than 75 dB(A) when works take place nearby for the Warringah Road and Wakehurst Parkway intersection. Up to five residential receiver buildings are predicted to experience noise levels greater than 75 dB(A) when works take place in the southern section of the Wakehurst Parkway surface road works at Seaforth.

During standard construction hours:

- For typical surface road works, there would be no exceedances greater than 20 dB(A).
- The highest noise impacts during typical surface road works would likely be during clearing and grubbing activities associated with the southern and central sections of Wakehurst Parkway. Daytime noise management levels for the southern section could be exceeded at up 15 residential receiver buildings, with six receivers by greater than 10 dB(A). For the central section, daytime noise management levels could be exceeded at up 20 residential receiver buildings. However, all exceedance levels would be less than 10 dB(A). Two receiver buildings would be exceeded in the northern area.
- For worst case surface road works, up to 21 residential receiver buildings could experience noise levels that exceed the relevant noise management levels during bulk earthworks for the cut and cover portal, with four receivers by greater than 10 dB(A).
- The highest worst case noise impacts during surface road works would likely be during paving and asphalting, when daytime noise management levels could be exceeded at up to 15 receiver buildings in the northern area, 77 in the central and 34 in the southern area along Wakehurst Parkway. Noise levels are predicted to be greater than 20 dB(A) above the daytime noise management level at up to five of those receiver buildings where noise levels could be considered highly intrusive. However, noise levels are not predicted to be more than 20 dB(A) above the daytime noise management level at any receiver buildings during typical construction work.

Outside standard construction hours:

- Around the Warringah Road and Wakehurst Parkway intersection, up to 431 receiver buildings could experience noise levels that exceed the noise management levels during typical works. Up to 886 receiver buildings are predicted to be noise affected during worst case works
- For oversized lifting works in the northern section of the Wakehurst Parkway surface road works area, up to 199 receiver buildings are predicted to exceed the noise management levels during typical works. Up to 249 receiver buildings are predicted to be noise affected during worst case works

- For the central and southern sections of the Wakehurst Parkway surface road works area, up to 77 and 33 receiver buildings respectively could experience noise levels that exceed the noise management levels during typical works. Up to 139 and 59 receiver buildings respectively are predicted to be noise affected during worst case works
- For the cut and cover portals and works associated with the ventilation outlet and motorway facilities, up to 91 receiver buildings could experience noise levels that exceed the noise management levels during typical works. Up to 168 receiver buildings are predicted to be noise affected during worst case works.

For the prediction of airborne noise impacts from construction sites, consideration was given to realistic worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009a). While the noise levels for the realistic worst case might occur at a sensitive receiver during the works, noise levels associated with the typical scenario occur more frequently.

The most likely source of potential sleep disturbance from night construction works would be from the use of rock hammers or concrete saws during utility modification works. The predicted maximum noise levels show exceedances of the sleep disturbance screening level across all areas with night construction works for both typical and worst case construction activities as follows:

- During typical construction works up to 86 receiver buildings would exceed the sleep disturbance screening levels, with up to 11 residential receiver buildings have the potential to experience noise levels in excess of the awakening reaction level during typical construction works
- During periods of worst case works up to 115 receiver buildings above the sleep disturbance screening level, with up to 16 residential receiver buildings have the potential to experience noise levels in excess of the awakening reaction level during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- Two commercial receivers located in NCA 58.2 for worst case construction works
- Up to one childcare receiver located in NCA 58.2 (Kindalin Early Childhood Learning Centre) for typical construction works, and up to two childcare receivers located in NCAs 55.1 (Little Bloomers Early Learning Centre) and 58.2 (Kindalin Early Childhood Learning Centre) for worst case construction works
- Two recreational receivers in NCAs 55.1 and 56.1 during the Warringah Road and Wakehurst Parkway intersection upgrade works and three recreational areas/facilities in NCAs 54.1, 55.1, and 55.4 during surface works along the Wakehurst Parkway
- One place of worship receiver in NCA 56.1 (Frenchs Forest Anglican Church)
- When works are closest to the Northern Beaches Hospital, construction noise levels are predicted to exceed the noise management level by up to 5 dB(A) during typical works, or 16 dB(A) during worst case construction works
- Two other sensitive receivers (community centres) in NCA 55.1.

Where noise management levels are exceeded there is a requirement to implement reasonable and feasible noise mitigation. Measures to avoid, minimise and mitigate the potential noise impacts from construction works during construction are provided in Section 10.7.

**Table 10-33 Number of residential receiver buildings over the noise management levels during Wakehurst Parkway surface road works (typical and realistic worst case scenarios)**

| Work activity | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| **Warringah Road/ Wakehurst Parkway works area** | | | | | | | | | | | | | | | | | | | | |
| Surface road works | Typical | 0 | 0 | 3 | 1 | 0 | 9 | 3 | 1 | 0 | 32 | 15 | 1 | 0 | 288 | 188 | 24 | 1 | 76 | 7 |
| | Worst case | 1 | 0 | 44 | 4 | 1 | 29 | 12 | 1 | 0 | 80 | 43 | 4 | 1 | 455 | 374 | 51 | 6 | 115 | 16 |
| **Wakehurst Parkway road upgrade (north) works area** | | | | | | | | | | | | | | | | | | | | |
| Clearing and grubbing | Typical | 0 | – | 2 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 4 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Surface road works | Typical | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 14 | 4 | 0 | 0 | 138 | 48 | 13 | 0 | 36 | 4 |
| | Worst case | 0 | 0 | 14 | 1 | 0 | 2 | 2 | 0 | 0 | 18 | 4 | 0 | 0 | 171 | 63 | 14 | 1 | 57 | 7 |
| Concrete barriers and traffic controls | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 7 | 0 | 0 | 36 | 4 |
| | Worst case | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 35 | 22 | 4 | 0 | 57 | 7 |
| | Typical | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Work activity | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| Road furniture installation/ modification | Worst case | 0 | – | 4 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Work activity | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| **Wakehurst Parkway road upgrade (centre) works area** | | | | | | | | | | | | | | | | | | | | |
| Clearing and grubbing | Typical | 0 | – | 20 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 51 | 1 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Surface road works | Typical | 0 | – | 4 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 67 | 10 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Concrete barriers and traffic controls | Typical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 30 | 47 | 0 | 0 | 86 | 2 |
| | Worst case | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 37 | 15 | 0 | 0 | 51 | 73 | 15 | 0 | 103 | 15 |
| Road furniture installation/ modification | Typical | 0 | – | 1 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 37 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Work activity | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| **Wakehurst Parkway road upgrade (south) works area** | | | | | | | | | | | | | | | | | | | | |
| Clearing and grubbing works | Typical | 0 | – | 9 | 6 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 1 | – | 13 | 9 | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Surface road works | Typical | 0 | – | 8 | 5 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 5 | – | 21 | 8 | 5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Concrete barriers and traffic controls | Typical | 0 | 0 | 5 | 0 | 0 | 2 | 5 | 0 | 0 | 4 | 8 | 1 | 0 | 12 | 14 | 7 | 0 | 26 | 11 |
| | Worst case | 0 | 0 | 8 | 1 | 0 | 4 | 8 | 1 | 0 | 10 | 8 | 5 | 0 | 22 | 24 | 8 | 5 | 31 | 13 |
| Road furniture installation/ modification | Typical | 0 | – | 8 | 3 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 12 | 7 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

| Work activity | Scenario | Highly noise affected ($L_{Aeq}$[1]) >75 dB(A)[3] | | Day (standard construction hours) ($L_{Aeq}$) | | | Day (out of hours) ($L_{Aeq}$) | | | | Evening ($L_{Aeq}$) | | | | Night ($L_{Aeq}$) | | | | Sleep disturbance ($L_{Amax}$[2]) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standard hours | Outside standard hours | 1 10 dB(A) | 11 20 dB(A) | >20dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | 1 5 dB(A) | 6 15 dB(A) | 16 25 dB(A) | >25dB(A) | Screening | Awakening |
| **Tunnel portals – cut and cover works area** | | | | | | | | | | | | | | | | | | | | |
| Piling – Bored | Typical | 0 | – | 3 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 11 | 3 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Bulk earthwork | Typical | 0 | 0 | 11 | 3 | 0 | 2 | 4 | 0 | 0 | 11 | 8 | 2 | 0 | 55 | 21 | 6 | 0 | 18 | 3 |
| | Worst case | 0 | 0 | 17 | 4 | 0 | 13 | 6 | 0 | 0 | 14 | 17 | 4 | 0 | 86 | 63 | 15 | 4 | 21 | 4 |
| Oversized lifting works | Typical | 0 | 0 | 4 | 0 | 0 | 6 | 4 | 0 | 0 | 9 | 10 | 2 | 0 | 56 | 25 | 8 | 2 | 18 | 3 |
| | Worst case | 0 | 0 | 5 | 0 | 0 | 7 | 5 | 0 | 0 | 9 | 11 | 2 | 0 | 57 | 30 | 10 | 2 | 21 | 4 |
| Deliveries | Typical | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 0 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Concrete pours | Typical | 0 | – | 6 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| | Worst case | 0 | – | 10 | 2 | 0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Note 1: $L_{Aeq}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a selected period of time
Note 2: $L_{Amax}$ is the maximum A-weighted sound pressure level measured over a given period
Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities
Note 4: Cells shaded in dark grey denote a result above the noise management level.

### Cumulative airborne construction noise

The Wakehurst Parkway surface road works would be sufficiently far removed from locations where activities associated with other major projects would be occurring that cumulative impacts are unlikely.

While these road works would occur over an extended duration and would generate significant noise levels at times, the majority of the activities that would onsite would not result in significant amenity impacts for nearby receivers due to the distances between the receiver and the work locations. The risk of construction fatigue due to elevated construction noise levels over an extended duration is therefore low.

Wakehurst Parkway south and north construction support sites (BL12 and BL14) would generally support any outside standard construction hours work for the Wakehurst Parkway surface road works. The use of Wakehurst Parkway south and north construction support site (BL12 and BL14) and the Wakehurst Parkway surface road works would be coordinated to ensure that affected receivers in the vicinity are provided with appropriate respite, minimising potential amenity impacts.

No cumulative airborne construction noise impacts are anticipated associated with the Wakehurst Parkway surface road work.

### Construction traffic noise

Construction traffic associated with the Wakehurst Parkway connection is unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is barely perceptible.

Two heavy vehicles per hour are expected to be required during the standard hours works typically associated with the road works upgrade and the operation of the support sites such as the Wakehurst Parkway south (BL12) or Wakehurst Parkway north (BL14). There would be additional heavy vehicle movements associated with the concrete batch plant at Wakehurst Parkway north construction support site (BL14) which could be a maximum of three heavy vehicles per hour. No vehicle movements other than oversized deliveries are expected to be required outside standard construction hours.

### Construction ground-borne noise

Ground-borne noise levels have the potential to be generated by vibration intensive works at the surface road works and associated temporary construction support sites. However, throughout these construction works it is likely that the airborne noise levels would be greater than ground-borne noise levels at the nearby noise sensitive receivers.

### Construction vibration

Table 10-34 shows four heritage items located in NCAs 54.1 (Frenchs Bullocks Track, Frenchs Forest; Bantry Bay; Wakehurst Parkway (45-6-0662) and Rock engraving (Garigal National Park) (45-6-2940)) and 55.1 (Bantry Bay Aboriginal Engraving Site (45-6-0655)) are predicted to be within the minimum working distances for major vibration generating activities. Up to 27 sensitive receiver buildings are identified within the minimum working distance for human response from the Wakehurst Parkway surface road works. The locations of these properties are presented in Annexure L of Appendix G (Technical working paper: Noise and vibration). The most vibration intensive activity at this site is likely to be use of large rock hammers for the cut and cover portal works. Refer to Appendix G (Technical working paper: Noise and vibration) and Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage) for further details on the heritage items potentially impacted.

Where vibration intensive works occur within the minimum working distances the risk of structural damage and/or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.7.

**Table 10-34 Number of receiver buildings within minimum working distances for vibration intensive work – Wakehurst Parkway surface road works**

| Location | NCA | Number of receiver buildings within minimum working distances for vibration intensive work | | |
|---|---|---|---|---|
| | | Cosmetic damage | | Human response |
| | | Heritage item[1] | Sound structure | |
| Warringah Road/Wakehurst Parkway | 57.1 | – | – | 2 |
| | 58.1 | – | – | 1 |
| Road length upgrade | 54.1 | 3 | – | 9 |
| | 55.1 | 1 | – | 6 |
| | 56.1 | – | – | 9 |
| Cut and cover portals and ventilation facility | 54.1 | 1 | – | – |

Note 1: Conservation areas have not been considered as they do not form a structure that would be impacted by vibration

### Controlled blasting

Controlled blasting has been identified as an alternative to rock hammering in deep cuts areas along the Wakehurst Parkway. While rock hammering may be still required for secondary breakage and/or trimming walls, controlled blasting has the potential to significantly reduce noise exposure period compared to traditional rock hammering excavation, which might have to occur over very long periods of time.

If controlled blasting is carried out, it would be planned to comply with overpressure noise and ground vibration management levels discussed in Section 10.4.5 and environmental management measures included in Chapter 19 (Biodiversity) regarding the Large-eared Pied Bat (*Chalinolobus dwyeri*). Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix S (Technical working paper: Biodiversity development assessment report) for further detail.

## 10.6.16 Other construction activities

### Local area works

Local area and utility connection works, such as service and utility identification works, electricity, sewer, communications and other utility adjustments, and local road integration works, may be needed as part of establishing temporary construction support sites. While some locations where local area work would be required are known and have been assessed as part of the relevant compound or surface road work area, other requirements are still being investigated or are unknown. They could, therefore, be required outside of areas specifically assessed in this document. These works are typically very short duration and are similar to works regularly carried out by utilities providers and road maintenance crews across Greater Sydney.

Around the temporary construction support sites, residences are typically set back by about ten metres from the nearest road. Table 10-35 shows predicted typical noise levels that would be expected at ten metres from local area works. The predictions account for distance attenuation and some localised shielding (such as temporary noise barriers) and are expected to be conservative (over-predict) as they do not account for other effects such as ground absorption and terrain effects.

**Table 10-35 Assessment local area works noise at the nearest receiver building**

| Item | Utilities modification | | Pavement modification | | Paving or asphalting | | Linemarking | |
|---|---|---|---|---|---|---|---|---|
| | Typical | Worst case | Typical | Worst case | Typical | Worst case | Typical | Worst case |
| Distance to the highly noise affected level (m) | 13 | 43 | 13 | 42 | 12 | 42 | 12 | 17 |
| $L_{Aeq(15\ minute)}$[1] noise level at 10 m (dB(A))[2] | 77 | 88 | 77 | 87 | 76 | 87 | 77 | 80 |

Note 1: $L_{Aeq(15\ minute)}$ is the A-weighted "equivalent noise level". It is the summation of noise events and integrated over a period of 15 minutes

Note 2: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Section 10.5 for a comparison of dB(A) for various activities

The results presented in Table 10-35 show that receiver buildings have the potential to be highly noise affected during local areas works, depending on the activity, the plant and equipment in use and the proximity of the works to the affected receivers. In most noise catchment areas, with a standard construction hours noise management level of 55 dB(A) or more, noise from local area works at the closest receivers would typically exceed the noise management level by about 20 dB(A) and in the worst case up to 33 dB(A).

Outside standard construction hours, noise from local area works at the closest receivers would typically exceed the night time noise management level by about 35dB(A) and in the worst case up to about 50 dB(A). This is based on a noise management level in most noise catchment areas of 40 dB(A) or more.

Local area works would typically consist of short duration (up to one week at any location) and would be managed in accordance with guidance *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016a).

### Truck marshalling areas

Spoil haulage trucks would likely require marshalling areas to be used when delays are experienced at the tunnel sites. The locations of these staging areas would be selected during development of the detailed construction methodology.

Where required, truck marshalling locations would be selected away from residential receivers and the site layout would take advantage of on-site or adjacent non-receiver structures to maximise acoustic shielding to nearby noise sensitive receivers.

All drivers would be required to comply with a Heavy Vehicle Code of Conduct, which would include noise management methods such as limiting idling and compression braking, and traffic management practises to minimise noise emissions from vehicles entering and leaving the site.

## 10.7 Environmental management measures

Environmental management measures for potential noise and vibration impacts during construction are outlined in Table 10-36. Additional measures to address cumulative impacts are included in Chapter 27 (Cumulative impacts).

**Table 10-36 Environmental management measures – construction noise and vibration**

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| CNV1 | Pre-construction and construction | Construction noise and vibration impacts | A Construction Noise and Vibration Plan will be developed for the project. This plan will:<br>a) Identify relevant criteria and management levels in relation to noise and vibration<br>b) Identify noise and vibration sensitive receivers and features in the vicinity of the project<br>c) Include standard and additional mitigation from the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016) and detail how and when these will be applied in the project<br>d) Describe the approach that will be adopted for carrying out location and activity specific construction noise and vibration impact assessments to assist with designing and selecting of the appropriate mitigation and management measures<br>e) Include protocols that will be adopted to manage works required outside standard construction hours<br>f) Detail the methodology and approach for managing construction noise impacts<br>g) Detail the process for managing construction vibration, including for heritage structures, considering all types of vibration generating works, including blasting<br>h) Outline the approach for identifying and managing potential cumulative impacts, including ensuring appropriate respite for works outside standard construction hours<br>i) Outline the procedures and approach for noise and vibration monitoring to be carried out to confirm construction noise and vibration levels in relation to noise and vibration management levels<br>j) Detail how construction noise impacts from concurrent or consecutive nearby construction works associated with the project will be managed where feasible and reasonable. | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | The Construction Noise and Vibration Management Plan will be implemented for the duration of construction of the project. | |
| CNV2 | Pre-construction | Construction noise and vibration impacts | Detailed location and activity specific construction noise and vibration impact statements will be prepared and implemented to cover:<br>• Construction support sites<br>• Works outside standard construction hours<br>• Works with the potential to result in highly noise affected residential receivers (ie exposed to noise levels that exceed 75 dB(A))<br>• Works with the potential to exceed relevant human response and cosmetic damage criteria for vibration<br>• Subsurface tunnelling activities.<br>The statements will consider the proposed site layouts and noise generating activities that will occur, identify potentially impacted sensitive receivers and assess predicted noise and vibration levels against the relevant criteria and management levels, and specify the feasible and reasonable mitigation and management measures that will be implemented in accordance with the requirements of the *Interim Construction Noise Guideline* (DECC, 2009) and the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016). | BL/GHF |
| CNV3 | Construction | Construction noise and vibration impacts during out of hours work | An out of hours works protocol will be developed for the construction of the project. The protocol will include:<br>a) Details of works required outside standard construction hours justifications of why the works are required outside standard construction hours<br>b) The noise and vibration impact assessment processes that will be followed to identify potentially affected receivers and clarify potential impacts<br>c) Mitigation and management measures that are to be considered and implemented where appropriate to manage potential impacts | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | associated with works outside standard construction hours<br>d) Details of the approval process (internal and external) for works proposed outside standard construction hours.<br>The protocol will be prepared in consultation with Department of Planning, Industry and Environment and the NSW Environment Protection Authority.<br>The project protocol will be implemented during the duration of the construction of the project. | |
| CNV4 | Construction | Construction noise and vibration impacts during out of hours work | For works outside standard construction hours on and adjacent to major roadways, the elevated existing ambient and background noise levels during the following shoulder periods will be investigated and confirmed:<br>• Shoulder period (night-day) – between 5.00am and 7.00am<br>• Shoulder period (evening-night) – between 10.00pm and 12.00am.<br>Where appropriate, these shoulder periods will be utilised where feasible and reasonable to minimise potential amenity impacts associated with project activities outside standard construction hours. | BL/GHF |
| CNV5 | Construction | Construction noise and vibration impacts | Construction noise and vibration impacts will be monitored periodically throughout all stages of the construction support site to ensure that:<br>a) Noise and vibration levels are consistent with the predictions detailed in the relevant construction noise and vibration impact statements<br>b) Noise and vibration impacts are being appropriately managed<br>c) Mitigation measures are effective. | BL/GHF |
| CNV6 | Construction | Construction noise impacts | Where feasible and reasonable, unless compliance with the relevant traffic noise criteria can be achieved, or alternative arrangements have been agreed with affected receivers, construction vehicle movements will not occur on local roads beyond those required for direct access to construction sites. | BL/GHF |
| CNV7 | Construction | Construction vibration impacts | Vibration generating activities will be managed through the establishment of | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | minimum working distances to achieve vibration screening levels.<br>Where vibration levels are predicted to exceed the screening levels, a more detailed assessment of the impacted structure will be carried out to assess the susceptibility of the structure to damage from vibration due to the project. Appropriate mitigation and management measures, such as equipment substitution and alternative methods, will be identified and implemented to avoid damage. Attended vibration monitoring will be carried out during vibration intensive activities in the vicinity to ensure vibration levels remain below appropriate limits for that structure.<br>For heritage items, the more detailed assessment will specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.<br>Pre-construction building structure condition surveys will be carried out in accordance with environmental management measure SG7. Any building and/or structure damage from vibration caused by the project would be repaired at no cost to the owner. | |
| CNV8 | Construction | Construction ground–borne noise impacts | Where ground-borne levels are predicted to exceed the relevant noise management levels, alternative construction techniques and equipment that are likely to generate less ground-borne noise will be investigated and used where feasible and reasonable. | BL/GHF |
| CNV9 | Construction | Construction impacts from surface road works | Mitigation measures will be implemented for surface road works, local area and utility works, where construction activities are predicted to exceed noise management levels at receivers. Where feasible and reasonable, the approaches that will be used include:<br>a) Carrying out works during the daytime period when near residential receivers<br>b) Selection of plant and equipment to minimise noise and vibration impacts<br>c) Management of plant and equipment to minimise the generation of noise and vibration impacts | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | d) Community consultation, engagement and notification<br>e) Detailed programming and respite protocols<br>f) Where out of hours works are required, programming the noisiest activities to occur during the less sensitive time periods<br>g) Out of hours works protocols<br>h) Limiting timing of noise intensive work<br>i) Use of portable noise barriers around particularly noisy equipment such as concrete saws and rock hammers in cases where it will effectively reduce noise levels at nearby receivers<br>j) Management of construction traffic to minimise movements during the night periods along local roads<br>k) Establishing minimum vibration working distances for vibration intensive works<br>l) Vibration and blasting trials and/or monitoring along with building condition surveys<br>Construction support sites that support surface road works will be designed to ensure that primary noise sources are located as far as possible from the nearby noise sensitive receivers, with solid structures (shed, containers, barriers, etc) placed between the noise sensitive receiver where feasible and reasonable to maximise acoustic shielding and block the line of site between the source and the receiver. | |
| CNV10 | Construction | Construction impacts from surface road works | Where feasible and reasonable, noise barriers proposed as part of the project to address road traffic noise will be implemented as early as possible to attenuate construction noise. | BL/GHF |
| CNV11 | Construction | Increased road traffic noise levels due to noise barrier removal | Where it is necessary to relocate or remove existing noise barriers to facilitate construction of new road infrastructure, the new noise barriers will be installed before removing the existing barriers where feasible and reasonable. Where it is not possible to install the new barriers before removing the existing barriers, the duration between removing the existing and installing the new barriers will be minimised. Temporary noise barriers will | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | be installed to ensure that road traffic noise levels do not increase by more than 2 dB(A) at the affected residential receiver buildings, where feasible and reasonable. | |
| CNV12 | Construction | Construction blasting impacts | Any blasting and associated activities will be carried out in a manner that does not generate unacceptable overpressure and vibration impacts or pose a significant risk of impact to structures and sensitive receivers (including threatened fauna and fauna habitat adjacent Wakehurst Parkway). Prior to any blasting all potentially affected sensitive receivers and features in the vicinity would be identified. Appropriate tests will be carried out at each proposed blasting location to develop site-specific laws that take into account relevant factors such as underlying geology and separation distance to sensitive receivers and features to determine appropriate charge sizes and blasting design to ensure compliance with relevant vibration and overpressure criteria. All blasting will be carried out in accordance with the specific-laws. Monitoring will occur to determine compliance with the relevant criteria, and the site-specific laws will be adjusted as required based on the monitoring results to ensure ongoing compliance. The potentially affected community will be kept informed about proposed blasting activities. | BL/GHF |
| CNV13 | Construction | Cumulative construction noise impacts and construction fatigue | Construction noise from concurrent and consecutive major projects in the vicinity of work locations associated with the project will be managed to minimise cumulative construction noise impacts. Where feasible and reasonable the approaches that will be used include:<br>a) Considering the potential for cumulative impacts due to other major projects in the locality during development of the detailed construction methodology. The construction methodology will be developed to minimise overall noise impacts and the need for respite for receivers potentially affected by cumulative impacts wherever feasible and reasonable | BL/GHF |

| Ref | Phase | Impact | Environmental management measure | Location |
|---|---|---|---|---|
| | | | b) Consulting with other major projects in the vicinity with the aim of coordinating work between the different projects that will affect the same area to ensure that affected receivers get appropriate respite from high noise impact activities and works outside standard construction hours<br>c) Implementing additional feasible and reasonable source mitigation for cumulative construction activities, where programming is not practical to avoid cumulative noise impacts<br>d) Community consultation to seek feedback on and identify key noise and vibration issues relevant to the local community so that current and future works can be managed to limit cumulative impacts. | |
| CNV14 | Construction | Impact piling | In any given week, impact piling will be carried out over no more than either:<br>• a two hour period each work day or<br>• a six hour period on a single work day. | BL |

Note 1: BL = Beaches Link, GHF = Gore Hill Freeway Connection